# Review of Endodontics and Operative Dentistry

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***Review of Endodontics and Operative Dentistry***



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*To*
*Our Beloved Daughter*
*Prisha*

# Preface

With such a vast amount of literature present in dentistry, sometimes it seems frustrating and overwhelming as being surrounded by books of all sorts providing the knowledge and yet not having the touch and how to attempt an answer in the examination. We felt the need of simple, systematized and comprehensive book to cover the maximum syllabus in shorter time.

Being an exam-oriented book, this acts as a guide and companion to neutralize the confusions and apprehensions occurring during the exams. The attempt has been made to solve long and short questions commonly asked during various university examinations over the 20 years.

It includes all the topics presented in the syllabus given by DCI in simple and easy language.

This book has been arranged in simple, small chapters illustrated with tables, charts and line diagrams which are easy to remember and reproduce during the examination .

We await the response and suggestions regarding this book for its further improvement.

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# Acknowledgments

First and foremost, we bow in gratitude to Almighty God. With His blessing, it is possible to complete our project.

We personally express our thanks to all our teachers, friends and colleagues who helped us directly and indirectly to complete this project.

We acknowledge our sincere thanks to Shri JP Vij, Chairman and Managing Director and Mr. Tarun Duneja, General Manager (Publishing) of M/s Jaypee Brothers Medical Publishers (P) Ltd., New Delhi and their devoted staff for their acceptance and endeavour to bring out this text in book form.

# Contents

## Section One: Endodontics

## Section Two: Operative Dentistry

# Suggested Reading

## Section One: Endodontics

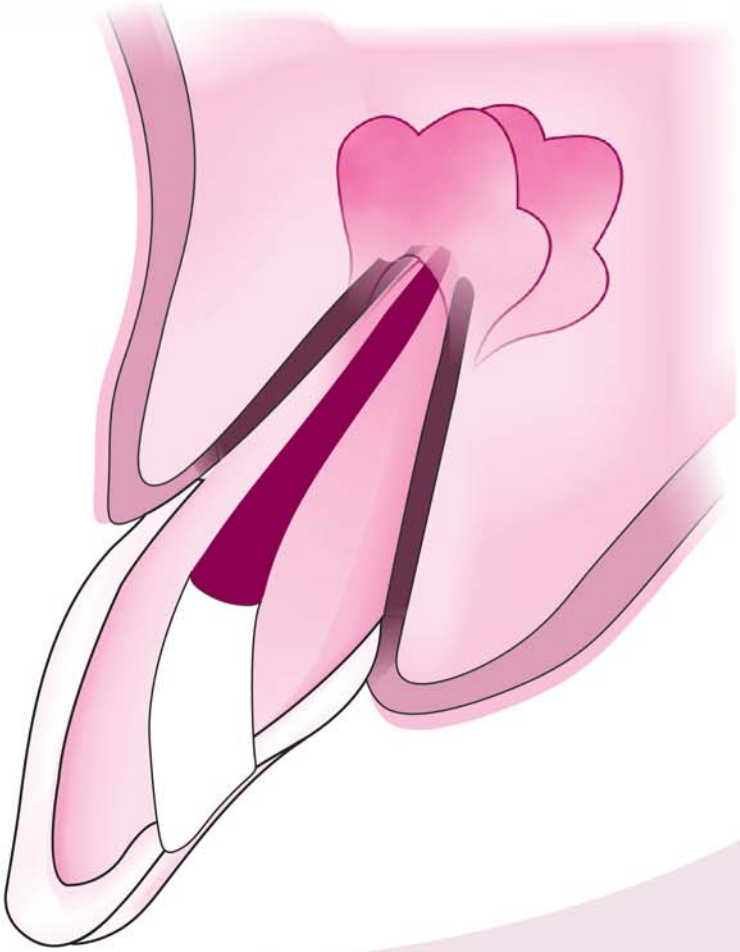
- Textbook of Endodontics by Nisha Garg and Amit Garg.
- Endodontics by L I Grossman
- Endodontic Therapy by FS Weine
- Pathways of Pulp by Stephen Cohen
- Principles and Practice of Endodontics by Walton and Torbinejad
- Endodontics by Stock and Gulabiwala
- Surgical Endodontics by Guttmann.

## Section Two: Operative Dentistry

- Sturdvent″s Art and Science of Operative Dentistry.
- Principles and Practice of Operative Dentistry by Charbeneau
- Craig″s Restorative Dental Materials
- Textbook of Operative Dentistry by Vimal K Sikri

# Section One

# Endodontics



# 1 Introduction to Endodontics

## WHAT ARE AIMS AND OBJECTIVES OF ENDODONTICS?

Endodontics is the branch of clinical dentistry associated with the prevention, diagnosis and treatment of the pathosis of the dental pulp and their sequelae.

It includes the study of basic sciences like biology of normal pulp, etiology, pathology and treatment of various pulpal diseases.

Aims and objectives of the endodontic therapy are:

i. Diagnosis of various pulpal diseases.
ii. To identify various etiological factors for pulpal and periapical diseases.
iii. Maintain vitality of the pulp.
iv. Preserve and store the tooth with damaged and necrotic pulp.
v. Preserve and restore the teeth which have failed to the previous endodontic therapy, to allow the tooth to remain functional in the dental arch.

Thus, we can say that the primary goal of endodontic therapy is to create an environment within the root canal system which allows the healing and continued maintenance of the health of the periradicular tissue.

# 2 Pulp and Periapex

## DENTAL PULP

- The dental pulp is soft tissue of mesenchymal origin located in the center of the tooth.
- It consists of specialized cells, odontoblasts arranged peripherally in direct contact with dentin matrix. This close relationship between odontoblasts and dentin is known as 'Pulp—dentin complex".
- Due to presence of the specialized cells, i.e. odontoblasts as well as other cells, which can differentiate into hard tissue secreting cells; the pulp retains its ability to form dentin throughout the life. This enables the vital pulp to partially compensate for loss of enamel or dentin occurring with age.
- Features of pulp which distinguish it from tissue found elsewhere in the body:
  a. Pulp is surrounded by rigid walls and so is unable to expand in response to injury as a part of the inflammatory process.
  b. There is minimal collateral blood supply to pulp tissue, which will reduce its capacity for repair following injury.
  c. The pulp is composed almost entirely of simple connective tissue, yet at its periphery it is a layer of highly sophisticated cells, the odontoblasts.
  d. The innervation of pulp tissue is both simple and complex. Simple in that there are only free nerve endings and consequently the pulp lacks proprioception. Complex because of innervation of the odontoblast processes which produces a high level of sensitivity to thermal and chemical change.

## WHAT IS ANATOMY OF DENTAL PULP?

Pulp lies in the center of tooth and shapes itself to miniature form of tooth. This space is called pulp cavity, which is divided into pulp chamber and root canal (Fig. 2.1).

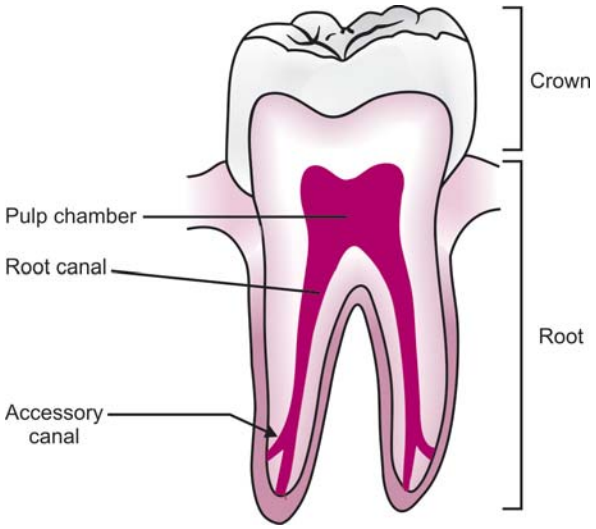



**Fig. 2.1:** Pulp cavity showing pulp chamber and root canal

In the anterior teeth, the pulp chamber gradually merges into the root canal and this division becomes indistinct. But in case of multirooted teeth, there is a single pulp chamber and usually two to four root canals.

*Pulp chamber* reflects the external form of enamel at the time of eruption, but anatomy is less sharply defined. The roof of pulp chamber consists of dentin covering the pulp chamber occlusally.

A specific stimulus such as caries leads to the formation of irritation dentin while with time, pulp chamber shows reduction in size as secondary or tertiary dentin is formed.

*Root canal* is that portion of pulp cavity, which extends from canal orifice to the apical foramen. The shape of root canal varies with size, shape, and number of the roots in different teeth.

*The apical foramen* is an aperture at or near the apex of a root through which nerves and blood vessels of the pulp enter or leave the pulp cavity. Normally, it is present near the apex but sometimes; opening may be present on the accessory and lateral canals of root surface forming the accessory foramina.

In young newly erupted teeth, it is wide open but as the root develops, apical foramen becomes narrower. The inner surface of the apex becomes lined with the cementum, which may extend for a short distance into the root canal.

*Accessory canals* are lateral branches of the main canal that form a communication between the pulp and periodontium. Accessory canals contain connective tissue and vessels and can be seen anywhere from furcation to apex but tend to more common in apical third and in posterior teeth.

Exact mechanism of their formation is not known but they occur in areas where there is premature loss of root sheath cells because these cells induce formation of odontoblasts. They also develop where developing root encounters a blood vessel. If vessel is located in this area, where dentin is forming; hard tissue may develop around it making a lateral canal from radicular pulp.

## VARIOUS CANAL CONFIGURATIONS

In most cases, number of root canals corresponds with number of roots but a root may have more than one canal. Despite of many combinations of canals which are present in the roots of teeth, the four categories of root canal system can be described (Weine) (Fig. 2.2). These are as follows:

1. *Type I*: Single canal from pulp chamber to apex.
2. *Type II*: Two separate canals leaving the chamber but exiting as one canal.
3. *Type III*: Two separate canals leaving the chamber and exiting as two separate foramina.
4. *Type IV*: One canal leaving the chamber but dividing into two separate canals and exiting in two separate foramina.

*Vertucci* established eight different classification of pulp anatomy rather than four. Classification for root canal system as given by Vertucci (Fig. 2.3).

- *Type I*: Single canal from orifice to apex.
- *Type II*: Two canals leaving the pulp chamber but joining shortly before apex.

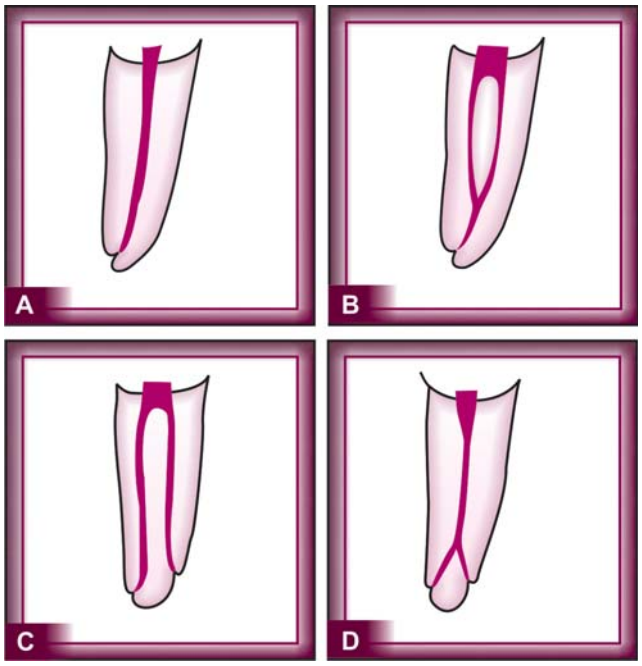



**Fig. 2.2:** Types I, II, III, IV root canal system

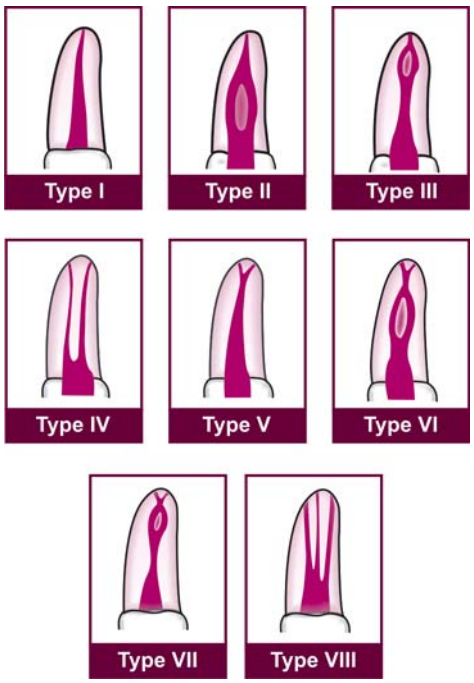



**Fig. 2.3:** Vertucci's classification of root canal system

- *Type III*: One canal dividing into two within the body of the root and then again forming one canal.
- *Type IV*: Two canals exiting into two apices.
- *Type V*: One canal leaving the chamber dividing into two with two apices.

- *Type VI*: Two canals leaving the chamber merging in body and then redividing into two apices.
- *Type VII*: One canal leaving the chamber, dividing and then rejoining in body of the root and finally redividing into two apices.
- *Type VIII*: Three canals from chamber to apex.

This classification does not consider possible positions of auxilliary canals or portion at which apical foramen exit the root.

## VARIATION IN THE INTERNAL ANATOMY OF TEETH

Commonly seen anomalies of pulp cavities are as follows:

### *Lingual Groove*

It is a surface in-folding of dentin directed from the cervical portion towards apical direction. It is frequently seen in maxillary lateral incisors.

### *High Pulp Horns*

Commonly high pulp horns are found in recently erupted teeth.

### *C-shaped Canals*

This type of canal is usually found in mandibular molars. They are named so because of its morphology. Pulp chamber in C-shaped molar is single ribbon shaped with 180 degree arc or more .

### Presence of Extracanals

More than 70 percent of maxillary first molar have shown the occurrence of second mesiobuccal canal. In mandibular molars extracanals are found in 38 percent of the cases. Two canals in mandibular incisors are reported in 41 percent of the cases.

### Dilacerations

Dilacerations is an extraordinary curving of the roots of the teeth.

### Dens in Dente or Dens Invaginatus

Tooth with dens invaginatus has tendency for plaque accumulation which predisposes it to early decay and thus pulpitis.

### Dens Evaginatus

In this condition an anomalous tubercle or cusp is located on the occlusal surface and is commonly seen in premolar teeth.

### Taurodontism

In taurodontism, teeth show elongated crowns or apically displaced furcations resulting in pulp chambers which have increased apico-occlusal height.

## INDIVIDUAL TOOTH ANATOMY

### Maxillary Central Incisor (Fig. 2.4)

#### *Pulp Chamber*

- It is located in the center of the crown, equal distance from the dentinal walls.
- Mesiodistally, pulp chamber follows the outline of the crown and it is ovoid in shape.
- Buccopalatally the pulp chamber is narrow as it transforms into the root canal with a constriction just apical to the cervix.

#### *Root Canal*

- One root with one root canal.
- Coronally, the root canal is wider buccopalatally.
- Coronally or cervically, the canal shape is ovoid in cross-section but in apical region, the canal is round.

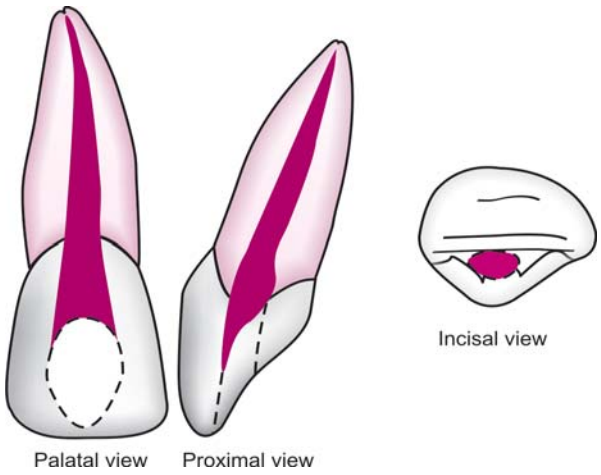



**Fig. 2.4:** Maxillary central incisor

## Maxillary Lateral Incisor

*Pulp Chamber*

The shape of pulp chamber is similar to that of maxillary central incisor but the incisal outline of the pulp chamber tends to be more rounded.

*Root Canal*

- Canal is ovoid labiopalatally in cervical third and round in apical third.
- Apical region of the canal is usually curved in a palatal direction.

## Maxillary Canine

*Pulp Chamber*

- Labiopalatally, the pulp chamber is almost triangular shape with apex pointed incisally.
- In cross-section it is ovoid in shape with larger diameter labiopalatally.

*Root Canal*

- Cross-section at cervical and middle third show its oval shape, at apex it becomes circular.
- Canal is usually straight but may show a distal apical curvature.

## Maxillary First Premolar (Fig. 2.5)

*Pulp Chamber*

- Pulp chamber is wider buccopalatally with two pulp horns.
- Floor of pulp chamber is convex with two canal orifices.

*Root Canal*

- Maxillary first premolar has two roots.
- Cross-section of root canals shows ovoid shape in cervical third, and in middle and apical third, they show circular shape.
- The root canals are usually straight and divergent.

## Maxillary Second Premolar

*Pulp Chamber*

- Maxillary second premolar usually has one root with a single canal.
- In cross-section, pulp chamber has narrow and ovoid shape.

*Root Canals*

- Single root with single canal is found.
- At cervix, cross-section shows ovoid and narrow shape, which becomes circular in apical third.

## Maxillary First Molar (Fig. 2.6)

*Pulp Chamber*

- It has the largest pulp chamber with four pulp horns, viz. mesiobuccal, mesiopalatal, distobuccal and distopalatal.
- The four pulp horns are arranged in such a fashion which gives it rhomboidal shape in the cross-section.

*Root Canals*

- Mesiobuccal canal is the narrowest of the three canals, flattened in mesiodistal direction at cervix but becomes round as it reaches apically.

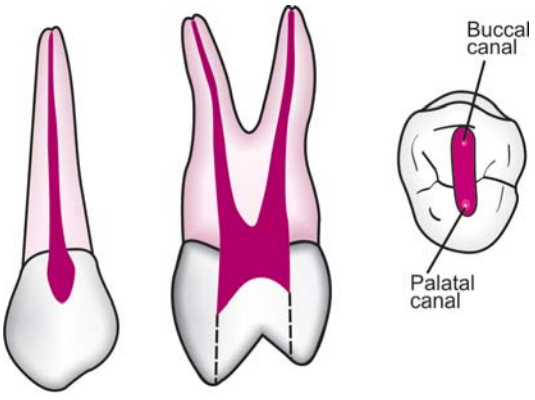



**Fig. 2.5:** Maxillary first premolar

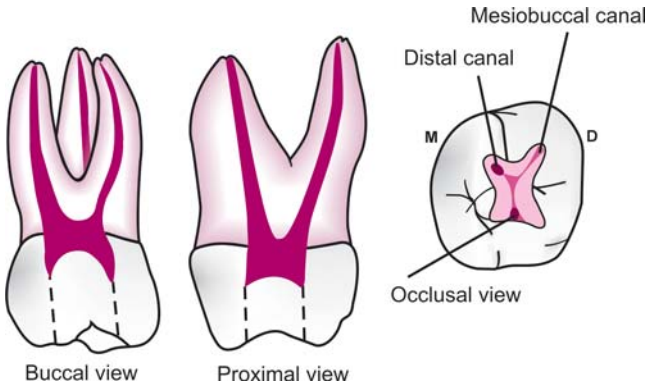



**Fig. 2.6:** Maxillary first molar

- Distobuccal canal is narrow and straight, generally it is round in cross-section.
- The palatal root canal has largest diameter which has rounded triangular cross-section coronally and becomes round apically.

## Maxillary Second Molar

*Pulp Chamber*

It is similar to maxillary first molar except that it is narrower mesiodistally.

*Root Canal*

Similar to first molar except that in maxillary second molar roots tend to be less divergent and may be fused.

## Mandibular Teeth Central Incisor

*Pulp Chamber*

- Mandibular central incisor is the smallest tooth in the arch.
- Pulp chamber is similar to maxillary central incisor being wider labiolingually pointed incisally with three pulp horns.

*Root Canals*

- Cross-section of root canals show wider dimension in labiolingual direction making it ovoid shape whereas round in the apical third.
- Since canal is flat and narrow mesiodistally and wide buccopalatally, ribbon shaped configuration is formed.

## Mandibular Lateral Incisor

*Pulp Chamber*

The configuration of pulp chamber is similar to that of mandibular central incisor except that it has larger dimensions.

*Root Canals*

It has features similar to those of mandibular central incisor.

## Mandibular Canine

*Pulp Chamber*

Pulp chamber appears to narrower mesiodistally.

*Root Canals*

- Coronally, the root canal is oval in cross-section, becomes round in the apical region.
- Lateral canals are present in 30 percent of cases.

## Mandibular First Premolar

*Pulp Chamber*

- Mesiodistally, the pulp chamber is narrow in dimension.
- Pulp chamber has two pulp horns, the buccal horn being most prominent.

*Root Canal*

Buccolingually, root canal cross-sections tend to be oval, at apical part becomes round.

## Mandibular Second Premolar

*Pulp Chamber*

It is similar to that of mandibular first premolar except that lingual pulp horn is more prominent.

*Root Canal*

- Buccolingually, canal is wider than that of mandibular first premolar.
- Root canal cross-sections tend to be oval coronally and round apically.

## Mandibular First Molar (Fig. 2.7)

*Pulp Chamber*

- It is quadrilateral in cross-section at the level of the pulp floor and is wider mesially than distally.
- The roof of the pulp chamber is rectangular in shape with straight mesial wall and rounded distal wall.

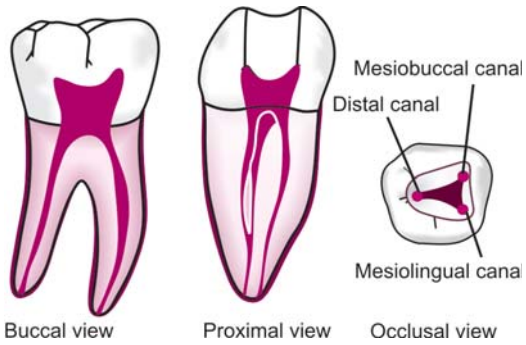



**Fig. 2.7:** Mandibular first molar

*Root Canals*

- Mesial root has two canals, viz. mesiobuccal and mesiolingual.
- Mesiobuccal canal is usually curved and longer.
- Distal root is straighter and shorter and generally has one canal.

### Mandibular Second Molar

- Pulp chamber is similar to that of mandibular first molar except that it is smaller in size.
- Root canal orifices are smaller and closer together.

## WHAT IS EFFECT OF POSTURE ON PULPAL BLOOD FLOW?

In normal upright posture, there is less pressure effect in the structures of head. On lying down, the gravitational effect disappears; there is sudden increase in pulpal blood pressure and thus corresponding rise in tissue pressure which leads to pain in lying down position.

Another factor contributing to elevated pulp pressure on reclining position is effect of posture on the activity of sympathetic nervous system. When a person is upright, baroreceptors maintain high degree of sympathetic stimulation, which leads to slight vasoconstriction. Lying down will reverse the effect leading to increase in blood flow to pulp. In other words, lying down increase blood flow to pulp by removal of both gravitational and baroreceptor effect.

## WHAT ARE FUNCTIONS OF PULP?

### Formation of Dentin

Pulp primarily helps in:

- Synthesis and secretion of organic matrix.
- Initial transport of inorganic components to newly formed matrix.
- Creates an environment favorable for matrix mineralization.

### Nutrition of Dentin

Nutrients exchange across capillaries into the pulp interstitial fluid, which in turn travels into the dentin through the network of tubules created by the odontoblasts to contain their processes.

### Innervation of Tooth

Through the nervous system, pulp transmits sensations mediated through enamel or dentin to the higher nerve centers.

### Defense of Tooth

The formation of reparative dentin and sclerotic dentin are defense mechanisms of the tooth.

Pulp also has the ability to elicit an inflammatory and immunologic response in an attempt to neutralize or eliminate invasion of dentin by caries causing microorganisms and their by products.

## ENLIST VARIOUS AGE CHANGES IN THE PULP

Pulp like other connective tissues, undergoes changes with time. Regardless of the cause, the pulp shows changes in appearance (morphogenic) and in function (physiologic).

## MORPHOLOGIC CHANGES

1. Continued deposition of intratubular dentin.
2. Reduction in pulp volume due to increase in secondary dentin deposition (Fig. 2.8).
3. Presence of dystrophic calcification and pulp stones.
4. Decrease in the number of pulp cells.
5. Decrease in sensitivity.
6. Reduction in number of blood vessels.

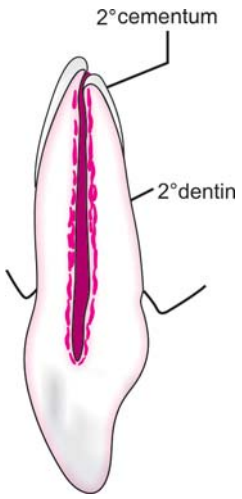



**Fig. 2.8:** Reduction in size of pulp volume

## PHYSIOLOGIC CHANGES

1. Decrease in dentin permeability provides protected environment for pulp.
2. Reduced ability of pulp to react to irritants and repair itself.

## NOTE ON PULP STONES

These may form either due to some injury or a natural phenomenon.

The larger calcifications are called denticles. Sometimes denticles became extremely large, almost obliterating the pulp chamber or the root canal.

Pulp stones may be classified: (1) according to structure (2) according to size (3) according to location.

### Classification of Pulp Stone

1. According to structure
   a. True
   b. False
2. According to size
   a. Fine
   b. Diffuse
3. According to location
   a. Embedded
   b. Attached
   c. Free.

### According to Structure

*True Denticle*

A true denticle is made up of dentin and is lined by odontoblasts. Development of true denticle is caused by inclusions of remnants of epithelial root sheath within the pulp. These epithelial remnants induce the cells of pulp to differentiate into odontoblast which form dentin masses called true pulp stones.

*False Denticles*

Appear as concentric layers of calcified tissue. They may arise around vessels. Calcification of thrombi in blood vessels called, phleboliths, may also serve as nidi for false denticles.

### According to Size

According to size, there are fine or diffuse mineralizations. The former are found more frequently in the root canals, but they may also be present in the coronal portion of the pulp.

### According to Location

They can be classified as:

*Free denticles* are entirely surrounded by pulp tissue.

*Attached denticles* are partially fused dentin.

*Embedded denticles* are entirely surrounded by dentin calcifications, are seen more in older pulps.

### Clinical Significance of Pulp Stones

Presence of pulp stones may alter the internal anatomy of the pulp cavity. Thus, making endodontic therapy challenging in these cases.

## CALCIFIC METAMORPHOSIS

Calcific metamorphosis is defined as a pulpal response to trauma that is characterized by deposition of hard tissue within the root canal space.

Calcific metamorphosis occurs commonly in young adults because of trauma.

The *clinical picture* of calcific metamorphosis shows darker hue of affected tooth than the adjacent teeth.

The *radiographic appearance* of calcific metamorphosis is partial or total obliteration of the pulp canal space with a normal periodontal membrane space and intact lamina dura.

*The mechanism of hard tissue formation during calcific metamorphosis* is characterized by an osteoid tissue that is produced by the odontoblasts at the periphery of the pulp space or can be produced by undifferentiated pulpal cells that undergo differentiation as a result of the traumatic injury. This results in a simultaneous deposition of a dentin-like tissue along the periphery of the pulp space and within the pulp space proper. These tissues can eventually fuse with one another, producing the radiographic appearance of a root canal space that has become rapidly and completely calcified.

The ***management of canals*** with calcific metamorphosis is similar to the management of pulpal cavity with any form of calcification.

## PERIAPICAL TISSUE

### Cementum

Cementum can be defined as hard, avascular connective tissue that covers the roots of the teeth. It is light yellow in color and can be differentiated from enamel by its lack of luster and darker hue.

### Types

There are two main types of root cementum
1. Acellular (Primary)
2. Cellular (Secondary).

### Periodontal ligament

Periodontal ligament forms a link between the alveolar bone and the cementum. It is continuous with the connective tissue of the gingiva and communicates with the marrow spaces through vascular channels in the bone. Periodontal ligament houses the fibers, cells and other structural elements like blood vessels and nerves.

The Periodontal ligament comprises the following components:
1. Periodontal Fibers
2. Cells
3. Blood vessels
4. Nerves.

### Alveolar Bone

Bone is specialized connective tissue which comprises of inorganic phases that is very well designed for its role as load bearing structure of the body.

### Cells and Intercellular Matrix

Cells present in bone are:
a. Osteocytes
b. Osteoblasts
c. Osteoclasts.

### Intercellular Matrix

Bone consists of two third inorganic matter and one third organic matter. Inorganic matter is composed mainly of minerals calcium and phosphate along with hydroxyl apatite, carbonate, citrate, etc. while organic matrix is composed mainly of collagen type I (90%).

# 3 Pathologies of Dental Pulp

## ENUMERATE VARIOUS CAUSES OF PULPAL DISEASES

A. Etiology of pulpal diseases can be broadly classified into:
   1. Physical
      - Mechanical
      - Thermal
      - Electrical
   2. Chemical
   3. Bacterial
   4. Radiation.

B. *WEIN* classifies the causes of pulpal inflammation, necrosis or dystrophy in a logical sequence beginning with the most frequent irritant, microorganisms.
   1. ***Bacterial***
      *Bacterial irritants*: In 1891, WD Miller—Bacteria were a possible cause of pulpal inflammation. Most common cause for pulpal injury-bacteria or their products may enter pulp through a break in dentin either from:
      - Caries
      - Accidental exposure
      - Fracture
      - Percolation around a restoration
      - Extension of infection from gingival sulcus
      - Periodontal pocket and abscess
      - Anachoresis (Process by which microorganisms get carried by the bloodstream from another source localize on inflamed tissue).
   2. ***Traumatic***
      Acute trauma like fracture, luxation or avulsion of tooth. Chronic trauma including parafunctional habits like bruxism.
   3. ***Iatrogenic*** (Pulp inflammation for which the dentists own procedures are responsible is designated as "Dentistogenic pulpitis"). *Various iatrogenic causes of pulpal damage can be*:
      a. *Thermal changes* generated by cutting procedures, during restorative procedures, bleaching of enamel, electrosurgical procedures, laser beam, etc. can cause severe damage to the pulp if not controlled.
      b. Orthodontic movement.
      c. Periodontal curettage.
      d. Periapical curettage.

      The *use of chemicals* like temporary and permanent fillings, liners and bases and use of cavity desiccants such as alcohol.
   4. ***Idiopathic***
      a. Aging
      b. Resorption internal or external.

## HOW DOES PROGRESSION OF PULPAL DISEASES TAKES PLACE?

Degree of inflammation of pulp to an irritant is proportional to its intensity and severity. For example slight irritation like incipient caries or shallow cavity preparation cause little or no pulpal inflammation, whereas extensive operative procedures may lead to severe pulpal inflammation.

Depending on condition of pulp, severity and duration of irritant, host response, pulp may respond from mild inflammation to pulp necrosis.

*Microbial irritation* is the main source of irritation of the pulp (Fig. 3.1).

Carious enamel and dentin contains numerous bacteria
↓
Bacteria decrease in deeper layers of carious dentin
↓
Pulp is affected before actual invasion "by bacteria via their toxic byproducts
↓
Byproducts cause local chronic cell infiltration
↓
When actual pulp exposure occurs pulp tissue gets locally infiltrated by PMN's to form an area of liquefaction necrosis at the site of exposure
↓
Eventually necrosis spreads all across the pulp and periapical tissue resulting in severe inflammatory lesion.

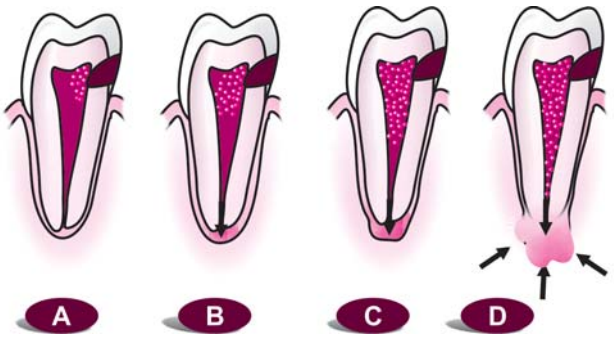



**Fig. 3.1:** Gradual response of pulp to microbial invasion

Degree and nature of inflammatory response caused by microbial irritants depends upon:

1. Host resistance
2. Virulence of microorganisms
3. Duration of the agent
4. Lymph drainage
5. Amount of circulation in the affected area
6. Opportunity of release of inflammatory fluids.

## CLASSIFY PULPAL PATHOLOGIES?

- *Seltzer and Bender's classification*: Based on clinical tests and histological diagnosis.
  1. *Treatable*
     a. Intact uninflamed pulp
     b. Transition stage
     c. Atrophic pulp
     d. Acute pulpitis
     e. Chronic partial pulpitis without necrosis
  2. *Untreatable*
     a. Chronic partial pulpitis with necrosis
     b. Chronic total pulpitis
     c. Total pulp necrosis
- *Grossman's clinical classification*
  1. *Pulpitis*
     a. Reversible
        – Symptomatic (Acute)
        – Asymptomatic (Chronic)
     b. Irreversible pulpitis
        i. Acute
           a. Abnormally responsive to cold
           b. Abnormally responsive to heat
        ii. Chronic
           a. Asymptomatic with pulp exposure
           b. Hyperplastic pulpitis
           c. Internal resorption
  2. *Pulp degeneration*
     a. Calcific (Radiographic diagnosis)
     b. Other (Histopathological diagnosis)
  3. *Necrosis.*

## WHAT ARE CAUSES AND CLINICAL FEATURES OF REVERSIBLE PULPITIS/ HYPEREMIA/ HYPERACTIVE PULPALGIA

### Definition

"Reversible pulpitis is the general category which histologically may represent a range of responses varying from dentin hypersensitivity without concomitant inflammatory response to an early phase of inflammation."

### Etiology

Under normal circumstances, enamel and cementum act as impermeable barrier to block the patency of dentinal tubules at dentinoenamel junction or dentino-cemental junction.

When caries and operative procedures interrupt this natural barrier, dentinal tubules become permeable. So inflammation can be caused by any agent which is capable of injuring pulp. It can be:

- Trauma
  – accident or occlusal trauma
- Thermal injury
  – While preparing cavity
  – Overheating during polishing a filling
- Chemical stimulus—Like sweet or sour foodstuff
- Following insertion of a deep restoration.

### Symptoms

- Sharp pain lasting for a moment, commonly caused by cold stimuli.
- Pain doesn't occur spontaneously and doesn't continue when irritant is removed.

### Histopathology

1. Increased blood volume of pulp associated with increased intrapulpal pressure.
2. Edema of tissue.
3. White cell infiltration.
4. Reparative dentin formation.

### Diagnosis

1. ***Pain***: It is sharp but of brief duration, ceasing when irritant is removed.
2. ***Visual examination and history***: may show caries, traumatic occlusion and undetected fracture.
3. ***Radiographs***: Show normal PDL and lamina dura.
   - Depth of caries or cavity penetration may be evident.
4. ***Percussion test***: Shows negative responses i.e. tooth is not tender to percussion.
5. ***Vitality test***: Pulp responds readily to cold stimuli. Electric pulp tester requires less current to cause pain.

### Treatment

No endodontic treatment is needed for this condition. The best treatment of this condition is prevention. Usually a sedative dressing will suffice, followed by permanent restoration when symptoms have completely subsided.

## IRREVERSIBLE PULPITIS

### Definition

"It is a persistent inflammatory condition of the pulp, symptomatic or asymptomatic, caused by a noxious stimulus". It has both acute and chronic stages in pulp.

### Etiology

- Most common cause of pulpitis is bacterial.
- Chemical, thermal, mechanical injuries of pulp.
- Reversible pulpitis when left untreated deteriorates into irreversible pulpitis.

### Symptoms

- A rapid onset of pain, which can be caused by sudden temperature change, sweet or acidic food. Pain remains even after removal of stimulus.
- Pain can be spontaneous in nature which is sharp, piercing, intermittent or continuous in nature.
- Pain exacerbated on bending down or lying down due to change in intrapulpal pressure.
- In later stages, pain is severe, boring, throbbing in nature which increases with hot stimulus.

### Diagnosis

1. ***Visual examination and history***: Examination of involved tooth may reveal previous symptoms. On inspection, one may see deep cavity involving pulp or secondary caries under restorations.
2. ***Radiographic findings***:
   - May show depth and extent of caries.
   - Periapical area shows normal appearance but a slight widening may be evident in advanced stages of pulpitis.
3. ***Percussion***: Tooth is tender on percussion.
4. ***Vitality tests***:
   i. *Thermal test*: Hyperalgesic pulp responds more readily to cold stimulation than for normal tooth, pain may persist even after removal of irritant.
   ii. *Electric test*: Less current is required in initial stages. As tissue becomes more necrotic, more current is required.

### Treatment

Pulpectomy, i.e. root canal treatment.

## HOW WILL YOU DIFFERENTIALLY DIAGNOSE REVERSIBLE AND IRREVERSIBLE PULPITIS? (TABLE 3.1)

## CHRONIC HYPERPLASTIC PULPITIS (PULPPOLYP)

- It is an inflammatory response of pulpal connective tissue to an irritant. Here pain is absent because of diminished exudative inflammatory activity and corresponding decrease in intrapulpal pressure to a point below threshold limits of pain receptors.
- It is characterized by overgrowth of granulomatous tissue into carious cavity (Fig. 3.2).

**Table 3.1: Differential diagnosis of reversible and irreversible pulpitis**

| | *Features* | *Reversible pulpitis* | *Irreversible pulpitis* |
|---|---|---|---|
| 1. | Pain Type | Sharp and fleeting pain, usually dissipates after stimulus is removed | Intense, continuous and prolonged pain due to pressure of secondary irritants |
| 2. | Stimulus | External stimulus for example—heat, cold, sugar | • No external stimulus<br>• Dead or injured pulp tissue acts as secondary stimulant |
| 3. | Pain at Night/ Postural | No | Yes |
| 4. | Pain Localization | Only with applied cold stimulus or PDL inflammation | Only with applied heat stimulus or PDL inflammation |
| 5. | Referred Pain | Not usually found | Common finding |
| 6. | History | • Any history of recent dental procedure done<br>• Sometimes cervical erosion/abrasion | History of:<br>• Deep carries<br>• Trauma<br>• Extensive restoration |
| 7. | Percussion/ Occlusion | If due to occlusion, percussion test is positive, otherwise normal | If inflamed, involved PDL-percussion test is positive otherwise normal |
| 8. | Pulp Tests | | |
| | a. EPT | Normal response | Normal to elevated response |
| | b. Cold | Exaggerated response | Pain relieved by cold occasionally |
| | c. Heat | Normal-exaggerated response | Acute pain |
| 9. | Color change | No | Yes |
| 10. | Radiograph | Caries, defective or unbased restoration | Caries, defective restorations, PDL space enlargement |
| 11. | Treatment | Removal of decay, repair of defect, restoration, ZOE dressing, occlusal adjustment | Pulpectomy (single root), Pulpotomy (multiple roots), occlusal adjustment |

**Fig. 3.2:** Hyperplastic form of chronic pulpitis

## Etiology

- Caused by slow and progressive carious exposure of pulp.
- Nature of pulpal response depends on strength and duration of irritant, previous health of pulp and extent of tissue affected.

## Signs and Symptoms

- Pain is absent because of low activity of exudative forces. Here proliferative granulomatous forces dominate.
- Commonly seen in teeth of children and adolescents in which pulp tissue has high resistance and large carious lesion permit free proliferation of hyperplastic tissue.
- Since it contains few nerve fibers, it is non-painful but bleeds easily due to rich network of blood vessels.

### Diagnosis

- *Pain*: It is usually absent.
- Shows a fleshy, reddish pulpal mass which fills most of pulp chamber or cavity.
- It is less sensitive than normal pulp but bleeds easily when probed.
- *Radiographic changes* show
  In young, patients low grade long standing irritation stimulates periapical bone deposition, i.e. condensing osteitis. Radiograph shows areas of dense bone around apices of involved teeth.

*Vitality Tests*

- Tooth may respond feebly or not at all to thermal test, unless one uses extreme cold.
- More current than normal is required to elicit response by electric pulp tester.
  - *Differential diagnosis*: Proliferating gingival tissue. It is done by raising and tracing the stalk of tissue back to its origin, i.e. pulp chamber.

### Treatment

- Endodontic therapy
- If tooth is in non-restorable stage, it should be extracted.

## INTERNAL RESORPTION

According to ***Shafer***, "internal resorption is an unusual form of tooth resorption that begins centrally within the tooth, apparently initiated in most cases by a peculiar inflammation of the pulp".

### Etiology

- Long standing chronic inflammation of the pulp
- Caries related pulpits
- Iatrogenic injuries
  a. Preparation of tooth for crown
  b. Deep restorative procedures
- Idiopathic.

### Clinical Features

- Usually asymptomatic until it perforates the root and communicates with the periodontium

**Fig. 3.3:** Internal resorption of tooth

- Common in maxillary central, but can affect any tooth
- Pathognomic feature is pink spot appearance of tooth which represents the hyperplasic vascular pulp tissue showing off through crown of tooth.

*Radiographic Features*

It presents round or ovoid radiolucent area in the central portion of the tooth with smooth well defined margins (Fig. 3.3). The defect does not change its relation to the tooth, when the range is projected from an angulation.

### Treatment Options in Teeth with Internal Resorption

- Without perforation - Endodontic therapy
- With perforation
  a. *Non-surgical*: $Ca(OH)_2$ therapy - Obturation
  b. *Surgical*:
     i. Surgical flap
     ii. Root resection
     iii. Intentional replantation.

## GIVE DIFFERENTIAL DIAGNOSIS OF INTERNAL AND EXTERNAL RESORPTION (TABLE 3.2)

## PULP DEGENERATION

- Pulp degeneration is generally present in older people.
- Induced by attrition, abrasion, erosion, bacteria, operative procedures, caries, pulp capping and reversible pulpitis.

**Table 3.2: Differential diagnosis of internal and external resorptions**

| *Internal resorption* | *External resorption* |
|---|---|
| **Radiographic Features** | |
| 1. There is enlargement of root canal which is well demarcated, enlarged "Ballooning area" of resorption | 1. There is ragged area, i.e. "scooped out" area on the side of the root. |
| 2. Lesion appears close to canal even if angulations of radiograph changes | 2. Lesion moves may from the canal as angulation changes |
| 3. Outline of canal is distorted | 3. Outline of root canal is normal |
| 4. Root canal and resorptive defect appears contiguous | 4. Root canal can be seen running through the defect. |
| 5. Does not involve bone, so radioleucency is confined to root. Bone resorption is seen only if lesion perforates the root. | 5. It is almost always accompanied by resorption of bone, so radioleucency appears in both root and adjacent bone. |
| **Pulp Testing** Commonly occurs in teeth with vital pulp so gives positive response to pulp tests but negative response is seen when pulp gets involved. | Involves commonly infected pulp space, so negative response to pulp tests. |
| ***Pink spot of pink tooth of mummery*** Pathognomic feature. It represents the hyperplastic vascular pulp tissue fitting the resorbed area showing off through the tooth structure. | Pulp is nonvital, granulation tissue which produces pink spot is not present. |

## Types

1. **Atrophic degeneration and fibrosis**
   - It is decrease in size which occurs slowly as tooth grows old.
   - Collagen fibers/unit area increased leading to fibrosis. Number of pulp cells and size of cells decreased so cells appear as "shrunken solid particles in a sea of dense fibers".
   - Fibroblastic process are lost.
2. **Calcifications**
   - In calcific degeneration, part of the pulp tissue is replaced by calcific material.
   - Mainly three types of calcifications are seen in pulp:

   *Dystrophic calcifications*: They occur by deposition of calcium salts in dead or degenerated tissue.

   *Diffuse calcifications*: They are generally observed in root canals.

   *Denticles/Pulp stone*: These are usually seen in pulp chamber.
3. **Pulp artifacts:** Fatty degeneration of pulp along with reticular atrophy and vacualization of odontoblasts.
4. **Tumor metastasis:** Metastasis of tumor cells in dental pulp.
5. **Fibrous degeneration:** Replacement of cellular components by fibrous connective tissue. Pulp has appearance of a leathery fiber.

## PULP NECROSIS

Pulp necrosis or death is a condition following untreated pulpitis. The pulpal tissue becomes dead and if the condition is not treated, noxious materials will leak from pulp space forming the lesion of endodontic origin.

The pulp necrosis is of two types:

- ***Coagulation necrosis***: In coagulation necrosis protoplasm of all cells becomes fixed and opaque.
- ***Liquefaction necrosis***: In liquefaction necrosis the entire cell outline is lost.

### Symptoms

- Discoloration of tooth—First indication of pulp death
- History from patient
- Tooth might be asymptomatic.

### Diagnosis

1. ***Pain***: It is absent in complete necrosis.
2. ***History of patient*** reveals past trauma or past history of severe pain which may last for some time followed by complete and sudden cessation of pain.
3. ***Radiographic changes***: Radiograph shows a large cavity or filling or normal appearance unless there is concomitant apical periodontitis or condensing osteitis.

4. ***Vitality test***: Tooth is nonresponding to vitality tests. But multirooted teeth may show mixed response because only one canal may have necrotic tissue. Sometimes teeth with liquefaction necrosis may show positive response to electric test when electric current is conducted through moisture present in a root canal.
5. ***Visual examination***: Tooth shows color change like dull or opaque appearance due to lack of normal translucency.
6. ***Histopathology***: Necrotic pulp tissue, cellular debris and microorganisms are seen in pulp cavity. If there is concomitant periodontal involvement, there may be presence of slight evidence of inflammation.

## Treatment

Complete removal of pulp followed by restoration or extraction of nonrestorable tooth.


# Pathologies of Periradicular Tissues

## CLASSIFY PERIRADICULAR PATHOLOGIES

I. *Grossman's classification*
   1. Acute periradicular disease
      a. Acute alveolar abscess
      b. Acute apical periodontitis
         i. Vital
         ii. Non vital
   2. Chronic Periradicular disease with areas of rarefaction:
      a. Chronic alveolar abscess
      b. Granuloma
      c. Cyst
   3. Condensing osteitis
   4. External root resorption
   5. Disease of the periradicular tissues of non-endodontic origin.

II. *Ingle's classification of pulpoperiapical pathosis*:
   1. Painful pulpoperiapical pathosis
      a. Acute apical periodontitis
      b. Advanced apical periodontitis
         i. Acute apical abscess
         ii. Phoenix abscess
         iii. Suppurative apical periodontitis (chronic apical abscess).
   2. Non-painful pulpoperiapical pathosis
      a. Condensing osteitis
      b. Chronic apical periodontitis both incipient and advanced stages
      c. Chronic apical periodontitis
         i. Periapical granuloma
         ii. Apical cyst
         iii. Suppurative apical periodontitis.

## WHAT ARE CLINICAL FEATURES OF ACUTE APICAL PERIODONTITIS (AAP)?

Acute apical periodontitis is defined as painful inflammation of the periodontium as a result of trauma, irritation or inflection, through the root canal, regardless of whether the pulp is vital or non-vital.

### Etiology

- In vital tooth it is associated with occlusal trauma, high points in restoration or wedging or forcing object between teeth.
- In non-vital tooth, AAP is associated with sequelae to pulpal diseases.
- Iatrogenic causes can be over-instrumentation of root canal pushing debris and microorganisms beyond apex, overextended obturation and root perforations.

### Signs and Symptoms

- Dull, throbbing and constant pain
- Pain occurs over a short period of time
- Pain on biting
- Cold may relieve pain or no reaction
- Heat may exacerbate pain or no reaction
- No radiographic sign; sometimes widening of periodontal ligament space.

### Treatment

- Endodontic therapy.
- If tooth is in hyper-occlusion, relieve the occlusion.

## WHAT ARE CLINICAL FEATURES OF ACUTE APICAL ABSCESS? HOW WILL YOU TREAT A CASE WITH ACUTE APICAL ABSCESS?

It is a localized collection of pus in the alveolar bone at the root apex of the tooth, following the death of pulp with extension of the infection through the apical foramen into periradicular tissue (Fig. 4.1).

### Etiology

Most common cause is bacterial invasion of dead pulp tissue but it can also occur by trauma, chemical or mechanical injury.

### Clinical Features

- Tooth is non-vital
- Pain
  - Rapid onset
  - Readily localized as tooth becomes increasingly tender to percussion
  - Marked pain to biting
- Swelling
  - Palpable, fluctuant
  - Localized sense of fullness
- Mobility may or may not be present
- Tooth may be in hyperocclusion
- Radiographic changes
  - No change to large periapical radiolucency.

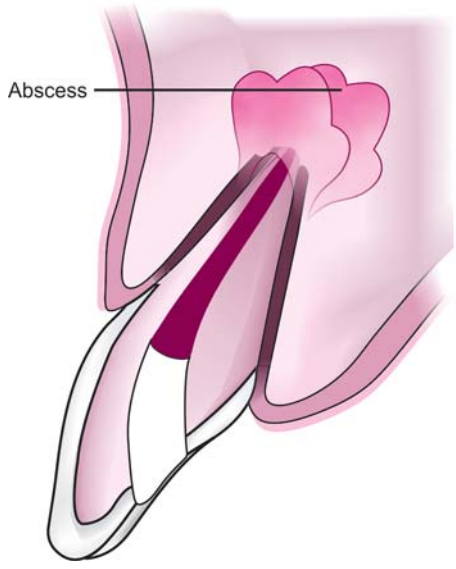



**Fig. 4.1:** Periapical abscess

### Diagnosis

- Clinical examination.
- Initially locating the offending tooth is difficult due to the diffuse pain. Location of the offending tooth is easier when there is extension of tooth following infection.
- Pulp vitality tests give negative response.
- Tenderness on percussion and palpation.
- Radiography helpful in determining the affected tooth as it shows a cavity or evidence of bone destruction at root apex.

### Treatment

- Drainage of the abscess should be initiated as early as possible. This may include:
  a. Non-surgical endodontic treatment
  b. Incision and drainage
  c. Extraction
- In the case of systemic complications such as fever, lymphadenopathy, cellulitis or patient who is immunocompromised, antibiotics should be given in addition to drainage of the tooth
- Relieve the tooth out of occlusion in hyper-occlusion cases
- To control postoperative pain following endodontic therapy, non-steroidal antiinflammatory drugs should be given.

## SHORT NOTE ON PHOENIX ABSCESS

Phoenix abscess is defined as an acute inflammatory reaction superimposed on an existing chronic lesion, such as a cyst or granuloma; acute exacerbation of a chronic lesion.

### Etiology

Chronic periradicular lesions are in a state of equilibrium during which they can be completely asymptomatic. Because of influx of bacteria and their toxins, the dormant lesion reacts, which leads to initiation of acute inflammatory response.

### Symptoms

- Clinically often indistinguishable from acute apical abscess.
- At the onset—tenderness of tooth and elevation of the tooth from socket.

### Diagnosis

- Most commonly associated with initiation of root canal treatment.
- Pulp tests show negative response.
- Radiographs show large area of radiolucency in the apex.
- Phoenix abscess should be differentiated from acute alveolar abscess by patient's history, symptoms and clinical tests results.

### Treatment

- Establishment of drainage.
- Complete root canal treatment.

## WHAT ARE DIAGNOSTIC FEATURES OF PERIAPICAL GRANULOMA?

Periapical granuloma is described as a mass of chronically inflamed granulation tissue found at the apex of non-vital tooth.

### Clinical Features

- Most of the cases are asymptomatic but sometimes pain and sensitivity is seen when acute exacerbation occurs.
- Tooth is not sensitive to percussion.
- No mobility.
- No response to thermal or electric pulp test.

### Radiographic Features

- Mostly discovered on routine radiographic examination.
- The earliest change in the periodontal ligament is found to be thickening of ligament at the root apex.
- In some cases root resorption is also seen.

### Histopathologic Features

- It consists of inflamed granulation tissue that is surrounded by a fibrous connective tissue wall.
- The granulation consists of dense lymphocytic infiltrate which further contains neutrophils, plasma cells, histiocytes and eosinophils.

### Treatment and Prognosis

- In restorable tooth, root canal therapy is preferred.
- In non-restorable tooth, extraction followed by curettage of all apical soft tissue.

## CHRONIC ALVEOLAR ABSCESS

Chronic alveolar abscess is also known as suppurative apical periodontitis which is associated with gradual egress of irritants from root canal system into periradicular area leading to formation of an exudate.

### Etiology

- Similar to acute alveolar abscess.
- From pulpal necrosis.

### Symptoms

- Generally asymptomatic.
- Detected either by the presence of a sinus tract or on routine radiograph.
- In case of open cavity drainage occurs through root canal.

### Diagnosis

- Asymptomatic or slightly symptomatic tooth.
- Clinical examination may show a large carious exposure, a restoration of composite, acrylic, amalgam or metal, or discoloration of crown of tooth.
- Radiographic examination shows diffuse area of rarefaction.

### Differential Diagnosis

- Granuloma.
- Cyst.
- Cementoma.

### Treatment

- Removal of irritants.
- Root canal treatment.

## EXTERNAL ROOT RESORPTION

*In external root resorption*, root resorption affects the cementum or dentin of the root of tooth. It can be:

- Apical root resorption.
- Lateral root resorption.
- Cervical root resorption.

### Etiology

- Infected necrotic pulp.
- Overinstrumentation during root canal treatment.
- Trauma.

- Granuloma/cyst applying excessive pressure on tooth root.
- Replantation of teeth.

### Symptoms

- Asymptomatic during development.
- When root is completely resorbed, tooth becomes mobile.
- When external root resorption extends to crown, it gives "Pink tooth" appearance.
- When replacement resorption/ankylosis occur, tooth becomes immobile with characteristic high percussion sound.

### Radiographs Show

Radiolucency at root and adjacent bone.

### Treatment

- Removal of the cause.
- RCT should be attempted before surgical treatment is initiated.

## RADICULAR CYST

The radicular cyst is an inflammatory cyst which results because of extension of infection from pulp into the surrounding periapical tissues.

### Etiology

- Caries
- Irritating effects of restorative materials
- Trauma.

### Clinical Features

- The cyst is asymptomatic.
- Incidence—Males are affected more than females.
- Site—Highest in anterior maxilla.
- Slowly enlarging swelling sometimes attains a large size.
- The involved tooth/teeth usually found to be non-vital, discolored, fractured or failed root canal.

### Radiographic Features

Radiographically radicular cyst appears as round, pear or ovoid shaped radiolucency, outlined by a narrow radiopaque margin.

### Treatment

Different options for management of residual cyst are:

- Endodontic treatment
- Apicoectomy
- Extraction
- Enucleation with primary closure
- Marsupilization (in case of large cysts).

## WHAT IS HISTOPATHOLOGY OF PERIAPICAL RESPONSE TO VARIOUS IRRITANTS?

Depending upon severity of irritation, duration and host, response to periradicular pathosis may range from slight inflammation to extensive tissue destruction. Reactions involved are highly complex and are usually mediated by nonspecific and specific mediators of inflammation.

### Nonspecific Mediators of Periradicular Lesions

Nonspecific mediators can be classified into cell derived and plasma derived mediators.

### Nonspecific Mediators of Inflammation

I. Cell Derived Mediators
   1. Vasoactive amines
   2. Leukotriences (Metabolites via lipo-oxygenase pathway)
   3. Platelet activating factor
   4. Lysosomal enzymes
   5. Cytokines
   6. Prostaglandins (Metabolites via cyclo-oxygenase pathway).

II. Plasma Derived Mediators
   1. The fibrinolytic system
   2. The complement system
   3. The kinin system.

### *Cell Derived Mediators*

*Vasoactive amines*: Vasoactive amines such as histamine, serotonin are present in mast cells, basophils and platelets which cause increase in tissue permeability and vasodilation.

*Leukotrienes*: These are produced by activation of lipoxygenase pathway of arachidonic acid metabolism.

*Platelet activating factor*: Its action includes increase in vascular permeability, chemotaxis and adhesion of leucocytes to endothelium.

*Lysosomal enzymes*: Lysosomal enzymes cause increase in vascular permeability, leukocytic chemotaxis, bradykinin formation and activation of complement system.

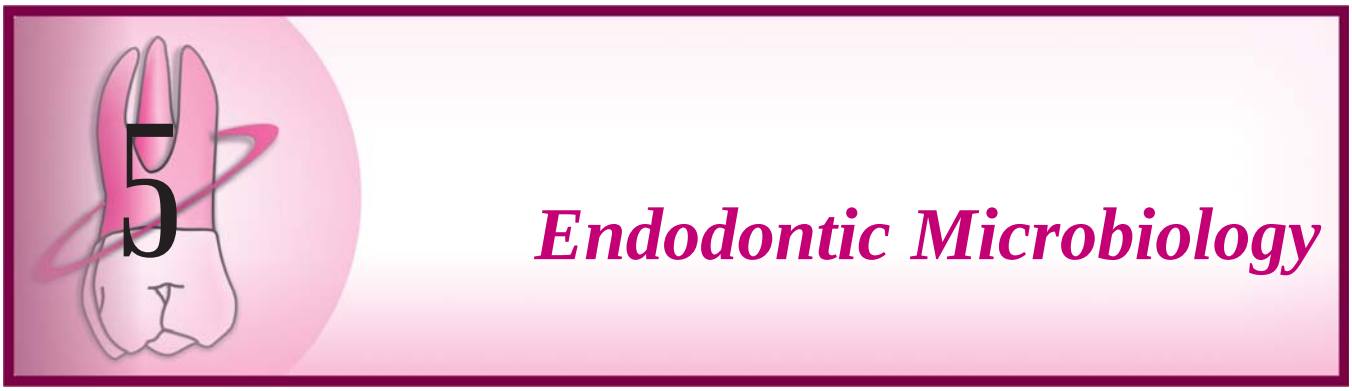
*Prostaglandins*: Studies have shown high levels of PG $E_2$ in periradicular lesions.

### *Plasma Derived Mediators*

*The fibrinolytic system*: Activation of fibrinolytic system results in release of fibrinopeptides and fibrin degradation products which cause increase in vascular permeability and leucocytic chemotaxis.

*The complement system*: Products released from activated complement system cause swelling, pain and tissue destruction.

*The kinin system*: Release of kinins cause smooth muscle contraction, vasodilation and increase in vascular permeability.



# 5 Endodontic Microbiology

## WHAT ARE PORTALS OF ENTRY TO ROOT CANAL SYSTEM FOR MICROORGANISMS?

Microorganisms may gain entry into pulp through several routes like:

1. Open cavity
2. Open dentinal tubules
3. Periodontal ligament or gingival sulcus
4. Anachoresis
5. Faulty restorations.

### Entry Through Open Cavity

This is the most common way of entry of microorganisms into the dental pulp. When enamel and dentin get destroyed by caries, traumatic injuries, fractures, cracks or restorative procedures, bacteria gain entry into the pulp.

### Through Open Dentinal Tubules

Bacteria are preceded in the course of the tubules by their breakdown products which may act as pulp irritants.

### Through the Periodontal Ligament or the Gingival Sulcus

Microorganisms also gain entry into pulp via accessory and lateral canals which connect pulp and the periodontium.

### Anachoresis

Anachoresis is a process by which microorganisms are transported in the blood to an area of inflammation where they establish an infection. But whether anachoresis contributes to pulpal or periradicular infection has not been determined.

### Through Faulty Restorations

Faulty restoration with marginal leakage can result in contamination of the pulp by bacteria.

## WHAT IS MICROBIAL ECOSYSTEM OF PRIMARY ENDODONTIC INFECTIONS? (TABLE 5.1)

It has been shown by various studies that endodontic infections are polymicrobial, though facultative bacteria predominate in early root canal infections, in latter stages they are replaced by strict anaerobic organisms.

Some species of black-pigmented bacteria, peptostreptococci, Fusobacterium and Actinomyces species have been found related to clinical signs and symptoms.

**Table 5.1: Microbiology of infected root canal**

| *Obligate anaerobes* | *Facultative anaerobes* |
|---|---|
| *(i) **Gram-negative bacilli*** | *(i) **Gram-negative bacilli*** |
| Porphyromonas* | Capnocytophaga |
| Prevotella** | Eikenella |
| Fusobacterium | |
| Campylobacter | |
| Bacteroides | |
| *(ii) **Gram-negative cocci*** | *(ii) **Gram-negative cocci*** |
| Veillonella | Neisseria |
| *(iii) **Gram-positive bacilli*** | *(iii) **Gram-positive bacilli*** |
| Actinomyces | Actinomyces |
| Lactobacillus | Lactobacillus |
| Proprionibacterium | |
| *(iv) **Gram-positive cocci*** | *(iv) **Gram-positive cocci*** |
| Streptococcus | Streptococcus |
| Peptostreptococcus | Enterococcus |
| *(v) **Spirochetes*** | *(v) **Fungi*** |
| Treponema | Candida |

*Dark pigmented bacteria.
**Dark pigmented bacteria and nonpigmenting bacteria.

Coaggregation of different species of bacteria or self aggregation of the same species may present the organisms protection from the host's defenses and supply nutrients from the surrounding bacteria.

***A. Israelii*** is a bacterial species of endodontic infections which is resistant to conventional endodontic treatment.

Other gram-positive bacteria often cultured from endodontic infections include Peptostreptococci, Streptococcus, Enterococcus, and Eubacterium.

***Fungi*** have been cultivated and detected using molecular methods in infected root canal.

***Viruses*** like HIV, cyto-megalovirus and Epstein Barr virus are seen to be associated with periapical pathologies.

## WHAT ARE VARIOUS TECHNIQUES USED FOR IDENTIFICATION OF BACTERIA?

### Culture

Culture taking method though done less these days, but it still holds its importance because of wide range of bacteria found in the endodontic infections.

### Various culture media used are:

- Brain heart infusion broth with 0.1% agar
- Glucose ascites broth
- Trypticase Soy broth (TSA) with 0.1% agar
- Stuart's transporting media
- TSA with 0.1 % agar
- Moiler's base culture media.

### Technique

- The fluctuant space of abscess is palpated and the most dependent part of swelling is determined.
- Mucosa in that area is disinfected.
- An empty, sterile, syringe and attached 16 to 20 gauge needle is used to aspirate the exudate.
- Sample is immediately injected into a container with prereduced transport media.
- Gram staining is performed on the sample to determine type of microorganism.
- This holds great importance for medically compromised patients regarding the selection of antibiotics.

### Disadvantages of Culturing Method

- Strictly depend on mode of sample transport which must allow growth of anaerobic bacteria.
- Low sensitivity and specificity.
- Time consuming.

### DNA-DNA Hybridization Method

This method uses DNA probes which target genomic DNA or individual genes. This method helps in simultaneous determination of the presence of a multitude of bacterial species in single or multiple clinical samples and is especially useful for large scale epidemologic research.

### Polymerase Chain Reaction (PCR) Method

PCR method involves in vitro replication of DNA, therefore it is also called as *genetic xeroxing method*. Multiple copies of specific region of DNA are made by repeated cycles or heating and cooling.

## HOW TO COMBAT MICROBES IN THE ENDODONTIC THERAPY?

The main factor which is needed for successful treatment of pulp and periradicular inflammation is complete removal of the microorganisms and their by products.

Following measures should be taken to completely rid of these irritants:

1. *Thorough cleaning and shaping of the root canal system*: Thorough cleaning and shaping followed by three dimensional obturation of the root canals have shown to produce complete healing of periradicular tissue.
2. A tooth with serous or purulent or hemorrhagic exudate should be allowed to ***drain*** with rubber dam in place for a time under supervision.
3. *Antibiotics* should be considered as adjunctive in severe infections. The choice of antibiotic agent should be done on the knowledge of microorganisms associated with the endodontic infections.
4. *Intracanal medicaments* play an important role in combating the microorganisms.
5. *Use of calcium hydroxide in canals* with necrotic pulps after instrumentation have shown to provide the beneficial results.

# 6 Diagnostic Methods

## WHAT ARE VARIOUS DIAGNOSTIC METHODS USED IN ENDODONTICS?

### Case History

The purpose of case history is to discover whether patient has any general or local condition that might alter the normal course of treatment. It includes:

*Chief Complaint*

It consists of information which promoted patient to visit a clinician.

*History of Present Illness*

Once the patient completes information about his/her chief complaint, a report is made which provides more descriptive analysis about this initial information. It should include signs and symptoms, duration, intensity of pain, relieving and exaggerating factors, etc.

*Medical History*

There are no medical conditions which specifically contraindicate endodontic treatment, but there are several which require special care, for example anemia, bleeding disorders, cardiorespiratory disorders, drug treatment and allergies and likelihood of pregnancy or pregnant itself.

### Clinical Examination

*Extraoral Examination*

Patient should be looked for any facial asymmetry or distention of tissues. After extraoral examination of head and neck region, one should go for extraoral palpation.

***Palpation of salivary glands*** should be done extraorally.

***Palpation of TMJ*** can be done by standing in front of the patient and placing the index fingers in the preauricular region to note any restricted or deviation in movement, locking or crepitus in TMJ.

***Palpation of lymph nodes*** should be done to note any lymph node enlargement, tenderness, mobility and consistency.

*Intraoral Examination*

During intraoral examination, look at the following structures systematically:

1. The buccal, labial and alveolar mucosa
2. The hard and soft palate
3. The floor of the mouth and tongue.

After examining this, ***general dental state*** should be recorded, which include:

a. Oral hygiene status
b. Amount and quality of restorative work
c. Prevalence of caries
d. Missing tooth
e. Periodontal status
f. Tooth wear and facets.

***Palpation is*** done using digital pressure to check any tenderness in soft tissue overlying suspected tooth. Sensitivity may indicate inflammation in periodontal ligament surrounding the affected tooth.

***Percussion of tooth*** indicates inflammation in periodontal ligament which could be due to trauma, sinusitis and/or PDL disease.

Percussion can be carried out by gentle tapping with gloved finger or blunt handle of mouth mirror.

***Periodontal evaluation*** can be assessed from palpation, percussion, mobility of tooth and probing. The mobility of a tooth is tested by placing a finger or blunt end of the instrument on either side of the crown and pushing it and assessing any movement with other finger.
Mobility can be graded as:
1. Slight (normal)
2. Moderate mobility within a range of 1 mm
3. Extensive movement (more than 1 mm) in mesiodistal or lateral direction combined with vertical displacement in alveolus.

## Radiographs

The radiograph is one of most important tools in making a diagnosis. Without radiograph, case selection, diagnosis and treatment would be impossible as it helps examination of oral structure that would otherwise be unseen by naked eye.

Generally, the *periapical lesions of endodontic origin have following characteristic features*:
- Loss of lamina dura in the apical region
- Etiology of pulpal necrosis is generally apparent
- Radiolucency remains at the apex even if radiograph is taken by changing the angle.

***Radiographs help us in following ways:***
a. Establishing diagnosis
b. Determining the prognosis of tooth
c. Disclosing the presence and extent of caries
d. Check the thickness of periodontal ligament
e. To see presence or absence of lamina dura
f. To look for any lesion associated with tooth
g. To see the number, shape, length and pattern of the root canals
h. To check any obstructions present in the pulp space
i. To check any previous root canal treatment if done
j. To see any resorption present in the tooth.

Though the radiographs play an important role in dentistry but they have a few shortcomings:
a. They are only two dimensional picture of a three dimensional object
b. Pathological changes in pulp are not visible in radiographs
c. They don't help in exact interpretation, for example radiographic picture of an abscess, inflammation and granuloma is almost same
d. Radiographs can misinterpret the anatomical structures like incisive and mental foramen with periapical lesions
e. To know the exact status of multirooted teeth, multiple radiographs are needed at different angles which further increase the radiation exposure.

## Pulp Vitality Tests

Pulp testing is often referred to as vitality testing. Pulp vitality tests play an important role in diagnosis because these tests not only determine the vitality of tooth but also the pathological status of pulp.

Various types of pulp tests performed are:
1. Thermal test
   a. Cold test
   b. Heat test
2. Electrical pulp testing
3. Test cavity
4. Anesthesia testing
5. Bite test.

### *Thermal Test*

In thermal test, the response of pulp to **heat** and **cold** is noted.

*Cold test*: It is the most commonly used test for assessing the vitality of pulp. It can be done in a number of ways. The basic step of the pulp testing, i.e. individually isolating the tooth with rubber dam is mandatory with all types. Following methods are used for performing cold tests:
1. ***Spray with cold air*** directed against the isolated tooth.
2. Application of cotton ***pellet saturated with ethyl chloride***.
3. The ***spray of ethyl chloride*** after isolating tooth.
4. The ***frozen carbon dioxide (dry ice)*** is applied to the facial surface of the tooth.
5. One of the easy methods for cold test is to ***wrap an ice piece in the wet gauge*** and apply to the tooth.
6. ***Dichlorodifluoromethane (Freon)*** and the recently available material 1, 1, 1, 2-tetrafluoroethane are also used as cold testing material.

*Heat test*: Heat test is most advantageous in the condition where patient's chief complaint is intense dental pain

upon contact with any hot object or liquid. It can be performed using different techniques like:

1. Direct the ***warm air*** to the exposed surface of tooth.
2. Use of heated stopping stick, hot burnisher, hot water, etc.
3. Use of ***frictional heat produced by rotating polishing rubber disc*** against the tooth surface.
4. ***Deliver warm water*** from a syringe on to the isolated tooth.

*[The preferred temperature for heat test is 150°F (65.5°C)]*

The patient may respond to heat or cold test in following possible ways:

- Mild, transitory response to stimulation show normal pulp
- Absence of response in combination with other tests indicates pulp necrosis
- An exaggerated and lingering response indicates irreversible pulpitis.

C***onditions which can give false negative response:***

1. Recently erupted teeth with immature apex
2. Recent trauma
3. Excessive calcifications may also interfere with the nerve conduction.

### *Electric Pulp Testing*

Electric pulp tester is used for evaluation of condition of the pulp by electrical excitations of neural elements within the pulp. A positive response indicates the vitality of pulp. No response indicates nonvital pulp or pulpal necrosis.

*Procedure*

1. Isolate the teeth to be tested.
2. Apply an electrolyte on the tooth electrode and place it on the facial surface of tooth.
3. Once the circuit is complete, slowly increase the current and ask the patient to point out when the sensation occurs.
4. Each tooth should be tested 2 to 3 times and the average reading is noted.

*Disadvantages*: Various conditions can give rise to wrong results and thus misdiagnosis. These conditions can be as follows:

1. When electrode may contact gingival tissue thus giving the false positive response.
2. In multirooted teeth, pulp may be vital in one or more root canals and necrosed in others, thus eliciting a false positive response.
3. In certain conditions, it can give false negative response for example:
   a. Recently traumatized tooth
   b. Recently erupted teeth with immature apex
   c. Teeth with extensive restorations or pulp protecting bases under restorations
   d. Partial necrosis of pulp sometimes is indicated as totally necrosis by electric pulp tester.

### *Test Cavity*

This method should be used only when all other test methods are inconclusive in results. Here a test cavity is made with high speed burs with air and water coolant. The sensitivity or the pain felt by the patient indicates pulp vitality.

### *Anesthesia Testing*

The main objective of this test is to anesthetize a single tooth at a time until the pain is eliminated. Injection is administered to the most posterior tooth in the suspected quadrant. If the pain persists, even after tooth has been fully anesthetized, then repeat the procedure to the next tooth mesial to it. It is continued until the pain disappears.

### *Bite Test*

This test helps if patient complains of pain on mastication. Tooth is sensitive to biting if pulpal necrosis has extended to the periodontal ligament space or if a crack is present in a tooth. In this patient is asked to bite on a hard object such as cotton swab, tooth pick or orange wood stick.

## ENUMERATE RECENT ADVANCES IN PULP VITALITY TESTING? WHAT IS LASER DOPPLER FLOWMETRY?

**Recently available pulp vitality tests are:**

- Laser Doppler flowmetry (LDF)
- Pulp oximetry
- Dual wavelength spectrophotometry
- Measurement of temperature of tooth surface
- Transillumination with fiber-optic light
- Plethysmography
- Detection of interleukin—1 beta
- Xenon—133
- Hughes probeye camera

- Gas desaturation
- Radiolabeled microspheres
- Electromagnetic flowmetry

### Laser Doppler Flowmetry (LDF)

The technique depends on Doppler principle in which a low power light from a monochromatic laser beam of known wavelength along a fiber optic cable is directed to the tooth surface.

The light that contacts a moving object is Doppler shifted, and a portion of that light will be back scattered out of tooth into a photodetector. Some light is reflected off moving red blood cells in pulpal capillaries and as a consequence frequency broadened. The reflected light is passed back to the flow meter where the frequency broadened light, together with laser light scattered from static tissue, is photo-detected for strength of signal and pulsatility.

Since, red blood cells represents the majority of moving objects within the tooth, measurements of Doppler shifted back scattered light may be interpreted as an index of pulpal blood flow.

*Advantages*

- An objective test
- Accurate to check vitality.

*Disadvantages*

- Medications used in cardiovascular diseases can affect the blood flow to pulp
- Requires higher technical skills to achieve
- Expensive.

### Pulp Oximetry

Pulp oximetry is a non-invasive device for determining pulp vitality. The principle of this technology is based on modification of Beer's law and the absorbency characteristics of hemoglobin in red and infrared range.

The probe of pulp oximeter consists of red and infrared light-emitting diodes opposite a photoelectric detector.

Pulp oximetry is especially helpful in cases of traumatic injury to the teeth during which nerve supply of the pulp may be injured, but the blood supply stays intact.

A distinctive advantage of this technique is its objectivity and lack of dependence on sensory response which eliminates the need for application of an unpleasant stimulus to the patient.

*Advantages*

- Effective and objective method to evaluate pulp vitality.
- Useful in cases of traumatic injuries where the blood supply remains intact but nerve supply is damaged.
- Easy to reproduce pulp pulse readings.

*Disadvantage*

Background absorption associated with venous blood.

## HOW WILL YOU DIAGNOSE AND TREAT A CASE WITH CRACKED TOOTH SYNDROME?

*The crack tooth syndrome means incomplete fracture of a tooth with vital pulp*. The fracture commonly involves enamel and dentin but sometimes pulp and periodontal structure may also get involved (Fig. 6.1).

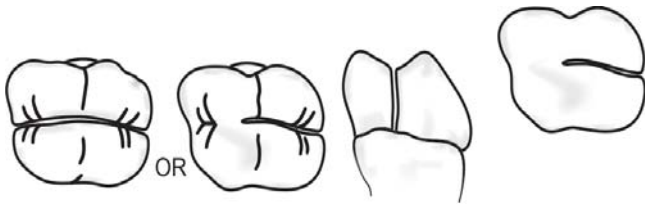



**Fig. 6.1:** Different patterns of cracked teeth

### Diagnosis

The careful history of the patient, examination, diagnosis tests, radiographs and sometimes surgical exposure are needed for accurate diagnosis of cracked tooth syndrome.

*History of the Patient*

It includes:

a. A detailed history regarding dietary and parafunctional habits.
b. History of any previous trauma.

*Visual Examination*

Look for any wear facets, steep cusps, cracked restorations or unusual gaps between restorations and tooth structure.

*Tactile Examination*

Pass the tip of sharp explore gently along the tooth surface, it may catch the crack.

*Bite Test*

The pain during biting or chewing especially upon the release of pressure is classic sign of cracked tooth syndrome.

*Transillumination*

*Use of Dyes*

Staining of fractured teeth with a dye such as **methylene blue** dye can aid in diagnosis. The dark stain present on the fracture line helps in detecting the fracture.

*Radiographs*

1. Taking radiographs from more than one angle can help in locating the crack (Fig. 6.2) .

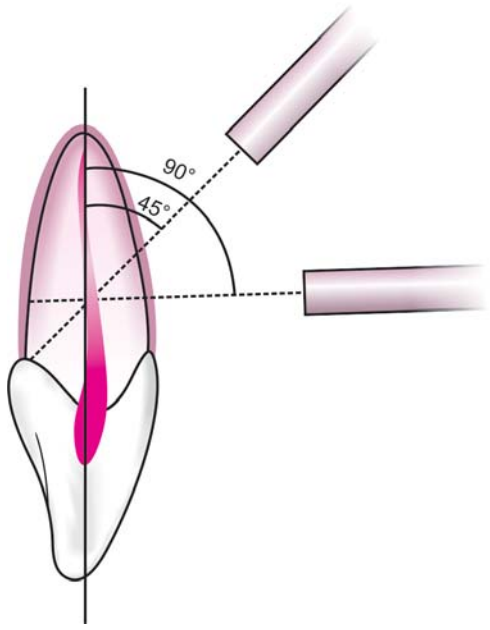



**Fig. 6.2:** Taking radiograph from more than one angle helps in locating the crack

2. A thickened periodontal ligament space, a diffused radiolucency especially with elliptical shape in apical area may indicate crack.

### Differential Diagnosis

There must be differentiation of a cracked tooth from a fractured cusp. The tooth crack occurs more towards the center of the occlusal surface as compared to the cusp fracture which is more peripheral in position.

- If the crack has progressed to involve the pulp or periodontium, patient may have thermal sensitivity which lingers after removal of the stimulus or slight to very severe spontaneous pain consistent with irreversible pulpitis, pulp necrosis or apical periodontitis.

### Treatment

The treatment plan for cracked teeth varies with location and extent of the crack.

- Urgent care of the cracked tooth involves the occlusal relief.
- Preserve the pulpal vitality by providing full occlusal coverage for cusp protection.
- When crack involves the pulp, do endodontic therapy.
- Apically extension and future migration of the crack apically onto the root determines the prognosis. Depending upon the treatment may involve extractions, root resection, or hemisection.

## WHAT ARE RECENT ADVANCES IN DENTAL RADIOGRAPHY?

### Digital Dental Radiology

In this, images in digital form can be readily manipulated, stored and retrieved on computer. The general principles of digital imaging are:

1. The chemically produced radiograph is represented by data that is acquired in a parallel and continuous fashion known as analogue.
2. Computers use binary (0 or 1) language, where information is usually handled in 8 character words called bytes.
3. If each character can be either 0 or 1. This result in 28 possible combination (words) that is 256 words. Thus digital dental images are limited to 256 shades of grey.
4. Digital images are made up of pixels (picture elements), each allocated a shade of grey.

5. The spatial resolution of a digital system is heavily dependent upon the number of pixels available per millimeter of image.

Digital dental radiology is possible with two methods:
1. One uses charged couple devices.
2. Other uses photo stimulable phosphor imaging plates.

## The CCD System

The CCD is a solid state detector composed of array of X-ray or light sensitive phosphores on a pure silicon chip. These phosphors convert incoming X-rays to a wave-length that matches the peak response of silicon.

## RVG

RVG is composed of three major parts:
- The radio part consists of a conventional X-ray unit
- A precise timer for short exposure times
- A tiny sensor to record the image.

The 'visio' portion of the system receives and stores incoming signals during exposure and converts them point by point into one of 256 discrete gray levels. It consists of a video monitor and display processing unit. As the image is transmitted to the processing unit, it is ***digitized*** and memorized by the computer.

The 'graphy' part of RVG unit consists of digital storage apparatus that can be connected to various print out or mass storage devices for immediate or later viewing.

*Advantages*

- Low radiation dose.
- Diagnostic capability is increased.
- Image distortion is eliminated.
- Contrast and resolution can be altered.

*Disadvantages*

- Expensive.
- Large disc space required to store images.

## Phosphor Imaging System

Here the image is captured on a phosphor plate as analogue information and is converted into a digital format when the plate is processed.

Two sizes of phosphor plates, similar in size to conventional intraoral film packets are provided. They have to be placed in plastic light-tight bags, before being used in the mouth. They are then positioned in the same manner as film packets, using holders, incorporating beam - aiming devices, and are exposed using conventional dental X-ray equipment. The image is displayed and manipulated.

*Advantages*

- Low radiation dose
- Almost instant image
- X-ray source can be remote from PC.

*Disadvantages*

- Cost
- Storage of images.

## WHAT ARE DIAGNOSTIC FINDINGS OF COMMON DENTAL PROBLEMS (TABLE 6.1)?

**Table 6.1: Diagnostic findings of common dental problems**

| | *Symptoms* | *X-ray findings* | *Pulp vitality tests* |
|---|---|---|---|
| Reversible pulpitis | Asymptomatic or slight symptoms to thermal stimulus | No changes | Gives response to vitality tests |
| Irreversible pulpitis | Asymptomatic or may have spontaneous or severe pain to thermal stimuli | No changes, except in long standing cases condensing osteitis | Gives response |
| Pulp necrosis | None | Depends on periapex status | No response |
| Acute apical periodontitis | Pain on biting or pressure | Not significant | Depending on status of pulp, response or no response |
| Chronic apical periodontitis | Mild or none | Not significant | Depending on pulp status, response or no response |
| Acute apical abscess | Pain and/or swelling | Radiolucency at apical end | No response |
| Chronic apical abscess | Draining sinus | Radiolucency | No response |
| Condensing osteitis | Varies according to status of pulp or periapex | Increased trabecular bone | Depending on pulp status response or no response |


# Case Selection and Treatment Planning

## WHAT ARE INDICATIONS AND CONTRAINDICATIONS OF ENDODONTIC THERAPY?

### Indications

*Actual Reason for Endodontic Therapy*

If there is pulp involvement due to caries, trauma, etc. the tooth must be treated endodontically.

*Elective Endodontics*

Sometimes elective endodontic is done in a tooth with crack or heavy restoration.

*Devitalization of Tooth*

In patients with rampant caries or recurrent decay endodontic therapy is required.

*Endodontic Emergency*

In patient comes with acute dental pain, in such cases endodontic therapy is often indicated.

### Contraindications

Following cases are considered ***poor candidates for endodontic treatment***:

1. *Nonrestorable teeth* such as teeth with extensive root caries, furcation caries, poor crown/root ratio and with fractured root.
2. *Teeth in which instrumentation is not possible* such as teeth with sharp curves, dilacerations, calcifications.
3. *Untreatable tooth resorption*: i.e. resorptions which are extremely large in size.
4. *Vertical tooth fracture*: Teeth with vertical root fractures pose the hopeless prognosis.
5. *Nonstrategic teeth*: Prognosis of tooth that cannot be restored or that has inadequate, unmaneable periodontal support is hopeless.
6. *Systemic conditions*: Most of the medical conditions don't contraindicate the endodontic treatment but patient should be thoroughly evaluated in order to manage the case optimally.

## WHAT ARE STEPS OF ENDODONTIC TREATMENT PLANNING?

The treatment planning signifies the planning of the management of the patient's dental problems in systematic and ordered way that assumes a complete knowledge of patient needs, nature of problem and prognosis of the treatment to be done very rarely, both dentist as well as the patient have complete picture of considerations mentioned above.

The treatment planning consists of following phases:

1. Treatment of acute problem which includes first step of endodontic treatment comprising of access opening, extirpation of pulp and allowing drainage through pulp space.
2. Oral hygiene instructions, diet instructions.
3. Temporary restoration of carious teeth, scaling and polishing.
4. Definitive restorations of carious teeth.
5. Complete root canal treatments of required teeth.
6. Do endodontic surgery if needed.
7. Evaluate the prognosis of treated teeth.
8. Provide post endodontic restorations.

## Factors Affecting Treatment Planning

1. Chief complaint regarding pain and swelling.
2. Previous history of dental treatment.
3. Medical history.
4. Intraoral examination.
5. Extraoral examination.
6. Oral hygiene.
7. Occlusion.
8. Special Tests.
9. Diagnosis.
10. Treatment options.

## RATIONALE OF ENDODONTIC TREATMENT

- Any injury to the pulp can result in many changes.
- Penetration of microorganisms and other irritants from infected root canals into periapical area can lead to formation and perpetuation of periradicular lesions.
- In contrast to pulp, periradicular tissue have unlimited source of undifferentiated cells which can participate in inflammation and repair in inflammation and repair.
- Reactions involved are highly complex and are usually mediated by nonspecific and specific mediators of inflammation.
- Following changes occur due to noxious stimuli from the diseased pulp :
  - Periapical infection
  - Cellular changes like infilteration of inflammatory cells
  - These changes in periapical area due to diffusion of toxins from root canals are experimentally demonstrated by Fish.
- For the success of endodontic treatment one must remove all the contents of the root canal completely because any communication from root canal system to periodontal space acts as portal of exit which can lead to formation of lesions of endodontic origin.
- Therefore, it is necessary to go for root canal treatment to remove the toxins from the root canals which leads to healing, repair and establishment of tooth function (Fig. 7.1).

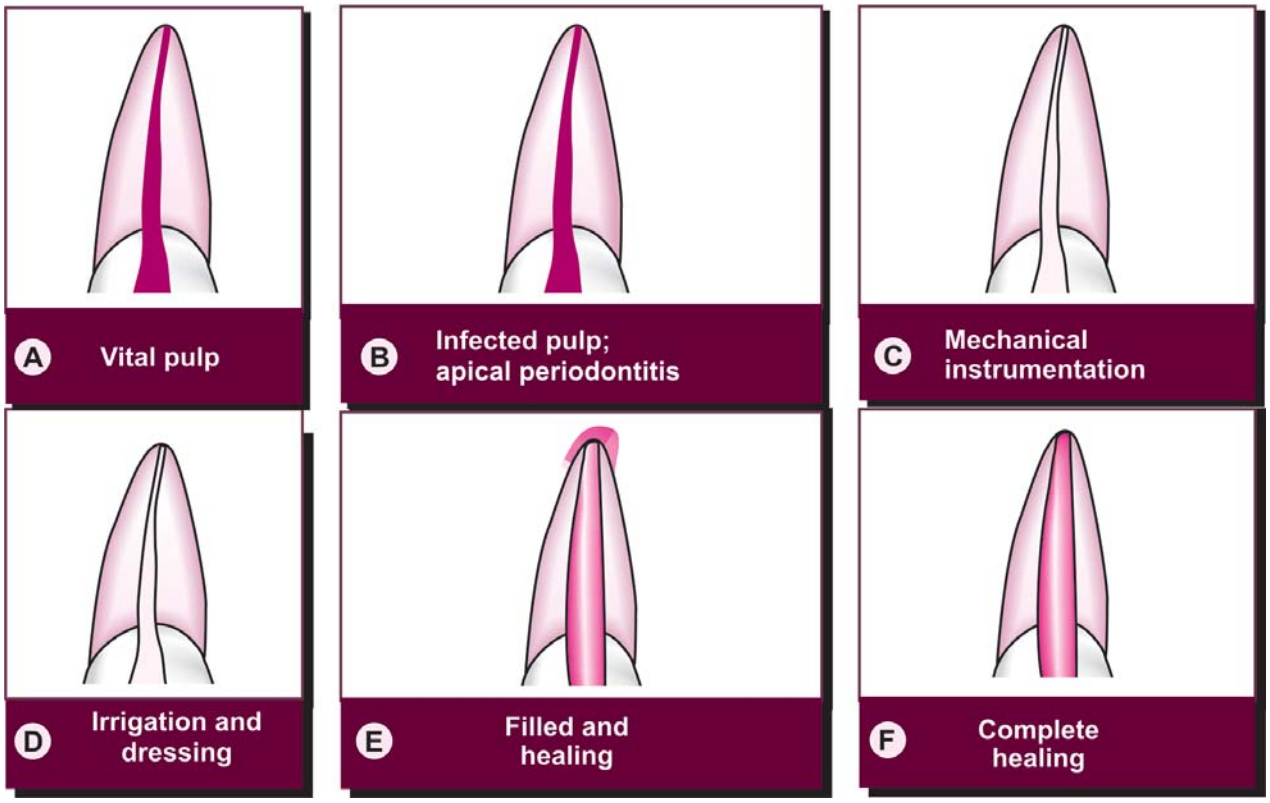



**Fig. 7.1:** Rationale of endodontic treatment

## FISH ZONES

Fish found experimental foci of infection in the jaws of guina pigs by drilling openings in the bone and packing in wool fibers saturated with broth culture of micro-organisms. He found four well defined zones of reaction. These are:

### Zones of Infection

- Characterized by polymorphonuclear leucocytes.
- Usually this zone is present in the center of the lesion.

### Zone of Contamination

- Characterized by round cell infiltration.
- Fish observed cellular destruction is due to toxins discharged from the central zone not from the bacteria alone.
- Appearance of empty lacunae due to death of bone cells.
- Prevalence of lymphocytes.

### Zone of Irritation

- Presence of macrophages and osteoclasts.
- Fish found evidence of irritation further from the central lesion as the toxins become more diluted.
- Phagocytic and macrophagic cells destroy the collagen framework, while on the other hand osteoclasts destroy the bone tissue.
- A small amount of repair is also seen.

### Zone of Stimulation

- Usually presented by fibroblasts and osteoblasts.
- At the periphery of zone, the action of toxins is mild enough to be a stimulant.
- In response to this stimulation, fibroblasts lay down collagen fibers which act both as a wall of defence around the zone of irritation and also act as scaffolding on which osteoblasts build new bone.
- New bone is formed in an irregular fashion.

## NOTE ON ASEPSIS IN ENDODONTICS

### Infection Control

The basic principles of asepsis and infection control used in general dentistry apply to endodontics with little variance.

### Sterilization

Sterilization is the process of destroying all microbial life from an article or surface, including spores.

*Various methods of sterilization are*:

- Moist heat/steam heat (autoclave)
- Dry heat (hot air oven, glass bead sterilizer)
- Chemical vapor pressure sterilization
- Ethylene oxide sterilization.

*The entire process of sterilization can be divided into three steps*:

1. Cleaning of instruments (presterilization cleaning).
2. Sterilization process.
3. Storage.

### Cleaning of Instruments

All surgical instruments must be cleansed of debris including blood, saliva and necrotic material, which can interfere with sterilization process.

### Sterilization Process

Moist heat/steam heat (autoclave): It is considered as a better method of sterilization due to higher efficiency of penetration of moist heat than dry heat. The commonly accepted specifications for autoclave are 121°C (250°F) at 15 psi with minimum holding time 15 minutes.

*Advantages*

- Better penetration of moist heat.
- Effective and rapid method of sterilization.
- Sterilization is confirmable.

*Disadvantages*

- Dulling and corrosion of sharp instruments.
- Items sensitive to elevated temperatures and moisture cannot be effectively autoclaved.
- Damage to plastic and rubber products.

### Dry Heat Sterilization

It is an alternative method for sterilization of instruments, particularly, the sharp instruments. Dry heat kills the microorganisms by denaturation and oxidation process.

### Hot Air Oven

The instruments are packed loosely inside the oven and a temperature of 160°C is achieved with a holding time of one hour.

*Advantages*

- No corrosion is seen in carbon steel instruments and burs.
- Low cost of equipment.
- Maintains the sharpness of cutting instruments.

*Disadvantages*

- Poor penetrating capacity of dry heat.
- Long cycle is required for sterilization (period).
- Higher temperature of sterilizer may damage the instruments.

### Glass Bead Sterilizer

- Rapid method of sterilization which is used for sterilization of endodontic instruments such as reamers, files and broaches, etc.
- Uses table salt which consists approximately of 1 percent sodium silicoaluminate, sodium carbonate or magnesium carbonate.
- Salt can be replaced by glass beads.
- The instruments can be sterilized in 5 to 15 seconds at a temperature of 437 to 465°F (260°C).

*Disadvantage*

Handle portion is not sterilized and therefore these articles are not entirely 'sterile'.

*Advantages*

- Uses salt- easily available and cheap.
- Salt does not clog the root canal.

### Chemical Vapor Pressure Sterilization

This method of sterilization is based on the factor of heat, water and chemical. The chemicals include formal dehydes, acetones and alcohols.

### Ethylene Oxide Sterilization

This method of sterilization is used for sterilizing heat sensitive instruments. It is highly penetrating, non-corrosive agent with cidal action against bacteria, spores and viruses.

### Personal Barrier Protection

Barrier protection in infection control is an important factor in disease prevention.

In dentistry, this involves the use of protective barriers such as gloves, masks, protective eyewear and protective clothing.

**Sterilization of the dental equipment**

| S.No. | Instrument | Method |
|---|---|---|
| 1. | Mouth Mirror Probes Explorer Tweezers | Autoclave |
| 2. | Endodontic Instruments—Files, reamers, broaches | Autoclave |
| 3. | Steel, burns | Disposable |
| 4. | Carbide and Diamond burs | Autoclave |
| 5. | Local anesthetic cartridges | Presterilized disposable |
| 6. | Needles | Disposable |
| 7. | Rubber dam equipment | |
| | a. Carbon steel clamps and metal frames | Dry heat ethylene oxide autoclave |
| | b. Punch | Dry heat ethylene oxide |
| 8. | Gutta percha points | Dip in 5.2% sodium hypochlorite for 1 min and then rinse with hydrogenperoxide and dry it |

## PAIN CONTROL IN ENDODONTICS

### Local Anesthesia

- It is defined as a loss of sensation in a circumscribed area of the body caused by depression of excitation in nerve endings or an inhibition of the conduction process in peripheral nerves.
- The primary action of the local anesthetics agent in producing a nerve conduction block is to decrease the nerve permeability to sodium ($Na^+$) ions, thus preventing the inflow of $Na^+$ ions into the nerve. Therefore local anesthetics interfere with sodium conductance and inhibit the propagation of impulse along the nerve fibers.

*Various Techniques of Local Anesthesia*

- Local infiltration technique
- Supraperiosteal technique
- Field block technique
- Nerve block technique.

*Techniques Used for Maxillary Tissues*

1. Supraperiosteal technique.
2*. Anterior and middle superior alveolar nerve block.
3. Posterior superior alveolar nerve block.
4. Greater palatine nerve block (anterior palatine nerve block).
5. Nasopalatine nerve block.
6*. Maxillary nerve block.
7. Periodontal ligament injection.

*Both can be given intraorally and extraorally while all other are given intraorally only.

*Various Mandibular Anesthesia Techniques*

1. Inferior alveolar nerve block.
2. Long buccal nerve block.
3. Mandibular nerve block.
   - Gow-gates technique.
   - Extra oral approach.
4. Vazirani-Akinosi closed mouth technique.
5. Mental nerve block.

## WHAT IS INTRAPULPAL INJECTION?

Adequate pulpal anesthesia is required for treatment of pulpally involved tooth. This injection control spain, both by applying pressure and utilizing the pharmacologic action of local anesthetic agent.

### Indication

Lack of obtaining profound anesthesia in pulpally involved teeth by other techniques.

### Nerves Anesthesized

Terminal nerve endings at the site of injection.

### Techniques

- Insert 25 or 27 gauge needle firmly into the pulp chamber.
- Always deposit local anesthetic solution under pressure as back pressure is shown to be the major factor in producing anesthesia (Fig. 7.2).

**Fig. 7.2:** Intrapulpal injection

- Deposit a very small amount of solution (0.2-0.3 ml) under pressure (5-10 seconds).

### Advantages

- Requires less volume.
- Early onset.
- Easy to learn.

### Disadvantages

- Results are not predictable as it may vary.
- Brief pain during or after insertion of solution.

# 8 Basic Endodontic Instruments

## HOW CAN YOU CLASSIFY ENDODONTIC INSTRUMENTS?

ISO-FDI (Federation Dentaire International) grouped root canal instruments according to their method of use:

Group I : *Hand use only*, for example K and H-files, reamers, broaches, etc.

Group II : *Latch type Engine driven*: Same design as group I but can be attached to hand piece.

Group III : *Drills or reamers Latch type Engine driven*, for example Gates-Glidden, Peeso reamers.

Group IV : *Root Canal points* like gutta-percha, silver point, paper point.

## WHAT IS STANDARDIZATION OF ENDODONTIC INSTRUMENTS?

Ingle and LeVine suggested few guidelines for instruments for having uniformity in instrument diameter and taper. The guidelines were:

1. Instruments are numbered from 10 to 100. Each number represent diameter of instrument in 100th of millimeter at the tip.
2. Working blade begins at tip ($D_1$) and extends 16 mm up the shaft ($D_2$). $D_2$ is 0.32 mm greater than $D_1$, ensuring that there is constant increase in taper, i.e 0.02 mm per mm of instrument (Fig. 8.1).
3. Tip angle of instrument varies as 75 ± 15°.
4. Instruments handles are color coded for their easier recognition (Pink, grey).

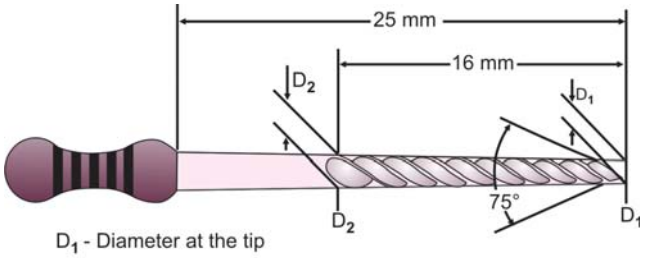



**Fig. 8.1:** Diagrammatic representation of an endodontic instrument in accordance with ANSI specification No. 57

5. Instruments available in length 21, 25, 28 and 30 mm are used for root canal therapy, and those of 40 mm size are used in preparing root canals for the endodontic implants.

| *Color code* | *Instrument number* |
|---|---|
| Pink | 06 |
| Grey | 08 |
| Purple | 10 |
| White | 15 |
| Yellow | 20 |
| Red | 25 |
| Blue | 30 |
| Green | 35 |
| Black | 40 |
| White | 45 |
| Yellow | 50 |
| Red | 55 |
| Blue | 60 |
| Green | 70 |
| Black | 80 |

## SHORT NOTE ON BROACHES, REAMERS AND FILES

### Broaches

1. Broaches are manufactured from round wires, smooth surface of which has been notched to form barbs (Fig. 8.2).
2. They are specifically designed to remove the pulp.
3. Broach does not cut the dentin but can effectively be used to remove cotton or paper points which might have lodged in the canal.
4. Smooth broach is free of barbs. It is used as pathfinder.

*Technique of Pulp Extirpation (Healey, 1984)*

Irrigate the canal with 5.2% solution of sodium hypochlorite
↓
Penetrate the barbed broach along the canal wall towards the apex
↓
As it reaches to the apical constriction, move it "into the center of mass of pulp tissue
↓
Rotate the broach several times in a watch winding manner to entrap the pulp which is then withdrawn from the canal

### Reamers

- Reamers are K-type instruments.
- They cut dentin by inserting into the canal, twisting clockwise one quarter to half turn and then withdrawing, i.e. penetration, rotation and retraction.
- Reamers have triangular blank (Fig. 8.3).
- Lesser number of flutes than files.
- Numbers of flutes in reamer are 1/2 to 1/mm, while in files the flutes are 1½ to 2/mm.

**Fig. 8.3:** Diagrammatic representation of reamer with triangular cross-section

### Files

- Files are the instruments used during cleaning and shaping of the root canals for machining of the dentin.
- Kerr manufacturing company was first to produce them, the files were also called K-files.

Commonly used files
1. K-file
2. K-Flex file
3. Flexofile
4. Flex-R file
5. Hedstrom file
6. Safety H-file
7. S-file

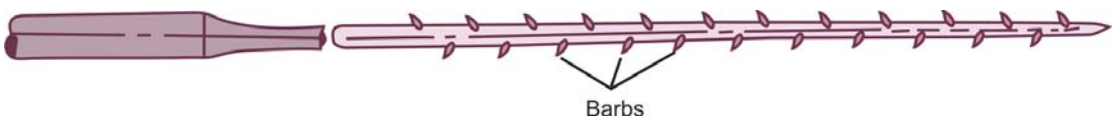



**Fig. 8.2:** Diagrammatic picture of a broach

*K-File*

- It is triangular or square in cross section, manufactured from stainless steel wire, which is grounded into desired shape.
- Tighter twisting of the file spirals increases the number of flutes in file.
- Triangular cross sectioned files show superior cutting and increased flexibility than the file or reamers with square blank (Fig. 8.4).

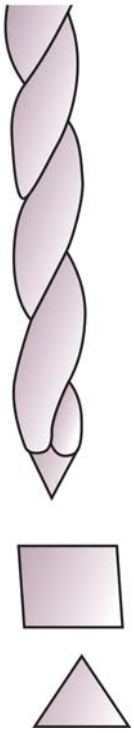


**Fig. 8.4:** Diagrammatic representation of K-file

*K-Flex Files*

They were introduced by Kerr manufacturing company in 1982. K-flex files are rhombus in cross section having two acute angles causing increased sharpness and two obtuse angles which make more space for debris removal (Fig. 8.5). Also the decrease in contact of instrument with canal walls provides more space for irrigation.

*Flexofile*

These are similar to the K-Flex files except that they have triangular cross section. This feature provides them more flexibility and thus ability to resist fracture.

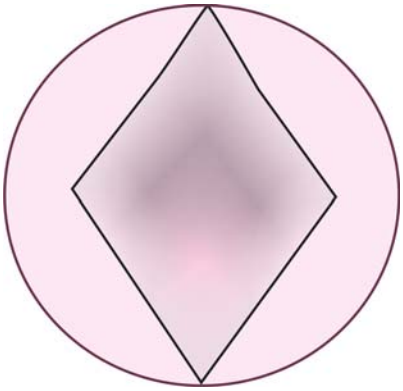


**Fig. 8.5:** Rhombus cross-section of K-flex File

*Flex-R File*

Flex-R files are made by removing the sharp cutting edges from the tip of instrument. This design reduces the ledge formation, canal trans-portation and other procedural accidents when used with balanced force technique.

*Hedstrom Files (H-files)*

- Hedstrom files have flutes which resemble successively triangles set one on another (Fig. 8.6).
- Hedstrom files cut only when instrument is withdrawn because its edges face the handle of the instrument.
- When used in torquing motion, their edges can engage in the dentin of root canal wall and causing H-files to fracture.

**Fig. 8.6:** Diagrammatic view of Hedstrom File

- Since they lack the flexibility and are fragile in nature, the H-files tend to fracture when used in torquing action.

*S-File*

- Produced by grinding, which makes it stiffer than Hedstrom file.
- Designed with two spirals for cutting blades, forming double helix design (Fig. 8.7).
- This file show 'S' shape in the cross section.
- S-file has good cutting efficiency in either filling or reaming action.

**Fig. 8.7:** Cross-section and longitudinal shape of S-file

## WHAT ARE ENGINE DRIVEN INSTRUMENTS?

### Gates-Glidden Burs

1. Traditional engine driven instruments include Gates-Glidden drills which have flame shaped cutting point mounted on long thin shaft attached to a latch type shank.
2. Gates-Gliddens are available in a set from 1 to 6 with the diameters from 0.5 to 1.5 mm.
3. Due to their design Gates-Glidden drills are side cutting instruments with safety tips.
4. If its cutting tip jams against the canal wall, fracture should occur at the junction of shank and the shaft but not at the tip of the instrument. This makes the easy removal of fractured drill from the canal.

### Peeso Reamers

They are rotary instruments used mainly for post space preparations. Disadvantages of using peeso reamers are:

1. They don't follow the canal curvature and may cause perforation by cutting laterally.
2. They are stiff instruments.
3. They have to be used very carefully to avoid iatrogenic errors.

## WHAT MEASURES SHOULD BE TAKEN FOR PREVENTION OF BREAKAGE OF INSTRUMENTS WHEN USING NICKEL-TITANIUM ROTARY INSTRUMENTS?

1. Use only torque controlled electric handpiece for these instruments.
2. Proper glide path must be established before using rotary files, i.e. getting the canal to at least size 15 before using them.
3. Use crown down method for canal preparation.
4. Frequent cleaning of flutes should be done.
5. Do not force the file apically against resistance.
6. Remove the maximum possible pulp tissue with broach before using rotary files.
7. Canals should be well lubricated and irrigated.
8. Dentin mud collected in the canal should be cleared off by frequent irrigation.
9. Discard a file if it is bent, stretched or has a shiny spot.
10. A file should be considered disposable when:
    a. It has been used in curved canals.
    b. Despite of existence of excellent glide path, if it doesn't cut dentin properly.

## WHAT ARE VARIOUS ROTARY NICKEL-TITANIUM SYSTEM (RNT)?

### Profile System

- Profile instruments made by Tulsa Dental were one of the first NiTi instruments available commercially.
- Cross-section of profiles show three equally shaped U-shaped grooves with radial lands (Fig. 8.8).
- Central parallel core present in profiles increase their flexibility.

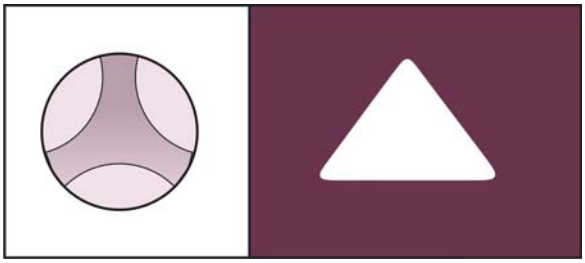


**Fig. 8.8:** Cross-section of profiles

## Greater Taper Files (GT Files)

1. The GT rotary instruments possess a U-shaped file design with ISO tip sizes of 20, 30 and 40 and tapers of 0.04, 0.06, 0.08, 0.10 and 0.12.
2. The maximum diameter of these instruments is 1.50 mm.
3. Recommended rotational speed for GT files is 350 rpm.

## Pro Taper Files

1. The ProTaper file has a triangular cross section and is variably tapered across its cutting length (Fig. 8.9).
2. A unique feature of the ProTaper files is each instrument has changing percentage tapers over the length of cutting blades. This progressively tapered design improves flexibility, cutting efficiency and the safety of these files.
3. Convex triangular cross section of these instrument decrease the friction between the blade of file and the canal wall while increasing its cutting efficiency.
4. ProTaper file acts in active motion, this further increases its efficiency and reduces torsional strain.
5. The ProTaper system consists of just three shaping and three finishing files.

### *Shaping Files*

These are termed as $S_X$, $S_1$ and $S_2$

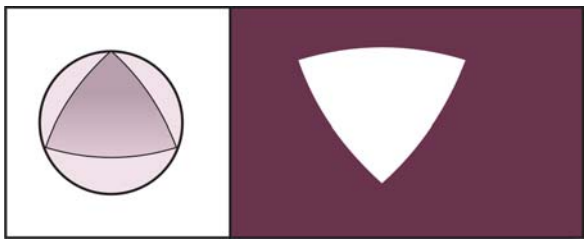


**Fig. 8.9:** Cross-section of ProTaper files

*$S_X$*
- No identification ring on its gold colored handle
- Shorter length of 19 mm
- Do diameter is 0.19 mm
- $D_{14}$ diameter is 1.20 mm
- Use is similar to Gates-Glidden drills or orifice shapers.

*$S_1$*
- Has purple identification ring on its handle
- Do diameter is 0.17 mm and $D_{14}$ is 1.20 mm
- Used to prepare coronal part of the root.

*$S_2$*
- Has white identification ring on its handle
- Do diameter is 0.20 mm and $D_{14}$ is 1.20 mm
- Used to prepare middle third of the canal.

### *Finishing Files*

Three finishing files $F_1$, $F_2$, $F_3$ are used to prepare and finish apical part of the root canal.

*$F_1$*
- Yellow identification ring
- Do diameter and apical taper is 20 and 0.07.

*$F_2$*
- Red identification ring on handle
- Do diameter and taper is 25 and 0.08.

*$F_3$*
- Blue colored ring on handle
- Do diameter and taper is 30 and 0.09.

## Quantec File System

Quantec file series are available in both cutting and noncutting tips with standard size of 25 No. in 0.12, 0.10, 0.08, 0.06, 0.05, 0.04, 0.03 and 0.02 tapers. 0.02 tapered Quantec file are also available in size 15 to 60 No.

## Light Speed System

1. Light speed system is engine driven endodontic instrument manufactured from nickel-titanium. These are so named because a "light" touch is needed as "speed" of instrumentation is increased.
2. Light speed instrument are slender with thin parallel shaft and have non cutting tip with gates glidden in configuration.

3. They are available in 21, 25, 31 and 50 mm length and ISO No. 20 to 140.

### $K_3$ Rotary File System

1. $K_3$ files are available in taper of 0.02, 0.04 or 0.06 with ISO tip sizes. An Axxess handle design shortens the file by 5 mm without affecting its working length.
2. They are flexible because of presence of variable core diameter.

### Hero 642

| | | |
|---|---|---|
| Hero | - | High elasticity in rotation |
| 642 | - | 0.06, 0.04 and 0.02 tapers |

1. It has trihelical Hedstorm design with sharp flutes (Fig. 8.10).
2. Due to progressively increasing distance between the flutes-reduced risk for binding of the instrument in root canal.

## WHAT IS ROLE OF ULTRASONICS IN ENDODONTICS?

### Ultrasonic Endodontics

- Ultrasonic Endodontics is based on a system on which sound as an energy source (at 20 to 42 kHz), activates an endodontic file resulting in three dimensional activation of the file in the surrounding medium.
- Ultrasonic handpiece uses K-file as a canal instrument.
- The irrigants are emitted from cords on the power source and travel down the file into the canal to be energized by the vibrations.

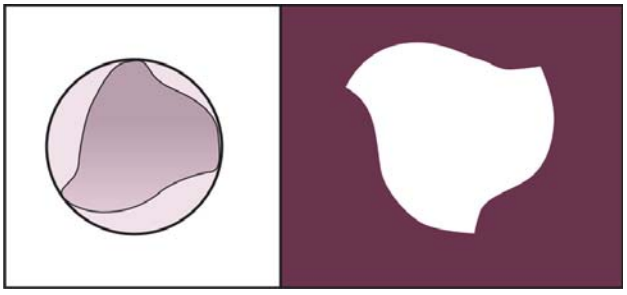


**Fig. 8.10:** Cross-section of Hero 642

### Uses of Endosonics

*Access Enhancement*

But use of round or tapered ultrasonically activated diamond coated tips has shown to produce smooth shapes of access cavity.

*Orifice Location*

Ultrasonic instruments are very useful in removal of the chamber calcifications.

*Irrigation*

There is a synergetic action of the physical action of the tip along with the chemical action of the irrigant resulting in cleaner canals.

*Gutta-Percha Obturation*

Moreno first suggested the technique of plasticizing gutta-percha in the canal with an ultrasonic instrument. The gutta-percha gets plasticized by the friction being generated. Final vertical compaction is done with hand or finger pluggers.

*MTA Placement*

Low powered ultrasonics can be used to vibrate the MTA into position with no voids.

*Endodontic Retreatment*

i. Intraradicular post removal
ii. Gutta-percha removal
iii. Silver point removal.

## WHAT ARE THE INSTRUMENTS USED FOR FILLING ROOT CANALS?

Spreaders and pluggers are the instruments used to compact the gutta-percha into root canal during obturation. The use of instrument depends on the technique employed for obturation.

*Hand spreaders* are made from stainless steel and are designed to facilitate the placement of accessory gutta-percha points around the master cone during lateral compaction technique.

*Finger spreaders* are shorter in length which allows them to afford a great degree of tactile sense and allow them to rotate freely around their axis. They are standardized and color coded to match the size of gutta-percha points.

*Pluggers* consist of diameter larger than spreader and have blunt end. They are used to compact the warm gutta-percha vertically and laterally into the root canal. They may also be used to carry small segments of gutta-percha into the canal during sectional filling technique.

## WHAT ARE VARIOUS MOVEMENTS OF INSTRUMENTS?

### Reaming

It involves clockwise rotation of an instrument. The instrument may be controlled from insertion to generate a cutting effect (Fig. 8.11).

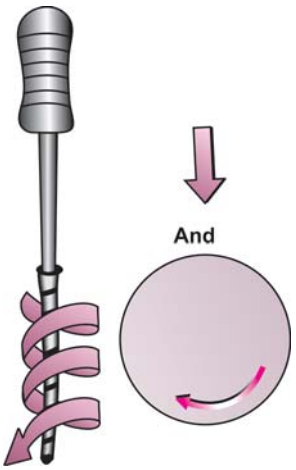



**Fig. 8.11:** Reaming motion involving clockwise rotation of instrument

### Filing

The term filing indicates push-pull motion with the instrument (Fig. 8.12). This method is commonly used for canal preparation.

### Combination of Reaming and Filing (Fig. 8.13)

In this technique file is inserted with a quarter turn clockwise and apically directed pressure (i.e. reaming) and then is subsequently withdrawn (i.e. filing).

### Balanced Force Technique

This technique involves oscillation of instrument right and left with different arcs in either direction. Instrument is first inserted into the canal by moving it clockwise with one quarter turn. Then to cut dentin, file is rotated counter clockwise and simultaneously pushing apically to prevent it from backing out of the canal. Finally, the file is removed by rotating file clockwise simultaneously pulling the instrument out of the canal (Fig. 8.14).

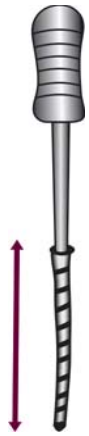


**Fig. 8.12:** Filing motion showing push and pull action of instrument

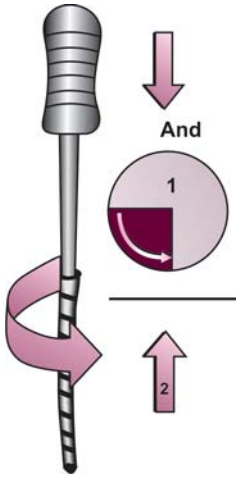



**Fig. 8.13:** Combination of reaming and filing

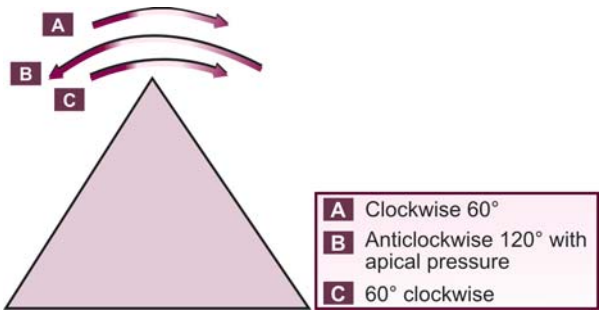



**Fig. 8.14:** Balanced force technique

### Watch Winding

It is back and forth oscillation of the endodontic instrument (file or reamer) right and left as it is advanced into the canal. The angle of rotation is usually 30 to 60° (Fig. 8.15).

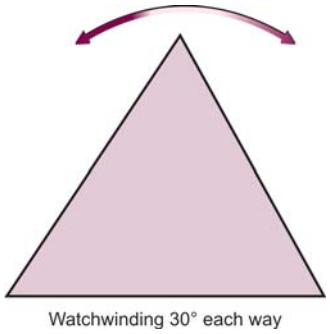



**Fig. 8.15:** Watch winding motion

### Watch Winding and Pull Motion

In this, first instrument is moved apically by rotating it right and left through an arc. When the instrument feels any resistance, it is taken out of the canal by pull motion (Fig. 8.16).

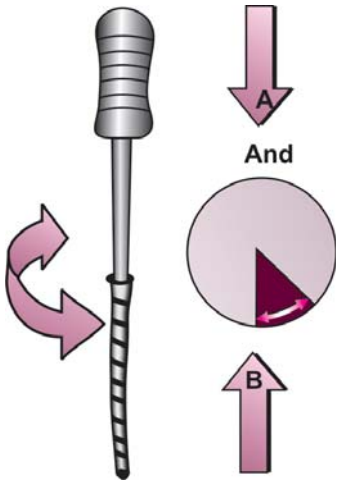



**Fig. 8.16:** Watch winding and pull motion

## SOTOKAWA'S CLASSIFICATION OF INSTRUMENT DAMAGE

Type I : Bent instrument
Type II : Stretching of twist contour
Type III : Peeling off metal at blade edges
Type IV : Partial clockwise twist
Type V : Cracking along axis
Type VI : Full fracture.

## SHORT NOTE ON SURGICAL OPERATING MICROSCOPE (SOM)

Use of microscope in endodontics was first introduced in 1990's and since its introduction in endodontics there has been made great change in the way endodontics is done and has also affected the success rate of endodontic therapy.

Most of surgical microscope come with 3 to 5 steps of magnification ranging from 3x to 27x.

### Uses of Endomicroscope

1. Diagnosis
   a. SOM allows calcified, accessory canals to be found with ease.
   b. SOM helps to detect microfractures which are not visible with naked eye.
2. The endodontic retreatment involving the removal of screw posts, separated instruments, silver points can be guided by use of endomicroscope.
3. Perforation repair can be precisely done by use of SOM by accurate placement of the repair material and by précised manipulation of the tissue.
4. Evaluation of the canal preparation can be accurately done by use of endomicroscope.

## SHORT NOTE ON MINERAL TRIOXIDE AGGREGATE (MTA)

Mineral trioxide aggregate (MTA) was developed by Dr Torabinejad at Loma Linda University in 1993.

### Composition

It contains
Tricalcium silicate
Dicalcium silicate
Tricalcium aluminate
Bismuth oxide
Calcium sulfate
Tetracalcium aluminoferrite

### Properties

1. pH of MTA is 12.5 (When set) so, it has biological and histological properties similar to calcium hydroxide.

2. Setting time is 2 hours and 45 minutes.
3. It sets in a moist environment (hydrophilic in nature).
4. It has low solubility.
5. It exhibits excellent biocompatibility in relation with vital tissues.

## Manipulation

To prepare MTA, a small amount of liquid and powder are mixed to putty consistency. Since, MTA mixture is a loose granular aggregate, it has to be carried into the canal with Messing gun, amalgam carrier or specially designed carrier.

## Advantages

- Water based chemistry, so requires moisture for setting.
- Excellent biocompatibility.
- Reasonably radiopaque.
- Bacteriostatic in nature.

## Disadvantages

- Difficult to manipulate.
- Expensive.

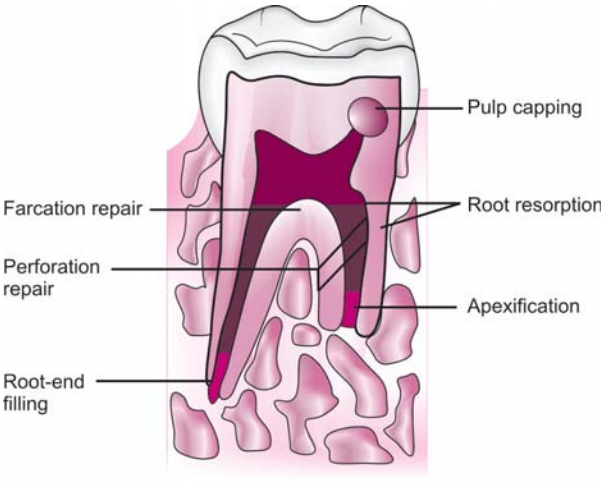



**Fig. 8.17:** Clinical applications of MTA

## Indications of Use of MTA (Fig. 8.17)

- As a pulp capping material.
- For the repair of root canals as an apical plug during apexification.
- For the repair of root perforations during root canal therapy.
- For the repair of root resorptions.
- As a root end filling material.

# 9 Principles of Access Cavity Preparation

## WHAT ARE OBJECTIVES AND GUIDELINES FOR ACCESS CAVITY PREPARATION?

Preparation of the access cavity is opening through the coronal portion of tooth which allows localization, cleaning, shaping, disinfection and a three dimensional obturation of the root canal system.

### Objectives

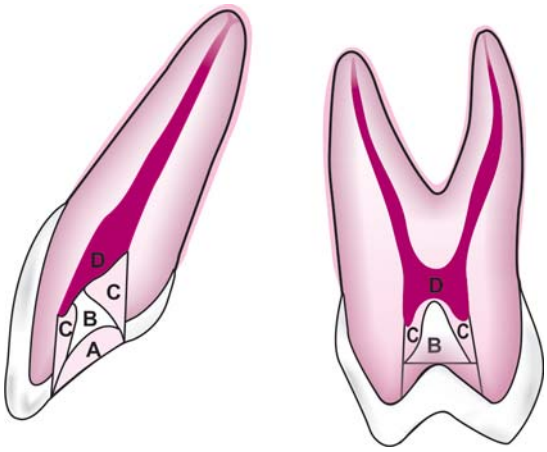
1. To gain the direct access to the apical foramen.
2. Pulp chamber debridement.
3. Conserve as much sound tooth structure as possible and as consistent with treatment objectives.

Before going for access cavity preparation, a study of preoperative periapical radiograph should be done to know:

i. Morphology of the tooth.
ii. Anatomy of root canal system.
iii. Number of canals.
iv. Curvature of branching of the canal system.
v. Position of apical foramen.
vi. Calcification, resorption present if any.

### Guidelines (Fig. 9.1)

1. Before starting the access cavity preparation check the depth of preparation by aligning the bur and handpiece against the radiograph.
2. Place a safe ended bur in handpiece complete the outline form. The bur is penetrated into the crown until the roof of pulp chamber is penetrated.
3. Remove all the unsupported tooth structure to prevent tooth fracture during treatment.
4. Remove the chamber roof completely as this will allow the removal of all the pulp tissue, calcifications, caries or any residuals of previous fillings.




**A**— Penetration into enamel with No. 2 or No. 4 high speed round bur
**B**— Exposure of pulp chamber with tapered fissure bur
**C**— Refinement of the pulp chamber and removal of pulp chamber roof using round bur from inside to outside
**D**— Complete debridement of pulp chamber space

**Fig. 9.1:** Guidelines for access cavity preparation

5. The walls of pulp chamber are flared and tapered to form a gentle funnel shape with larger diameter towards occlusal surface.
6. Endodontic access cavity is prepared through the occlusal or lingual surface never through proximal or gingival surface. If access cavity as made through wrong entry, it will cause inadequate canal instrumentation resulting iatrogenic errors.
7. Inspect the pulp chamber for determining the location of canals, curvatures, calcifications using well magnification and illumination.

## WHAT ARE PRINCIPLES OF MAKING ACCESS CAVITY OF ANTERIOR TEETH?

- The access cavity shape varies with size and shape accordingly the internal anatomy of the pulp chamber, so internal anatomy of tooth must be determined before starting the treatment.
- Access opening is started at center of the lingual surface (Fig. 9.2).
- Direct a round bur perpendicular to the lingual surface at its center to penetrate the enamel. Once enamel is penetrated, bur is directed parallel to the long axis of the tooth, until 'a drop' in effect is felt.
- Now remainder of chamber roof is removed by working a round bur from inside to outside.
- Now locate the canal orifices using endodontic explorer.
- Once the canal orifices have been located, the lingual shoulder is removed using Gates-Glidden drills or safe tipped diamond or carbide burs.
- After the straight line access of the canal is confirmed by passing a file passively into the canal, one should evaluate the access cavity using magnification and illumination.

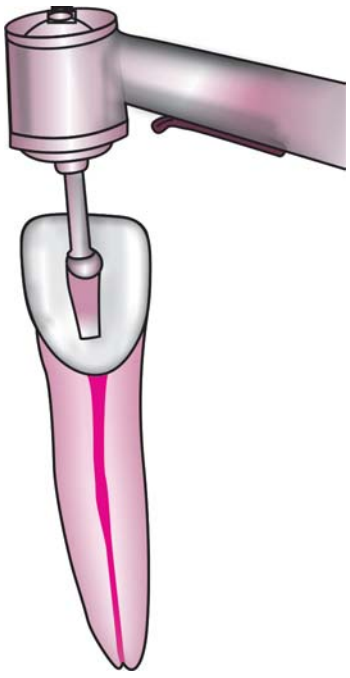


**Fig. 9.2:** Access cavity should be started at the center of lingual surface

## ACCESS CAVITY PREPARATION FOR PREMOLARS

- Determine the site of access opening on the tooth. In premolars, it is in the center of occlusal surface between buccal and the lingual cusp tips.
- Slight variations exist between mandibular and maxillary premolars because of the lingual tilt of mandibular premolars.
- Penetrate the enamel with No. 4 round bur in high speed contra angle handpiece. The bur should be directed parallel to the long axis of tooth and perpendicular to the occlusal table.
- Once the clinician feels "drop" into the pulp chamber, penetrate deep enough to remove the roof of pulp chamber without cutting the floor of pulp chamber.
- Now locate the canal orifices with the help of sharp endodontic explorer.
- The walls of access cavity are then smoothened and sloped slightly towards the occlusal surface. The divergence of access cavity walls creates a positive seat for temporary restorations.

## ACCESS CAVITY PREPARATION FOR MAXILLARY MOLARS

- Determine the shape and size of access opening by measuring the boundaries of pulp chamber mesially and distally and coronally on the radiograph.
- Now penetrate the enamel with No. 4 round bur in the central groove directed palatally and prepare an external outline form.
- Penetrate the bur deep into the dentin until the clinician feels "drop" into the pulp chamber. Now remove the complete roof of pulp chamber working from inside to outside. The shape and size of the internal anatomy of pulp chamber guides the cutting.
- Explore the canal orifices with sharp endodontic explorer.
- After the canal orifices has been located, remove any cervical bulges, ledges or obstruction if present.
- Smoothen and finish the access cavity walls.

### Maxillary First Molar

- The shape of pulp chamber is rhomboid. Palatal canal orifice is located palatally. Mesiobuccal canal orifice is located under the mesiobuccal cusp. Distobuccal canal orifice is located slightly distal and palatal to the mesiobuccal orifice (Fig. 9.3) .

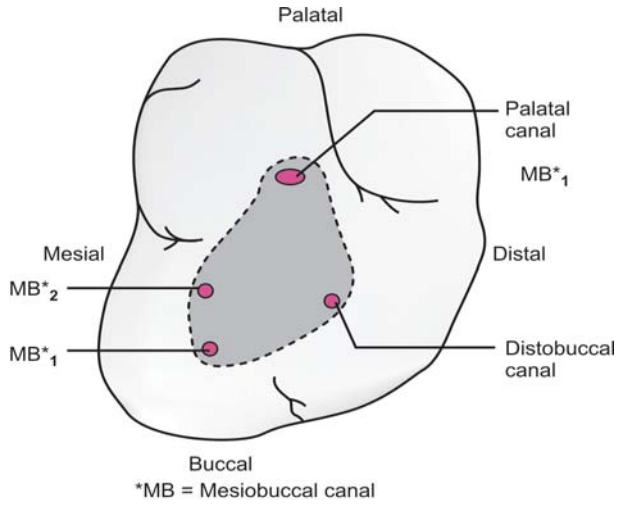



**Fig. 9.3:** Position of root canal orifices of maxillary first molar

A line drawn to connect all three orifices (i.e. MB, DB and palatal) forms a triangle, termed as ***molar triangle***.

- ***Luebke*** has shown that an entire wall is not extended to search and facilitate cleaning, shaping and obturation of extracanal. He recommended extension of only that portion of the wall where extracanal is present, and this may result in "***cloverleaf appearance***" in the outline form. Luebke referred this to as a ***shamrock preparation***.

## ACCESS CAVITY PREPARATION FOR MANDIBULAR MOLARS

- Here the enamel is penetrated with No. 4 round bur on the central fossa midway between the mesial and distal boundaries. The mesial boundary is a line joining the mesial cusp tips and the distal boundary is the line joining buccal and the lingual grooves.
  - Bur is penetrated in the central fossa directed towards the distal root. Once the "drop" into pulp chamber is felt, remove whole of the roof of pulp chamber working from inside to outside.
  - Explore the canal orifices with sharp endodontic explorer and finally finish and smoothen the cavity with slight divergence towards the occlusal surface.

### Mandibular First Molar

- Mesiobuccal orifice is under the mesiobuccal cusp.
- Mesiolingual orifice is located in a depression formed by mesial and the lingual walls.
- The distal orifice is oval in shape with largest diameter buccolingually, located distal to the buccal groove.
- The shape of access cavity is usually trapezoidal or rhomboid irrespective of number of canals present (Fig. 9.4).

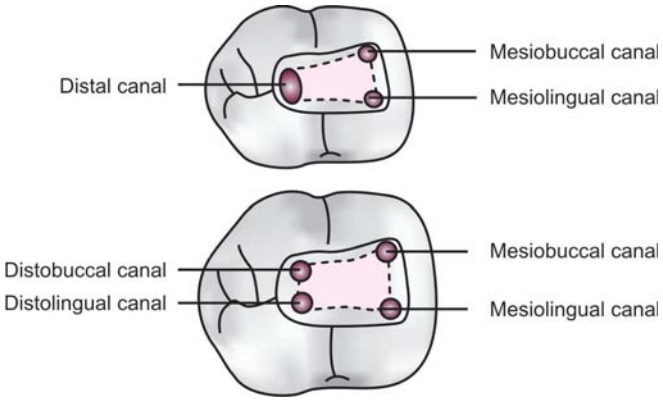



**Fig. 9.4:** Outline of access cavity of mandibular molars

# 10 Working Length Determination

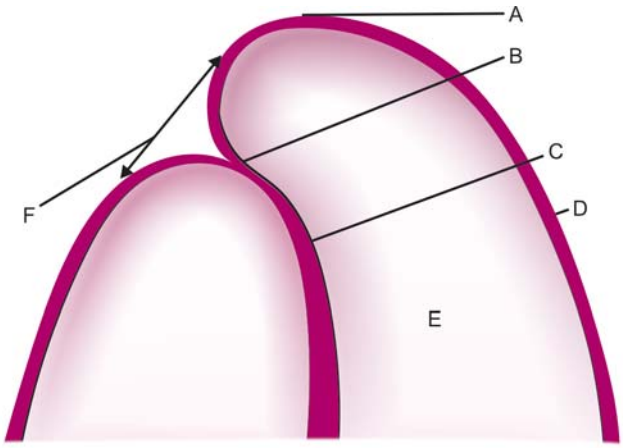
## DEFINITIONS

According to endodontic glossary *working length* is defined as "the distance from a coronal reference point to a point at which canal preparation and obturation should terminate" (Fig. 10.1).

*Anatomic apex* is "tip or end of root determined morphologically."

*Radiographic apex* is "tip or end of root determined radio graphically."

The *cementodentinal junction* is the region where cementum and dentin are united, the point at which cemental surface terminates at or near the apex of tooth.




| | | | | | |
|---|---|---|---|---|---|
| A | = | Root apex | B | = | Apical constriction |
| C | = | Root canal | D | = | Cementum |
| E | = | Dentine | F | = | Apical foramen |

**Fig. 10.1:** Different landmarks present at root apex

## SIGNIFICANCE OF WORKING LENGTH

- Working length determines how far into canal, instruments can be placed and worked.
- If placed in correct limits, it plays an important role in determining the success of treatment.
- Before determining a definite working length, there should be straight line access for the canal orifice.
- Failure to accurately determine and maintaining working length may result in length being over than normal which will lead to post operative pain, prolonged healing time and lower success rate.
- When working length is made short of apical constriction it may cause persistent discomfort because of incomplete cleaning and underfilling.

## ENUMERATE VARIOUS METHODS OF WORKING LENGTH DETERMINATION

### Different Methods of Determining Working Length

- Average root length from anatomic studies
- Use of radiographs
- Mathematics method
- Tactile sensation
- Bleeding on paper point
- Apical periodontal sensitivity
- Electronic apex locator

## WHAT IS RADIOGRAPHIC METHOD OF WORKING LENGTH DETERMINATION?

- Radiographic method of length determination involves measurement of radiographic apex and then subtracting a specific value from that length (Fig. 10.2).

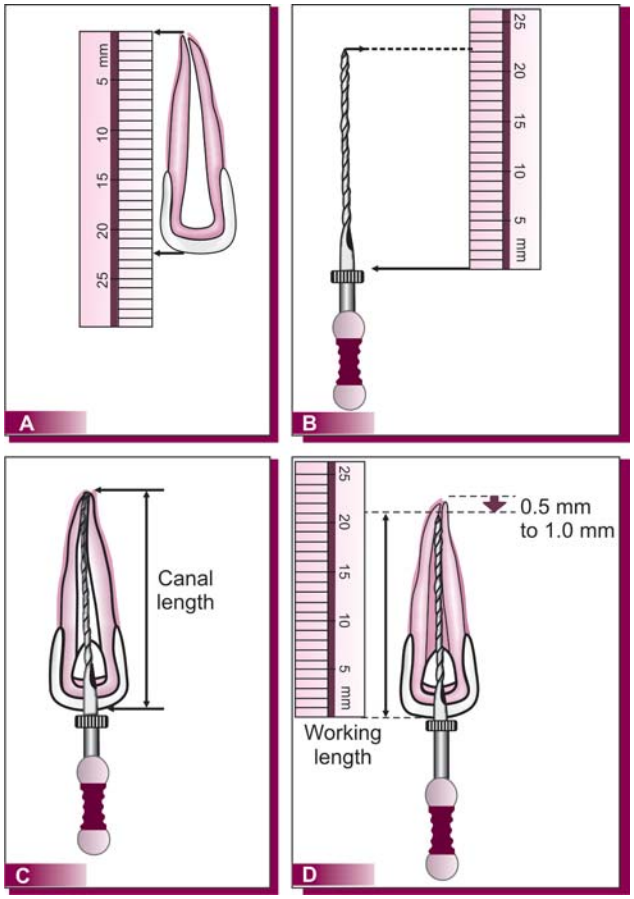



**Fig. 10.2:** Radiographic method of length determination

- Before access opening, fractured cusps, cusps weakened by caries or restorations are reduced to avoid fracture of weakened enamel during the treatment.
- Measure the estimated working length from pre-operative periapical radiograph (Fig. 10.2A).
- Adjust stopper of instrument to this estimated working length and place it in the canal up to the adjusted stopper (Fig. 10.2B).
- Take the radiograph.
- On the radiograph measure the difference between the tip of the instrument and root apex. Add or subtract this length to the estimated working length to get the new working length (Fig. 10.2C).
- Correct working length is finally calculated by subtracting 1 mm from this new length (Fig. 10.2D).

### Modification in the Length Subtraction as given by Weine

1. No resorption - Subtract 1 mm
2. Periapical bone resorption - Subtract 1.5 mm
3. Periapical bone + root apex resorption - Subtract 2 mm

## WHAT IS MATHEMATIC METHOD OF WORKING LENGTH DETERMINATION?

It is based on simple mathematical formulations to calculate the working length. In this, an instrument is inserted into the canal, stopper is fixed to the reference point and radiograph is taken. The formula to calculate actual length of the tooth is as follows:

$$\frac{\text{Actual length of the tooth}}{\text{Actual length of the instrument}} = \frac{\text{Apparent length of tooth in radiograph}}{\text{Apparent length of instrument in radiograph}}$$

$$\text{Actual length of tooth} = \frac{\text{Actual length of the instrument} \times \text{Apparent length of tooth in radiograph}}{\text{Apparent length of instrument in radiograph}}$$

### Disadvantages

Wrong readings can occur because of:

a. Variations in angles of radiograph
b. Curved roots.

## WHAT ARE ELECTRONIC APEX LOCATORS?

Electronic apex locators (EAL) are basically used to locate the apical constriction or cementodentinal junction or the apical foramen, and not the radiographic apex.

### Classification

This classification is based on type of the current flow and opposition to current flow as well as number of frequencies involved.

*First Generation Apex Locators (Resistance Apex Locators)*

They are also known as resistance apex locators which measure opposition to flow of direct current i.e. resistance. It is based on the ***principle*** that resistance offered by periodontal ligament and oral mucous membrane is the same, i.e. 6.5 k ohms.

*Technique for Using Resistance Based EAL*

1. Turn on the device and attach the lip clip near the arch being treated. Hold a 15 number file and insert

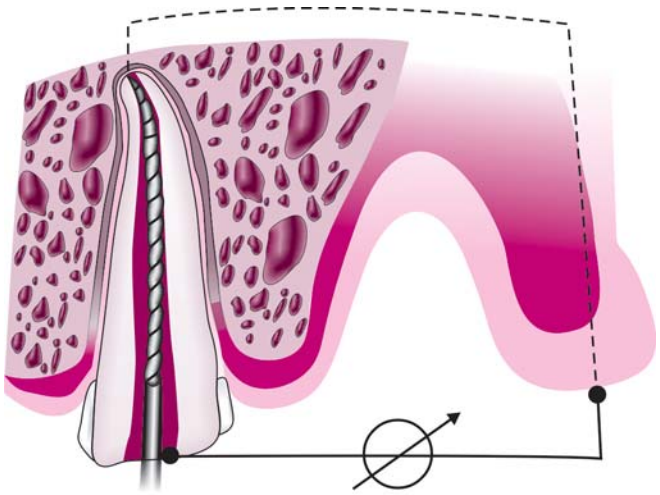


**Fig. 10.3:** Diagrammatic representation of working of resistance type of apex locator

it approx 0.5 mm into sulcus of tooth (like PD probe). Adjust the control knob until the reference needle is centered on the meter scale and produces audible beeps. Note this reading (Fig. 10.3).

2. Insert the file into canal unless the reference needle moves from extreme left to center of scale and alarm beeps sound. Reset the stop at reference point and record the lengths.
3. Take the radiograph with file in place at the length indicated by apex locator.

*Second Generation Apex Locators (Impedence Apex Locators)*

They are also called as ***impedance apex locator*** which measure opposition to flow of alternating current or impedance.

*Various second generation apex locators:*

- Sono explorer.
- The apex finder (has digital LED indicator and is self calibrating).
- Endo analyzer (combination of apex locator and pulp tester).
- Digipex (has digital LED indicator but requires calibration).

*Third Generation Apex Locator*

They are also called ***frequency dependent apex locator***. They are based on the fact that different sites in canal give difference in impedance between high (8 kHz) and low (400 Hz) frequencies. The difference in impedance is least in the coronal part of canal. As the probe goes deeper into canal, difference increases. It is the greatest at cemento-dentinal junction.

*Various Third Generation Apex Locators*

| | |
|---|---|
| Endex | Original 3rd generation apex locator |
| Root Zx | Shaping and cleaning of root canals with simultaneous monitoring of working length |

*Combination of Apex Locator and Endodontic Handpiece*

| | |
|---|---|
| Tri Auto Zx | Cordless electrical handpiece with three safety mechanism |
| Endy 7000 | Reverses the rotation when tip reaches apical constriction |

*Fourth Generation Apex Locators*

Recently fourth generation electronic apex locators have been developed which measure resistance and capacitance separately rather than the resultant impedance value.

## WHAT ARE BASIC CONDITIONS FOR ACCURACY OF EALS?

Whatever is the generation of apex locator; there are some basic conditions, which ensure accuracy of their usage.

1. Canal should be free from most of the tissue and debris.
2. The apex locator works best in a relatively dry environment. But extremely dry canals may result in low readings, i.e. long working length.
3. If residual fluid is present in the canal, it should be of low conductivity value, so that it does not interfere the functioning of apex locator.
4. Canals should be free from any type of blockage, calcifications, etc.
5. Battery of apex locator and other connections should be proper.

## ENLIST VARIOUS USES OF APEX LOCATORS

1. They provide objective information with high degree of accuracy.
2. They are useful in conditions where apical portion of canal system is obstructed by:
   a. Impacted teeth
   b. Zygomatic arch
   c. Tori

3. They are useful in patient who cannot tolerate X-ray film placement because of gag reflex.
4. In case of pregnant patients, to reduce the radiation exposure, they can be valuable tool.
5. They are valuable tool for:
   a. Detecting site of root perforations.
   b. Diagnosis of external and internal resorption which have penetrated root surface.
   c. Detection of horizontal and vertical root fracture.

## WHAT ARE CONTRAINDICATIONS TO THE USE OF APEX LOCATORS?

- Apex locators are contraindicated in the patients who have cardiac pacemaker functions. Electrical stimulation to such patients can interfere with pace maker function.
- In teeth with periapical radiolucencies, and necrotic pulps associated with root resorption, etc. the use of apex locators is not much beneficial.

# 11 Root Canal Irrigants

## WHAT ARE PROPERTIES OF AN IDEAL IRRIGANT SOLUTION?

1. It must have broadspectrum antimicrobial properties.
2. It must aid in the debridement of the canal system.
3. It should have the ability to dissolve necrotic tissue or debris.
4. It should have low toxicity level.
5. It should be a good lubricant.
6. It should have low surface tension so that it can easily flow into inaccessible areas.
7. It should be able to effectively sterilize the root canal.
8. It should be able to prevent formation of smear layer during instrumentation or dissolve the latter once it is formed.
9. It should inactivate endotoxin.

## WHAT ARE FUNCTIONS OF IRRIGANTS?

1. Dentin shavings get removed from canals by irrigation.
2. Efficiency of instruments increases in wet canals.
3. Irrigants act as solvent of necrotic tissue.
4. Irrigants help in removing the debris from accessory and lateral canals where instruments cannot reach.
5. Most irrigants are germicidal but they also have antibacterial action.

## ENUMERATE VARIOUS ROOT CANAL IRRIGANTS

### Chemically Non-active Solution

- Water
- Saline
- Local anesthetic.

### Chemically Active Materials

- *Alkalis*: Sodium hypochlorite 0.5 to 5.25 percent.
- *Chelating agents*: Ethylene diamine tetra acetic acid (EDTA)
- *Oxidizing agents*: Hydrogen peroxide, carbamide peroxide
- *Antibacterial agents*: Chlorhexidine, Bisdequalinium acetate
- *Acids*: 30 percent hydrochloric acid
- *Enzymes*: Streptokinase, papain, trypsin
- *Detergents*: Sodium laruyl sulphate

## SODIUM HYPOCHLORITE

- Sodium hypochlorite is a clear, pale, green-yellow liquid with strong odor of chlorine. It is easily miscible with water and gets decomposed by light.
- It is also known as **Dakin's solution**. The original concentration suggested by Dakin was 0.5 percent but concentration commonly used in practice is 5.25 percent.
- Sodium hypochlorite contains 5 percent of free chlorine which is important for breakdown of proteins into amino groups.

If sodium hypochlorite gets extruded into periapical tissues, it causes excruciating pain, periapical bleeding and swelling. As potential for spread of infection is related to tissue destruction, medication like antibiotics, analgesics, antihistamine should be prescribed accordingly.

Methods by which we can increase the efficacy of sodium hypochloride are (Fig. 11.1):

1. *Time:* Greater the contact time of solution with canal, more effective it is.

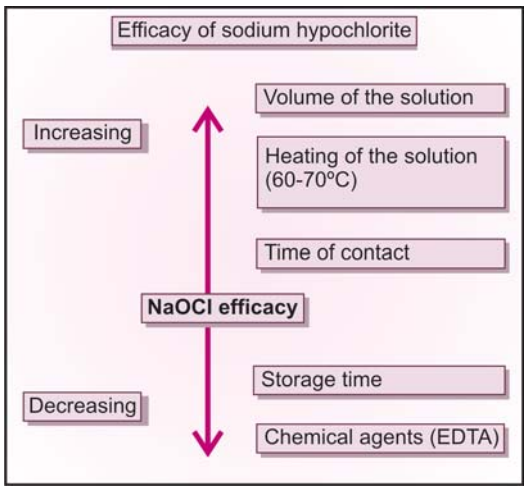



**Fig. 11.1:** Factors affecting the efficacy of sodium hypochlorite

2. *Heat*: Warming sodium hypochlorite to 60-70°, increases its solvent properties and tissue dissolving properties.
3. *Ultrasonic activation of* sodium hypochlorite has also shown to accelerate chemical reaction.

## HYDROGEN PEROXIDE?

It is clear, odorless liquid. It is mainly the 3 percent solution which is used as an irrigating agent.

### Mechanism of Action

1. It is highly unstable and easily decomposed by heat and light. It rapidly dissociates into water and nascent oxygen. The liberated [O] has bactericidal effect but this effect is transient and diminishes in presence of organic debris.
2. The rapid release of [O] nascent oxygen on contact with organic tissue results in effervescence or bubbling action which is thought to aid in mechanical debridement by dislodging particles of necrotic tissue and dentinal debris and floating them to the surface.

### Use

It is used as an irrigating solution either alone or alternatively with sodium hypochlorite. The advantage of using alternating solutions of 3 percent $H_2O_2$ and 5.2 percent NaOCl are:

1. Effervescent reaction by Hydrogen peroxide bubbles pushes debris mechanically out of root canal.
2. Solvent action of sodium hypochlorite on organic debris.
3. Disinfecting and bleaching action by both solutions.

## WHAT ARE CHELATING AGENTS ?

*Chelating agent* is defined as a chemical which combines with a metal to form chelate.

### EDTA

- EDTA is most commonly used chelating agent. It was introduced in dentistry by Nygaard Ostby for cleaning and shaping of the canals.
- It contains four acetic acid groups attached to ethylenediamine.
- EDTA is relatively nontoxic and slightly irritating in weak solutions.
- The effect of EDTA on dentin depends on the concentration of EDTA solution and length of time it is in contact with dentin.
- It is commercially available as 15 percent solution and pH of 7.3 under the name EDTAC because it contains cetavelon, which has been added to it for its disinfecting properties.
- Various studies have shown that combined use of sodium hypochlorite and RC Prep causes an efficient cleaning of canals. Their combination causes release of nascent oxygen which kills anaerobic bacteria and effervescence action which mechanically pushes the debris out of canal.

### Citric Acid

Other commonly used chelating agent for removal of smear layer as irrigating solution is citric acid.

It can be used alone or in combination with other irrigants.

## WHAT ARE RECENT ADVANCES IN IRRIGATING SOLUTIONS?

### Electrochemically Activated Solution

It is one of newer irrigant solution which is produced from the tap water and low concentrated salt solutions. Electrochemical treatment results in synthesis of two type of solutions, i.e. anolyte and catholyte.

Advantages of electrochemically activated solution:

1. Non-toxic in contact with biological tissues.
2. Effective over wide range of microbial spectra.

## Ozonated Water Irrigation

Its advantages include:
- Its potency
- Rapid microbial effects.

## Ruddle's Solution

*Composition*

Ruddle's solution consists of:
a. 17 percent EDTA
b. 5 percent NaOCl
c. Hypaque which is an aqueous solution of Iodide salts viz; Ditrizoate and sodium iodine.

## Photo Activated Disinfection (PAD)

1. It can effectively kill gram-negative, gram-positive, aerobic and anaerobic bacterias.
2. It can kill bacteria present in complex bio-film such as subgingival plaque which is typically resistant to action of anti microbial agents.
3. It does not cause any sensitization
4. Neither the PAD solution nor its products are toxic to patients.

## MTAD

*Composition*

It consists of:
a. Tetracycline isomer (doxycycline)
b. An acid (citric acid )
c. Detergent (Tween-80)

*Advantages*

- It is an effective solution for removal of most of the smear layer.
- It is biocompatible.
- It has minimal effect on properties of teeth.

## WHAT PRECAUTIONS SHOULD BE TAKEN WHILE IRRIGATING THE ROOT CANALS?

1. The solution must be introduced slowly and passively into the canal.
2. Needle should never be wedged into the canal and should allow an adequate back-flow.
3. Blunted needle of 25 gauge or 27 gauge are preferred.
4. In case of small canals, deposit the solution in pulp chamber.
5. Irrigants must never be forcibly inserted into apical tissues (Fig. 11.2).
6. In order to clean effectively in both anterior and posterior teeth canals, a blunt bend of 30° in the center of needle can be given to reach the optimum length to the canal.

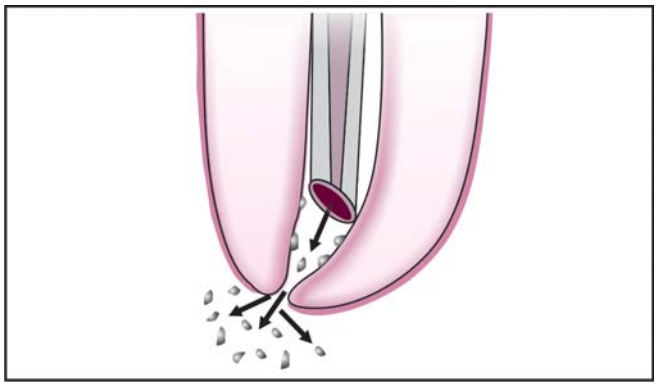


**Fig. 11.2:** Forceful irrigation can cause periapical extrusion of sodium hypochlorite solution

## Ideal Properties of Irrigating Needle

1. Needle should be blunt.
2. It should allow back-flow.
3. It should be flexible.
4. Longer in length.
5. Easily available.
6. Cost-effective.

# 12 Root Canal Medicaments

## WHAT ARE FUNCTIONS AND PROPERTIES OF AN IDEAL INTRACANAL MEDICAMENT?

### Functions of Intracanal Medicaments

- Destroy the remaining bacteria and also limits the growth of new arrivals.
- Useful in cases of inflammation caused due to over instrumentation.
- Antisepsis and disinfection of the canal.
- Pain control.
- Control of exudation.
- Hard tissue formation.

An ideal intracanal medicament should have following properties:

1. It should be effective germicide and fungicide.
2. It should be non-irritating to pulpal tissue.
3. It should remain stable in the solution.
4. It should have prolonged antimicrobial action.
5. It should remain active in presence of blood and pus, etc.
6. It should have low surface tension.
7. It should not interfere with repair of periapical tissue.
8. It should not stain tooth.
9. It should be capable of inactivation in the culture media.
10. It should not induce immune response.

## ENUMERATE COMMONLY USED INTRACANAL MEDICAMENTS

1. Essential oils — Eugenol
2. Phenolic compounds
   - i. Phenol
   - ii. Paramonochlor
   - iii. Camphorated phenol
   - iv. Cresatin
   - v. Aldehydes
     - a. Formocresol
     - b. Paraformaldehyde
     - c. Glutaraldehyde
3. Calcium hydroxide
4. Halogens
   - i. Chlorine-sodium Hypochlorite
   - ii. Iodine
     - 2% $I_2$ in 5% KI solution, i.e. iodophores.
     - 5 percent $I_2$ in tincture of alcohol
5. Chlorhexidine gluconate
6. Antibiotics
7. Corticosteroid-antibiotic combination.

## WHAT ARE CHARACTERISTICS OF VARIOUS INTRACANAL MEDICAMENTS?

### Essential Oils

*Eugenol*

It has been used in endodontics for many years. Effects of eugenol are dependent on tissue concentrations of the eugenol.

*Uses of Eugenol*

1. Used as an intracanal medicament.
2. Used as a root canal sealers.

## Phenolic Compounds

### *Phenol*

It has strong inflammatory potential, so it is rarely used as an intracanal medicament.

*Uses*

a. It is used for disinfection before periapical surgery.
b. It is also used for cauterizing tissue tags that resist removal with broaches or files.

### *Parachlorophenol*

This is substitution product of phenol in which chlorine replaces one of the hydrogen atoms. It is used as a dressing of choice for infected tooth.

### *Camphorated Monoparachlorophenol (CMCP)*

*Composition*

2 parts of para-chlorophenol
+
3 parts gum camphor
↓
Camphorated monochlorophenol (CMCP)

It is used as a dressing of choice for infected teeth.

### *Aldehydes*

*Formocresol*

*Composition of Formocresol*

| | | |
|---|---|---|
| Formaldehyde | – | 19 percent |
| Cresol | – | 35 percent |
| Water and glycerine | – | 46 percent |

*Uses*

Used as dressing for pulpotomy to fix the retained pulpal tissue.

*Paraformaldehyde*: It is polymeric form of formaldehyde and is commonly found as component of some root canal obturating materials like endomethasone.

## Calcium Hydroxide

Various functions of calcium hydroxide which have been reported are as follows:

1. It shows antiseptic action probably because of its high pH.
2. It hydrolyses the lipid part of bacterial lipopolysaccharide (LPS) and thus inactivates the activity of LPS.
3. It is medicament of choice in "Weeping Canal" cases.

## Halogens

### *Chlorine*

*Sodium hypochlorite*: This compound is sometimes used as an intracanal medicament.

*Iodides:* Iodine is highly reactive, combining with proteins in a loosely bound manner so that its penetration is not impeded. It is also a very potent antibacterial agent of low toxicity.

## PBSC Paste

The constituents of the paste are as follows:
*Penicillin:* Effective against gram-positive microorganisms.

*Bacitracin:* Effective against penicillin-resistant microorganisms.

*Streptomycin:* Effective against the gram-negative microorganisms.

*Caprylate* (*sodium salt*): Effective against fungi.

## Corticosteroid Antibiotic Combinations

Medications that combine antibiotic and corticosteroid elements are highly effective in the treatment of over instrumentation. The corticosteroid constituent reduces the periapical inflammation and gives almost instant relief of pain, while the antibiotic constituents prevent the overgrowth of microorganisms when the inflammation subsides.

## PLACEMENT OF INTRACANAL MEDICAMENT

1. Copiously irrigate the canal to remove debris present if any.
2. Place the master apical file in the canal.
3. Dry the canal using absorbent paper points.
4. Apply the intracanal medicament on a sterile cotton pellet and place it in the pulp chamber.
5. Over this place another sterile cotton pellet.
6. Finally seal the cavity with a temporary restorative material.

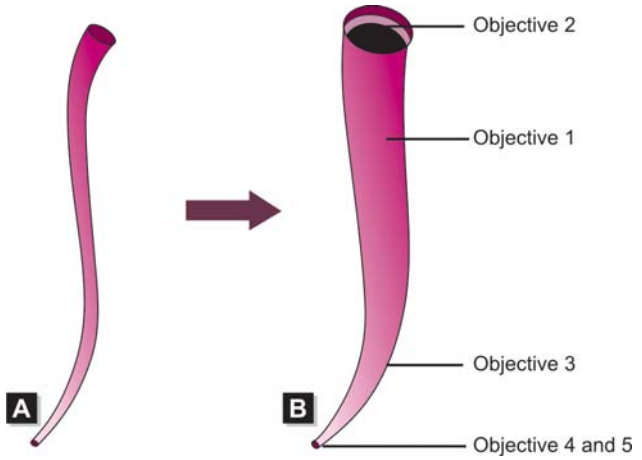
# 13 Cleaning and Shaping of Root Canals

## WHAT ARE OBJECTIVES OF BIOMECHANICAL PREPARATION OF ROOT CANALS?

*Biologic objectives* of biomechanical preparation are to remove the pulp tissue, bacteria and their by-products from the root canal space.

*Mechanical Objectives of Root Canal Preparation (given by Schilder) (Fig. 13.1)*

1. The root canal preparation should develop a continuously tapering cone.
2. Making the preparation in multiple plane which introduces the concept of "Flow".
3. Making the canal narrower apically and widest coronally.
4. Avoid transportation of foramen.
5. Keep the apical opening as small as possible.




**Figs 13.1A and B:** Diagrammatic representation of objectives of canal preparation: (A) Unprepared canal, (B) Prepared root canal

## WHAT ARE BASIC PRINCIPLES OF CANAL INSTRUMENTATION?

1. There should be a straight line access to the canal orifices.
2. Files are always worked with in a canal filled with irrigant.
3. Preparation of canal should be completed while retaining its original form and the shape.
4. Canal enlargement should be done by using instruments in the sequential order without skipping sizes.
5. All the working instruments should be kept in confines of the root canal to avoid any procedural accidents.
6. After each insertion and removal of the file, its flutes should be cleaned and inspected.
7. Recapitulation is regularly done to loosen debris by returning to working length.
8. Over preparation and too aggressive over enlargement of the curved canals should be avoided.
9. Never force the instrument in the canal.
10. Establish the apical patency before starting the biomechanical preparation of tooth. Apical patency of the canal established and checked, by passing a smaller number file (No. 10) across the apex.

## WHAT IS STEP BACK TECHNIQUE FOR ROOT CANAL PREPARATION?

1. Step back technique is also known as ***Telescopic canal preparation*** or ***serial root canal preparation.***
2. Step back technique emphasizes keeping the apical preparation small, in its original position and producing a gradual taper coronally.

3. Basically, this technique involves the canal preparation into ***two phases; phase I*** involves the preparation of apical constriction and ***phase II*** involves the preparation of the remaining canal.

*Phase I*

1. Initially prepare the access cavity and locate the canal orifices (Fig. 13.2).
2. Establish the working length.
3. Now insert the first instrument into the canal with watch winding motion (Fig. 13.3).
4. Remove the instrument and irrigate the canal.
5. Place the next larger size file to the working length in similar manner and again irrigate the canal.
6. Don't forget to recapitulate the canal with previous smaller number instrument.
7. Repeat the process until a size 25 K-file reaches the working length.

*Phase II*

1. Repeat the above procedure with successively larger files at 1 mm increments from the previously used file.
2. Finally, refining of the root canal is done by master apical file with push-pull strokes to achieve a smooth taper from of the root canal.

**Fig. 13.2:** Prepare the access cavity and locate the canal orifices

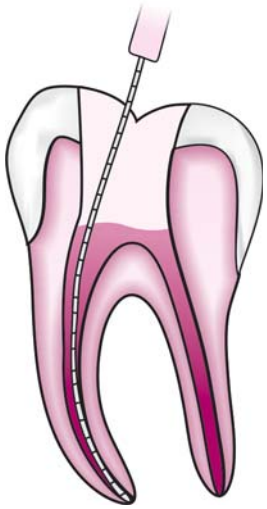


**Fig. 13.3:** Place file to working length

## Advantages

- Less likely to cause periapical trauma.
- One can achieve apical matrix or step which prevents overfilling.
- Greater condensation pressure can be exerted to fill lateral canals.

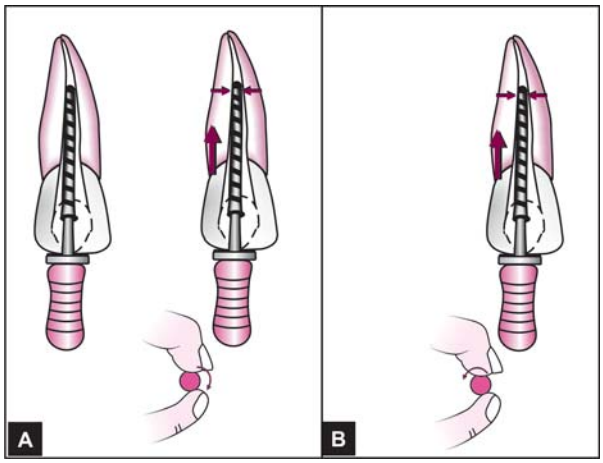
## WHAT IS BALANCED FORCE TECHNIQUE?

### Technique

1. In balanced force technique, first file to bind short of working length is inserted into the canal and rotated clockwise a quarter of a turn. This causes flutes to engage a small amount of dentin (Fig. 13.4A).
2. Now file is rotated counterclockwise with apical pressure at least one-third of a revolution. It is the counterclockwise rotation with apical pressure which actually provides the cutting action by shearing off small amount of dentin engaged during clockwise rotation (Fig. 13.4B).
3. Then a final clockwise rotation is given to the instrument which loads the flutes of file with loosened debris and the file is withdrawn (Fig. 13.5).

## Advantages

- With the help of this technique, there are lesser chances of canal transportation.
- One can manipulate the files at any point in the canal without creating a ledge or blockage.




**Figs 13.4A and B:** (A) Engaging dentin with quarter clockwise turn (B) Cutting action by anticlockwise motion with apical pressure

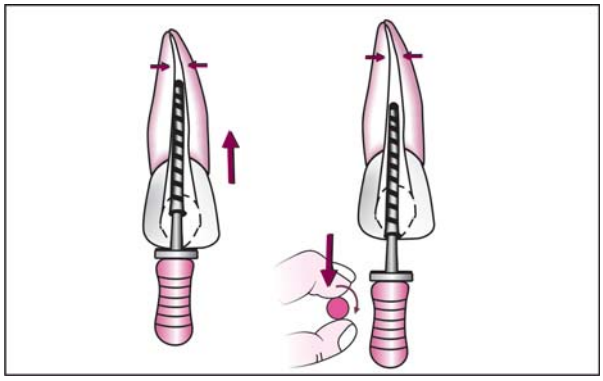


**Fig. 13.5:** Now file is turned quarter clockwise. It picks the debris and withdraws the instrument

## CROWN-DOWN TECHNIQUE

In the crown-down technique, one prepares the canal from crown of the tooth, shaping the canal while moving towards the apical portion of the canal (Fig. 13.6).

### Technique

1. Locate the canal orifices with sharp explorer and start preflaring of the canal orifices. Preflaring of the coronal third of the canal can be done by using hand instruments, Gates-Glidden drills or the nickle-titanium rotary instruments.
2. Frequent irrigation with sodium hypochlorite and recapitulation with a smaller file to prevent canal blockage.

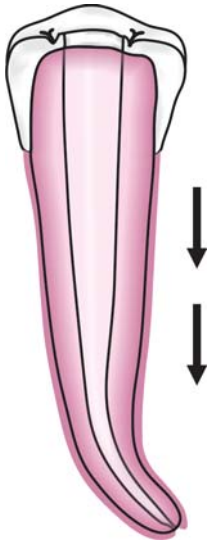


**Fig. 13.6:** Crown-down technique

3. After establishing coronal and mid root enlargement explore the canal and establish the working length with small instruments.
4. Introduce larger files to coronal part of the canal and prepare it. Subsequently introduce progressively smaller number files deeper into the canal in sequential order and prepare the apical part of the canal.
5. Final apical preparation is prepared and finished along with frequent irrigation of the canal system.

### Clinical Advantages

- Enhanced tactile sensation with instruments because of removal of coronal interferences.
- In curved canals, after doing coronal flaring, files can go up to apex more effectively due to decrease deviation of instruments in the canal curvature.
- Provides more space of irrigants.
- Desired shape of canal can be obtained that is narrow at apex, wider at coronal.
- Decreased frequency of canal blockages.

## WHAT IS CLINICAL TECHNIQUE FOR USE OF DIFFERENT ROTARY INSTRUMENTS?

### Clinical Technique using Profile System

1. Estimate the working length of the canal from preoperative radiograph.

2. Use orifices shapers sizes 4, 3, 2, and 1 in the coronal third of the canal.
3. Perform crown-down technique using the profile instruments of taper/size 0.06/30, 0.06/25, 0.04/30 and 0.04/25 to the resistance. For larger canals use 0.06/35, 0.06/30, 0.04/35 and 0.04/30.
4. Now determine the exact working length by inserting conventional number 15 K-file.
5. After this complete the crown-down procedure up until this length. Use profile 0.04/25, 0.04/30 for apical preparation.

### Clinical Technique using ProTaper Files

1. After gaining straight line access to the canal orifices prepare the coronal third of the canal by inserting S1 into the canal using passive pressure.
2. Irrigate and recapitulate the canal using number 10 file.
3. In shorter teeth, use of Sx is recommended.
4. After this S2 is worked up to the estimated canal length.
5. Now confirm the working length using small stainless steel K-files.
6. Use F1, F2 and F3 finishing files up to established working length and complete the apical preparation.

### Clinical Technique using Quantec File System

1. Obtain the straight line access to the canal orifices.
2. Establish the patency of canal using number 10 or 15 stainless steel files.
3. Insert the Quantec number 25, taper 0.06 file passively into the canal.
4. After negotiation of the canal using Quantec file, prepare the canal from 0.12 to 0.03 taper.
5. Finally, complete the apical preparation of canal using 40 or 45 No., 0.02 taper hand or rotary files.

## WHAT IS EVALUATION CRITERIA OF CANAL PREPARATION?

1. Spreader should be able to reach within 1 mm of the working length if spreader does not reach the estimated length, it indicates canal is not well prepared.
2. After canal preparation, when master apical file is pressed firmly against each walls should feel smooth.

## WHAT PRECAUTIONS SHOULD BE TAKEN WHILE PREPARING CURVED CANALS?

In curved canals, frequently seen problem is occurrence of uneven cutting. File can cut dentine evenly only if it engages dentine around its entire circumference. Once it becomes loose in a curved canal, it will tend to straighten up and will contact only at certain points along its length. These areas are usually outer portion of curve apical to the curve, on inner part of curve at the height of curve and outer or inner curve coronal to the curve. All this can lead to occurrence of procedural errors like formation of ledge, transportation of foramen, perforation or formation of elbow and zip in a curved canal. To avoid these problems following measures should be taken:

i. ***Precurving the file:*** A precurved file has shown to traverse the curve better than a straight file.
ii. ***Extravagant use of smaller number files:*** Since smaller sized instruments can follow the canal curvature because of their flexibility, they should be used until the larger files are able to negotiate the canal without force.
iii. ***Use of intermediate sizes of files:*** In severely curved canals the clinician can cut 0.05 mm of the file to increase the instrument diameter by 0.01 mm. This allows the smoother transition of the instrument sizes to cause smoother cutting in curved canals.
iv. ***Use of flexible files:*** Flexible files help in maintaining the shape of the curve and avoid occurrence of procedural errors like formation of ledge, elbow or zipping of the canal.
v. ***Modifying cutting edges of the instrument:*** The cutting edges of the curved instrument can be modified by dulling the flute on outer portion of the apical third and inner portion of the middle third. Dulling of the flutes can be done with the help of diamond file (Fig. 13.7).

## WHAT ARE GUIDELINES FOR NEGOTIATING CALCIFIED CANALS?

- To locate the calcified orifice, first mentally visualize and plan the normal spatial relationship of the pulp space onto a radiograph of calcified tooth.

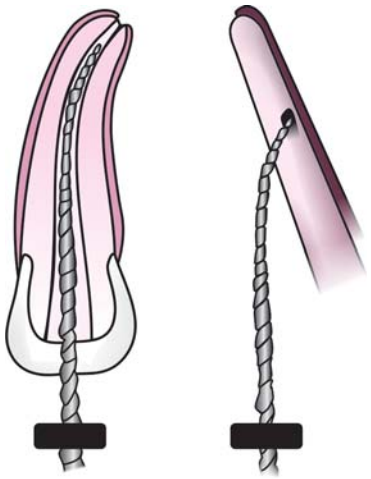


**Fig. 13.7:** Dulling of flutes is done with the help of diamond file

- After this access preparation is initiated, with the rotary instrument directed toward the assumed location of pulpal space.
- In a tooth with a calcified pulp chamber, the distance from the occlusal surface to the pulp chamber is measured from the preoperative radiograph.

## Guidelines

- Always advance instruments slowly in calcified canals.
- When a fine instrument has reached the approximate canal length, do not remove it; rather obtain a radiograph to ascertain the position of the file.
- Use chelating agents to assist in canal penetration.
- Well angulated periapical and bite using radiographs should be taken.
- Avoid removing large amount of dentin in the hope of finding a canal orifice.
- Small round burs should be used to create a glide path to the orifice. This will further ease the instruments into the proper lane to allow effortless introduction of files into the canals.


# Obturation of Root Canal

## WHAT ARE CHARACTERISTICS OF AN IDEAL ROOT CANAL FILLING MATERIAL?

An ideal root canal filling material should be:

- Easily introduced in the canal.
- Dimensionally stable after being inserted.
- Impervious to moisture.
- Bacteriostatic or at least should not encourage bacterial growth.
- Radiopaque.
- Nonstaining to tooth structure.
- Nonirritating.
- Sterile/easily sterilized.
- Removed easily from canal if required.

### Note on Gutta-Percha

***Gutta-percha is derived from two words.***

**"GETAH"** meaning gum

**"PERTJA"** name of the tree

Composition of commercially available gutta-percha:

| | | |
|---|---|---|
| • Matrix (Organic) | Gutta-percha | 20% |
| • Filler (Inorganic) | Zinc oxide | 66% |
| • Radiopacifiers (Inorganic) | Heavy metal sulfates | 11% |
| • Plasticizers (Organic) | Waxes or resins | 3% |

- Chemically pure gutta-percha exists in two distinctly different crystalline forms, i.e. α and β forms which differ in molecular repeat distance and single bond form.

  These phases are interconvertible.
  - α-runny, tacky and sticky (lower viscosity)
  - β-solid, compactable and elongatable (higher viscosity)
- Gutta-percha cannot be heat sterilized. For disinfection of gutta-percha points, they should be immersed in 5.25 percent NaOCl for one minute. Then, gutta-percha should be rinsed in hydrogen peroxide or ethyl alcohol.
- Gutta-percha is soluble in certain solvents like chloroform, eucalyptus oil, etc. This property can be used to plasticize gutta-percha by treating it with the solvent for better filling in the canal. But it has shown that gutta-percha shrinks (1-2%) when solidifies.

*Advantages of Gutta-Percha*

- Compactiblity
- Inertness
- Dimensional stablity
- Tissue tolerance
- Radiopacity

*Disadvantages of Gutta-Percha*

- Lack of rigidity
- Lacks adhesive quality.

## WHAT ARE REQUIREMENTS OF AN IDEAL ROOT CANAL SEALERS?

Grossman listed eleven requirements and characteristics of a good root canal sealer:

1. It should be tacky when mixed to provide good adhesion between it and the canal wall when set.
2. It should create hermetic seal.
3. It should be radiopaque.
4. The particles of powder should be very fine so that they can mix easily with the liquid.
5. It should not shrink upon setting.
6. It should not stain tooth structure.
7. It should be bacteriostatic or at least not encourage bacterial growth.

8. It should set slowly.
9. It should be insoluble in tissue fluids.
10. It should be tolerant, nonirritating to periradicular tissue.
11. It should be soluble in a common solvent if it is necessary to remove the root canal fitting.

## WHAT ARE FUNCTIONS OF ROOT CANAL SEALERS?

- As antimicrobial agent.
- Fill the discrepancies between the materials and dentin walls.
- As lubricant.
- Give radiopacity.
- As canal obturating material.

## CLASSIFY VARIOUS ROOT CANAL SEALERS

Sealers may be broadly classified according to their composition:

1. **Eugenol group**
   a. Silver containing
   b. Silver free

   *Silver containing cements:*
   - Kerr sealer

   *Silver free cements:*
   - Grossman's sealer (Grossman, 1974)
   - Tubliseal (Kerr, 1961)
   - Wach's paste (Wach)
2. **Non-eugenol**
   - Diaket
   - AH-26
   - Chloropercha
   - Nogenol
   - Hydron
   - Endofil
   - Glass ionomer
3. **Medicated**
   - Diaket-A
   - Endomethasone
   - Iodoform paste
   - $Ca(OH)_2$ paste

## EXPLAIN DIFFERENT ZINC OXIDE EUGENOL SEALERS

### Kerr Root Canal Sealer or Rickert's Formula

The original zinc oxide-eugenol sealer was developed by Rickert.

*Composition*

*Powder*

| | |
|---|---|
| Zinc oxide | 34-41.2% |
| Precipitated silver | 25-30.0% |
| Oleo resins | 30-16% |
| Thymol iodide | 11-12% |

*Liquid*

| | |
|---|---|
| Oil of cloves | 78-80% |
| Canada balsam | 20-22% |

### Advantages

- Excellent lubricating properties.
- It allows a working time of more than 30 min, when mixed in 1:1 ratio.

### Disadvantages

The major disadvantage is that the presence of silver makes the sealer extremely staining if any of the material enters the dentinal tubuli.

### Grossman's Sealer

*Composition*

*Powder*

| | |
|---|---|
| Zinc oxide (reagent) | 40 parts |
| Staybelite resin | 30 parts |
| Bismuth subcaronate | 15 parts |
| Barium sulfate | 15 parts |
| Sodiumborate | 1 part |

*Liquid*

Eugenol

*Properties*

1. It has plasticity and slow setting time due to the presence of sodiumborate anhydrate.
2. It has good sealing potential.

*Disadvantage*

Resin is of coarse particle size, unless the material is spatulated vigorously during mixing, a piece of resin may lodge on the walls of the canal.

### Wach's Sealer

*Composition*

*Powder*

| | |
|---|---|
| Zinc oxide | 10 g |
| Tricalcium phosphate | 2 g |

| | |
|---|---|
| Bismuth subnitrate | 3.5 g |
| Bismuth subiodide | 0.3 g |
| Heavy magnesium oxide | 0.5 g |

*Liquid*

| | |
|---|---|
| Canada balsam | 20 ml |
| Oil of clove | 6 ml |

*Properties*

1. Medium working time.
2. It is sticky due to the presence of Canada balsam.

*Advantages*

- It is germicidal.
- Less periapical irritation.

*Disadvantage*

Odor of liquid.

### Tubliseal (1961)

Slight modifications have been made in Ricket's formula to eliminate the staining property.

*Composition*

*Base*

| | |
|---|---|
| Zinc oxide | 57-59% |
| Oleo resins | 18.5-21.25% |
| Bismuth trioxide | 7.5% |
| Thymol iodide | 3.75-5% |
| Oil and waxes | 10% |

*Catalysts*

Eugenol
Polymerized resin

*Advantages*

- Easy to mix.
- Extremely lubricated.
- Does not stain the tooth structure.

*Disadvantages*

- Irritant to periapical tissue.
- Short working time.

## EXPLAIN DIFFERENT NON-EUGENOL ROOT CANAL SEALERS

### Chloropercha

This is a mixture of gutta-percha and chloroform.

*Composition*

*Power*

| | |
|---|---|
| Canada balsam | 19.6% |
| Rosin | 11.8% |
| Gutta-percha | 19.6% |
| Zinc oxide | 49% |

*Liquid*

Chloroform

### Hydron

Hydron is a rapid setting hydrophilic, plastic material used as a root canal sealer without the use of a core.

### Nogenol

Nogenol was developed to overcome the irritating quality of eugenol. Base is ZnO with Barium sulfate as radiopacifier along with vegetable oil. Set is accelerated by hydrogenated rosin, chlorothymol and salicylic acid.

### Resin-based Sealers

*Diaket*

Diaket is a polyvinyl resin (Polyketone), a reinforced chelate formed between zinc oxide and diketone.

### AH-26

*Composition*

*Powder*

| | |
|---|---|
| Bismuth oxide | 60% |
| Hexamethylene tetramine | 25% |
| Silver powder | 10% |
| Titanium oxide | 5% |

*Liquid*

Bisphenol diglycidyl ether

*Properties*

1. It has good adhesive property.
2. It has good flow.

3. The addition of a hardener, hexamethylene tetramine, makes the cured resin chemically and biologically inert.

## AH Plus

AH Plus is an Epoxide-Amine resin pulp canal sealer, developed from it predecessor AH26.

*Composition*

*AH Plus–Paste A*

Epoxy resins
Calcium tungstate
Zirconium oxide
Silica
Iron oxide

*AH Plus–Paste B*

Adamantianeamine
N,N-Dibenzyl-5-Oxanonane-diamine-1,9,TCD-diamine
Calcium tungstate
Zirconium oxide
Silica
Silicone oil

## Fiberfill

Fiberfill is a new methacrylate resin-based endodontic sealer. Fiberfill root canal sealant is used in combination with a self-curing primer (Fiberfill primers A and B). Its composition resembles that of dentin bonding agents.

## ENUMERATE CALCIUM HYDROXIDE SEALERS

## Seal Apex

It is a noneugenol calcium hydroxide polymeric resin root canal sealer.

*Composition*

*Base*

| | |
|---|---|
| Calcium hydroxide | 25% |
| Zinc oxide | 6.5% |
| Calcium oxide | |
| Butyl benzene | |
| Fumed silica (silicon dioxide) | |

*Catalyst*

| | |
|---|---|
| Barium sulfate | 18.6% |
| Titanium dioxide | 5.1% |
| Zinc stearate | 1.0% |
| Isobutyl salicylate | |
| Disalicylate | |
| Trisalicylate | |
| Bismuth trioxide | |

In 100 percent humidity it takes three weeks to reach a final set. It never sets in a dry atmosphere.

## Calcibiotic Root Canal Sealer (CRCS)

*Composition*

*Powder*

| | |
|---|---|
| Zinc oxide | Hydrogenated resin |
| Barium sulfate | Calcium hydroxide |
| Bismuth subcarbonate | |

*Liquid*

Eugenol
Eucalyptol

## Medicated Sealers

*Endomethasone*

*Composition*
*Powder*

| | |
|---|---|
| Zinc oxide | 100.00 g |
| Bismuth subnitrate | 100.00 g |
| Dexamethasone | 0.019 g |
| Hydrocortisone | 1.60 g |
| Thymol iodide | 25.0 g |
| Paraformaldehyde | 2.20 g |

*Liquid*

Eugenol

## Glass Ionomer Sealer (Ketac-Endo)

*Composition*

*Powder*

Calcium aluminium lanthanum flurosilicate glass
Calcium volframate
Cilicic acid
Pigments

*Liquid*

Polyethylene polycarbonic acid/ Maleic acid Copolymer
Tartaric acid
Water

*Advantages*

- It has optimal physical qualities.
- It shows bonding to dentin

*Disadvantages*

It cannot be removed from the root canal in the event of retreatment as there is no known solvent for glass ionomer.

## WHAT IS RESILON?

A new material, resilon has been developed to replace gutta-percha and traditional sealers for root canal obturation.

*Resilon system is comprised*:

1. ***Primer*** a self etch primer.
2. ***Resilon sealer*** a dual-curable, resin-based composite sealer.
3. ***Resilon core material*** is a thermoplastic synthetic polymer based (polyester) root canal core material that contains bioactive glass, bismuth oxychloride and barium sulphate.

The excellent sealing ability of the resilon system may be attributed to the "mono block" that is created by the adhesion of the resilon cone to the Epiphany sealer, which adheres and penetrates into the dentin walls of the root canal system.

## WRITE IN DETAIL ABOUT VARIOUS ROOT CANAL OBTURATION TECHNIQUES INCLUDING THE LATEST METHODS

Generally, speaking the root canal obturation with gutta-percha as filling material, can be mainly divided into following groups:

1. Use of cold gutta-percha
   - Lateral compaction technique
2. Use of chemically softened gutta-percha
   - Chloroform
   - Halothane
   - Eucalyptol
3. Use of heat softened gutta-percha
   - Vertical compaction technique
   - System B continuous wave condensation technique
   - Lateral/vertical compaction
   - Sectional compaction technique
   - McSpadden compaction of gutta-percha
   - Thermoplasticized gutta-percha technique including
     - Obtura II
   - Solid core obturation technique including
     - Thermafil system
     - Silver point obturation

## LATERAL COMPACTION TECHNIQUE

It involves placing tapered gutta-percha cones in the canal and then compacting them under pressure against the canal walls using a spreader.

### Technique

- Select the master gutta-percha cone, feel the tugback with it.
- Select the size of spreader to be used for lateral compaction of that tooth. It should reach 1-2 mm of true working length.
- Dry the canal with paper points and apply sealer in the prepared root canal.
- Now premeasured cone is coated with sealer and placed into the canal. After master cone placement, spreader is placed into the canal alongside the cone (Fig. 14.1).
- An accessory cone is placed in the space created by spreader and the above procedure is repeated until the spreader can no longer penetrate beyond the cervical line (Fig. 14.2).
- Now sever the protruding gutta-percha points at canal orifice with hot instrument.

### Advantage

During compaction of gutta-percha, it provides length control, thereby prevent overfilling.

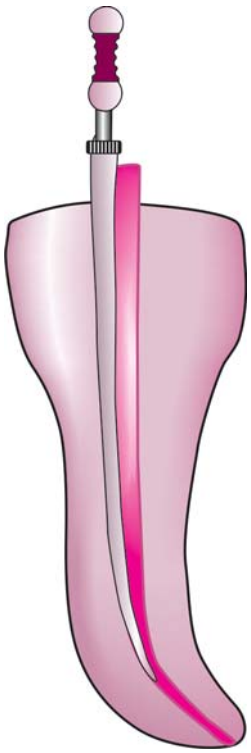


**Fig. 14.1:** Placing spreader along gutta-percha cone

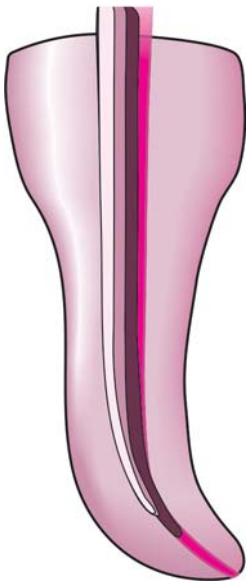


**Fig. 14.2:** Use of accessory cones to complete obturation of the canal

### Disadvantages

- May not fill the canal irregularities efficiently.
- Space may exist between accessory and master cones.

## CHEMICAL ALTERATION OF GUTTA-PERCHA

This technique is used in:

- Teeth with blunderbuss canals.
- Root ends with resorptive defects.

### Technique

- The cone is adjusted to the working length.
- The apical 2-3 mm of cone is dipped for a period of 3-5 seconds into a dappen dish containing solvent.
- Softened cone is inserted in the canal with slight apical pressure.
- Radiograph is taken to verify the fit and correct working length of the cone. When found satisfactory, cone is removed from the canal and canal is irrigated with sterile water or 99 percent isopropyl alcohol to remove the residual solvent.
- After this canal is coated with sealer. Cone is dipped again for 2-3 seconds in the solvent and thereafter inserted into the canal.
- A spreader is then placed in the canal, and accessory gutta-percha cones are then placed in the space created by spreader.
- Protruding gutta-percha points are cut at canal orifice with hot instrument.

## VERTICAL COMPACTION TECHNIQUE

It was introduced by Schilder and is also known as Schilder's technique of obturation. In this technique using heated pluggers, pressure is applied in vertical direction to heat softened gutta-percha which causes it to flow and fill the canal space.

### Technique

- Select a master cone according to shape and size of the prepared canal.
- Confirm the fit of cone radiographically, if found satisfactory, remove it from the canal and place in sodium hypochlorite.
- Irrigate the canal and then dry it.
- Lightly coat the canal with sealer.

- Cut the coronal end of selected gutta-percha at incisal or occlusal reference point.
- Now use the heated plugger to force the gutta-percha into the canal (Fig. 14.3).
- Once apical filling is done, complete obturation by doing backfilling. Obturate the remaining canal by heating small segments of gutta-percha, carrying them into the canal and then compacting them using heated pluggers as described above.

### Advantage

Excellent sealing of canal apically, laterally and obturation of lateral as well as accessory canals.

### Disadvantages

- Increased risk of vertical root fracture.
- Overfilling of canals with gutta-percha or sealer from apex.
- Time consuming.

## SYSTEM B: CONTINUOUS WAVE OF CONDENSATION TECHNIQUE

System B is newly developed device by ***Buchanan*** for warming gutta-percha in the canal.

### Technique

- Select the Buchanan plugger which matches the selected gutta-percha cone.
- Confirm the fit of the gutta-percha cone.
- Apply sealer in the canal.
- With the system B turned on, sever the cone at the orifice with preheated plugger. Afterwards plugger is used to compact the softened gutta-percha at the orifice (Fig. 14.4).
- Switch off the system box, keep the plugger here for 10 seconds with a sustained pressure.
- Maintaining the apical pressure, activate the heat switch for 1 second and then remove the plugger.
- After removal of plugger, introduce a small flexible end of another plugger with pressure to confirm that apical mass of gutta-percha has not dislodged, has cooled and set.
- Following radiographic confirmation canal is ready for the backfill by any means.

### Advantages

- Excellent apical control.
- Fast, easy, predictable.
- Thorough condensation of the main canal and lateral canals.

## LATERAL/VERTICAL COMPACTION OF WARM GUTTA-PERCHA

### Technique

- Adapt master gutta-percha cone in canal.
- Insert the heated plugger in canal beside master cone to within 3-4 mm of the apex using light apical pressure.

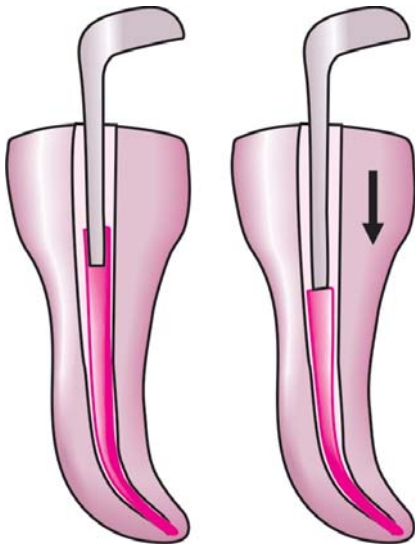


**Fig. 14.3:** Heated plugger used to compact gutta-percha

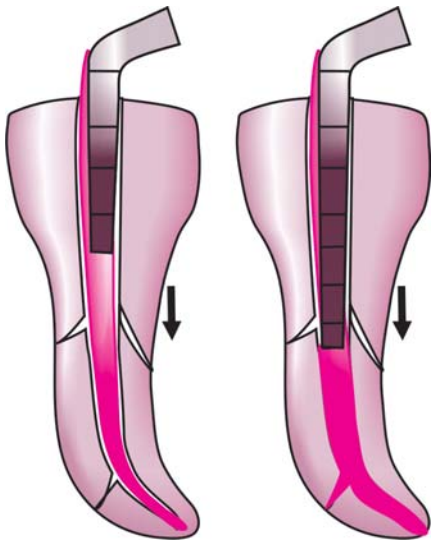


**Fig. 14.4:** Filling the canal by turning on system B

- Afterwards unheated spreader can be placed in the canal to create more space for accessory cones. This process is continued until canal is filled.

### Advantages

- Three dimensional obturation of canal.
- Better sealing of accessory and lateral canals.

## SECTIONAL METHOD OF OBTURATION

In this technique, small pieces of gutta-percha cones are used to fill the sections of the canal. It is also known as ***Chicago technique.***

### Technique

- A gutta-percha cone of same size of the prepared root canal is selected and cut into sections of 3 to 4 mm long.
- Apply sealer in the canal.
- One end of gutta-percha is mounted to heated plugger and is then carried into the canal and apical pressure is given. After this plugger is disengaged from gutta-percha by rotating it.
- Radiograph is taken to confirm its fit.

If found satisfactory, remainder of the canal is filled in same manner.

### Advantage

In case of post and core cases, only apical section of canal is filled.

### Disadvantage

Time consuming.

## McSPADDEN COMPACTION/THERMOMECHANICAL COMPACTION OF THE GUTTA-PERCHA

This technique involves the use of a compacting instrument (McSpadden compacter) which resembles reverse Hedstorm file. This instrument is rotated at 8000-15000 rpm alongside gutta-percha cones inside the canal walls (Fig. 14.5). At this speed, heat produced by friction softens the gutta-percha and designs of blade forces the material apically.

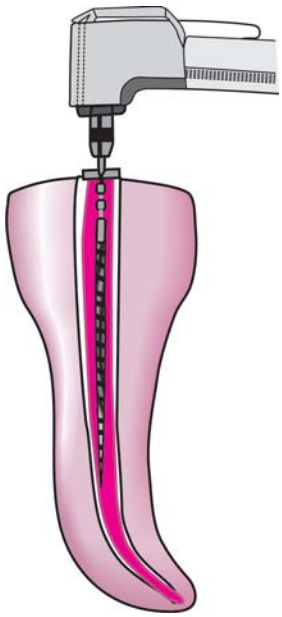


**Fig. 14.5:** Thermomechanical compaction of gutta-percha

### Advantages

- Requires less chair side time.
- Dense, three dimensional obturation.

### Disadvantages

- Frequent breakage of compactor blades.
- Shrinkage of gutta-percha on cooling.

## THERMOPLASTICIZED INJECTABLE GUTTA-PERCHA OBTURATION

### Obtura II Heated Gutta-Percha System

### Indication

- For backfilling of canals.
- For obturation of roots with internal resorption, perforations, etc.

### Technique

- Before starting the obturation, applicator needle and pluggers are selected.
- Apply sealer in the canal.
- Place obtura needle loosely 3-5 mm short of apex, and allow warm gutta-percha to flow and fill the canal.
- Now use pluggers to compact the gutta-percha.

## SOLID CORE CARRIER TECHNIQUE

### Thermafil Endodontic Obturators

Thermafil endodontic obturators are specially designed flexible steel, titanium or plastic carriers coated with gutta-percha.

### Technique

- Select a thermafil obturator and verify its fit by taking a radiograph.
- Obturator is preheated in "Therma Prep" oven for sometime.
- Canal is dried and lightly coated with sealer. Heated obturator is placed into the canal with a firm apical pressure to the marked working length (Fig. 14.6).

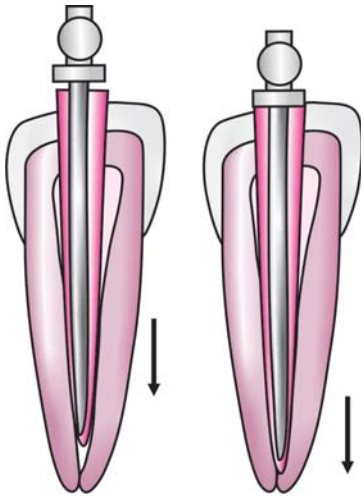


**Fig. 14.6:** Heated thermafil obturator should reach up to the working length

- Verify the fit of obturation in radiograph. When found accurate, while stabilizing the carrier with index finger, sever the shaft level with the orifice using an inverted cone bur in high speed handpiece.
- Now a small condenser coated with vaseline or dipped in alcohol, is used to condense gutta-percha vertically around the shaft.

### Advantages

- Dense three dimensional obturation as gutta-percha flows into canal irregularities such as fins, anastomoses, and lateral canals, etc.
- Since this technique requires minimum compaction so less strain while obturation with this technique.

## OBTURATION WITH SILVER CONE

Use of silver cones is restricted to teeth with fine, tortuous, curved canals which make the use of gutta-percha difficult.

### Steps

1. Select a silver cone conforming the final shape and size of the prepared canal.
2. Dry the canal and coat the canal walls with sealer.
3. Insert the cone into the canal.
4. Take a radiograph to see the fit of cone. It satisfactory, fill the remaining canal with accessory gutta-percha cones.

# 15 Mid Treatment Flare-Ups

## WHAT IS ETIOLOGY OF MID TREATMENT FLARE-UPS?

***American Association of Endodontics (AAE) defines a flare-up "as an acute exacerbation of periradicular pathosis after initiation or in continuation of root canal treatment".***

Its etiology is multifactorial and can be categorized as related to the patient, to pulpal or periapical diagnosis or to treatment procedures done. If a patient comes with a history of preoperative swelling and pain, one can still think of inter-appointment emergencies.

## FACTORS CONTRIBUTING FOR FLARE-UPS

1. ***Over instrumentation***: Inter treatment pain is directly proportional to over instrumentation.
2. ***Inadequate debridement***: Inadequate debridement causes pain, and also the mid-treatment flare-ups.
3. ***Periapical extrusion of debris*** leads to periapical inflammation and flare.
4. ***Re-treatment***: Retreatment cases show more flare-ups.

## EXPLAIN MICROBIOLOGY AND IMMUNOLOGY OF FLARE-UPS

1. ***Alteration of local adaptation syndrome***: When a new irritant is introduced in a chronically inflamed tissue, a violent reaction may occur because of disturbance in local tissue adaptation to applied irritants.
2. ***Changes in periapical tissue pressure***: In teeth with increased periapical pressure, excessive exudate creates pain by causing pressure on nerve endings.
3. ***Microbial factors***: It has been shown by many studies that bacteria are main causative factor in the flare-ups.
4. ***Effect of chemical mediators***: Chemical mediators can be in form of cell mediators, plasma mediators and in form of neutrophils products. Cell mediators include histamine, serotonin, prostaglandins which may lead to pain.
5. ***Changes in cyclic nucleotides***: Studies have shown that during flare-up, there is increased level of cGMP over cAMP concentrations.
6. ***Immunological response***: Immunologic response of periapical infection can also cause perpetuation and aggravation of inflammatory process.
7. ***Psychological factor***: Anxiety, apprehension, fear and previous history of dental experience appears to play an important role in mid treatment flare-ups.

## WHAT MEASURES SHOULD BE TAKEN FOR MANAGEMENT OF FLARE-UPS?

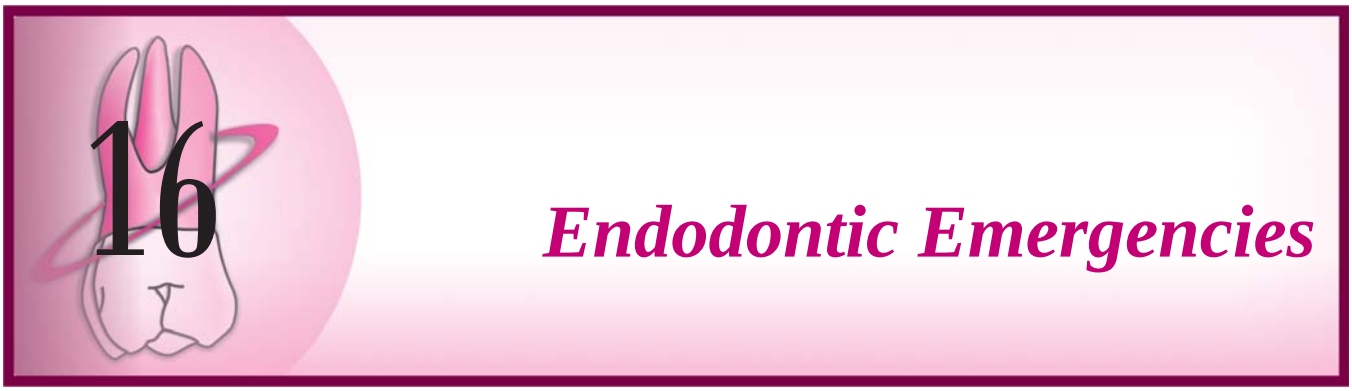
### General Management of Flare-Ups

1. ***Reassurance to the patient***: Reassurance is the most important aspect of treatment, explain the patient about procedure completely.
2. ***Complete debridement of root canal system***: Most effective method to reduce flare-ups is complete debridement by cleaning and shaping of root canal system.
3. ***Establishment of drainage***: In the presence of suppuration, drainage of exudate is the most effective method for reducing pain and swelling.
4. ***Relief of occlusion***: It also reduces intra-appointment pain.
5. ***Calcium hydroxide therapy***: It is intracanal dressing used as therapeutic in prevention or treatment of flare-ups.

6. ***Intracanal medicaments***: For relief of pain during root canal treatment, commonly used intracanal medicaments are antimicrobial agents, irrigating solutions and corticosteroids.
7. ***Medications***: Commonly used systemic drugs are:
   a. *Analgesic*: NSAIDS and narcotic analgesics.
   b. *Antibiotic*: Pencillins and its derivatives, metronidazole, tinidazole, ornidazole and clindamycin.
   c. Corticosteroid.

## WHAT PRECAUTIONS SHOULD BE TAKEN TO PREVENT OCCURRENCE OF FLARE-UPS?

1. Proper diagnosis of the case.
2. Determination of correct working length.
3. Complete extirpation of the vital pulp.
4. Reduce tooth from occlusion especially if apex is severely violated by over instrumentation.
5. Placement of intracanal medicaments.
6. Prescription of analgesics and antibiotics whenever condition warrants it.



# 16 Endodontic Emergencies

## WHAT IS AN ENDODONTIC EMERGENCY? HOW WILL YOU DIAGNOSE AN EMERGENCY CONDITION?

***Endodontic emergency*** is defined as the condition associated with pain and/or swelling which requires immediate diagnosis and treatment.

### Three Main Types

1. Pretreatment
2. Intra-appointment
3. Postobturation

**Diagnosis of an endodontic emergency:** It can be done by following steps:

### History of the Patient

Pain is frequently the main component of chief complaint. Ask the patient about *two basic components* of pain; *time (chronicity)* and *severity (intensity)*.

### Subjective Examination

A patient should be asked questions about history, location, duration, severity and aggravating factors of pain.

### Objective Examination

In objective examination, tests are done to reproduce the response which mimics what the patient reports subjectively.

### Radiographic Examination

Intraoral periapical and bitewing radiographs may detect caries, restorations, pulp exposures, root resorption-external or internal and periradicular pathologies.

## WHAT ARE PRETREATMENT ENDODONTIC EMERGENCIES?

*Hot tooth* refers to a painful tooth and initial therapy for hot tooth refers to what needs to be done to give relief from pain at first appointment for tooth with pulpal or periapical involvement.

### Conditions Requiring Emergency Treatment

#### *Acute Reversible Pulpitis*

Acute reversible pulpitis is characterized by the following features:

1. Localized inflammation of the pulp.
2. Exaggerated, non-lingering response to stimuli.

*Management*

1. Removal of the cause.
2. Placement of a sedative dressing.

#### *Acute Irreversible Pulpitis*

If the inflammatory process progresses, irreversible pulpitis can develop. Here patient gives the history of spontaneous pain and exaggerated response to hot or cold that lingers after the stimulus is removed.

*Management*

1. Profound anesthesia of the affected tooth.
2. Extirpation of the pulp, thorough irrigation and debridement of the pulp chamber.
3. Determination of the working length.
4. Total extirpation of the pulp followed by cleaning and shaping of the root canal.

5. Placement of a dry cotton pellet or pellet moistened with CMCP, formocresol or eugenol in the pulp chamber and sealing it with the temporary restoration.

### *Acute Periapical Abscess*

Acute periapical abscess is a result of local collection of purulent exudates.

*Management*

1. It involves biphasic treatment:
   a. Pulp debridement
   b. Incision and drainage
2. In case of systemic features, antibiotics should be given.
3. Relieve the tooth out of occlusion in cases of hyper-occlusion.

### *Acute Apical Periodontitis*

It is inflammation of periodontal ligament caused by tissue damage; extension of pulpal pathosis or occlusal trauma. There is discomfort to biting or chewing.

*Management*

1. Total extirpation of the pulp followed by cleaning and shaping of the root canal.
2. Relieve occlusion if indicated.

## WHAT ARE INTRA-APPOINTMENT ENDODONTIC EMERGENCIES?

Read chapter "Mid Treatment Flare-Ups".

## WHAT ARE POSTOBTURATION EMERGENCIES?

Following completion of root canal treatment, patients usually complain of pain especially on biting which is usually caused by pressure inherent upon insertion of root canal filling materials or by chemical irritation from ingredients of root canal cements and pastes.

### Etiology

- Over instrumentation
- Overfilling
- Fracture of crown and root
- Hyperocclusion
- Poor coronal seal.

### Treatment

- Reassurance of the patient
- Prescribe analgesics
- Check occlusion
- Retreatment is done only in cases of persistent untreatable problems.

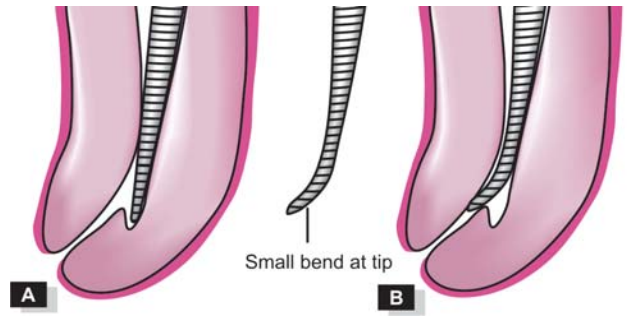
# 17 Endodontic Mishaps

## ENUMERATE VARIOUS PROCEDURAL ACCIDENTS

1. Inadequately cleaned and shaped root canal system.
   a. Loss of working length
   b. Canal blockage
   c. Ledging of canal
   d. Missed canals
2. Instrument separation
3. Deviation from normal canal anatomy
   a. Zipping
   b. Stripping or lateral wall perforation
   c. Canal transportation
4. Inadequate canal preparation
   a. Over instrumentation
   b. Over preparation
   c. Under preparation
5. Perforations
   a. Coronal perforations
   b. Root perforations
      i. Cervical canal perforations
      ii. Mid root perforations
      iii. Apical perforations
   c. Post space perforations
6. Obturation related
   a. Over obturation
   b. Under obturation
7. Vertical root fracture
8. Instrument aspiration

## Ledging

- Ledge is an internal transportation of the canal which prevents positioning of an instrument to the apex in an otherwise patent canal.




**Figs 17.1A and B:** (A) Formation of ledge by use of stiff instrument in curved canal, (B) Correction of ledge; Ledge is bypassed by making a small bend at tip of instrument. Bent instrument is passed along canal wall to locate original canal

- Caused by forcing uncurved instruments apically short of working length in a curved canal (Fig. 17.1).
- Ledges occur on the outer wall of the canal curvature.
- Suspected when there is loss of tactile sensation at the tip of the instrument, loose feeling instead of binding at the apex.
- When in doubt a radiograph of the tooth with the instrument in place is taken to provide additional information.

*Treatment*

- To negotiate a ledge, choose a smaller number file, usually No. 10 or 15.
- Penetrate the file carefully into the canal.
- Once the tip of the file is apical to the ledge, it is moved in and out of the canal utilizing ultra short push-pull movements with emphasis on staying apical to the defect.
- When the file moves freely, it may be turned clockwise upon withdrawal to rasp, reduce, smooth or eliminate the ledge.

When the ledge can be predictably bypassed, same procedure is repeated with larger instruments.

## HOW CAN YOU AVOID INSTRUMENT SEPARATION?

Any time during the cleaning and shaping of root canal file, reamer, broach or Gates Glidden may break especially while working in curved, narrow or tortuous canals.

Certain factors affect the instrument separation and their removal, for example, cross-sectional diameter, curvature and length of the canal, location of the separated instrument and type of the broken material, i.e. whether stainless steel or NiTi.

### Prevention

1. Instead of using carbon steel, use stainless steel files.
2. Use smaller number of instruments only once.
3. Examine each instrument before placing it into the canal.
4. Always use the instruments in sequential order.
5. Never force the instrument into the canal.
6. Canals should be copiously irrigated during cleaning and shaping procedure.
7. Never use instruments in dry canals.
8. Always clean the instrument before placing it into the canal. Debris collected between the flutes retard the cutting efficiency and increase the frictional torque between the instrument and canal wall.
9. Don't give excessive rotation to instrument while working with it.

## WHAT IS CANAL TRANSPORTATION?

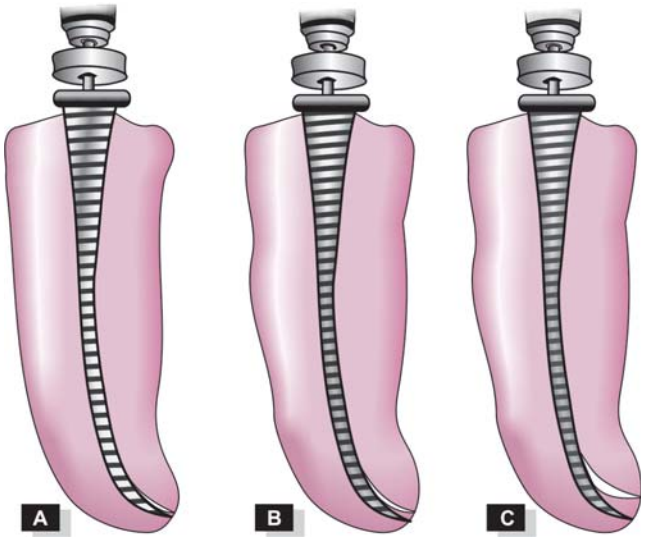
"Apical canal transportation is moving the position of canal's normal anatomic foramen to a new location on external root surface" (Figs 17.2A to C).

Canal transportations can be classified into three types, viz. Type I, II and III.

*Type I*: It is minor movement of physiologic foramen.

*Type II*: Apical transportations of Type II show moderate movement of the physiologic foramen to a new location. Such cases compromise the prognosis and are difficult to treat.

*Type III*: Apical transportation of Type III shows severe movement of physiological foramen. In such type prognosis is poorest when compared to Type I and Type II.




**Figs 17.2A to C:** Type I, II and III canal transportation (A) Minor movement of apical foramen (Type I), (B) Moderate movement of apical foramen (Type II), (C) Severe movement of apical foramen (Type III)

## WHAT IS INADEQUATE CANAL PREPARATION?

### Over Instrumentation

Excessive instrumentation beyond the apical constriction violates the periodontal ligament and alveolar bone. Loss of apical constriction creates an open apex with an increased risk of overfilling, lack of an adequate apical seal and pain and discomfort for the patient.

*Prevention*

Over instrumentation beyond apical constriction can be prevented by:

1. Using good radiographic techniques.
2. Accurately determining the apical constriction of the root canal.
3. Maintaining all instruments within the confines of the canal system.
4. Occlusal alterations before determination of the working length.
5. Intermittent radiographic confirmation of the working length.

### Overpreparation

Overpreparation is excessive removal of tooth structure in mesiodistal and buccolingual direction. During biomechanical preparation of the canal, size of apical

preparation should correspond to size, shape and curvature of the root.

Adherence to the guidelines for the recommended range of size termination for each type of root is mandatory, with modification made as necessary.

## Underpreparation

Underpreparation is the failure to remove pulp tissue, dentinal debris and microorganisms from the root canal system.

Inadequate preparation of the canal system can be prevented in the following ways:

1. Copious use of irrigants to dissolve tissues and debris.
2. Thorough cleaning and shaping of the canal system.
3. Establishing the working length up to apical constriction.
4. Recapitulation during instrumentation.

## PERFORATIONS

*Perforation is defined as "the mechanical or pathological communication between the root canal system and the external tooth surface".*

1. ***Access cavity perforation*** can occur during access cavity preparation (Fig. 17.3).
2. ***Root canal perforations*** can occur at three levels:
   a. ***Cervical canal perforations:*** They commonly occur while locating the canal orifices and flaring of the coronal third of the root canals.

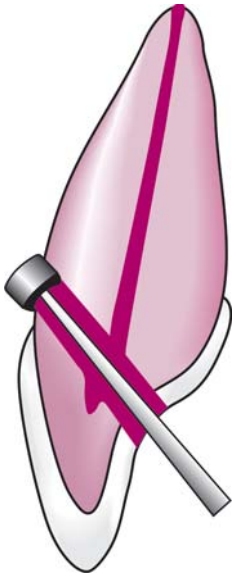


**Fig. 17.3:** Perforation caused during access cavity preparation

   b. ***Mid root perforations:*** Usually, it is caused by over-instrumentation and over-preparation of the thin wall of root or concave side of the curved canals.
   c. ***Apical root perforations:*** Apical root perforations occur when instrument goes into periradicular tissue, i.e. beyond the confines of the root canal.

*Occurrence of a perforation can be recognized by:*

1. Placing an instrument into the opening and taking a radiograph.
2. Using paper point.
3. Sudden appearance of bleeding.

## Repair of the Perforation

Treatment of the endodontics perforation depends on recognition of the condition, location, size, level of the perforation, timing of therapeutic intervention and clinician's skill and experience.

## Material Used for Perforation Repair

### *An Ideal Material for Perforation Repair should*

- Be nontoxic
- Be easy to handle
- Be radiopaque
- Be dimensionally stable
- Be well tolerated by periradicular tissue
- Not to be affected by moisture.

Some of the most investigated materials for perforation repair include amalgam, calcium hydroxide, IRM, Super EBA, gutta-percha, MTA, other materials tried for repair include dentin chips, hydroxyapatite, glass ionomer cements and plaster of paris.

### *Management of the Coronal Third Perforations*

Here the materials used for perforation repair could be composites, amalgam, glass ionomer cements and white MTA.

### *Management of Perforations in Mid Root Level*

If the defect is small and hemostasis can be achieved, perforation can be sealed and repaired during three dimensional obturation of the root canal. But in case the perforation defect is large and moisture control is difficult, then one should prepare the canal before going for perforation repair.

*Management of Perforations in Apical Third of the Root Canal*

These types of perforations can be repaired both surgically as well as non-surgically.

Though various materials have been tried for perforation repair but nowadays MTA has shown to provide promising results.

*Technique*

- Dry the canal system with paper points and isolate the perforation site.
- Prepare the MTA material according to manufacturer's instructions.
- Using the carrier provided, dispense the material into perforation site. Condense the material using pluggers or paper points.
- While placing MTA, instrument is placed into the canal to maintain its patency and moved up and down in short strokes till the MTA sets.
- In next appointment, one sees the hard set MTA against which obturation can be done (Fig. 17.4).

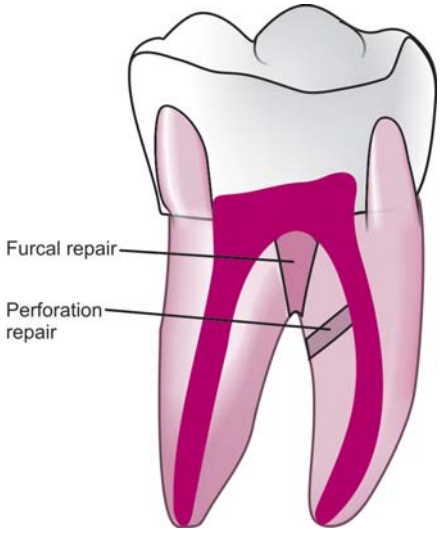



**Fig. 17.4:** Use of MTA for repair of perforation

*Perforations can be avoided by*:

1. Evaluation of the anatomy of the tooth before starting the endodontic therapy.
2. Using the smaller, flexible files for curved canals.
3. Not skipping the filling sizes.
4. Recapitulation with smaller files between sizes.
5. Confirming the working length and maintaining the instruments with in the confines of working length.

## VERTICAL ROOT FRACTURE

Vertical root fracture can occur at any phase of root canal treatment that is during biochemical preparation, obturation or during post-placement.

### Clinical Features

- Sudden crunching sound accompanied by pain is the pathognomic of the root fracture.
- The fracture begins along the canal wall and grows outwards to the root surface.
- The susceptibility of root fracture increases by excessive dentin removal during canal preparation or post space preparation. Also the excessive condensation forces during compaction of gutta-percha while obturation increases the frequency of root fractures.
- Radiographically vertical root fracture may vary from no significant changes to extensive resorption patterns.

*Treatment of vertical root fracture* involves extraction in most of the cases. In multirooted teeth root resection or hemi-section can be tried.

### Prevention

- Avoid over preparation of the canal.
- Use less tapered and more flexible compacting instruments to control condensation forces while obturation.


# Endodontic Failures and Retreatment

## HOW CAN ONE EVALUATE SUCCESS OF ENDODONTIC TREATMENT?

### Clinical Criteria for Success

- No tenderness to percussion or palpation.
- Normal tooth mobility.
- No sign of infection or swelling.
- No sinus tract or integrated periodontal disease.

### Radiographic Criteria for Success of Endodontic Treatment

- Normal or slightly thickened periodontal ligament space.
- Reduction or elimination of previous rarefaction.
- No evidence of resorption.
- Normal lamina dura.

### Histological Criteria for Success

- Absence of inflammation.
- Regeneration of periodontal ligament fibers.
- Presence of osseous repair.
- Repair of cementum.
- Absence of resorption.
- Repair of previously resorbed areas.

## ENUMERATE FACTORS AFFECTING SUCCESS OR FAILURE OF ENDODONTIC THERAPY OF A PARTICULAR CASE

- Pulpal status.
- Periodontal status.
- Size of periapical radioleucency.
- Canal anatomy like degree of canal calcification, presence of accessory or lateral canals, resorption, degree of curvature of canal, etc.
- Iatrogenic errors.
- Occlusal discrepancies if any.
- Extent and quality of the obturation.
- Quality of the postendodontic restoration.

## ENLIST VARIOUS CAUSES OF THE ENDODONTIC FAILURES

### Local Factors Causing Endodontic Failures

*Infection*

For success of the endodontic therapy, thorough debridement of the root canal system is required for removal of these irritants.

*Incomplete Debridement of the Root Canal System*

The poor debridement can lead to residual microorganisms, their byproducts and tissue debris which contribute to endodontic failure.

*Over Instrumentation*

Instrumentation beyond apical foramen causes decrease in the prognosis of endodontic treatment because of trauma to periodontal ligament and the alveolar bone.

*Chemical Irritants*

Chemical irritants in form of intracanal medicaments, irrigating solution decrease the prognosis of endodontic therapy if they get extruded in the periapical tissues.

*Iatrogenic Errors Contributing Endodontic Failures*

- Separated instruments.
- Canal blockage and ledge formation.
- Perforations.

- Incompletely filled teeth.
- Overfilling of root canals.
- Anatomic factors like presence of overly curved canals, calcifications, numerous lateral and accessory canals may pose problems in adequate cleaning and shaping.
- Root fractures.
- Traumatic occlusion.

### Systemic Factors

Systemic diseases may influence the local tissue resistance and thus interfering with the normal healing process.

Various systemic factors which can interfere in the success of endodontic therapy are:

- Nutritional deficiencies
- Diabetes mellitus
- Renal failure
- Blood dyscrasias
- Hormonal imbalance
- Autoimmune disorders
- Opportunistic infections
- Aging
- Patients on long-term steroidtherapy.

## WHAT ARE STEPS OF ENDODONTIC RETREATMENT?

- Coronal disassembly.
- Establish access to root canal system.
- Remove canal obstructions.
- Establish patency.
- Thorough cleaning, shaping and obturation of the canal.

### Coronal Disassembly

Endodontic retreatment procedures commonly require removal of the existing coronal restoration. But in some cases access can be made through the existing restoration (Fig. 18.1).

It is advisable to remove the existing restoration especially if it has poor marginal adaptation, secondary caries to avoid procedural errors. To maintain form, function and aesthetics, temporary crown can be placed.

### Establish Access to Root Canal System

Some teeth are restored with post and core which need to be removed for gaining access to root canal system or sometimes they can be perforated to gain access.

**Fig. 18.1:** Retreatment of a premolar with endodontic failure and access is made by removing coronal restoration

### Removing Canal Obstructions and Establishing Patency

Patency of canal can be regained by removing obstructions in the canal which can be in the form of silver points, gutta-percha, pastes, sealers, separated instruments and posts, etc.

*Silver Point Removal*

Silver points can be retrieved from the canal by:

a. Using microsurgical forceps
b. Using ultrasonics (Fig. 18.2)

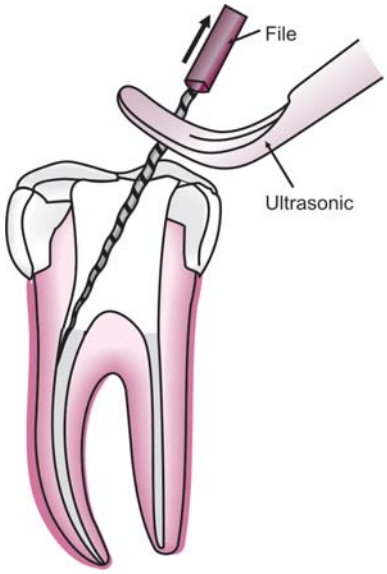
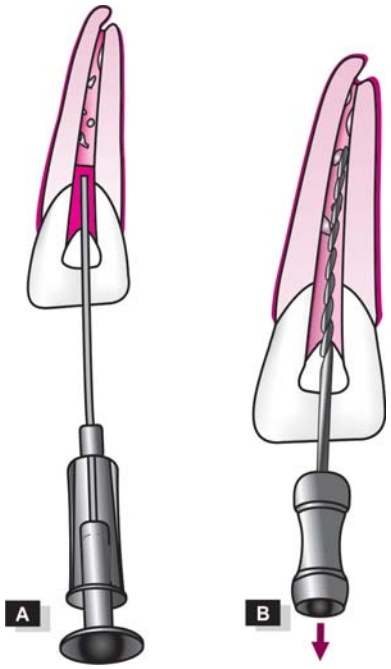



**Fig. 18.2:** Use of ultrasonics to remove silver point




**Figs 18.3A and B:** (A) Use of solvent for removal of gutta-percha. (B) Further removal of dissolved gutta-percha using hand instrument

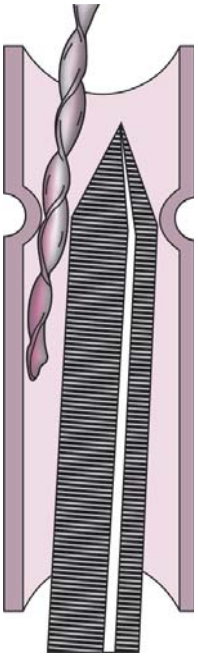


**Fig. 18.4:** Use of massermann extractor to remove fractured instrument

c. Using Hedstroem files
d. Using instrument removal system.

*Gutta-Percha Removal*

Gutta-percha can be removed by:
- Using solvents (Fig. 18.3)
- Using hand instruments
- Using rotary instruments.

## Pastes and Cements

***Soft setting pastes*** can be removed using the normal endodontic instruments.

***Hard setting cements***: Hard setting pastes can also be drilled out using lone shank, small round burs, ultrasonics, etc.

## Separated Instruments and Foreign Objects

They can be removed by using:
- Instruments like Stieglitz pliers and Massermann extractor (Fig. 18.4).
- Ultrasonics
- When it is not possible to remove the foreign objects, attempts should be made to bypass the object and complete biomechanical preparation of the canal system.

## Completion of the Retreatment

After gaining access to the root canal system, with its thorough cleaning and shaping and managing other complications, the treatment is completed using the routine procedures.

# WHAT ARE CONTRAINDICATIONS OF ENDODONTIC RETREATMENT?

- Unfavorable root anatomy (shape, taper, remaining dentin thickness).
- Presence of untreatable root resorptions or perforations.
- Presence of root or bifurcation caries.
- Insufficient crown/root ratio.

# 19 Single Visit Endodontics

## SINGLE VISIT ENDODONTICS (SVE)

SVE implies to cleaning, shaping and disinfection of a root canal system followed by obturation of the root canal at the same appointment. The concept of single visit endodontics started atleast 100 years back.

Though the concept of SVE is gaining the recognition, but it is still surrounded by controversies regarding post-operative, pain, flare-ups and the healing rate followed by root canal therapy.

*The most common factors which appear to be responsible for not performing SVE are as follows*:

- Doubt of postoperative pain.
- Fear of failure of the endodontic therapy.
- Discomfort to patient because he/she has to keep the mouth open for a long period of time.
- Lack of time.
- Lack of experience and equipment.

### Advantages

- ***Convenience***: Patient does not have to endure the discomfort of repetitive local anesthesia, treatment procedure and postoperative recovery.
- ***Efficiency***: The clinicians does not have to refamiliarize himself/herself to patient's particular anatomy or landmarks.
- ***Patient comfort***: Because of reduced number of visits and injections.
- ***Reduced intra-appointment pain***: Mostly the mid treatment flare-ups are caused by leakage of the temporary cements. This figure has seen to be reduced in SVE cases.
- ***Economics***: Extra cost of multiple visits, use of fewer materials and comparatively less chair side time all increase the economics to both patient as well as doctor.
- ***Minimizes the fear and anxiety***: Specially beneficial for patients who have psychological trauma and fear of dentist.
- ***Reduces incomplete treatment***: Some patients do not return to complete the root canal therapy, so SVE reduces this risk.
- ***Lesser errors in working length***: In multiple visits, the reference point could be lost because of fracture or unwanted grinding in case of flare-ups leading to loss of actual working length. These errors are avoided in SVE.
- ***Restorative consideration***: In SVE, immediate placement of coronal restoration (post and core placements) ensures effective coronal seal and esthetics.

### Disadvantages

- It is tiring for patients to keep their mouth open for long durations.
- If mid treatment flare-ups happen to occur, it is easier to establish drainage in a tooth which is not obturated.
- Clinician may lack the proficiency to properly treat a case in single visit
  - SVE cannot be performed in all cases.
  - If hemorrhage or exudation occurs, it becomes difficult for the clinician to control and complete the case in same visit.
  - Difficult cases with very fine, curved, calcified, multiple canals may not be treatable in single visit.

## Conditions where Single Visit Endodontics cannot be Performed

- Teeth with anatomic anomalies such as calcified and curved canals.
- Asymptomatic nonvital teeth with periapical pathology and no sinus tract.
- Acute alveolar abscess cases with frank pus discharge.
- Patients with acute apical periodontitis.
- Symptomatic non-vital teeth and no sinus tract.
- Retreatment cases.
- Patients with allergies or previous flare-ups.
- Teeth with limited access.
- Patients who are unable to keep mouth open for long durations such as patients with TMJ disorders.

## Criteria of Case Selection as given by Oliet Include

- Positive patient acceptance.
- Absence of acute symptoms.
- Absence of continuous hemorrhage or exudation.
- Absence of anatomical interferences like presence of fine, curved or calcified canals.
- Availability of sufficient time to complete the case.
- Absence of procedural difficulties like canal blockage, ledge formation or perforations.

## Indications

- Vital teeth.
- Fractured anteriors where esthetics is the concern.
- Patients who require sedation every time.
- Nonvital teeth with sinus tract.
- Medically compromised patients who require antibiotics prophylaxis.
- Physically compromised patients who cannot come to dental clinics frequently.

In conclusion, single-visit endodontics has been shown to be an effective treatment modality, which compared to multiple-visit therapy, is more beneficial to patients and dentists in many ways provided there is careful case selection and adherence to standard endodontic principles.

# 20 Restoration of Endodontically Treated Teeth

## WHAT ARE EFFECTS OF ENDODONTIC TREATMENT ON THE TOOTH?

- ***Structural changes***
  *Tooth weakening caused by*:
  - Caries
  - Trauma
  - Access cavity preparation
  - Radicular preparation

  Compromised structural integrity.
- ***Changes in dentin***
  A reduced amount of moisture in nonvital teeth.
- ***Aesthetic considerations***
  - Loss of tooth structure
  - Change in appearance because of alteration in biochemical properties of dentin.

## WHAT ARE REQUIREMENTS OF A TOOTH TO ACCEPT A POST AND CORE?

- Optimal apical seal
- Absence of active inflammation
- No sensitivity to percussion
- Absence of associated periodontal disease
- Sufficient bone support around the root.

## WHAT SHOULD BE THE PROPERTIES OF AN IDEAL POST?

Post is relatively rigid restorative material placed in the root of a nonvital tooth. It extends coronally to anchor the core material which supports the crown (Fig. 20.1).

### A Post should

- Provide maximum protection of the root to resist root fractures.

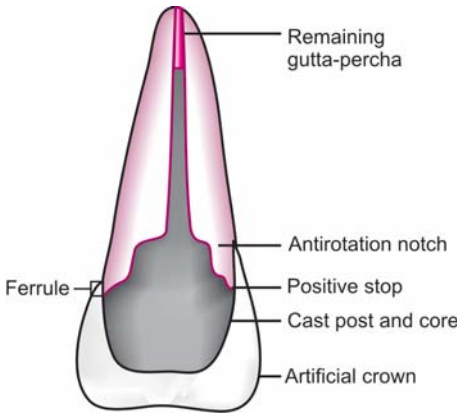



**Fig. 20.1:** Complete post and core system

- Provide maximum retention of the core and crown.
- Be easy to place.
- Be less technique sensitive.
- Have high strength and fatigue resistance.
- Be visible radiographically.
- Be biocompatible.

## GIVE CLASSIFICATION OF POSTS. WHAT ARE ADVANTAGES AND DISADVANTAGES OF VARIOUS POST SYSTEMS?

**A.** ***Posts can be classified as***

### Prefabricated Post

1. Metal prefabricated posts are made up of
   - Gold alloy
   - Stainless steel
   - Titanium and titanium alloys
2. Carbon fiber post

3. Quartz fiber post
4. Zirconia posts
5. Glass fiber post

## Custom Made Posts

They can be cast from a direct pattern fabricated in patient's month or indirect pattern fabricated in the lab.

These can be of two types:

**a.** ***Custom cast metal post and core*** are usually made up of:
- Gold alloys
- Base metal alloys
- Ni-Cr alloys.

**b.** ***Ceramic custom made posts*** are made up of all ceramic.

***B. Posts can also be classified as:***

1. *Active post*: Active posts mechanically engage the canal walls.
2. *Passive or cemented posts*: Passive posts don't engage the canal walls.

## Custom Cast Metal Post

*Advantages*

- Adaptable to large irregularly shaped canals.
- Very strong.
- Better core retention because core is an inherent part of the post.
- In multirooted teeth, they are cost effective.

*Disadvantages*

- Requires more chair side time.
- Very rigid so lead to greater stress concentration in root causing root or post fracture.
- Poor aesthetics.
- Require temporization.
- Prone to corrosion.

## All Ceramic Post and Cores

*Advantages*

- Excellent aesthetics
- Biocompatibility
- Good radiopacity

*Disadvantages*

- Brittle, so not indicated in high stress conditions like bruxism.
- Very rigid, so more risk of root or post fracture.
- Gross undercuts in root canals make pattern fabrication for cast posts difficult.

## Prefabricated Metal Posts

*Advantages*

- Simple to use.
- Less time consuming.
- Retentive with in the root specially serrated and parallel sided posts.
- Radiopaque.
- Cost effective.

*Disadvantages*

- Not conservative because root is designed to accept the post.
- Cannot be placed in tortuous canals.
- Poor aesthetics.
- Very rigid.

## Carbon Fiber Posts

Carbon fiber post consists of bundle of stretched carbon fibers embedded into an epoxy matrix.

*Advantages*

- Clinical procedure is less time consuming.
- Strong but low stiffness and strength than ceramic and metal posts.
- Easily retrievable.
- Less chair side time.
- Modulus of elasticity similar to dentin.

*Disadvantages*

- Black in color, so unaesthetic.
- Radiolucent, so impossible to detect radiographically.

## Glass Fiber Post

It consists of unidirectional glass fibers embedded in a resin matrix which strengthens the dowel without compromising the modulus of elasticity.

*Advantages*

- Aesthetically acceptable.
- Modulus of elasticity similar to dentin.
- Biocompatible.
- High resistance to fracture.
- Easy retrieval.

*Disadvantages*

- Poor radiographic visibility.
- Expensive.
- Technique sensitive.

## WHAT FACTORS ARE TO BE CONSIDERED WHILE PLANNING POST AND CORE?

- Retention and the resistance form
- Preservation of tooth structure
- Ferrule effect
- Mode of failure
- Retrievability.

### Retention and the Resistance Form

Post retention refers to the ability of post to resist vertical dislodging forces. Post resistance refers to the ability of the post and the tooth to with stand the lateral and rotational forces.

*Factors affecting post retention*

- Post length
- Post diameter
- Post taper and design
- Luting agent
- Luting method
- Canal shape
- Post position in dental arch.

*Factors affecting post resistance*

- Post length
- Rigidity
- Presence of antirotational features
- Presence of ferrule.

*Post Length*

Accepted guidelines for determining post length include:

- Post should be equal to clinical crown length.
- Post should end halfway between the crestal bone and the root apex.
- Post should be as long as possible without disturbing the apical seal.

*Post Diameter*

It has been seen that post diameter has little difference in the retention of post, but increase in post diameter increases the resistance form but it also increases the risk of root fracture.

*Post Design*

Different types of post designs available are (Fig. 20.2):

- Tapered, smooth sided
- Tapered, serrated type
- Parallel smooth sided
- Parallel serrated type

**Generally parallel sided are more retentive than tapered ones.*

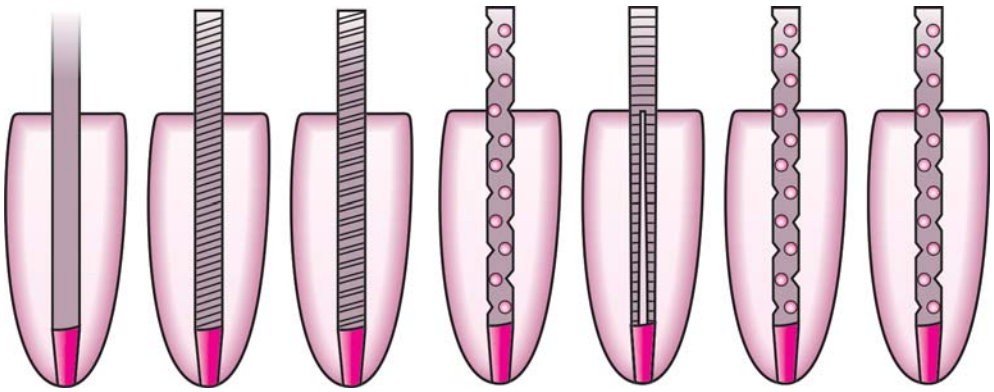


**Fig. 20.2:** Different post designs

*Luting Agents*

Commonly used dental cements for luting the posts are zinc phosphate, polycarboxylate, glass ionomer cement, resin-based composite.

*Luting Method*

Luting method also affects the retention of post. Since luting agents are susceptible to moisture present in the canal so canal should be absolute dry.

### Preservation of the Tooth Structure

One should try to preserve maximum of the coronal and radicular tooth structure whenever possible.

### Ferrule Effect

Ferrule is encircling collar of metal band or ring used to fit the root or crown of a tooth (Fig. 20.3). Basically, it braces the tooth and protects it against the wedging stresses and vertical root fracture.

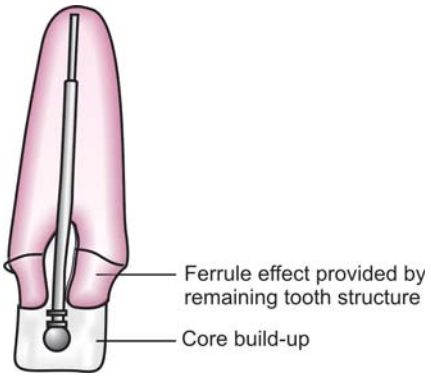



**Fig. 20.3:** Ferrule effect

### Mode of Failure

All post systems show some percentage of failure but with variable range.

Failures of posts and core can occur in form of:

- Post fracture
- Root fracture
- Core fracture
- Post dislodgement

### Retrievability

Ideally a post system selected should be such that if an endodontic treatment fails, or failure of post and core occurs, it should be retrievable.

## WHAT ARE STEPS OF PREPARATION OF THE CANAL SPACE AND THE TOOTH FOR ACCEPTING POST AND CORE?

1. Plan for the length and diameter of the post according to the tooth type.
2. Remove the gutta-percha filling.
3. Prepare the canal space using Gates-Glidden drills or Peeso reamers.
4. Following the preparation of canal space, preparation of coronal tooth structure is done (Fig. 20.4).
5. Remove all the unsupported tooth structure (Fig. 20.5).
6. Place an antirotational notch with the help of cylindrical diamond or carbide bur.
7. Ferrule effect is provided thereafter. Ferrule ensures that the final restoration encircles the tooth apical to the core and rests on sound tooth structure. It also presents the vertical root fracture by posts.
8. Finally eliminate all the sharp angles, undercuts and establish a smooth finish line (Fig. 20.6).

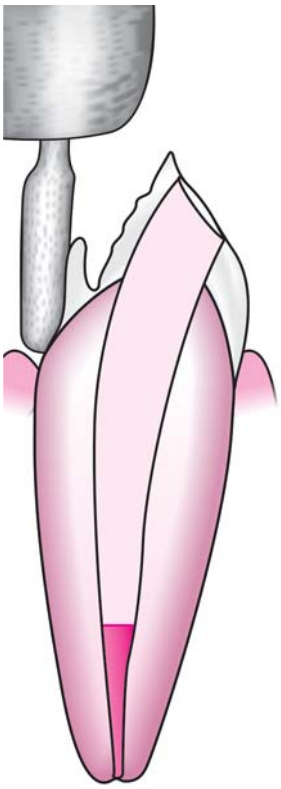


**Fig. 20.4:** Preparation of coronal surface

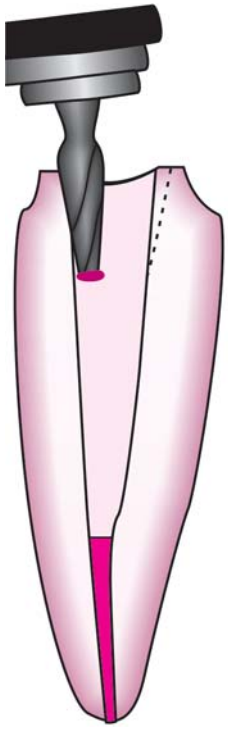


**Fig. 20.5:** Placement of anti-rotational notch

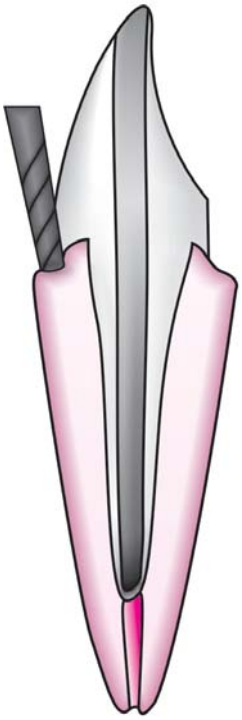


**Fig. 20.6:** Establish a smooth finish line

## WHAT SHOULD BE THE IDEAL PROPERTIES OF A CORE MATERIAL? ENLIST VARIOUS CORE MATERIALS

Core is the supragingival portion that replaces the missing coronal tooth structure and forms the center of new restoration.

### Ideal Requirements for a Core Material

- Biocompatibility
- Ease of manipulation
- Ability to bond to tooth structure and post
- Coefficient of thermal expansion similar to dentin
- Minimal water absorption
- Dimensionally stable
- No reaction with chemicals
- Low cost
- Easily available.

### Various Core Build-up Materials Available

- Dental amalgam
- Resin modified glass ionomers
- Composite resin
- Reinforced glass ionomers cement.


# Surgical Endodontics

## WHAT ARE INDICATIONS AND CONTRAINDICATIONS OF ENDODONTIC SURGERY?

Endodontic surgery is defined "as removal of tissues other than the contents of root canal to retain a tooth with pulpal or periapical involvement".

### Indications

1. Need for surgical drainage
2. Failed non-surgical treatment:
   a. Irretrievable root canal filling material.
   b. Recurring exacerbations of non-surgical endodontic treatment.
3. Calcific metamorphosis of the pulp space.
4. Horizontal fracture at the root tip with associated periapical disease.
5. Procedural errors:
   a. Instrument separation
   b. Non-negotiable ledging
   c. Root perforation
6. Anatomic variations
   a. Root dilacerations
   b. Non-negotiable root curvatures.
7. Biopsy
8. Corrective surgery
   a. Root resection
   b. Hemisection
   c. Bi-cuspidization
9. Replacement surgery
   a. Intentional replantation
   b. Post-traumatic replantation
10. Implant surgery
    a. Endodontic implants
    b. Osseo-integrated implants

### Contraindications

1. Poor periodontal health of the tooth
2. Patient's health considerations
   a. Recent cardiac or cancer surgery
   b. Very old patients
   c. Uncontrolled hypertension
   d. Uncontrolled bleeding disorders
   e. Immuno-compromised patients
3. Patient's mental or psychological status:
   a. Patient does not desire surgery
   b. Very apprehensive patient
4. Surgeon's skill and ability—Clinician must be completely honest about their surgical skill and knowledge.
5. Short root length in which removal of root apex further compromises the prognosis.
6. Proximity to nasal floor and maxillary sinus
7. Miscellaneous
   a. Non-restorable teeth
   b. Vertically fractured teeth.

## CLASSIFY VARIOUS ENDODONTIC SURGERY PROCEDURES

1. Surgical drainage
   a. Incision and drainage (I and D)
   b. Cortical trephination
2. Periradicular surgery
   a. Curettage
   b. Biopsy
   c. Root end resection
   d. Corrective surgery
      i. Perforation repair
      ii. Root resection
      iii. Hemisection.
3. Replacement surgery

4. Implant surgery
   a. Endodontic implants
   b. Root-form osseointegrated implants.

## WHAT ARE PRINCIPLES AND GUIDELINES FOR FLAP DESIGNS? DISCUSS VARIOUS FLAP DESIGNS

1. Avoid horizontal and severely angled vertical incisions.
2. Avoid incisions over radicular eminences, for example in canines and maxillary first premolars.
3. Incisions should be placed and flaps repositioned over solid bone.
4. Avoid incisions across major muscle attachment.
5. Extent of horizontal incision should be adequate to provide visual and operative access with minimal soft – tissue trauma.
6. Avoid incisions in the mucogingival junction.
7. The junction of the horizontal sulcular and vertical incisions should either include or exclude the involved interdental papilla.
8. The flap should include the complete muco-periosteum.

### Triangular Flap

Earlier triangular flap was usually formed by giving two incisions, i.e. horizontal and vertical. Nowadays, intrasulcular incision is also given along with these two incisions. Vertical incision is usually placed towards the midline (Fig. 21.1).

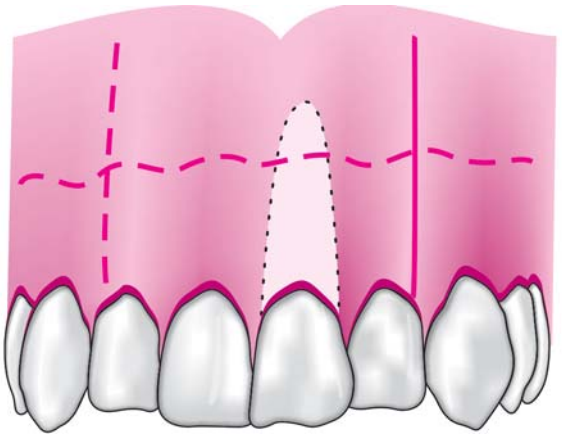


**Fig. 21.1:** Triangular flap

*Advantages*

- Enhanced rapid wound healing.
- Greater access and visibility.

*Disadvantages*

- Limited surgical access.
- Difficult to retract.

### Rectangular Flap

Earlier a rectangular flap was made by giving only two vertical and a horizontal incision but nowadays, instrasulcular incision has also been added in this design (Fig. 21.2).

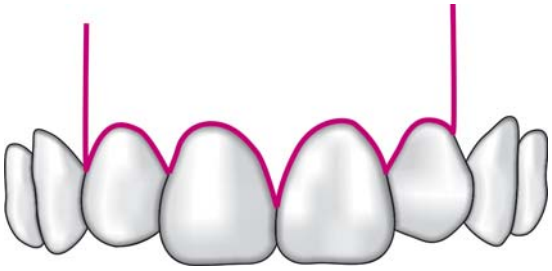


**Fig. 21.2:** Rectangular flap

*Advantage*

Enhanced surgical access.

*Disadvantages*

- Wound closure as flap re-approximation and post-surgical stabilization are more difficult than triangular flap.
- Potential for flap dislodgement is greater.

### Trapezoidal Flap

Trapezoidal flap is formed by two releasing incisions which join a horizontal intrasulcular incision at obtuse angles (Fig. 21.3).

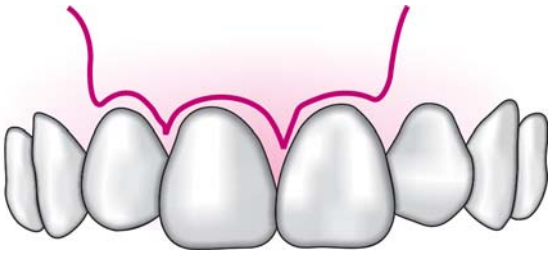


**Fig. 21.3:** Trapezoidal flap

*Disadvantage*

Wound healing by secondary intention.

### Envelope Flap

It is formed by a single horizontal intrasulcular incision and is usually recommended for corrective endodontic surgery.

*Advantage*

Improved wound healing

*Disadvantage*

Extremely limited surgical access.

### Semilunar Flap

It is formed by a single curved incision. This flap is called as semilunar flap because horizontal incision is modified to have a dip towards incisal aspect in centre of the flap, giving resemblance to the half moon (Fig. 21.4).

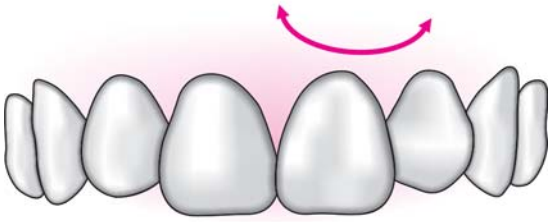


**Fig. 21.4:** Semilunar flap

*Disadvantages*

- Limited surgical access
- Difficult wound closure

### Ochsenbein-Luebke Flap

This flap is modification of the rectangular flap (Fig. 21.5). Flap design—in this scalloped horizontal incision is given in the attached gingiva which forms two vertical incisions made on each side of surgical site .

*Advantages*

- Marginal and inter-dental gingiva are not involved.
- Crestal bone is not exposed.

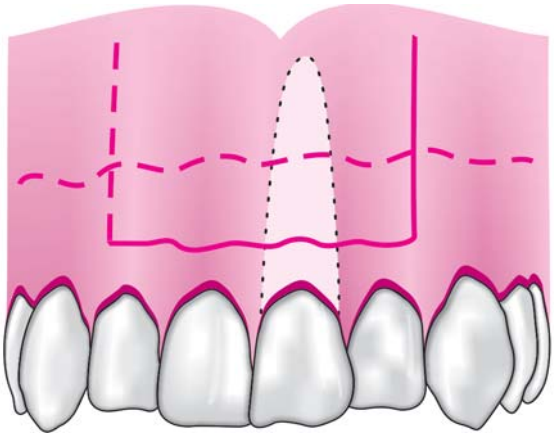


**Fig. 21.5:** Ochsenbein-Luebke flap

*Disadvantages*

- Difficult flap re-approximation and wound closure
- healing with scar formation
- Limited apical orientation.

## WHAT IS PERIRADICULAR CURETTAGE?

It is a surgical procedure to remove diseased tissue from the alveolar bone in the apical or lateral region surrounding a pulpless tooth.

### Indications

- Access to the root structure for additional surgical procedures.
- For removing the infected tissue from the bone surrounding the root.
- For removing overextended fillings.
- For removing necrotic cementum.

### Surgical Techniques

- Inject local anesthetic with vasoconstrictor into soft tissue.
- Expose the surgical site.
- Use the bone curette to remove the pathologic tissue surrounding the root.
- After removing the tissue from the bony area, grasp the soft tissue with the help of tissue forceps.
- Send the pathological tissue for histopathological examination.

## WHAT ARE INDICATIONS OF ROOT-END RESECTION (APICOECTOMY, APICECTOMY)? HOW DO WE PERFORM IT?

Apicoectomy is the ablation of apical portion of the root-end attached soft tissues.

The current indications of root-end resection are:

- Inability to perform nonsurgical endodontic therapy due to anatomical, pathological and iatrogenic defects in root canal.
- Persistent infections after conventional endodontic treatment.
- Need for biopsy.
- For removal of iatrogenic errors like ledges, fractured instruments, and perforation which are causing treatment failure.
- For evaluation of apical seal.
- Blockage of the root canal due to calcific metamorphosis or radicular restoration.

### Factors to be Considered before Root-End Resection

*Instrumentation*

High speed handpiece with surgical length fissure bur usually results in satisfactory resection. Use of round bur may result in gouging of root surface whereas crosscut fissure burs can lead to uneven and rough surface.

Recently studies have shown the use of Er:YAG laser and Ho:YAG laser for root end resection but among these Er:YAG laser is better as it produces clean and smooth root surface. *Advantages of use of laser in periradicular surgery over the traditional methods include*:

1. Reduction of postoperative pain.
2. Improved hemostasis.
3. Reduction of discomfort.

*Extent of Resection*

Factors to be considered while performing root-end resection are:

1. Access and visibility of surgical site.
2. Anatomy of the root, i.e. its shape, length, etc.
3. Anatomy of the resected root surface to see number of canals.
4. Presence and location of iatrogenic errors.
5. Presence of any periodontal defect.

According to Cohen et al, root resection of 3 mm at a 0° bevel angle eliminates most of the anatomic features that are possible cause of failure (Fig. 21.6).

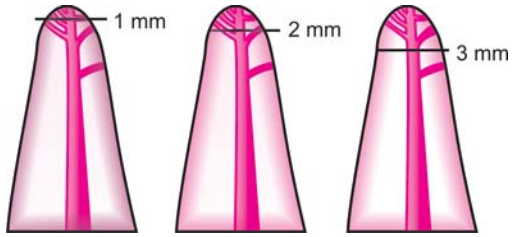



**Fig. 21.6:** Frequency of ramifications at different levels of root canal

*Angle of Resection*

Earlier it was thought that root-end resection at 30° to 45° from long axis of root facing buccally or facially provides:

- Improved visibility of the resected root-end.
- Improved accessibility.

But nowadays 0° bevel with resection at the level of 3 mm is recommended.

*Advantages of a Zero Degree Bevel (Fig. 21.7)*

- Maintains maximum root length.
- Reduced osteotomy size.
- Lesser apical leakage.

### Root-End Preparation

The main objective of root-end preparation is to create a cavity to receive root-end filling. Root-end preparation

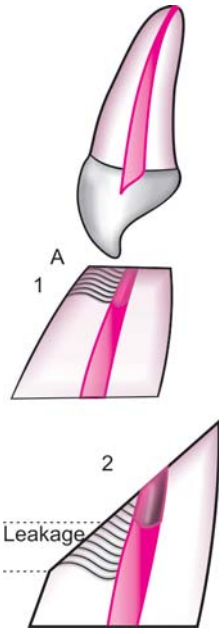



**Fig. 21.7:** Bevelling of root end results in more exposure of dentinal tubuls and thus leakage

should accept filling materials so as to seal off the root canal system from periradicular tissues.

An ideal root-end preparation as "a class I preparation at least 3.0 mm into root dentine with walls parallel to a coincident with the anatomic outline of the pulp space".

*Traditional Root-End Cavity Preparation*

Miniature contra angle or straight handpiece, with a small round or inverted cone bur is used to prepare a class I cavity at the root-end within confines of the root canal (Fig. 21.8). One of the main problems in root-end preparation is that these preparations seem to be placed

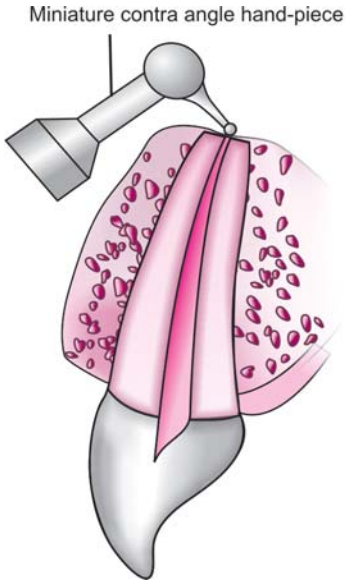



**Fig. 21.8:** Root end preparation using endopiece

in the long axis of the tooth, but they are directed palatally, ultimately causing the perforations.

*Ultrasonic root-end preparation* was developed to resolve the main shortfalls of bur preparation. For this specially designed ultrasonic root-end preparation instruments have been developed.

## Retrograde Filling

Root canal filling material is placed in the prepared root-end in a dry field. To place a material in the retro-preparation, it is mixed in the desired consistency, carried on the carver and placed carefully into the retro-preparation and compacted with the help of burnisher (Fig. 21.9).

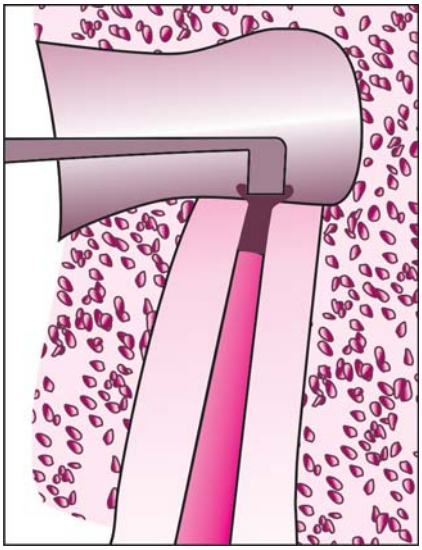


**Fig. 21.9:** Removal of excess material

## WHAT ARE IDEAL PROPERTIES OF ROOT-END FILLING MATERIALS?

Ideal properties of a root-end filling material are that it:

1. Should be well tolerated by periapical tissues
2. Should adhere to tooth surface.
3. Should be dimensionally stable.
4. Should be resistant to dissolution.
5. Should promote cementogenesis.
6. Should be bactericidal or bacteriostatic.
7. Should be non-corrosive.
8. Should be electrochemically inactive.
9. Should not stain tooth or periradicular tissue.
10. Should be readily available and easy to handle.
11. Should allow adequate working time, then set quickly.
12. Should be radioopaque.

*Commonly used root-end filling materials are*:

1. Amalgam
2. Gutta-percha
3. Glass ionomers
4. Zinc oxide eugenol
5. Cavit
6. Composite resins
7. Polycarboxylate cement
8. Poly HEMA
9. Mineral trioxide aggregate

## WHAT ARE POSTSURGICAL COMPLICATIONS?

### Postoperative Swelling

Postoperative swelling usually reaches maximum after 24 or 48 hours. It usually resolves within a week.

*Management*

1. Inform the patient earlier as it reduces the anxiety.
2. Application of ice packs should be advocated for next 6-8 hours to decrease the swelling.
3. Application of hot moist towel is recommended after 24 hours.

### Postoperative Bleeding

Postoperative bleeding can be reduced by compression of the surgical flap both before and after suturing.

*Management*

1. First and foremost step in managing bleeding is applying firm pressure over the area for 10-20 minutes.
2. If bleeding still continues, then sutures should be removed and then search for blood vessels causing bleeding. Cauterization should be done.

### Extraoral Ecchymosis (Extraoral Discoloration)

Discoloration/ecchymosis usually results when blood has leaked into the surrounding tissues. This condition is self limiting in nature and lasts up to 2 weeks and does not affect the prognosis.

### Pain

Postoperative pain is usually maximum on the day of surgery and it decreases thereafter.

*Management*

1. Pain can be managed by prescribing NSAIDs.
2. If severe pain is present, opoid analgesics may be combined with NSAIDs.

### Infection

Postoperative infection usually occurs due to inadequate aseptic technique and improper soft tissue handling, approximation and stabilization.

*Management*

Systemic antibiotics should be prescribed.


# Endodontic Periodontic Interrelationship

## WHAT ARE DIFFERENT PATHWAYS OF COMMUNICATION BETWEEN PULP AND PERIODONTIUM?

### Dentinal Tubules

- Traverse from pulpodentinal junction to cemento-dentinal or dentinoenamel junction.
- Congenital absence of cementum, cemental exposure by periodontal disease, caries, root surface instrumentation–exposes dentinal tubules.

### Lateral or Accessory Canals

- Most common in apical third of posterior teeth.
- Difficult to identify on radiographs.
- Identified by isolated defects on the lateral surface of roots or by postobturation radiographs showing sealer puffs.

### Apical Foramen

- Major pathway of communication.
- Inflammatory factors exit through apical foramen and irritate periodontium.

### Perforation of the Root

Perforation creates an artificial communication between the root canal system and the periodontium.

### Vertical Root Fracture

Vertical root fracture can form a communication between root canal system and the periodontium.

## WHAT IS ETIOLOGY OF ENDODONTIC-PERIODONTAL PROBLEMS?

Pulpal diseases can result in the periodontal problems and vice versa. It is the length of time that the etiological factor persists in the susceptible environment which is directly related to the probability of occurrence of combined lesions.

### Predisposing Factors Resulting in Combined Endodontic Periodontal Lesions

- Malpositioned teeth causing trauma.
- Presence of additional canals in teeth.
- Large number of accessory and the lateral canals.
- Trauma combined with gingival inflammation.
- Vertical root fracture.
- Crown fracture.
- Root resorption.
- Perforations
- Systemic factors such as diabetes.

## HOW WILL YOU DIAGNOSE A CASE OF ENDODONTIC-PERIODONTAL LESIONS?

### Clinical Tests

Different signs and symptoms can be assessed by visual examination, palpation and percussion.

### Radiographs

Radiographs are of great help in diagnosing caries, extensive restorations, root resorption, root fracture, thickened periodontal ligament space and any changes in the alveolar bone.

### Pulp Vitality Tests

Determination of pulp vitality is essential for accurate differential diagnosis of the lesions.

### Tracking Sinus or Fistula

Tracking the fistula may aid the clinician to differentiate the source.

### Pocket Probing

Pocket probing helps in knowing location and extent of the pockets.

### Microbiological Examination

Occasionally the microbiological analysis can provide an important information regarding the main source of the problem.

## CLASSIFY ENDODONTIC PERIODONTAL LESIONS

Simon et al have classified the lesions based on the primary source of the infection. It is:

1. Primary endodontic lesion.
2. Primary endodontic lesion with secondary periodontal involvement.
3. Primary periodontal lesions.
4. Primary periodontal lesions with secondary endodontic involvement.

### Primary Endodontic Lesions (Fig. 22.1)

- Sometimes an acute exacerbation of chronic apical lesion in a nonvital tooth may drain coronally through periodontal ligament into the gingival sulcus, thus mimic clinically the presence of periodontal abscess.
- Tooth is associated with necrotic pulp, pulp does not show response to vitality tests.
- Sinus tract may be seen from apical foramen, lateral canals or the furcation area.
- Probing shows true pockets. Pocket is associated with minimal plaque or calculus. The significant sign of this lesion is that patient does not have periodontal disease in other areas of oral cavity.

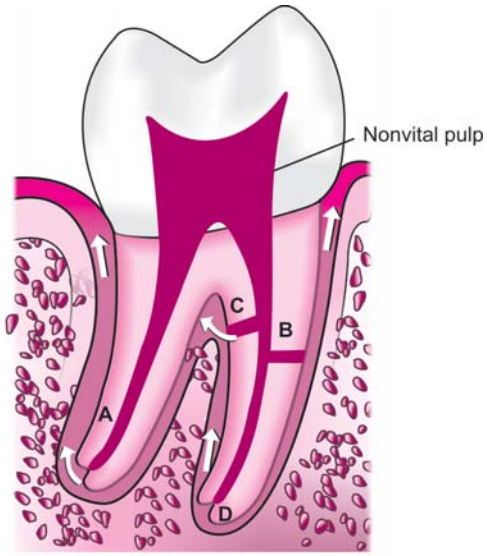



**Fig. 22.1:** Spread of infection can occur (A) from apical foramen to gingival sulcus via periodontium (B) from lateral canal to pocket (C) from lateral canal to furcation (D) from apex to furcation

*Treatment*

- Root canal therapy.
- Good prognosis.

### Primary Endodontic Lesion with Secondary Periodontal Involvement (Fig. 22.2)

These lesions appear if primary endodontic lesion is not treated. The endodontic disease will continue, resulting in destruction of periapical alveolar bone, progression into the interradicular area, and finally causing break down of surrounding hard and soft tissues.

*Treatment*

- Root canal treatment to remove irritants from pulp space.
- Concomitant periodontal therapy.

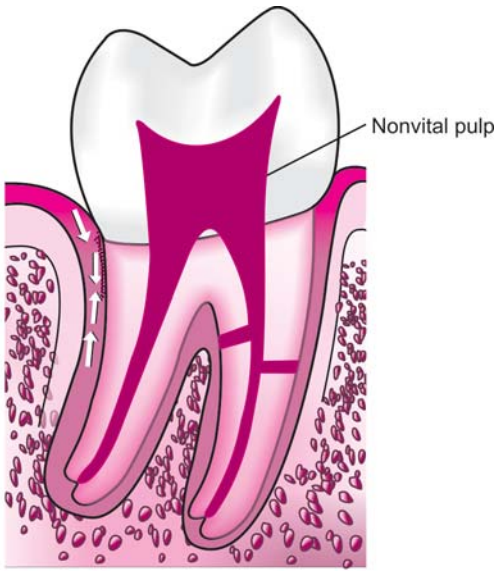



**Fig. 22.2:** Primary endodontic lesion with secondary periodontal involvement

- Extraction of teeth with vertical root fracture if prognosis is poor.

### Primary Periodontal Lesions (Fig. 22.3)

- Primarily these lesions are produced by the periodontal disease. In these lesions periodontal

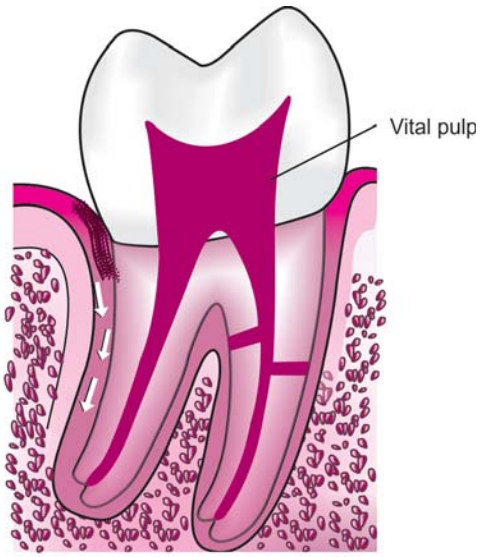



**Fig. 22.3:** Primary periodontal lesion

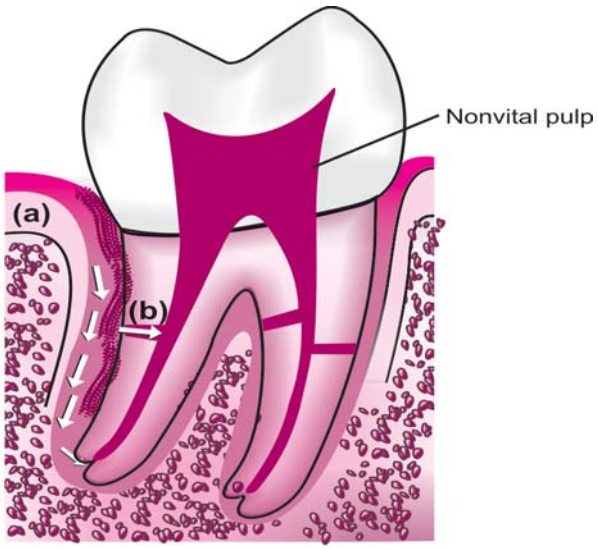



**Fig. 22.4:** Spread of periodontal lesion into endodontic space via: (a) periodontium into apex (b) lateral canals

break down slowly advances down to the root surface until the apex is reached. Pulp may be normal in most of the cases but as the disease progress, pulp may become affected.
- Periodontal probing may show presence of plaque and calculus within the periodontal pocket.
- Usually generalized periodontal involvement is present.

*Treatment*

- Oral prophylaxis and oral hygiene instructions.
- Scaling and root planning.
- Periodontal surgery, root amputation.

## Primary Periodontal Lesions with Secondary Endodontic Involvement (Fig. 22.4)

- Periodontal disease may have effect on the pulp through lateral and accessory canals, apical foramen, dentinal tubules or during iatrogenic errors. Once the pulp gets secondarily affected, it can in turn affect the primary periodontal lesion.
- Oral examination of patient reveals presence of generalized periodontal disease.

*Treatment*

- Root canal treatment
- Periodontal surgery in some cases.

## Independent Endodontic and Periodontal /Lesions which do not Communicate

- One may commonly see a tooth associated with pulpal and periodontal disease as separate and distinct entities. Both the disease states exist but with different etiological factors and with no evidence that either of disease has impact on the other.
- Periodontal examination may show periodontal pocket associated with plaque or calculus.
- Tooth is usually nonvital.
- Root canal treatment is needed for treating pulp space infection.
- Periodontal therapy is required for periodontal problem.

## True Combined Endo-Perio Lesions (Fig. 22.5)

- The true combined lesions are produced when one of these lesion (pulpal or periodontal) which are present in and around the same tooth coalesce and become clinically indistinguishable. These are difficult to diagnose and treat.
- After completion of endodontic therapy, periodontal therapy is started which may include scaling, root planning, surgery along with oral hygiene instructions.

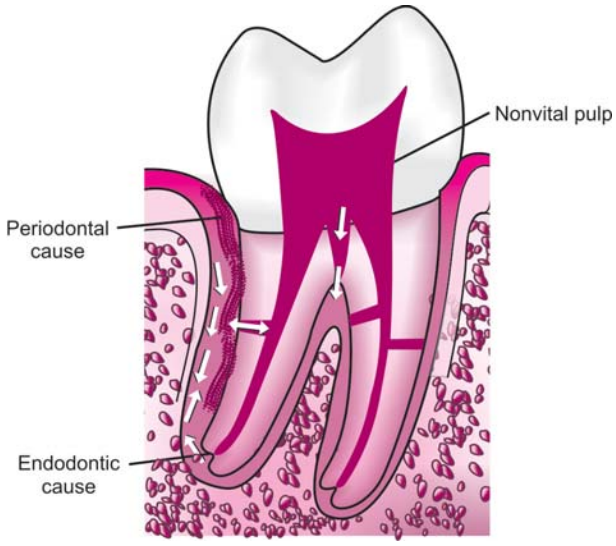



**Fig. 22.5:** True combined endo-perio lesion

## HOW IS DIFFERENTIAL DIAGNOSIS BETWEEN PULPAL AND PERIODONTAL DISEASE MADE?

| *Features* | *Periodontal* | *Pulpal* |
|---|---|---|
| Etiology | Periodontal infection | Pulpal infection |
| Plaque and calculus | Commonly seen | No relation |
| Tooth vitality | Tooth is vital | Non vital |
| Periodontal destruction | Usually present, and generalized | If present single, isolated |
| Pattern of disease | Generalized | Localized |
| Radiolucency | Usually not related | Periapical radiolucency |
| Treatment | Periodontal therapy | Root canal therapy |

# 23 Management of Dental Traumatic Injuries

## ETIOLOGY OF TRAUMATIC INJURIES

- **A**utomobile injury
- **B**attered child
- **C**hild abuse
- **D**rug abuse
- **E**pilepsy
- **F**alls from height
- **S**ports related injuries.

## CLASSIFY DENTOFACIAL INJURIES

The most recommended classification is one based on the WHO and modified by Andreasen and Andreasen.

*Soft Tissues*

Lacerations - 873.69
Contusion - N 902.0
Abrasions - N 910.00

*Tooth Fractures*

N873.60 Enamel fracture
N873.61 Crown-fractures-uncomplicated (no pulp exposure)
N873.62 Crown-fractures-complicated (with pulp exposure)
N873.64 Crown-root fractures
N873.63 Root fractures

*Luxation Injuries*

873.66 - Tooth concussion
873.66 - Subluxation
873.66 - Extrusive luxation
873.66 - Lateral luxation
873.67 - Intrusive luxation
873.68 - Avulsion

*Facial Skeletal Injuries*

- Alveolar process: maxilla/mandible
- Body of maxilla/mandible
- Temporomandibular joint.

### Ellis and Davey's Classification (1960)

- Class I - Simple fracture of the crown involving enamel.
- Class II - Extensive fracture of the crown, with considerable amount of dentin involved but no pulp exposure.
- Class III - Extensive fracture of the crown, with considerable amount of dentin involved, with pulp exposure.
- Class IV - Traumatized tooth becomes non-vital (with or without loss of crown structure).
- Class V - Tooth lost due to trauma.
- Class VI - Fracture of root with or without crown or root structure.
- Class VII - Displacement of the tooth without crown or root fracture.
- Class VIII - Fracture of crown en mass.
- Class IX - Fracture of deciduous teeth.

### WHO Classification

WHO gave following classification in 1978 with code no. corresponding to International Classification of Diseases.

- 873.60 - Enamel fracture

- 873.61 - Crown fracture involving enamel, dentin without pulpal involvement
- 873.62 - Crown fracture with pulpal involvement
- 873.63 - Root fracture
- 873.64 - Crown - root fracture
- 873.66 - Luxation
- 873.67 - Intrusion or extrusion
- 873.68 - Avulsion
- 873.69 - Other injuries such as soft tissue lacerations

* *This classification was modified by Andreasen as following:*

- 873.64 - Uncomplicated crown-root fracture without pulp exposure
- 873.64 - Complicated crown-root fracture without pulp exposure
- 873.66 - Concussion
- 873.66 - Subluxation
- 873.66 - Lateral luxation

## WHAT ARE STEPS FOR EXAMINATION OF TRAUMATIC INJURIES?

### Chief Complaint

Patient should be asked for pain and other symptoms.

### History of Chief Complaint

When, how and where of the trauma are significant.

### Medical History

*Patient should be asked for:*

- Allergic reaction to medication
- Disorders like bleeding problems, diabetes, epilepsy, etc.
- Any current medication patient is taking.

### Clinical Examination

- Extraoral examination should rule out any facial bone fracture and should include meticulous evaluation of the soft tissues.
- Occlusion and temporomandibular joints should also be examined carefully.
- Explore the extent of tooth fracture involvement, i.e. enamel, dentin, cementum and/or pulp.
- Teeth and their supporting structures should be examined carefully.
- Examine mobility in all the directions.
- Condition of pulp should be noted at the time of injury and at various times following traumatic incidence.
- Radiographic examination should be done in the area of suspected injury.

## CROWN INFRACTION/ ENAMEL FRACTURE

- It is incomplete fracture of enamel without loss of tooth structure.
- Appears as craze lines running parallel with direction of enamel rods and ending at dentinoenamel junction.
- It can occur alone or can be a sign of a concomitant attachment injury where force taken up by attachment injury leaves enough force to crack the enamel.

### Diagnosis

- Tooth is usually vital.
- Best seen by fiberoptic light source, resin curing light, indirect light and transillumination.

### Treatment

- Smoothening of rough edges by selectively grinding of enamel.
- Repairing fractured tooth surface by composite if needed for cosmetic purposes.

## EXPLAIN CROWN FRACTURE

### Uncomplicated Crown Fractures

Crown fractures involving enamel and dentin and not the pulp are called as ***uncomplicated crown fractures*** (Fig. 23.1).

**Fig. 23.1:** Uncomplicated crown fracture

*Biological Consequences*

If only enamel is fractured -Minimal consequences.

If dentin is exposed—A direct pathway for various irritants to pass through dentinal tubules to underlying pulp is formed.

*Diagnosis*

It could be easily revealed by clinical examination.

If dentin is exposed, sensitivity to heat or cold may be present.

*Treatment*

- For esthetic reasons, composite restorations can be placed after acid etching.
- ***If there is involvement of both enamel and dentin:*** A restoration is needed to seal the dentinal tubules and to restore the aesthetics.

If the fracture fragment of crown is available, reattach it.

## Complicated Crown Fractures

Crown fracture involving enamel, dentin and pulp are called as complicated crown fractures (Fig. 23.2).

*Diagnosis*

Diagnosis is made by:

- Clinically evaluating the fracture
- Pulp testing.

**Fig. 23.2:** Complicated crown fracture involving pulp

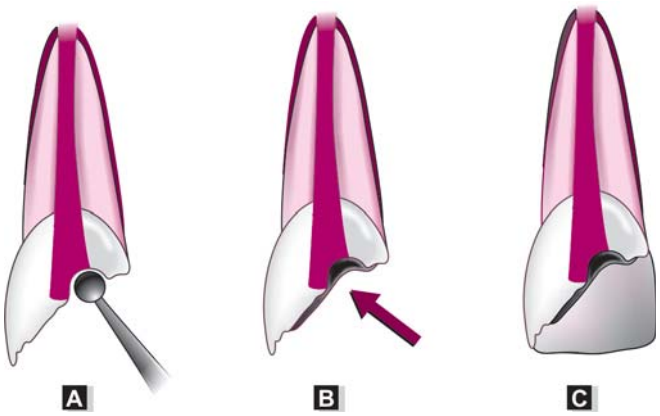
*Factors Affecting the Treatment Plan*

Factors like extent of fracture, stage of root maturation are imperative in deciding the treatment plan for complicated root fracture.

*Treatment*

Pulp capping and pulpotomy are the measures that permit apexogenesis to take place and may avoid the need for root canal therapy. The choice of treatment depends on the size of the exposure, the presence of hemorrhage and the length of time since the injury.

- **Pulp exposure within 3 hours**:
  Pulp capping – implies placing the dressing directly on to the pulp exposure.
- **Pulp exposure between 24 to 72 hours**:
  Pulpotomy- implies removal of the coronal pulp tissue to the level of healthy pulp (Fig. 23.3).
- **Pulp exposure beyond 72 hours**:
  Apexification- for young permanent teeth
  Pulpectomy- for primary teeth
  Endodontic therapy- for mature permanent tooth




**Figs 23.3A to C:** Shallow pulpotomy of fractured tooth

## Prerequisites for Success of Vital Pulp Therapy

Vital pulp therapy has an extremely high success rate if the clinician strictly adheres to the following requirements:

1. ***Treatment of a non-inflamed pulp:*** Treatment of a non-inflamed pulp is found to be better than the inflamed pulp.
2. ***Pulp dressing:*** Many materials such as zinc oxide eugenol, calcium hydroxide, tricalcium phosphate

and composite resin are used as medicaments for vital pulp therapy.

3. *Bacteria tight seal:* Introduction of bacteria during the healing phase can cause failure.

## Apexification

If the pulp tissue is necrotic, apexification is the process which stimulates the formation of a calcified barrier across the apex. Apexification is done to stimulate the hard tissue barrier. For this, after cleaning and shaping, calcium hydroxide is packed against the apical soft tissue and later backfilling with calcium hydroxide is done to completely obturate the canal.

When completion of hard tissue is suspected (after 3-6 months), calcium hydroxide is removed and radiograph is taken. When found satisfactory, obturation of the canal using softened gutta percha techniques is done.

## WHAT ARE CROWN ROOT FRACTURES?

Crown root fracture involves enamel, dentin and cementum with or without the involvement of pulp.

**In anterior teeth,** usually occurs by direct trauma causing chisel type fracture which splits crown and root (Fig. 23.4).

**In posterior teeth**, fracture is rarely seen. It can occur because of indirect trauma like large sized restorations and high speed instrumentation, etc.

**Fig. 23.4:** Shattering of crown by crown root fracture

## Diagnosis

A tooth with crown-root/fracture exhibits following features:

- Coronal fragment is mobile.
- Inflammatory changes in pulp and periodontal ligament are seen due to plaque accumulation in the line of fracture.
- Patient may complain of sensitivity to hot and cold.
- Radiographs are taken at different angles to assess the extent of fracture (Fig. 23.5).

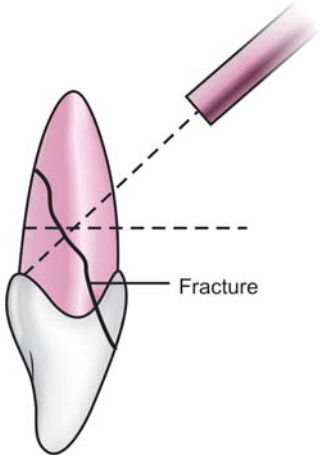



**Fig. 23.5:** Radiographic technique used for crown root fracture

## Treatment

*Following should be considered while management of crown root fracture*:

- If there is no pulp exposure, fragment can be treated by bonding alone or by restoring tooth structure with composites.
- If pulp exposure has occurred, pulpotomy or root canal treatment is indicated depending upon condition of the tooth.
- When root portion is long enough to accommodate a post-retained crown, then surgically removal of the coronal fragment and surgical extrusion of the root segment is done.
- To accommodate a post-retained crown, after removal of the crown portion, orthodontic extrusion of root can also be done.

## HOW ARE ROOT FRACTURES TREATED?

These are uncommon injuries but represent a complex healing pattern due to involvement of dentin, cementum, pulp and periodontal ligament (Fig. 23.6).

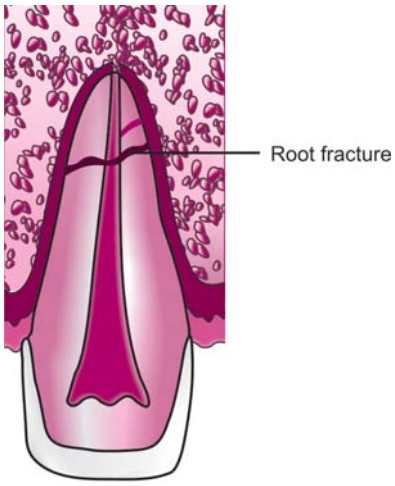



**Fig. 23.6:** Root fracture can be transverse or oblique in nature

### Classification

*According to direction*:
- Horizontal
- Vertical
- Oblique

*According to number*
- Single
- Multiple
- Comminuted

*According to extent*
- Partial
- Total

*According to location*
- Apical third
- Middle third
- Cervical third

*According to position of root fragments*
- Displaced
- Not displaced.

### Diagnosis

- Displacement of coronal segment.
- Radiographs at varying angles (usually at 45°, 90° and 110°).

### Treatment

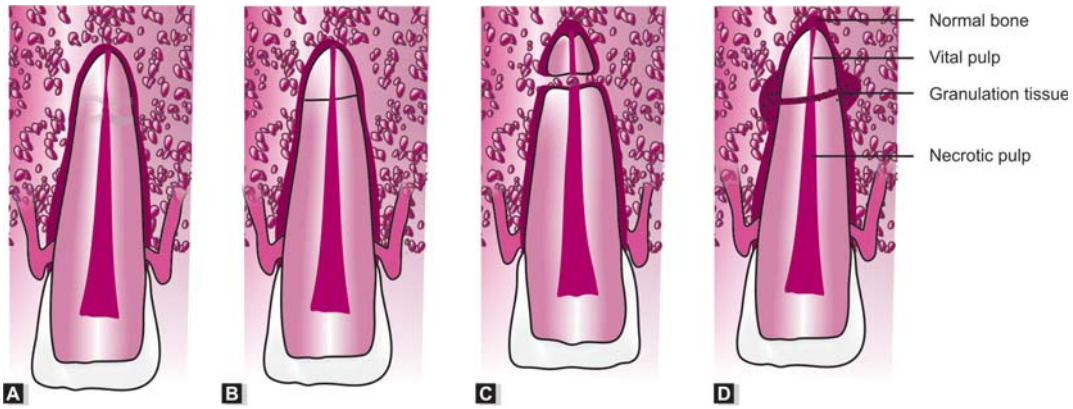
If only apical third fracture is suspected, displaced coronal portion should be repositioned and stabilized by splinting for 2-3 weeks.

Commonly, it is seen that apical segment of fractured root contains vital pulp whereas coronal pulp has become necrotic. In these cases, following treatment options are available.

1. Root canal therapy for both coronal and apical segment.
2. Root canal therapy of coronal segment and no treatment of apical segment.
3. Root canal therapy for coronal segment and surgical removal of apical third.
4. Apexification type procedure of coronal segment.
5. Use of intraradicular splint.
6. Root extrusion for teeth with fracture at or near alveolar crest.

*Root fracture can show healing in following ways (Fig. 23.7)*:

1. Healing with calcified tissue in which fractured fragments are in close contact.




**Figs 23.7A to D:** (A) Interproximal inflammatory tissue seen in root fracture, (B) Healing of root fracture with calcified tissue, (C) Healing of root fracture by interproximal bone, (D) Healing of root fracture by formation of connective tissue between the segments

2. Healing with interproximal connective tissue in which radiographically fragments appear separated by a radiolucent line.
3. Healing with interproximal bone and connective tissues. Here fractured fragments are seen separated by a distinct bony bridge radiographically.
4. Interproximal inflammatory tissue without healing. Radiographically it shows widening of fracture line.

## PROGNOSIS DEPENDS ON

- *Amount of dislocation and degree of mobility of coronal segment*: More is the dislocation, poorer is the prognosis.
- *Stage of tooth development*: More immature the tooth, better the ability of pulp to recover from trauma.

## WHAT ARE LUXATION INJURIES?

Luxation injuries cause trauma to supporting structures of teeth ranging from minor crushing of periodontal ligament and neurovascular supply of pulp to total displacement of the teeth.

**In concussion**
- Tooth is not displaced.
- Mobility is not present.
- Pulp may respond normal to testing.

**In subluxation**
- Teeth are sensitive to percussion and have some mobility.
- Sulcular bleeding is seen showing damage and rupture of the periodontal ligament fibers.
- Pulp responds normal to testing.

### *Treatment of Concussion and Subluxation*

- Relief the occlusion by selective grinding of opposing teeth.
- Immobilize the injured teeth.

**In lateral luxation**
- Trauma displaces the tooth away from its long axis (Fig. 23.8).
- Sulcular bleeding is present.
- Tooth is sensitive to percussion.

**In extrusive luxation**
- Tooth is displaced from the socket along its long axis (Fig. 23.9).
- Tooth is very mobile.

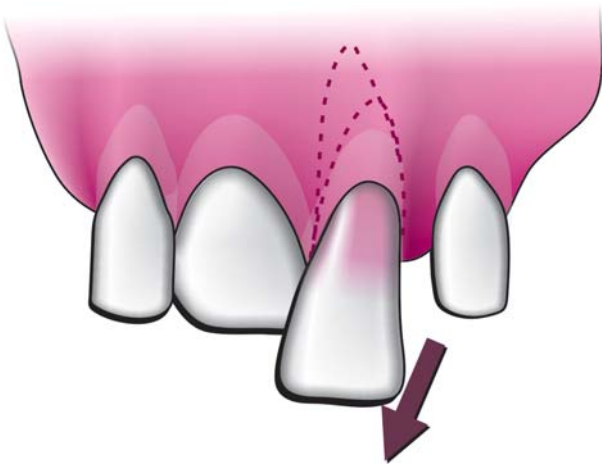


**Fig. 23.8:** Lateral luxation

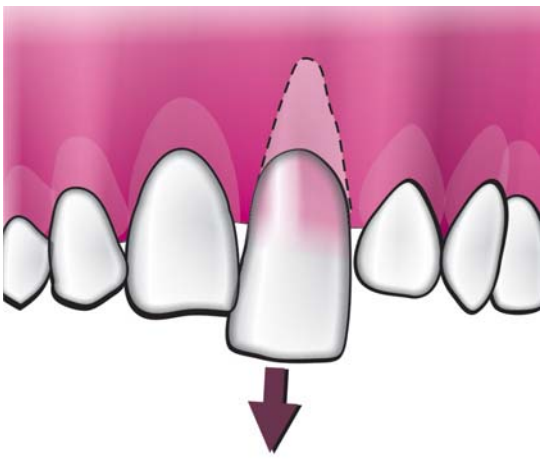


**Fig. 23.9:** Extrusive luxation

### *Treatment of Lateral and Extrusive Luxation*

Treatments of these injuries consist of a traumatic repositioning and fixation of teeth which prevents excessive movement during healing.

Pulp testing should be performed on regular intervals.

**In intrusive luxation**
- Tooth is forced into its socket in an apical direction (Fig. 23.10).
- Maximum damage has occurred to pulp and the supporting structures.
- Tooth is in infraocclusion.
- Radiographic evaluation is needed to know the position of tooth.

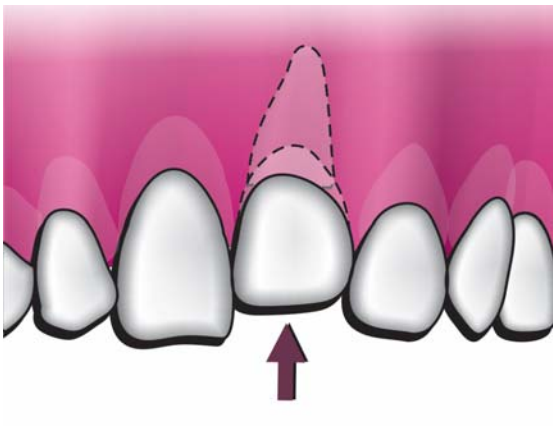


**Fig. 23.10:** Intrusive luxation

***Treatment***

- In immature teeth, spontaneous re-eruption is seen.
- If re-eruption stops before normal occlusion is attained, orthodontic movement is initiated before tooth gets ankylosed.

If tooth is severely intruded, surgical extrusion is done.

## HOW WILL YOU MANAGE A CASE OF AVULSION (EXARTICULATION)?

It is defined as complete displacement of the tooth out of socket (Fig. 23.11). It can result in formation of:

- Infection
- Loss of space in the dental arch
- Ankylosis
- Resorption of root structure
- Abnormal root development
- Color changes.

**Fig. 23.11:** Avulsion of tooth

### What to Do When a Patient Comes with Avulsed Tooth?

When a patient comes with an avulsed tooth, the main aim of the reimplantation is to preserve the maximal number of periodontal ligament cells which have capability to regenerate and repair the injured root surface. Thus periodontal ligament cells should be prevented from drying. If it is not possible to reimplant the tooth immediately, it should be placed in an adequate storage media. Following are tooth storage media:

- Hank's balanced solution
- Milk
- Saline
- Saliva
- Water

### Management Options for an Avulsed Tooth

- ***If the tooth has been out of its socket less than 15 minutes,*** place it in a tooth-preservation solution, wash out the socket and reimplant the tooth firmly.
- ***If the tooth has been out 15 minutes to 2 hours,*** soak for 30 minutes to replenish nutrients. Local anesthesia will probably be needed before reimplanting as above.
- ***If the tooth was out over two hours***, the periodontal ligament is dead, and should be removed. Tooth should be thoroughly cleaned and disinfected before reimplanting.
- ***If the patient is between 6 and 10 years old,*** soak the tooth for 5 minutes in 5 percent doxycycline to kill bacteria which could enter the immature apex and form an abscess.
- Reimplanted primary teeth heal by ankylosis. Ankylosis of deciduous teeth will have the following consequences:
  - It will result in cosmetic deformity since the area of ankylosis will not grow at the same rate as the rest of the dentofacial complex.
  - Ankylosis can also interfere with the eruption of the permanent tooth.

### Postemergency Treatment

- The splint should be removed after 7 days unless the excessive mobility is present.
- Endodontic therapy should be started in 7-10.

# 24 Bleaching of Discolored Teeth

- Teeth are polychromatic, color varies among the gingival, incisal and cervical areas according to the thickness, reflections of different colors and translucency of enamel and dentin (Fig. 24.1).
- Color of healthy teeth is primarily determined by the translucency and color of dentine and is modified by:
  - Color of enamel covering the crown
  - Translucency of enamel
  - Thickness of enamel
  - Normal color of primary teeth is bluish white whereas color of permanent teeth is grayish yellow, grayish white or yellowish white.

## CLASSIFICATION AND ETIOLOGY OF TOOTH DISCOLORATION

### Classification

- Extrinsic discoloration
- Intrinsic discoloration
- Combination of both.

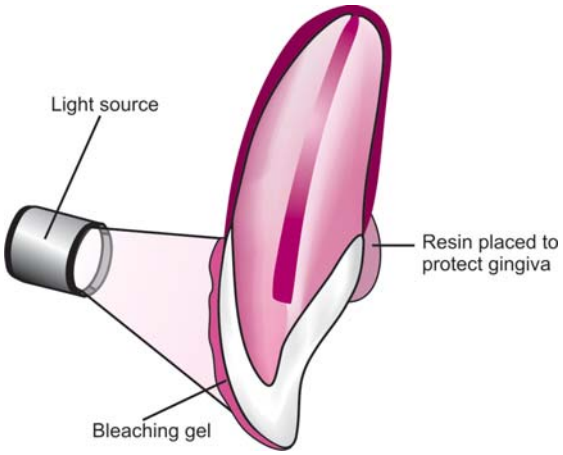



**Fig. 24.1:** Power bleaching technique

### Etiology

*Intrinsic Stains*

A. Pre-eruptive causes
   i. Disease
      - Hematological diseases
      - Disease of enamel and dentine
   ii. Medication
      - Tetracycline stains and other antibiotic use
      - Fluorosis stain

B. Post-eruptive causes of discoloration
   i. Pulpal changes
   ii. Trauma
   iii. Dentin hypercalcification
   iv. Dental caries

*Extrinsic Stains*

A. Daily acquired stains
   i. Plaque
   ii. Food and beverages
   iii. Tobacco use
   iv. Poor oral hygiene

B. Chemicals
   i. Chlorhexidine
   ii. Metallic stains

## WHAT ARE CONTRAINDICATIONS FOR BLEACHING?

### Contraindication

- Poor patient and case selection: Psychological or emotional patient.

- Dentin hypersensitivity
- Extensive resorted tooth
- Teeth with hypoplastic marks and cracks
- Defective and weakly restoration
  - Defective obturation
  - Discoloration from metallic salts as mercury.

## WHAT SHOULD AN IDEAL BLEACHING AGENT HAVE?

### An Ideal Bleaching Agent should

- Be easy to apply on the teeth.
- Have a neutral pH
- Lighten the teeth efficiently
- Not irritate or dehydrate the oral tissues
- Not cause damage to the teeth.

## WHAT ARE EFFECTS OF BLEACHING AGENTS ON TOOTH?

### Effects of Bleaching Agents on Tooth

- Tooth sensitivity
- Alteration of enamel surface
- Effects on Dentine: Bleaching has shown to cause uniform change in color through dentine
- Effects of bleaching on pulp:
  - Transient reduction in pulpal blood flow
  - Occlusion of pulpal blood vessels.
- Effects on Restorative Materials: Application of bleaching on composites has shown following changes:
  - Increased surface hardness
  - Surface roughening and etching
  - Increased microleakage
- Mucosal irritation
- Toxicity.

## HOME BLEACHING TECHNIQUE/NIGHT GUARD VITAL BLEACHING FOR VITAL TEETH

It involves use of chemical agents within the coronal portion of an endodontically treated tooth to remove tooth discoloration.

### Composition

- Superoxol
- Sodium perborate

### Indications

- Mild generalized staining
- Age related discolorations
- Mild tetracycline staining
- Mild fluorosis.

### Contraindications

- Teeth with insufficient enamel for bleaching
- Teeth with deep and surface cracks and fracture lines
- Teeth with inadequate or defective restorations
- Severe tetracycline staining
- Teeth exhibiting extreme sensitivity to heat, cold or sweets
- Teeth with opaque white spots.

### Advantages

- Simple method for patients to use
- Less chair time and cost effective.

### Disadvantages

- Patient compliance is mandatory
- Color change is dependent on amount of time the trays are worn.

### Composition of Solution

- 10 percent carbamide peroxide solution
- 3 percent hydrogen peroxide
- 7 percent urea.

### Technique

- Take the impression and make a stone model
- Trim the model
- Place the stock out resin and cure it
- Choose the tray sheet material
- Cast the plastic in vacuum tray forming machines
- Trim and polish the tray
- Checking the tray for correct fit, retention and over extension
- Demonstrate the amount of bleaching material to be placed.

### Treatment Regimen

When and how long to keep the trays in the mouth, depends on patients lifestyle preference and schedule. Wearing the tray during day time allows replenishment

of the gel after 1-2 hrs for maximum concentration. Overnight use causes decrease in loss of material due to decreased salivary flow at night and decreased occlusal pressure. Patient is recalled 1-2 weeks after wearing the tray.

## IN OFFICE BLEACHING FOR VITAL TEETH

### Various Available Light Sources are

- Conventional bleaching light
- Tungsten halogen curing light
- Xenon plasma arc light
- Argon and $CO_2$ lasers
- Diode laser light.

### Procedure

- Isolate the teeth with rubber dam.
- Mix power bleach gel or solution.
- Apply 2-3 mm thick over labial surface using a disposable brush.
- Depending upon light, expose the teeth/tooth (Fig. 24.1) .
- Remove gel with the help of wet gauge.
- Repeat the procedure until desired shade is produced.
- Polish teeth and apply neutral sodium fluoride gel.
- Instruct the patient to avoid coffee, tea, etc. for 2 weeks.

Second and third appointment is done 3-6 weeks after. This will allow pulp to settle.

### Advantages

- Patient preference
- Less time than overall time needed for home bleaching

### Disadvantages

- More chair time
- More expensive
- Dehydration of teeth.

## WALKING BLEACH OF NONVITAL TEETH/ ENDODONTICALLY TREATED TEETH

It involves use of chemical agents within the coronal portion of an endodontically treated tooth to remove tooth discoloration.

When paste is placed in pulp chamber, it causes oxidation of the stain and thus its lightening.

### Indications of Intracoronal Bleaching

- Discolorations of pulp chamber origin
- Moderate to severe tetracycline staining.

### Contraindications of Intracoronal Bleaching

- Superficial enamel discoloration
- Defective enamel formation.

### Steps

1. Assess the quality of obturation.
2. Evaluate tooth color with shade guide.
3. Isolate the tooth with rubber dam.
4. Prepare the access cavity, remove the coronal gutta-percha, expose the dentine and refine the cavity.
5. Place mechanical barriers of 2 mm thick, preferably of glass ionomer cement, zinc phosphate, IRM on root canal filling material.
6. Now mix sodium perborate with an inert liquid and place this paste into pulp chamber (Fig. 24.2).
7. Place a temporary restoration over it.
8. Recall the patient after 1-2 weeks, repeat the treatment until desired shade is achieved.

**Fig. 24.2:** Placement of bleaching mixture into pulp chamber and sealing of cavity using temporary restoration

### Complications of Intracoronal Bleaching

- External root resorption.
- Chemical burns if using 30-35 percent $H_2O_2$.
- Damage to restorations.

# 25 Dentin Hypersensitivity

## EXPLAIN TOOTH/DENTINE HYPERSENSITIVITY

Dentin hypersensitivity is defined as "sharp, short pain arising from exposed dentine in response to stimuli typically thermal, chemical, tactile or osmotic and which cannot be ascribed to any other form of dental defect or pathology.

### Theories of Dentin Sensitivity

- Neural theory
- Odontoblastic transduction theory
- Hydrodynamic theory
- Modulation theory.

*Neural Theory*

- Attributes activation to an initial excitation of those nerves ending within the dentinal tubules.
- These nerve signals are then conducted along the parent primary afferent nerve fibers in the pulp, into the dental nerve branches, and then into the brain.

*Odontoblastic Transduction Theory*

The theory says that stimuli initially excite the process or body of the odontoblast, and the odontoblast transmits the excitation of these associated nerve endings.

*The Hydrodynamic Theory*

- Given by Brannstrom (1962).
- Stimulus causes displacement of the fluid that exists in the dentinal tubules, this mechanical disturbance activates the nerve endings present in the dentin or pulp.
- The dehydration of dentin by air blasts also causes outward fluid movement and stimulates the mechanoreceptor of the odontoblast, causing pain.
- The pain produced when sugar or salt solutions are placed in contact with exposed dentin can also be explained by dentinal fluid movement. Dentinal fluid is of relatively low osmolarity, which have tendency to flow towards solution of higher osmolarity, i.e. salt or sugar solution (Fig. 25.1).

### Incidence and Distribution of Dentine Hypersensitivity

- Most sufferers range in range from 20-40 years.
- A slightly higher incidence of dentine hypersensitivity is reported in females than in males.

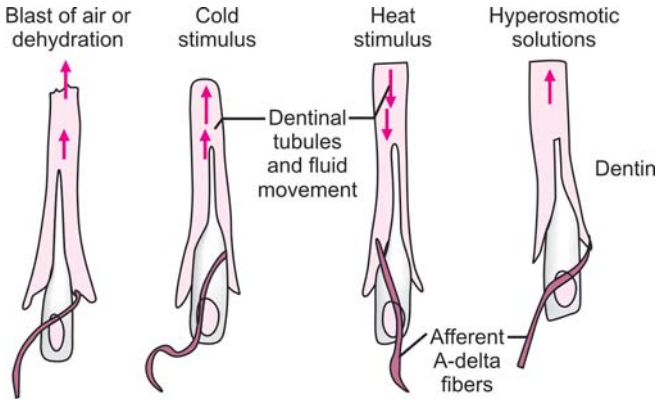



**Fig. 25.1:** Pain produced by different stimuli

- Hypersensitivity is most commonly noted on buccal cervical zones of permanent teeth.
- Regarding the side of mouth, in right handed tooth brushers the dentine hypersensitivity is greater on the left sided teeth compared with the equivalent contralateral teeth.

## Etiology and Predisposing Factors

The primary underlying cause for dentin hypersensitivity is exposed dentin tubules. Dentin may become exposed by two processes; either by loss of covering periodontal structures (gingival recession), or by loss of enamel.

## Common Reasons for Gingival Recession

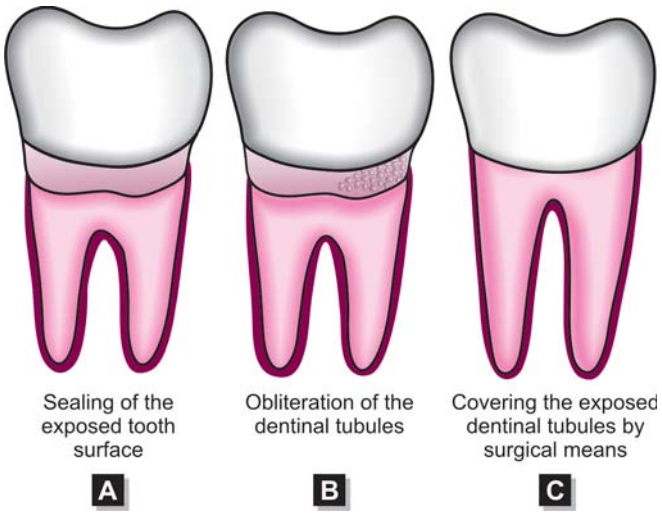
- Toothbrush abrasion.
- Pocket reduction periodontal surgery.
- Oral habits resulting in gingiva laceration, i.e. traumatic tooth picking, eating hard foods.
- Excessive tooth cleaning.

## Causes of Loss of Enamel

- Attrition by exaggerated occlusal functions like bruxism.
- Abrasion from dietary components or improper brushing technique.

## Management of Dentine Hypersensitivity

1. Home care with dentifrices:
   a. Strontium chloride dentifrices
   b. Potassium nitrate dentifrices
2. In office treatment procedure: Treatment of hypersensitive teeth should be directed towards reducing the anatomical diameter of the tubules, obliteration of the tubules or to surgically cover the exposed dentinal tubules so as to limit fluid movement (Fig. 25.2). It can be done by following options:
   a. Cavity varnishes: Open tubules can be covered with a thin film of varnish, providing a temporary relief; cavity varnish such as copalite can be use for this purpose.
   b. Treatments that partially obturate dentinal tubules.
      - Zinc chloride: Potassium ferrocyanide
      - Calcium compounds: The exact mechanism of action is unknown but evidence suggests that:
        i. It may block dentinal tubules.
        ii. Promote peritubular dentin formation.
        iii. On increasing the concentration of calcium ions around nerve fibers, may results in decreased nerve excitability. So, calcium hydroxide might be capable of suppressing nerve activity.
      - Fluoride compounds:
        — Sodium fluoride: Application of NaF leads to precipitation of calcium fluoride crystals, thus, reducing the functional radius of the dentinal tubules.
        — Sodium silicofluoride
        — Stannous fluoride: Ten percent solution of stannous fluoride forms dense layer of tin and fluoride containing globular particles blocking the dentinal tubules.
        — Iontophoresis: The objective of fluoride iontophoresis is to drive fluoride ions more deeply into the dentinal tubules than cannot be achieved with topical application of fluoride alone.
   c. Tubule sealant
      - Restorative resins: The objective in employing resins and adhesives is to seal the dentinal tubules to prevent pain producing stimuli from reaching the pulp.
      - Dentin bonding agents: GLUMA is a dentin bonding system that includes gluteraldehyde primer and 35 percent HEMA (hydroxyethyl methacrylate). It provides an attachment to dentin which is immediate and strong.
3. Patient education
   a. Dietary counseling
   b. Tooth brushing technique
   c. Plaque control




**Figs 25.2A to C:** Treatment of dentin hypersensitivity

# 26 Pediatric Endodontics

## PULPOTOMY

Pulpotomy refers only to coronal extirpation of vital pulp tissue.

### Criteria for Successful Pulpotomy

- No indication of root resorption should be present.
- No radiographic sign of periradicular periodontitis.
- Continued root development should be evident radiographically.

### Indications

- A vital tooth with healthy periodontal condition
- No mobility of tooth
- No tenderness to percussion
- A restorable tooth.

### Contraindications

- Presence of sinus or fistula
- Swelling
- History of spontaneous toothache
- Tooth sensitive to percussion
- Mobility present
- Root resorption or radicular disease is present radiographically
- Pus at exposure site
- Presence of pulp calcifications.

*Materials used:*

- Formocresol
- Gluteraldehyde.

### Complete Pulpotomy

*Formocresol Pulpotomy*

Formocresol is preferred in primary teeth because of high success rate.

*Indications*

- Vital primary tooth with carious or accidental exposure
- No evidence of pulpal pain
- Clinical signs of normal pulp.

*Contraindications*

- Presence of spontaneous pain
- Tooth tender on percussion
- Presence of any associated swelling
- Any evidence of external or internal root resorption
- Evidence of pulpal pathologies.

*Clinical technique*

- Give adequate local anesthesia in the area
- Apply rubber dam to isolate the tooth
- Extirpate coronal pulp down to pulp stump at orifice of canals with the help of round bur or spoon excavator
- Extirpate coronal pulp down to pulp stump at orifice of canals with the help of round bur or spoon excavator
- Moisten a cotton pellet with Buckley's formocresol and blot it on sterile gauze to remove excess of the formocresol
- After the bleeding has been controlled, formocresol cotton pellet is placed in contact with pulp for five minutes and it will cause fixation of the pulp tissue (Fig. 26.1)
- Over it, place zinc oxide eugenol dressing.

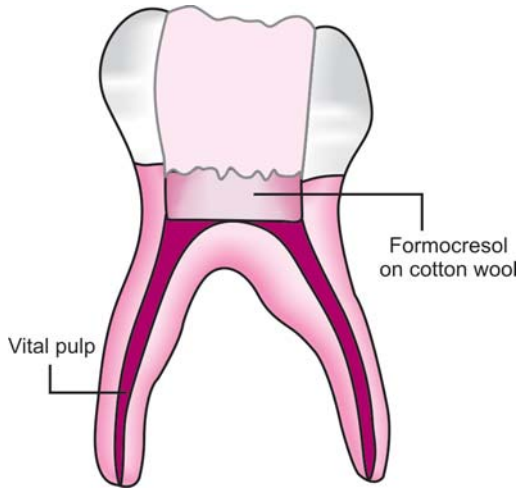



**Fig. 26.1:** Formocresol pulpotomy

## Partial Pulpotomy/Shallow Pulpotomy/ Cvek Pulpotomy

It implies removal of the coronal pulp tissue to the level of healthy pulp.

*Technique*

- After anesthetizing the tooth rubber dam is applied.
- After that 1-2 mm deep cavity into the pulp is prepared using a diamond bur.
- Bleeding is controlled using cotton pellet moistened with saline.
- A thin coating of calcium hydroxide mixed with saline solution or anesthetic solution is placed over it and the access cavity is sealed.

## Laser Pulpotomy

Nd:YAG Laser has also been used for pulpotomy, though not a treatment of a choice as it is expensive.

## PULPECTOMY FOR PRIMARY TEETH

Pulpectomy for primary teeth refers to the complete removal of pulp tissue from a tooth.

### Indications

- History of spontaneous pain.
- In primary tooth with irreversible pulpitis or necrosis.
- Internal resorption that does not perforate root.

### Contraindications

- A nonrestorable tooth
- Extensive bony loss.

### Clinical Sequence

- Give adequate local anesthesia.
- Penetrate pulp chamber with the help of slow speed round bur (Fig. 26.2).
- Remove pulp tissue and take the working length X-ray.
- Complete the biomechanical preparation of canals (Fig. 26.3).
- Copious irrigation is necessary to flush out debris.
- Now place the paper points moistened with formocresol approximately for five minutes to fix any remaining tissue.
- After this, remove the paper point and fill the canal with zinc oxide eugenol cement (Fig. 26.4).
- Finally, tooth is restored with stainless steel crown.

**Fig. 26.2:** Penetrate the pulp chamber with round bur

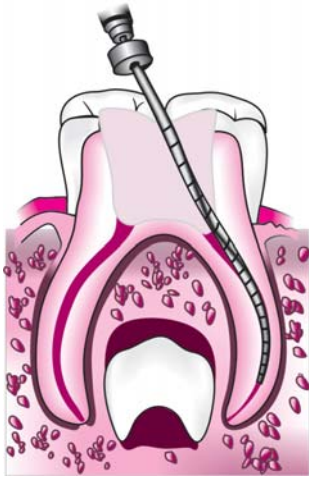


**Fig. 26.3:** Extirpate the pulp and complete biomechanical preparation

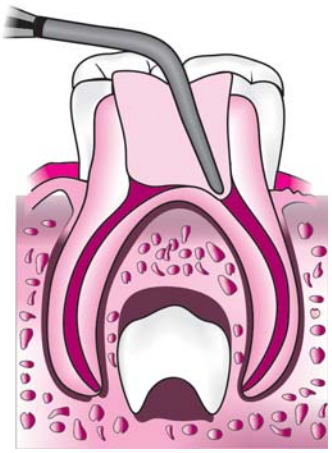


**Fig. 26.4:** Placement of ZOE cement in the canal

*Commonly used material for filling the canals are*:

1. Zinc oxide eugenol
2. Iodoform paste
3. $Ca(OH)_2$ and zinc oxide paste.

## WHAT IS APEXIFICATION?

Apexification is the process of inducing the development of the root and the apical closure in an immature pulpless tooth with an open apex.

### Indications

- Young permanent teeth with blunderbuss canal and necrotic pulp.
- Long standing fractures of crown involving pulp.

### Contraindications

- Replacement resorption
- Very short roots
- Horizontal and vertical root fractures.

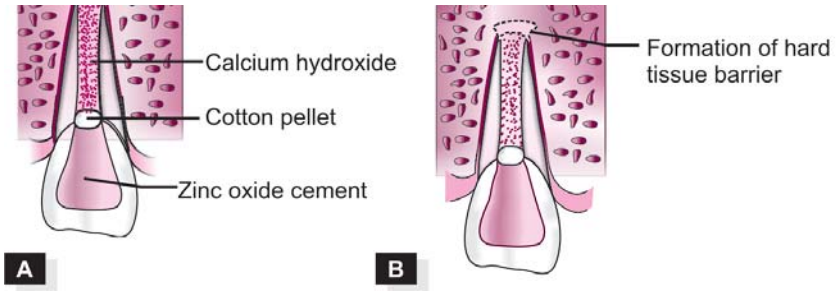
### Materials used for Apexification

1. Calcium hydroxide
2. Calcium hydroxide in combination with other drugs like:
   a. Camphorated paramonochlorophenol
   b. Cresanol
3. Zinc oxide paste
4. Antibiotic paste
5. Tricalcium phosphate.

### Technique (Fig. 26.5)

1. Anesthetize the tooth, extirpate the pulp tissue remnants from the canal.
2. Establish the working length of canal.
3. Complete cleaning and debridement of canal, irrigate and then dry the canal.
4. Place an appropriate material for apexification procedure in the canal and the seal it with temporary filling.
5. Second visit is done at the interval of three months for monitoring the tooth. If tooth is symptomatic, canal is cleaned and filled again with calcium hydroxide paste.
6. Patient is again recalled until there is radiographic evidence of root formation.
7. If apexification is incomplete, repeat the above said procedure again. If apexification is complete, radiograph is taken to confirm it. If found satisfactory, final obturation of canal is done with gutta-percha points.

MTA a recently introduced material is also used in the apexification procedure. To place MTA in the canal isolate




**Figs 26.5A and B:** (A) Restoration of the tooth with zinc oxide cement, (B) Formation of hard tissue barrier at apex

the tooth, mix MTA and compact it to the apex of the tooth, creating a 2 mm thickness of plug. Wait for it to set; then fill in the canal with cement and gutta-percha.

## APEXOGENESIS

Apexogenesis is the physiological root end development and formation.

This procedure is used to initiate the full apical closure.

### Indications

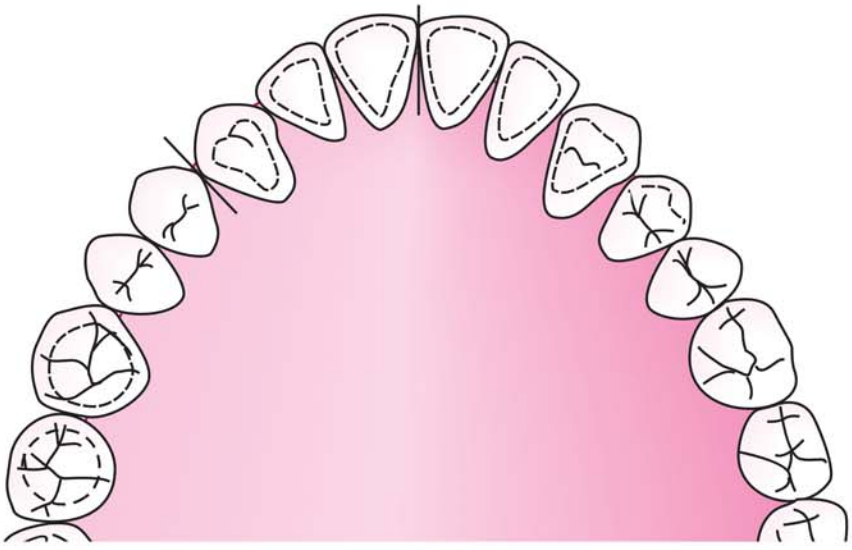
- Immature teeth with incomplete root formation
- Damage to coronal pulp but healthy radicular pulp.

### Contraindications

- Unrestorable teeth
- Avulsed teeth
- Severely luxated teeth
- Teeth with horizontal and vertical root fractures.

# Section Two

# Operative Dentistry




# Introduction to Operative Dentistry

## WHAT ARE AIMS OF OPERATIVE DENTISTRY?

Operative dentistry is defined as that branch or specialty of the science and art of dentistry which deals with diagnosis, treatment, and prognosis of defects of hard tissues of the teeth which do not require full coverage restorations for correction.

Dr. GV Black (1898) is known as the "Father of Operative dentistry".

### Aims of Operative Dentistry

There are six fundamental aims of operative dentistry, which are as follows:

*Diagnosis*

Proper diagnosis of lesions is vital for planning the treatment.

*Prevention*

It includes the procedures undertaken for prevention before the appearance of any sign and symptom of disease.

*Interception*

It includes the procedures undertaken after some signs and symptoms of disease have appeared, in order to prevent the disease from developing into a more serious or full extent.

*Preservation*

It means preservation of what has remained along with an effort to restore what has been lost.

*Restoration*

This includes re-establishment and maintenance of health, form, functions and esthetics.

*Maintenance*

After restoration is done, it must be maintained for longer useful service.

## WHAT IS FUTURE OF OPERATIVE DENTISTRY?

The future of operative dentistry is very bright.

By the continuous research and improvements, better restorative materials with improved techniques are being continuously marketed. Significant developments in operative dentistry are the following:

- Introduction of acid etch technique and composite resins.
- Lasers.
- Newer concepts of treating dental caries, other than restorative materials.
- Introduction of castable ceramic materials.
- Efforts are being done to develop composite and other materials which will adhesively and absolutely bond to enamel and dentin.
- Introduction of RVG.

# 28 Basic Concepts

## WHAT ARE DIFFERENT TOOTH NUMBERING SYSTEMS?

There are more than 12 systems available for tooth numbering but most commonly used systems are as follow:

### Universal System of Tooth Numbering

It has been approved by American Dental Association. It is as follows.

*Deciduous (Primary) Dentition*

Consecutive uppercase letters (A through T moving clockwise) are assigned to identify the deciduous dentition. The deciduous dentition is divided into quadrants as follows.

Maxillary
A B C D E • F G H I J
Patient's right side ——— Patient's left side
T S R Q P • O N M L K
Mandibular

A denotes maxillary right second deciduous molar and J denotes maxillary left second deciduous molar. K denotes the mandibular left second deciduous molar and T denotes mandibular right second deciduous molar.

*Permanent Dentition*

Tooth numbering of permanent dentition presented by universal system is as follows.

Maxillary arch
1 2 3 4 5 6 7 8 • 9 10 11 12 13 14 15 16
Patient's right side ——— Patient's left side
32 31 30 29 28 27 26 25 • 24 23 22 21 20 19 18 17
Mandibular arch

Number 1 denotes permanent maxillary right third molar and 16 denotes permanent maxillary left third molar. Moving clockwise permanent mandibular left third molar is denoted by 17 and permanent mandibular right third molar is represented by 32. Significance of this system is that each tooth has its unique letter or number.

### Zsigmondy or Palmer System

It is the oldest and the most widely used system. Here numbering of teeth starts from the mid-line, moves distally in both maxillary and mandibular arches.

*Deciduous Dentition*

In deciduous dentition quadrants and the teeth are designated as follows:

Maxillary arch
E D C B A • A B C D E
Patient's right side ——— Patient's left side
E D C B A • A B C D E
Mandibular arch

*Permanent Dentition*

In permanent dentition quadrants and the teeth are designated as follows:

Maxillary arch
8 7 6 5 4 3 2 1 • 1 2 3 4 5 6 7 8
Patient's right side ——— Patient's left side
8 7 6 5 4 3 2 1 • 1 2 3 4 5 6 7 8
Mandibular arch

## Federation Dentaire Internationale (FDI) or Two-digit System

FDI has adopted the two-digit system for designating teeth. In the two-digit system, the first digit indicates the quadrant and the second digit specifies tooth within that quadrant. In permanent dentition quadrants are denoted by the digits 1 to 4 and in deciduous quadrants are denoted by 5 to 8. This system has the following advantages:

i. Easy to pronounce in conversation
ii. Simple in teaching and understanding
iii. Easy to make standard charts used in practice.

Federation Dentaire Internationale presents tooth numbering as follows:

Permanent teeth

Maxillary

18 17 16 15 14 13 12 11 | 21 22 23 24 25 26 27 28

Patient's right side — Patient's left side

48 47 46 45 44 43 42 41 | 31 32 33 34 35 36 37 38

Mandibular

Deciduous Teeth

Maxillary

55 54 53 52 51 | 61 62 63 64 65

Patient's right side — Patient's left side

85 84 83 82 81 | 71 72 73 74 75

Mandibular

## WHAT ARE DIFFERENT TOOTH SURFACES?

Coronal portion of each tooth is divided into surfaces that are designated according to their related anatomic structures and landmarks (Fig. 28.1).

*Buccal* — Towards the cheek.
*Facial* — refers to either buccal or labial or both.
*Labial* — Towards the lip
*Mesial* — Towards the anterior midline
*Distal* — Foremost (most distant or distal) from anterior midline
*Lingual/ Palatal* — Towards the tongue, in maxillary teeth the surface towards the palate are also called palatal
*Occlusal* — Masticating surfaces of premolars or molars (posterior teeth)
*Incisal* — Cutting edges of anterior teeth (incisors and canines)
*Gingival* — Nearest and towards the gingiva
*Cervical* — Nearest and towards the cervix or neck of the tooth

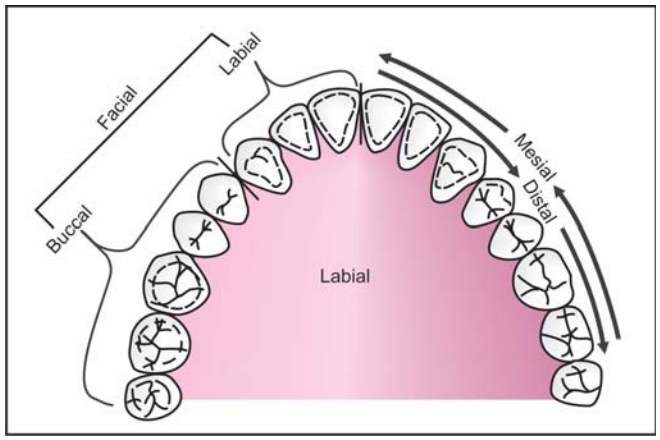



**Fig. 28.1:** Maxillary arch showing different tooth surfaces

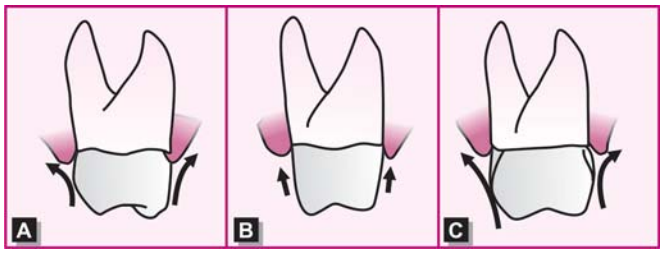
## WHAT IS SIGNIFICANCE OF PHYSIOLOGY OF TOOTH FORM?

### Contours

There is small degree of convexity on buccal and lingual surfaces of all the teeth, known as contours. On facial surfaces of all the teeth contours are present at cervical third of crown. On lingual surface of posterior teeth contours are present at the middle third of crown.

*Importance*

- It permits and provides an adequate stimulation for supporting tissues during mastication (Fig. 28.2).
- Maintains the health of gingiva.
- Make the area self cleaning.
- Maintains normal mesiodistal relationship between teeth.
- Overcontour causes under-stimulation of gingiva.
- Under contouring of teeth causes direct impact of food on supporting tissues.




**Figs 28.2A to C:** (A) Normal contour of tooth helps in physiological stimulation of gingiva, (B) Undercontoured surfaces causing food impaction and injury to interdental papilla, (C) Overcontoured surface causes deflection of food without touching gingiva, so no gingival stimulation

## Proximal Contact Area

Physiological significance of properly located and properly formed proximal contacts is to provide normal healthy interdental papillae filling the interproximal space. The improper proximal contact is the cause of impaction of food, movement of teeth, periodontal diseases, caries and halitosis.

## Embrasures

Embrasures are spillway V-shaped spaces that originate at the proximal contact areas between adjacent teeth. If embrasures are too large they can damage the supporting tissues as food is forced into the interproximal space by the opposing cusp, and if too small or absent, additional stress is created on teeth and supporting tissues, during mastication.

*Importance*

- Makes spillway for escape for food
- Reduce loads of occlusal forces
- Provides stimulation to gingiva

## Marginal Ridges

They are rounded borders of enamel which form mesial and distal margins of occlusal surfaces of posterior teeth and lingual surfaces of anteriors.

*Form and Functions of Teeth*

Teeth perform four main functions: (1) Mastication, (2) Esthetics, (3) Speech and (4) Protection.

Proper alignment of the teeth and their normal form ensure efficiency in their functions.

## WHAT ARE PERIODONTAL ASPECTS BEFORE DOING ANY RESTORATION?

Before doing any restoration the gingiva should be healthy. Rubber dam should be applied prior to any restorative procedure so that any kind of trauma to the gingiva can be prevented. If the cavity is being prepared subgingivally the epithelium gets totally separated from the tooth surface. But the epithelium gets attached to the tooth surface within 7 days.

## Effects of Faulty Restorations on Periodontium

*Level of Restoration*

Subgingivally placed restoration often causes gingival irritation. Rough surface of the restoration facilitates the deposition of plaque.

*Margins of the Restoration*

If margin of the restoration is placed subgingivally, it can result in food impaction and gingival irritation which is due to:

- If the restoration attaches plaque on its surface.
- If the restoration and tooth do not contact evenly.

The degree of inflammation depends on the material and the contouring and finishing of the restoration.

As far as possible the restoration should not be placed more than 0.5 to 1 mm below the gingival margin.

*Contour*

- If the contour of the restoration is flat the gingiva becomes thicker.
- Overcontoured and undercontoured, both restorations are harmful to periodontium. Overcontoured restorations are much more harmful compared to the restorations that are very slightly undercontoured.
- Undercontour restorations can result in food impaction and area which is difficult to clean.

*Contact*

- If the occlusal contacts are not functionally acceptable then it may lead to accumulation of food and periodontal trauma
- If food gets accumulated it will cause irritation of the periodontal tissues
- Contact placed too occlusally causes flattened marginal ridges
- Contact placed too gingivally causes increased depth of occlusal embrasure and injury to col area
- Open contact can result in continuity of embrasure with each other and with interdental papilla.

*Post-restorative Care*

If a patient is having high caries index the patient should be instructed for regular dental check up and oral prophylaxis once in 3 months. During oral prophylaxis the following should also be done.

a. Patient should be reinstructed about the oral hygiene measures.
b. Polishing of the tooth surface.
c. Plaque and calculus below the gingival margin should be removed by a curette.
d Pockets around the tooth should be probed with a periodontal probe.

## HOW IS PERIODONTIUM AFFECTED WHILE DOING OPERATIVE PROCEDURES?

### *Separation of Teeth*

When separators are used, the width of the periodontal ligament should be greater than the amount of separation to be achieved. But if reverse is true, the periodontal ligament will be excessively compressed on one side and get torn on the other side.

### *Rubber Dam*

Carelessness in application of rubber dam can harm the periodontium as following:
a. The rubber dam which is applied between the two septa can cause ischemia.
b. When clamps are not used properly.
c. When the dental floss is forced injudiciously.

### *Instrumentation*

During instrumentation the following can damage the periodontium.
a. Excessive vibration causes tearing of the fibers of the periodontal ligament.
b. Care must be taken while preparing gingival cavosurface margin to avoid laceration of the tissues.

### *Placement of Matrix Band*

Matrices and bands should not be irritating to the tissues. They should be:
a. Well contoured for the mesial and distal as well as buccolingual sides.
b. Well contoured on occlusal and gingival sides.
c. On or after fitting, should never slip, apically and laterally. The slipping can cause tearing of the gingiva and contusion of gingiva as well as other periodontal tissues.

### *Procedures involved in Impression Taking*

While making cast restorations, the impression procedures, and the materials used in that procedure may irritate the periodontal tissues. Such situations are the following:
a. When hydrocolloid and heat producing are used for impression making.
b. In some conditions where catalyst and derivatives of rubberbase elastomeric impression material cause allergy.
c. Impression taking can also cause trauma to the surrounding periodontium.

### *Fabrication of Interim Restorations*

Periodontium may be injured due to following:
a. If self-curing resin is used, excess monomer and heat production can cause irritation.
b. The cement used may be of irritating nature.
c. During cementation of restoration irritation may occur.

### *Restorations*

The periodontium is affected by restorations in the following ways:
1. The facial and lingual surfaces if are overcontoured may act as a reservoir for food particles.
2. Overhanging restorations or underhanging restorations can cause irritation to the gingiva.
3. If two dissimilar metals are used then galvanism may cause atrophy of the surrounding gingiva.
4. Various restorative materials if in contact of gingiva may cause inflammatory changes.
5. Some of the restorative materials or their constituents may cause allergy, redness and ulcers in the surrounding gingiva.
6. During the excess material removal from the gingival margin of the restoration the periodontium can be traumatized.

# 29 Dental Caries

## WHAT IS ETIOLOGY OF DENTAL CARIES?

### Definition

Dental caries is defined as a microbiological disease of the hard structure of teeth, exposed in oral cavity, that results in localized demineralization of the inorganic portion and destruction of the organic substances of the tooth, beginning on the external surface.

### Etiology

The etiological agents of dental caries are pathogenic bacterial plaque. There are two basic hypothesis concerning the pathogenicity of plaque.

1. Non-specific plaque hypothesis: According to this hypothesis all plaques are pathogenic because pathogenic bacteria are universally present in plaque.
2. Plaque and caries: The carious lesions are started when specific bacteria in plaque are increased and active pH is decreased. The plaque will become pathogenic when signs of caries develop.

*Theories of Etiology of Dental Caries*

1. Endogenous theories:
   - Humoral theory
   - Vital theory.
2. Exogenous theories:
   - Chemical theory
   - Parasitic theory
   - Miller's acidogenic theory
   - Proteolysis theory
   - Proteolysis chelation theory.
3. Other theories:
   - Autoimmune theory
   - The legend of worm
   - Sulfatase theory.

*Local Factors Affecting the Incidence of Caries (Fig. 29.1)*

A. Microorganisms: Microorganisms present, on the tooth surface like Streptococcus mutans and Lactobacillus cause dental plaque.
B. Tooth
   a. Morphological variation
   b. Composition
   c. Position
C. Environmental factors
   a. Saliva
      1. Composition
      2. Quantity
      3. pH viscosity
      4. Antibacterial factors like enzymes.

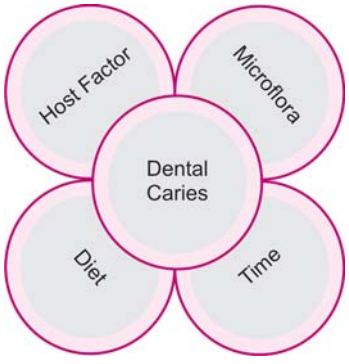



**Fig. 29.1:** Etiological factors of caries

b. Diet
   1. Physical factors
   2. Local factors
      a. Carbohydrate content—Presence of refined cariogenic carbohydrate particles on the tooth surface
      b. Vitamin content
      c. Fluoride content
      d. Fat content

D. Time period

## GIVE CLINICAL CLASSIFICATION OF DENTAL CARIES?

Dental caries may be classified according to the following:
*The surface topography and environmental conditions:*

1. Pits and fissures caries (Fig. 29.2):
   - Initially, they appears brown or black in color and with a fine explorer it will feel soft and a 'catch' is felt.
   - The enamel which borders the pits and fissures appears opaque bluish-white.
   - If enamel is thin at the base of pits and fissures, it causes early involvement of dentino-enamel junction and caries spreads laterally and involves dentin.
2. Smooth enamel surface caries (Fig. 29.2):
   - Occur on gingival third of buccal and lingual surfaces and on proximal surfaces.
   - Occur because of lack of plaque control.
   - Shape is two triangles.
   - On proximal surface caries begins below the contact point.

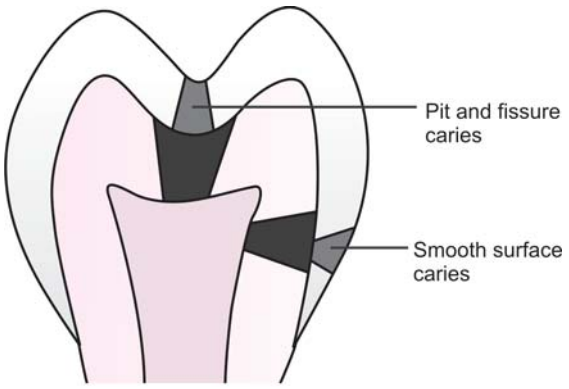



**Fig. 29.2:** Diagrammatic representation of pit and fissure and smooth surface caries

   - It appears as a slightly roughened chalky area which gradually becomes excavated.
3. Root surface caries:
   - Located on dentin and cementum of root surface.
   - Rapidly progressive
   - Associated with old age
4. Cervical caries – It starts from cervical region of the tooth.

*The rapidity of the caries progress, it is classified as follows:*

a. Acute dental caries:
   - Travels towards the pulp at a very fast speed.
   - Multiple and light colored
   - Rapidly involve pulp.

b. Rampant caries:

It is a suddenly appearing, rapidly burrowing type of caries resulting in early pulp involvement, in which more than 10 new lesions appear every year on healthy teeth surfaces which are generally immune to caries.

- It occurs usually in deciduous dentition.
- Usually affects maxillary four incisors, then molars followed by canines
- Due to severe carious process only root stumps remain.

Rampant caries is of following three types:

- Nursing bottle rampant caries
- Adolescent rampant caries
- Xerostomia induced rampant caries (radiation rampant caries).

c. Chronic dental caries:
   - Progresses slowly
   - Involves the pulp much later than acute caries
   - Due to slow progression of caries process there is sufficient time for sclerosis of dentin and formation of reparative response to the adverse irritation
   - There is no or less pain in chronic caries.

d. Arrested caries:
   - Arrested caries occurs on occlusal and proximal surfaces
   - Characterized by a large open cavity which no longer retains food and becomes self-cleansing.
   - On the proximal surface they occur due to extraction of adjacent tooth.
   - It appears as brown-stained area just below contact point of retained tooth.
   - The caries process is arrested due to area of proximal surface becoming self cleansing because of extraction of adjacent teeth.

*Whether caries attacks previously intact surface or margin of restoration, it is classified as follows:*

1. Primary caries:
   - They are white spot lesions
   - Reversible
   - Can be mineralized
   - Describe first attack on the tooth surface
   - Shape of lesion depends on location i.e. whether pit and fissure or smooth surface lesion.
2. Secondary or recurrent caries:
   - They occurs at the margins of a restoration.
   - The causes of secondary caries are poor adaptability of restorative materials to the cavity walls and leaky margins or inadequate extension of restorative materials to margin of cavity, which favour the retention of food debris and bacteria.

*The proximity of caries to pulp*:
By relating the caries to their clinical location, GV Black gave a simple cavity classification listed as class I, class II, class III, class IV and class V. An additional class VI was later on added by Simon as modification to Black's classification.

*Class I*: Pit and fissure cavities occur in the occlusal surfaces of premolars and molars, the occlusal two-third of buccal and lingual surface of molars, lingual surface of incisors.

*Class II*: Cavities in the proximal surface of premolars and molars.

*Class III*: Cavities in the proximal surface of anterior teeth and not involving the incisal angles.

*Class IV*: Cavities in the proximal surface of anterior teeth also involving the incisal angle.

*Class V*: Gingival cavities on gingival third (not pit and fissure cavities) on facial and lingual or palatal surfaces of all teeth.

*Class VI*: Cavities on incisal edges of anterior and cusp tips of posterior teeth without involving any other surface.

## WHAT IS CARIES OF ENAMEL?

Caries of enamel starts by deposition of microbial plaque on enamel surface. Two types smooth surface caries, and pit and fissure caries.

### Smooth Surface Caries

- Earliest manifestation of incipient caries is like a smooth chalky white area.
- Carious lesions have cone or triangular shape, in which apex is toward the pulp and base toward the outer surface of tooth.
- Smooth surface caries occurs on gingival third of buccal and lingual surfaces and on proximal surfaces.
- On proximal surface caries begins below the contact point.
- Caries in the cervical area is in the form of crescent shaped cavities.

### Pit and Fissure Caries

- Shape of pits and fissures contributes to their high susceptibility to caries because in these structures bacteria and food debris are packed.
- The microorganisms ferment this food and acid is produced and caries is initiated.
- Initially they appear brown or black in color, enamel which borders the pits and fissures appears opaque bluish-white.
- Early involvement of dentino-enamel junction and dentin because of thin enamel at pits and fissures causes undermining of enamel. This undermined enamel is sometimes fractured by masticatory forces.
- When undermined enamel fractures, it causes cavitation and caries.

### Zone in Caries Lesions

These zones are beginning on the dentinal side of the lesion.

*Zone 1: Translucent Zone*

- It represents the advancing front of the enamel lesion.
- Not always present.
- This is ten times more porous than sound enamel.

*Zone 2: Dark Zone*

- Lies adjacent and superficial to the translucent zone.
- Called as dark zone because it does not transmit polarized light
- Also known as positive zone, because it is usually present.

- Formed by demineralization because demineralization and remineralization both occur in this zone.

*Zone 3: Body of Lesion*

- Largest portion.
- Stria of Retzius are well marked indicating more demineralization and thus more porous.
- Varying from 5 percent at the periphery to 25 percent at the center.

*Zone 4: Surface Zone*

- Least affected by caries because it is hypermineralized and has more fluoride.
- More resistant to caries.
- Less than 5 percent porous.

## WHAT IS CARIES OF DENTIN?

Caries in dentin spreads more rapidly in comparison to enamel because dentin provides much less resistance to acid attack.

### Changes in Early Dentinal Caries

- Slowly progressing caries causes dentinal sclerosis.
- This alteration in dentin is a reaction of vital dentinal tubules and vital pulp to prevent further penetration by microorganisms.
- In slowly advancing caries, formation of sclerotic dentin is more.
- When dentinal tubules are completely occluded by the mineral precipitate, tooth gives transparent appearance, this is termed as transparent dentin.
- In the earliest stages of caries when only a few tubules are involved, microorganisms found in these tubules are termed as "pioneer bacteria".

### Changes in Advanced Dentinal Caries

- The diameter of dentinal tubules increases due to packing of microorganisms. Due to the focal coalescence and breakdown of a few dentinal tubules, tiny "liquefaction foci" are formed.
- These "foci" are ovoid areas of destruction, which tend to increase in size by expansion producing compression and distortion of adjacent dentinal tubules.

### Zones of Dentinal Caries

- Five different zones in dentinal caries.
- Are clearly distinguished in slowly progressing caries and less distinguished in rapidly progressing caries.
- Zones begin from the pulpal side.

*Zone 1: Normal Dentin*

- There is fatty degeneration of Tomes fibers.
- Dentin is normal and produces sharp pain on stimulation.

*Zone 2: Subtransparent Dentin*

- Intertubular dentin is demineralized.
- In this zone dentinal sclerosis takes place.
- Damage to the odontoblastic zone process is evident.
- No bacteria in this zone.
- This zone is capable of remineralization.

*Zone 3: Zone of Dentinal Sclerosis (Transparent Dentin)*

- Further demineralization of intertubular dentin lead to softer dentin.
- Pain on stimulation.
- No bacteria present.
- Zone has the capacity of self-repair by remineralization of the intertubular dentin.

*Zone 4: Turbid Dentin*

- Characterized by widening and distortion of the dentinal tubules which are filled with bacteria.
- Dentin is not self-repairable.
- There is less mineral content and irreversibly denatured collagen. So during cavity preparation for restoration this zone should be removed.

*Zone 5: Decomposed Dentin*

- Outermost zone which consists of decomposed dentin filled with bacteria.
- Must be removed prior to restoration of carious tooth.

## DIFFERENCE BETWEEN INFECTED AND AFFECTED DENTINE

### Infected Dentine

- It is a superficial layer.

- Demineralized dentine.
- Can't be remineralized.
- Lacks sensation.
- In this intertubular layer is demineralized with irregularly scattered crystals.
- Collagen fibers are broken down, appear as only indistinct cross bands.
- It can be stained with:
  - 0.2 percent propylene glycol
  - 10 percent acid red solution
  - 0.5 percent basic fuschin.

### Affected Dentine

- It is a deeper layer.
- Intermediate demineralized dentine.
- Can be remineralized.
- It is sensitive.
- In this intertubular layer is only partly demineralized.
- Distinct cross bands are present.
- It can not be stained with any solution.

## WHAT ARE DIFFERENT METHODS OF CARIES DIAGNOSIS?

Following methods are used for the diagnosis of caries:

- *Visual inspection methods*: For inspections following instruments, devices and techniques are used.
  - Magnifying mouth mirror.
  - Magnifying lens.
- *Special illumination techniques*:
  - Ultraviolet Illumination: Ultraviolet (UV) light increases optical contrast between carious area and the surrounding healthy tissue.

*Advantage*

It is more sensitive and gives more reliable results than visual and tactile methods.

*Disadvantage*

Carious lesion and developmental defect cannot be distinguished by UV illumination.

### Fiberoptic Transillumination (FOTI)

Light is delivered via fiberoptics from a light source on the surface of the tooth. The light travels from the fiber illumination across tooth tissue to non-illuminated surface. This results in image formation which is used for diagnosis.

*Advantages*

- Lesions which cannot be diagnosed radiographically can be diagnosed
- No radiation hazard
- Comfortable to patient

*Disadvantage*

FOTI is not possible in all locations of carious lesions

### Wavelength Dependent FOTI

*Advantages*

- It gives quantitative information about depth of the lesion
- There is no radiation hazard.

*Disadvantage*

Same as with FOTI.

### Digital Imaging FOTI

It works on basis of the principle that the images of teeth obtained through visible light fiberoptic trans-illumination (FOTI) are acquired with digital CCD camera and sent to a computer for analysis with dedicated algorithms.

### Detection of Carious Enamel by Dyes

- Calcein
- Procion
- Brilliant blue

### Endoscope Technique

Endoscope technique is based on observing the fluorescence which takes place when the tooth is illuminated with blue light in the wavelength range of 400 to 500 nm. Sound enamel and carious enamel produce different fluorescence.

### Tactile Method

Here smoothness, roughness and softness is determined by sharp explorers of various shapes.

## Radiographic Methods

1. Intraoral periapical radiographs.
2. Bitewing radiographs: They provide good view of the following:
   a. Interproximal caries
   b. Recurrent caries
   c. Recurrent or secondary caries below proximal restoration.
3. Xeroradiography: In this the latent images are recorded on an aluminum plate coated with selenium particles. The latent images are developed in the positive images.
4. Digital imaging.

*Direct digital imaging*: In this radiation rays are directly collected by digital image receptor.

*Indirect digital imaging*: In this video camera forms digital image of radiographs.

5. Subtraction radiography:

By this technique structured radiographic noise is reduced in order to increase the detectability of changes in the radiographic pattern.

## Electrical Conductance Measurement Method

Due to high mineralization sound enamel is very bad conductor. Electric conductivity is directly proportional to the amount of demineralization present.

## Lasers

Following types of lasers are used for diagnosis of caries.

### *Diagnodent*

Diagnodent is a diode-laser caries detector. It can be used to determine the soundness of tooth structure on occlusal surfaces.

### *Quantitative Laser Fluorescence (QLF)*

Here argon laser is used to monitor caries lesions

### *Optical Coherence Tomography (OCT)*

In OCT cross sectional images of biological tissues are created using differences in the reflection of light.

### *DNA Chip Technology (DNACT)*

DNACT is a new system which combines the use of computer and molecular biology technologies.

## Caries Activity Tests (Table 29.1)

Caries activity tests are important in individual persons to help the practitioner arrive at decisions in relation to preventing and controlling measures. The timing of recall appointments, indication of type of restorative procedures and materials, and assessing the prognosis.

**Table 29.1: Caries activity tests and their principles**

| *S. No* | *Test* | *Principles and Results* |
|---|---|---|
| 1. | Buffering capacity | To estimate buffering capacity, a saliva sample is used |
| 2. | Fosdick | Capacity of saliva sample to dissolve powdered enamel is measured |
| 3. | Dewar | |
| 4. | Lactobacillus count | By counting colonies on a culture media plate the number of bacteria in saliva is estimated |
| 5. | Snyder | In culture media the rapidity of acid formation from a saliva sample is measured |
| 6. | Mutans streptococci screening | By use of selective culture media the number of colony forming bacteria are estimated |
| 7. | Reductase | From a saliva sample, activity of reductase enzyme to change the color is measured sample in culture media is measured |

## WHAT ARE DIFFERENT WAYS FOR CARIES PREVENTION?

Caries can be prevented by three methods.

### Chemical Method

- Fluoride: Fluoride alters the tooth surface or/and tooth structure to increase resistance to demineralization and prevent dental caries. Fluorides are used in the following forms:
  a. Fluoridation of water supplies
  b. Topical application of fluoride
     i. Sodium fluoride (NaF)
     ii. Stannous fluoride ($SnF_2$)
     iii. Acidulated fluorido-phosphate
     iv. Prophylactic paste
     v. Fluoride dentifrices
     vi. Fluoride mouthwashes or rinses.
- Chlorhexidine
- Zinc chloride
- Caries vaccine
- Vitamin K.

### Dietary Method

Caries can be prevented by the restriction of intake of refined carbohydrate. Sucrose is most cariogenic carbohydrate, hence its use in food should be restricted.

### Mechanical Methods

- Tooth brushing
- Dental floss
- Mouth rinsing
- Pit and fissure sealants.

## HOW IS PULP PROTECTION DONE IN MODERATE AND DEEP CARIOUS LESIONS?

### Pulp Protection in Moderate Carious Lesions

- Moderate carious lesion is one in which the caries penetrates the enamel and may involve one half of the dentin, but not to the extent of endangering the pulp.
- After cavity preparation, the liner is applied to cover the axial and/or pulpal wall.
- Then, base is placed over the liner.
- After this permanent restoration is done.

### Pulp Protection in Deep Carious Lesions

In deep cavity, the caries can reach upto the pulp.

If hard dentin is present, protective cement base and permanent restoration is done as in moderate lesion.

### Indirect Pulp Capping

Here all the carious tissue is removed except the soft undiscolored carious dentin which is adjacent to the pulp.

*Indications*

- Deep carious lesion near the pulp tissue but not involving it.
- No mobility of tooth.
- No history of spontaneous toothache.
- No tenderness to percussion.
- No radiographic evidence of pulp pathology.
- No root resorption or radicular disease should be present radiographically.

*Contraindications*

- Presence of pulp exposure.
- Radiographic evidence of pulp pathology.
- History of spontaneous toothache.
- Tooth sensitive to percussion.
- Mobility present.
- Root resorption or radicular disease is present radiographically.

*Materials Used*

- Zinc oxide eugenol.
- Calcium hydroxide.

*Technique*

- Cavity is cleaned, dried and covered by calcium hydroxide and temporary restoration.
- After 2 to 3 months, the cement is removed and the cavity is inspected.
- If due to remineralization and/or formation of secondary dentin the soft dentin has become hard, then remove any residual soft debris.
- Finally give protective cement base and place the permanent restorative material.

### Direct Pulp Capping

The purpose of direct pulp capping is to preserve the vitality of the pulp by placing the medicament over the

exposure site, so as to provide an environment for the healing of the pulp.

*Indications*

- Small mechanical exposure of pulp during
  - Cavity preparation
  - Traumatic injury
- No or minimal bleeding at the exposure site.

*Contraindications*

- Wide pulp exposure.
- Radiographic evidence of pulp pathology.
- History of spontaneous pain.
- Presence of bleeding at exposure site.

*Technique*

- When vital and healthy pulp is exposed, fresh bleeding of bright red blood takes place.
- After the bleeding at the exposure site is stopped, clean and dry the area.
- Over the exposure site, calcium hydroxide is placed, which is sealed by temporary cement.
- After 2 to 3 months, the cement is removed.
- If secondary dentin formation takes place, tooth is restored permanently.

## MATERIALS USED FOR PULP PROTECTION

Various materials are used to:

- Insulate the pulp
- Protect the pulp
- Act as barriers to microleakage
- Prevent bacteria and toxins from affecting the pulp.

### The Materials Used for Pulp Protection

- Cavity Varnish
- Cavity Liners
- Calcium Hydroxide and Mineral Trioxide Aggregate (MTA)
- Zinc Oxide-Eugenol
- Zinc Phosphate Cement
- Polycarboxylate Cement
- Glass Ionomer Cement.


# Dental Materials

## GIVE CLASSIFICATION OF RESTORATIVE MATERIALS

A. According to their lasting qualities
   I. Temporary
      1. Zinc oxide-eugenol
      2. Zinc phosphate cement
      3. Silicate cement
      4. Self-curing acrylic resin
      5. Gutta-percha.
   II. Permanent
      1. Pure gold
      2. Cast metal alloy
      3. Amalgam
      4. Ceramics.
B. According to their working properties
   I. Plastic restorative materials
      1. Amalgam
      2. Cements
      3. Resins
      4. Pure gold
      5. Ceramics.
   II. Non-plastic restorative materials
      1. Cast gold alloys
      2. Castable dental ceramics
      3. Autocopy milling ceramics-CAD-CAM etc.
C. According to mode of use of restorative materials
   I. Directly used restorative materials
      1. Amalgam
      2. Cements, bases
      3. Bonding agents
      4. Pit and fissure sealants
      5. Composites
      6. Glass ionomer cements
      7. Direct filling gold
      8. Direct filling ceramics.
   II. Indirectly used using restorative materials
      1. Cast metal restorative materials
      2. Indirect dental ceramic materials
      3. Metal ceramic materials
      4. CAD-CAM/CEREC 2 and 3 system materials.

## NOTE ON AMALGAM

Amalgam is an alloy in which mercury occurs as a main constituent.

### Uses

- For restoration of class I, II, III, V and VI cavities.
- Core build up of grossly decayed teeth.
- As root end filling material.
- In patients where isolation is difficult.
- For dies preparation.

### Advantages

- Easy to insert
- Not technique sensitive
- Has adequate resistance to fracture
- Self sealing property
- Good strength
- Long service life
- Economical
- Adequate wear resistance
- Require less chair side time.

### Disadvantages

- Nonesthetic
- Brittle

- Subject to corrosion
- Show galvanic reaction
- Show marginal breakdown
- Risk of mercury toxicity
- Microleakage
- Delayed expansion
- Do not bond to tooth structure.

## Classification

*Based on Shape of Alloy Particle*

- Lathecut
- Spherical
- Spheroidal.

*Based on Size of Alloy Particle*

- Microcut
- Macrocut.

*Based on Copper Content*

High copper- contain 6-30 percent of Cu content
Low copper- contain less than 6 percent of Cu content

*Based on Number of Alloying Metals*

*Binary*: Two metals- Ag, Sn
*Ternary*: Three metals- Ag, Sn, Cu
*Quaternary*: Four metals- Ag, Sn, Cu, In

*Based on Zinc Content*

Zinc free alloys: less than 0.01 percent Zn
Zinc containing alloys: more than 0.01 percent Zn.

*Based on Content of Noble Metals*

- Noble metal alloys
- Non-noble metal alloys.

Difference between Lathecut and Spherical Alloys

| *Lathecut alloys* | *Spherical alloys* |
|---|---|
| • Particles are irregular in shape | They are spherical |
| • Manufactured by milling an ingot of alloy | Manufactured by atomization of molten alloy |
| • Need more mercury | Require less mercury |
| • Less plastic | More plastic |
| • Has inferior properties | Has better properties |

**Composition**: Amalgam consists of amalgam alloy and mercury. Amalgam alloy is composed of silver-tin alloy with varying amounts of copper and small amount of zinc. Dental amalgam alloys are mainly of two types, low copper and high copper alloys (Table 30.1).

## Effects of Constituent Metals on the Properties of Amalgam

*Silver*

Contain 60 to 70 percent (by weight) of silver. It: a. Increases strength
b. Decreases flow after hardening of amalgam
c. Increases setting expansion
d. Accelerates setting and thereby reduces setting time
e. Resists tarnish and corrosion

*Tin*

Contain 25 to 28 percent (by weight) of tin. It:
a. Increases setting time
b. Reduces strength, hardness, and setting expansion
c. It has greater affinity for mercury hence helps in amalgamation.

**Table 30.1:** Approximate composition of few popular low and high copper amalgam alloys

| | | *Percentage of elements by weight* | | | | | |
|---|---|---|---|---|---|---|---|
| *Types of alloy's shape* | *Particle* | *Silver* | *Tin* | *Copper* | *Zinc* | *Palladium* | *Indium* |
| 1. Low copper | Lathecut or Spherical | 65 to 77 | 25 to 28 | 2 to 6 | 0 to 2 | 0 | 0 |
| 2. High copper | | | | | | | |
| A. Admixed | Lathecut | 40 to 68 | 25 to 30 | 9 to 30 | 0 to 2 | 0 | 0 |
| | Spherical | 40 to 70 | 0 to 30 | 20 to 30 | 0 | 0 | 0 |
| B. Unicom-positional | Spherical | 40 to 60 | 22 to 30 | 15 to 30 | 0 to1 | 0 to 4 | 0 |

*Copper*

Two to 30 percent (by weight ) in alloy.

a. It increases the compressive strength
b. It reduces flow and setting contraction of amalgam
c. It helps in uniform comminution of the alloy during trituration

*Zinc*

Zero to 2 percent (by weight):

a. It prevents oxidation during alloy ingot manufacture.
b. It gives rise to delayed or secondary expansion if zinc containing alloys are contaminated with moisture.

*Palladium*

It may be present 0 to1 percent (by weight). It improves the corrosion resistance and the mechanical properties.

*Indium*

Present 0 to 4 percent (by weight). It reduces the evaporation of mercury and the amount of mercury required to wet the alloy particles.

## Alloy Manufacturing

*Lathecut Alloys*

- Metal ingredients are heated and placed in a milling machine or lathe.
- Resultant needle like chips are got by milling.
- Chip size can be reduced by ball milling.
- A freshly cut alloy particle reacts with mercury very fast, but alloy stored at room temperature show decreased reactivity. These alloys are said to be aged.
- Aging can be done quickly by heating alloy powder at 100 degrees for one hour.

*Spherical Alloy Powder*

- Prepared by process of atomization.
- All components are melted together and liquid alloy is then sprayed under high pressure, through a fine crack into the chamber.
- Droplets of alloy solidify as they hit the surface.

## SETTING REACTIONS OF DIFFERENT ALLOYS

### Low Copper Alloys

- When alloy powder and mercury are mixed, silver and tin form an intermediate compound ($Ag_3Sn$).
- $Ag_3Sn + Hg \rightarrow Ag_2Hg_3 + Sn_{7\text{-}8}Hg + Ag_3Sn$ (unreacted)
  (gamma) (gamma 1) (gamma 2)
- Set material contains core of unreacted gamma and matrix of gamma 1 and gamma 2 compounds.
- More the unconsumed AgSn particles retained in the final mix, stronger is the mix.
- Gamma 2 is least stable to corrosion.

### High Copper Alloys

*High Copper Unicomposition Alloy*

In these alloys final set consists of a core of $Ag_3Sn$ and $Cu_6Sn_5$ as matrix.

$$\underset{\text{(gamma)}}{Ag_3Sn} + \underset{\text{(epsilon)}}{Cu_3Sn} + Hg \rightarrow \underset{\text{(gamma 1)}}{Ag_2Hg_3} + \underset{\text{(eta)}}{Cu_6Sn_5}$$

*Admixed Alloy Particle*

- It has silver copper eutectic alloy
- Here set mass consists of core of $Ag_3Sn$ + Ag-Cu and surrounded by $Ag_2Hg_3 + Cu_6Sn_5$
- Set phase is free of gamma 2 phase.

$$\underset{\text{(gamma)}}{Ag_3Sn} + \underset{\text{(eutectic)}}{Ag\text{-}Cu} + Hg \rightarrow \underset{\text{(gamma 1)}}{Ag_2Hg_3} + \underset{\text{(gamma 2)}}{Sn_{7\text{-}8}Hg} + \underset{\text{(gamma)}}{Ag_3Sn} + Ag\text{-}Cu$$

$$\underset{\text{(gamma 2)}}{Sn_{7\text{-}8}Hg} + \underset{\text{(eutectic)}}{Ag\text{-}Cu} \rightarrow Ag_2Hg_3 + Cu_6Sn_5$$

## Properties of Amalgam

*Creep*

It is time dependent deformation or strain which is produced by a stress.

It can cause extrusion of amalgam out of the cavity, thus can lead to marginal breakdown.

Creep rate increases with higher mercury alloy ratio and low condensation pressure.

Creep rates increase with higher gamma 1 and gamma 2 phases.

*Dimensional Change*

Three types of dimensional changes are seen:

1. Initial contraction: It occurs by absorption of mercury into interparticle spaces of alloy particles.
2. Expansion: It occurs due to formation and growth of matrix crystals.
3. Delayed contraction: It results from absorption of unreacted mercury.

*Dimensional changes in amalgam are affected by following factors:*

- More is **gamma phase**, more is the expansion
- More is the **amount of tin**, lesser is the expansion.
- More is **mercury**, more prolonged is second stage, i.e. expansion.
- **Contamination with moisture**, results in delayed expansion in zinc ec alloys.
- Smaller is the **particle size**, lesser is the expansion.
- Higher is the **condensation pressure**, more is the contraction.
- Optimal **trituration** causes no obvious expansion.

*Delayed Expansion*

- It is gradual expansion of zinc containing alloys due to production of hydrogen gas when plastic mass gets contaminated with moisture during manipulation.
- Usually starts after 3-5 days and may continue for months reaching values greater than 4 percent, i.e. 400 μm.

*Consequences*

- Extrusion of restoration out of the cavity.
- Increased flow and creep.
- Pulpal pressure pain.
- Fracture of restoration.
- Increased microleakage around restoration.

*Compressive Strength*

Hardened amalgam has very good compressive strength, weak tensile strength.

*Factors affecting strength are:*

- Both under and over **trituration** decreases the strength.
- More is the **mercury content**, weaker is the set mass.
- Greater the **condensation pressure** more is the strength.
- Presence of **voids** decreases the strength.
- More is the **gamma 2 phase**, lesser is the strength.

*Corrosion*

Amalgam restorations show tarnish and corrosion.

*Factors responsible for increased corrosion are*:

- Higher amount of mercury.
- Contact of dissimilar metals.
- Moisture contamination during condensation.
- Low copper alloys show more corrosion than high copper alloys.

Difference between low copper and high copper alloys:

| | *Low copper alloys* | *High copper alloys* |
|---|---|---|
| • Compressive strength | Less | More |
| • Marginal integrity | Poor | Good |
| • Creep | High | Low |
| • Corrosion resistance | Less | More |

## TECHNICAL CONSIDERATIONS

### Manipulation of Amalgam

*Selection of Alloy and Mercury*

- High copper alloys show superior clinical performance
- Non-zinc alloys are preferred when moisture control is difficult
- Mercury should possess no surface contamination.

*Proportion of Alloy and Mercury*

- Excess of mercury has to be removed for success of amalgam restoration.
- Excess mercury can be removed by squeezing excess of mercury using squeeze cloth and removing mercury rich layer which comes at the top of the restoration during condensation of each increment.
- Nowadays Eame's technique is being employed in which alloy and mercury are used in 1:1 proportion by weight.
- With this technique one can have 50% or less mercury in the final restoration.

### Trituration

It is the process of mixing amalgam alloy particles with mercury.

*Objectives*

- To obtain a workable mass of amalgam in minimum time.
- To remove layer of oxides from the alloy particles.
- To increase the surface area of alloy particles by reducing particle size.
- To dissolve powder particles with mercury.

*Methods of Trituration*

*Hand trituration* Here alloy particles are triturated by hand with mortar and pestle.

*Mechanical trituration*

- Here pre- proportioned capsules contain powder and mercury act as mortar.
- A cylindrical piston is inserted into capsule, this act as pestle.
- Mechanical amalgamators have automatic timer and speed controlled device.

*Advantages*

- Better mix
- Shorter mixing time
- Requires less mercury.

*Normal Mix*

- Shiny in appearance
- Homogenous in character
- Convenient to handle
- Maximum strength
- Usually warm when it is removed from the capsule.

*Overtriturated Mix*

- Low strength
- Increase in creep
- Difficulty in handling
- Consistency is soupy in character
- Decreased working time
- Higher contraction of amalgam due to high amount of mercury.

*Undertriturated Mix*

- Consistency is dry and crumbly in character.
- Dull in appearance.
- Difficult to manipulate during insertion of amalgam.
- Rough and grainy mixture.
- Greater chances of tarnish after carving.
- Less strength.

## Mulling

Mulling is:

- Continuation of trituration.
- The process by which the mix is given a cohesive form.
- Done to improve the homogenicity of mass and to achieve consistent mix.

## Condensation of Amalgam

In this process, the mix is compacted into the prepared cavity to attain a dense mass.

*Objectives*

- To adapt amalgam intimately to cavity walls.
- To minimize residual mercury content.
- To make a continuous matrix.
- To increase strength of the restoration.
- Condensation can be done by hand, mechanical or ultrasonic means.
- There should not be time lapse between condensation and trituration.
- Different shapes of condensers are available viz; round, parallelogram, diamond, etc.
- Since condensation pressure is inversely proportional to area, increasing the area of condensation decreases the amount of pressure acting at the condenser tip.

## Carving

- Carving is done to simulate the functional anatomy of the restoration.
- Amalgam should be properly set before starting the carving.
- Carving in an unset mass causes pulling out of amalgam from the margins.
- A ringing sound should appear when carver is rubbed on set mass.
- Carving is carried out by keeping half of the blade on restoration and half on the tooth following the incline plane of each cusp.

## Burnishing of Amalgam

It is the process by which smooth, rigid, instrument is used for smoothening the restoration surface, which has become rough by carcing.

*Aims*

- To bring excess of mercury to the surface.
- To adapt amalgam intimately to cavity walls.
- It acts as continuation of the condensation process.

*Types*

*Precarving burnishing*

- It is continuation of condensation process.
- It produces smoother margins and shapes the amalgam to contours and curvatures.

*Postcarving burnishing*

- It is done to smoothen the final restoration and produce a shiny surface.

- Produces denser amalgam at the margins of occlusal preparation restored with low copper alloys.
- Improves marginal integrity of the amalgam restoration.

## MERCURY TOXICITY

- Threshold limit value of mercury vapour allowed in a work place is 0.05 percent.
- Lowest dose of mercury that brings out toxic reaction is 3-7 µg/kg.
- Maximum allowable mercury in blood is 3 µg/kg.

### Effects of Mercury Toxicity

- CNS symptoms: Depression, headache, insomnia, tremors.
- Hypersalivation.
- Stomatitis.
- Glossitis.
- Dark line on free gingival margin.

### Following Precautions must be Observed

- Dental personnel should help to minimize the contamination with mercury.
- There should be proper ventilation.
- Mercury vapors should be monitored in office periodically.
- Avoid the skin contact with mercury.
- Prevent any spilling of mercury.
- Floor should be smooth, without carpets, cracks and well ventilated.
- Small droplets of spilled mercury can be collected with the aid of a 'mercury-collecting forceps' or a small amount of freshly mixed amalgam, that will easily absorb liquid mercury.
- High-energy mixer should be equipped with a protective cap to cover the capsule while mixing.
- Removal of amalgam fillings must be done under water cooling and with effective suction.
- Use eye protection and mouth mask.
- Excess mixed amalgam should be kept in a special 'Mercontainer' or at least in a closed container filled with photographic fixer.

## BONDED AMALGAM

Newer concept of bonding systems to bond the amalgam to dentin and enamel has been developed.

Bonded amalgam restorations adhere to the tooth structure through a resin mediated attachment.

To achieve this the thick layers of bonding agents are applied.

### Advantages

- Dentin sealing.
- Resistance form is very much improved.
- Retention form is increased.
- Cavity can be made very conservatively, and extensive undercut is not required.
- Improves marginal seal.
- Use of retention pins is eliminated.
- Microleakage is reduced as bond at tooth restoration interface is provided.
- Incidence of marginal fracture is reduced.

### Indications

- When remaining tooth structure after cavity preparation is weak.
- Bonding provides auxiliary retention in deep bite cases where cervico-occlusal dimension is less than normal.
- In extensively carious posterior teeth.
- As core for cast crown restoration.

### Disadvantages

- Technique sensitive.
- After few years of use bond strength is reduced.
- Cost of bonded amalgam restoration is more than non-bonded amalgam restoration.

### Steps

- The tooth is isolated.
- Cavity is prepared.
- Enamel and dentin walls of the cavity are etched with 10 percent citric or phosphoric acid gel for 15 seconds.
- Cavity is washed and dried.
- Adhesive primer is applied on cavity walls.
- Enamel dentin bonding agent is applied.
- Freshly triturated high copper amalgam is condensed into the cavity.
- The amalgam is carved, finished and polished as usual.

## GALLIUM ALLOYS

To overcome harmful effects of mercury, gallium metal is triturated with silver-tin-copper alloy powder.

### Properties of Silver Gallium Alloy

- With same instruments used for silver amalgam, gallium amalgam can be manipulated and condensed.
- Strength is equal to silver mercury amalgam.
- Gallium amalgam alloys provide better marginal seal than silver amalgam.
- It sets faster than silver mercury amalgam.
- Gallium alloys stick to the instruments, hence its handling is untidy.

### Composition

| 1. **Amalgam Alloy for Gallium** | | **Percentage** |
|---|---|---|
| • Silver | - | 55 to 65 |
| • Tin (Sn) | - | 20 to 30 |
| • Copper (Cu) | - | 10 to 16 |
| • Palladium (Pd) | - | 10 to 15 |
| 2. **Liquid** | | |
| • Gallium (Ga) | - | 57 to 67 |
| • Indium (In) | - | 15 to 25 |
| • Tin (Sn) | - | 15 to 25 |

### Setting

The reaction between powder AgSn particles and liquid gallium results into the formation of AgGa phase and a pure tin phase.

$$AgSn + Ga \rightarrow AgGa + Sn$$

### Clinical Considerations

- In gallium alloys creep value is less which is favorable for the restoration.
- Compressive strength is adequate for small restoration.
- The amalgam being sticky, takes more time for condensation.
- Cleansing of the instruments is also time consuming.
- Gallium amalgam has very high wetting ability thus resistant to microleakage.
- It is 16 times costlier than the silver mercury amalgam.

## WHAT ARE PULP PROTECTING AGENTS?

### Cavity Varnish

- In varnish, organic copal or resin gum is suspended in solutions of ether or chloroform.
- They form coating on tooth by evaporating the solvent.
- It is used for pulp protection and reduction of leakage.
- On drying, cavity varnish acts as an inert plug between the tooth and restoration.
- Minimum of two layers of varnish are applied to achieve a uniform and continuous coating.

*Uses*

- In case of amalgam restoration, it improves the sealing ability of the amalgam, reduces postoperative sensitivity and prevents discoloration of tooth.
- Reduces passage of irritants to dentinal tubules.
- Prevent galvanic shock in case of metallic restorations.
- Prevents penetration of corrosion products of amalgam into dentinal tubules.
- If casting is to be cemented, by zinc phosphate cement, varnish application is advantageous as it will block the seepage due to the available acid.
- With restorative resins, cavity varnish is not used because the varnish dissolves in the monomer of the resin.

### Cavity Liners

- Liners are thicker barrier than varnish used in conjunction with cement base.
- Frequently used liners are calcium hydroxide or zinc oxide eugenol.
- Nowadays, light activated glass ionomer and resin are also used as liners because of their ability to release fluoride.
- Calcium hydroxide liners are soluble and thus should not be applied to the margins of the restorations.

*Uses*

- Reduces passage of irritants from cements to dentinal tubules.
- Reduce sensitivity of freshly cut dentin.
- Accelerates formation of reparative dentin.

## Cavity Bases

Bases are used for prevention of thermal and chemical irritation and complement mechanical support during condensation of amalgam and cementation of indirect restorations.

### *Classification of Cements Bases*

*Low strength bases*

- They have minimum strength.
- They act as barrier to chemical irritants.
- Provide therapeutic benefits to the pulp.
- Examples:
  Calcium hydroxide [$Ca(OH)_2$]
  Zinc oxide eugenol.

*High strength bases*

- They provide thermal insulation.
- Provide mechanical support to the restoration.
- Applied 0.5 to 0.75 mm in thickness.
- Examples:
  - Zinc phosphate
  - Polycarboxylate
  - Zinc-silico-phosphate
  - Glass ionomer
  - Mineral trioxide aggregate (MTA).

*Use*

- Thermal and electrical insulating properties.
- Prevent galvanic shock.
- Prevent chemical irritation.
- Provide mechanical support to restoration.
- Provide therapeutic action to pulp.

## Selection of Base or Liner Depends upon following Conditions

1. Thickness of remaining pulpal dentin.
2. Adhesive properties of the base or liners.
3. Type of restorative material being used over the base and liner.
   - There is no need for pulp protection when remaining dentin thickness is more than 2 mm.
   - When remaining dentin thickness is less than 2 mm, calcium hydroxide liner or base and zinc oxide eugenol cement base are used.

## GLASS IONOMER CEMENTS

This cement is extensively used to replace dentin, hence it is also referred as 'artificial dentin; 'dentin substitute' and 'man made dentin'.

## Composition

*Powder*: It is referred as an ion leachable glass, consists of aluminosilicate containing calcium and fluoride.

*Liquid*: It is essentially 50 percent of polyacrylic acid.

## General Properties

1. Esthetically acceptable.
2. Anticariogenic.
3. True chemical bonding to both enamel and dentin.
4. Biocompatible.
5. Insoluble in oral fluids at intraoral temperatures.
6. Conservative tooth preparation is required.
7 Good color and shade range with translucency is available.

## Types

### *Type I: Conventional*

Type I is used as cements, liners and bases.

### *Type II: Restorative*

Type II is used in restorations, liners, bases and cores.

They are of following two types:

*Class I*: Esthetic restorative cement. It is mostly used for anterior teeth.

*Class II*: Reinforced restorative cement or metal modified GIC. They are subclassified as follows:

i. Amalgam alloys mixed with cement, i.e. Ag-Sn or Ag-Pd admixed with silver alloy admix.
ii. Ceramic metal mixtures.

### *Type III: Light Cured Glass Ionomer Cements*

Type III is used as liners and bases. It is available in powder and liquid form.

1. *Powder:* Powder consists of ion leachable glass with other powder particles also mixed with alumino-silicate glass.
2. *Liquid:* Dentin bonding agents such as HEMA is added to liquid component.

*Type IV: Hybrid Resin*

Modified Glass Ionomer Cements.

1. *Powder*: Polymers and other phases are added to powder component.
   Composites are blended with tiny beads of precured glass ionomer.
2. *Liquid:* HEMA and other monomers are added to liquid component for bonding.

*Types V: Polyacid*

Modified resin composite or glass ionomer resin composite

1. *Powder:* Consists of an ion leachable glass as in a conventional GIC. Initiators are present for light or chemical curing or both.
2. *Liquid*: Consists of methacrylate monomers with multiple carboxylic groups.

## Uses of GIC

1. Cementing or luting agent—for inlays and onlays, crowns, pins and posts, veneers, orthodontic bands.
2. Restorations of teeth
   - — Class III, V and VII cavities
   - — Root caries
   - — Abrasion/Erosion lesions
   - — Atraumatic restorative treatment (ART)
3. Pit and fissure sealant
4. In endodontics
   - — GIC is used as sealer
   - — GIC is for repairing perforations and resorptions
5. For core build up.

## Disadvantages of GIC

- Poor wear resistance
- Lower resistance to fracture
- Poor toughness.

## MODIFICATIONS OF GIC

### Metal Modified Glass Ionomers

*Miracle mix*

- Prepared by incorporating silver tin alloy into glass ionomer cement powder.
- Toughness and abrasive resistance increased.
- No change in compressive strength, solubility and abrasive resistance.

*Glass cermets*

- Made by sintering glass and metal powders at high temperature.
- Improved wear resistance and flexure strength.
- It has optimal radiopacity.

*Uses*

- In small class I cavities.
- For restoration of deciduous teeth.
- As core build-ups.

### Resin Modified Glass Ionomers

*Composition*

*Powder*

- Initiator for light or chemical curing
- Fluoroalumino silicate glass particles.

*Liquid*

- Polyacrylic acid
- Water
- Dimethyl methacrylate monomer
- Hydroxyl ethyl methacrylate.

*Uses*

- As restorative cement
- For core build ups
- As pit and fissure sealants
- As liners and bases.

*Advantages*

- Insoluble
- Strong

- Good wear resistance
- Fluoride release
- Acceptable esthetics
- Micromechanical and chemical bonding to tooth structure.

*Disadvantages*

- Microleakage
- Polymerization reaction.

## COMPOLYMERS/ POLYACID MODIFIED COMPOSITE RESINS

- They are combination of composites and glass ionomers.
- Contain dimethacrylate monomer and two carboxylic groups along with ion leachable glass.
- There is no water in composition of single component system (one paste form). They set by free radical polymerization reaction. They do not bond to tooth surface.
- In two component system (powder and liquid or two pastes) water is present and an acid base reaction takes place at the time of mixing. These bond to the tooth structure.

### Uses

- Class I and II cavities in children.
- For restoration of cervical lesions.
- For orthodontic bonding.
- As luting cement.

### Advantages

- High flexure and compressive strength.
- Fluoride release.
- Low solubility.

### Disadvantages

- Physical properties are inferior to composites.
- Less fluoride release.

## WHAT ARE RECENT ADVANCES IN PORCELAIN SYSTEMS?

Dental ceramics are inorganic compounds with nonmetallic properties, usually composed of oxygen and metallic and non metallic elements.

*Classification*

*According to their use:*
- Crowns
- Veneers
- Post and core
- FPDs.

*According to composition:*
- Silica glass
- Pure alumina
- Pure zirconia
- Lucite based glass ceramic.

*According to firing temperature:*
- Ultra low fusing < 850°C
- Low fusing 850-1000°C
- Medium fusing 1100-1300°C
- High fusing > 1300°C.

*According to processing method:*
- Sintering
- Glass infiltration
- CAD-CAM
- Copy milling.

*According to translucency:*
- Opaque
- Translucent
- Transparent.

### Recent Advances in Porcelain Systems

1. Magnesia core porcelains
2. Injection molded ceramics
3. Castable glass ceramics (Dicor)
4. Leucite reinforced (OPTEC HSP)
5. Glass infiltrated alumina core (INCERAM) and glass infiltrated spinel core ceramic (Inceram spinel)
6. Computer generated ceramic restorations.

*Magnesia Core Porcelain*

- It has a high coefficient of thermal expansion
- Can be used with veneer porcelain
- Used as core as it has high strength.

*Injection Molded Core Materials (IPS Empress)*

- Leucite reinforced ceramic is blended with resins to form a plastic mass which is heated to 180°C and injected at 1,500 psi pressure into a mold.
- Deflasking followed by firing is then done.

- Resins are burnt off by firing and a rigid core of aluminous ceramic is formed.
- Used to form the core layer of porcelain crown.

*Castable Glass Ceramic (DICOR)*

- Dicor is a castable glass that is formed into an inlay, facial veneer or full crown restorations.
- Strength is equivalent to aluminous porcelains.

*Leucite Reinforced Porcelain (OPTEC HSP)*

- Has higher leucite content than conventional porcelain.
- Used for Unlays, onlays crown and veneer in anterior teeth.

*Advantages*

- Has good translucency and esthetics.
- Higher strength than conventional porcelains.

*Disadvantages*

- Marginal shrinkage during firing
- Fitting not as good as PFM crowns
- Not strong enough for posterior use.

*Glass Infiltrated Alumina Core Ceramic (Inceram) and Glass Infiltrated Spinel Core Ceramic (Inceram Spinel)*

- Inceram has good fit and marginal adaptation.
- Inceram bridges are weak when compared to PFM.
- Less esthetic due to higher opacity of the core.
- Specialized equipment is needed.

*Computer Generated Ceramic Restorations*

The CEREC® system was the first commercially available CAD/CAM system developed for the rapid chair-side design and fabrication of ceramic restorations.

Basic fabrication steps for restorations generated with the CEREC® system can be summarized as follows:

After tooth preparation, a scanning device is used to collect the information on the shape and size of the preparation. This step is termed an "optical impression".

A video image of the prepared tooth is displayed to ensure proper positioning of the scanning device.

System projects image of the tooth preparation on a monitor so as to use the CAD portion of the system to design the restoration.

After designing, the computer directs a micromilling device (CAM portion), to mill the restoration out of a block of ceramic.

Restoration is removed from the milling device, ready for try-in and cementation.

*Advantages*

- Saves lots of time.
- No laboratory expenses in inlays and onlays.
- Conventional impression, multiple sittings and temporary restorations are not required.
- Quality of restoration is very good.

*Disadvantages*

- Expensive.
- Require special training.
- Technique sensitive.
- Computer prepares rough occlusal anatomy without consideration of opposing occlusal anatomy and final occlusal adjustments are to be carried out.

## GIVE BIOLOGICAL CONSIDERATIONS OF THE TOOTH WHILE SELECTING THE RESTORATIVE MATERIALS?

### Size of the Carious Lesion

If the posterior teeth are greatly destroyed by caries, then gold cast restorations or metal ceramic restorations should be done.

In anterior teeth if carious lesion is small, they can be restored with a tooth-colored restorative material. If the carious lesion is large full coverage metal ceramic or composite restoration should be done.

### Condition of the Pulpal Tissue

If by a carious lesion there is no threat to the health of the pulp, remove the caries avoiding pulpal exposure and then restore the tooth with permanent restoration.

The questionable teeth, after removal of caries, are temporarily sealed with calcium hydroxide and with zinc oxide eugenol.

### Condition of the Periodontium

If teeth are covered by debris, or calculus, surrounded by diseased gingival tissues and are loose, they cannot be restored properly.

### Occlusion

The static and dynamic occlusion must be carefully examined and analyzed before initiating restorative treatment.

### Size, Form and Structure of Teeth

Sometimes it is desirable to alter the tooth form, or contour in the proposed restoration to improve the health of the supporting tissues. Recontouring of interproximal surfaces is usually done with gold castings and metal ceramic restorations.

## HOW DO PHYSICAL AND CLINICAL PROPERTIES OF THE RESTORATIVE MATERIALS AFFECT THEIR SELECTION?

### Dimensional Stability

After the placement of the restoration in the cavity, changes in the dimension of the restorative materials take place due to setting reaction or due to thermal expansion or contraction.

### Percolation

It is one of the consequences of difference of thermal expansion and contraction between material and tooth. Percolation gives rise to marginal leakage.

The more is the difference between linear coefficient of thermal expansion, more will be percolation and more will be the marginal leakage. Therefore such restorative material should be selected which have linear coefficient of thermal expansion as near to as that of tooth.

### Strength

The restorative material must have sufficient strength to sustain the masticatory forces. During mastication, occlusal surfaces of the posterior teeth receive maximum stress, so the restoration in these areas requires material of high strength.

### Adaptability

An ideal restorative material should have both chemical and physical bonding to the tooth structure. Acid etching, use of liners and sound manipulation helps in increasing the adaptability of the material.

### Abrasion Resistance

Abrasion resistance is determined by the application of abrasives on the surface of the restoration. Abrasion resistance to wear and fracture is required more for the occlusal surfaces of posterior teeth and incisal edges of the anterior teeth.

### Thermal Conductivity

The material should have low thermal conductivity so as to avoid pulpal irritation. As the cavity becomes deeper and closer to pulp, protection becomes very important. Liners and bases are placed between deep dentin and the restoration to provide pulp protection.

### Resistance to Tarnish and Corrosion

The material should be resistant to tarnish and corrosion so as to prevent the degradation of the restoration surface.

# 31 Fundamentals of Tooth Preparation

## WHAT IS TOOTH PREPARATION?

### Tooth Preparation

It is a mechanical alteration of a tooth to make it disease free and/or to give it such a shape that it can retain the restorative material which will maintain the original morphology of tooth and provide proper function and esthetics.

### Simple, Compound and Complex Cavity Preparation

A cavity preparation involving only one tooth surface is termed simple cavity. If two surfaces are involved, it is termed compound cavity, whereas if more than two surfaces are involved it is called as *complex cavity* preparation.

### Cavity Preparation Walls (Figs 31.1 to 31.5)

*Internal wall*: It is a wall in the prepared cavity, which is not extended to the external tooth surface.

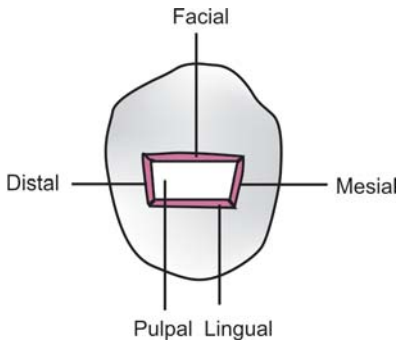



**Fig. 31.1:** Diagrammatic representation of walls of class I cavity

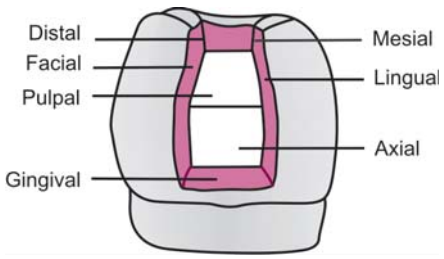



**Fig. 31.2:** Diagrammatic representation of class II cavity walls

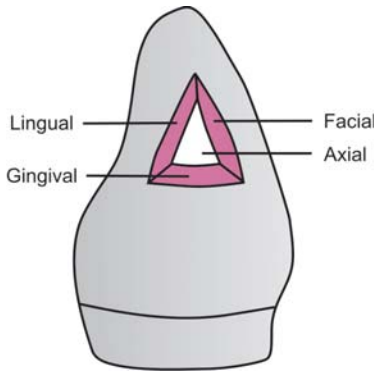



**Fig. 31.3:** Diagrammatic representation of class III cavity walls

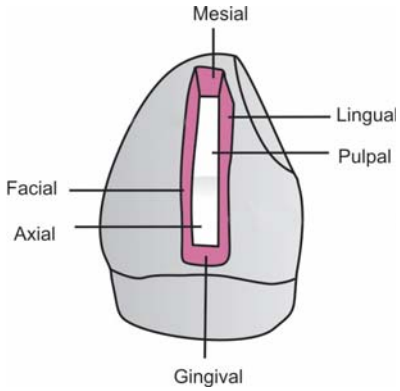



**Fig. 31.4:** Diagrammatic representation of class IV cavity walls

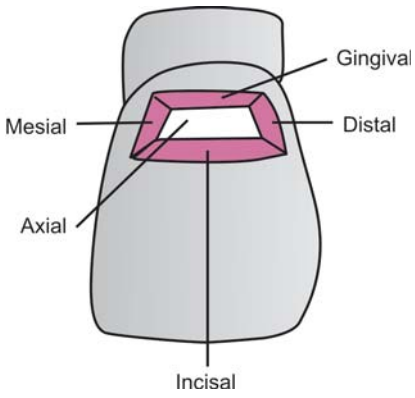



**Fig. 31.5:** Diagrammatic representation of class V cavity

*External wall*: An external wall is a wall in the prepared cavity surface that extends to the external tooth surface, and this wall take the name of the tooth surface towards which it is situated.

*Pulpal wall*: A pulpal wall is an internal wall that is towards the pulp and covering the pulp.

*Axial wall*: It is an internal wall which is parallel to the long axis of the tooth.

*Floor*: It is a prepared cavity internal wall, which is usually flat and perpendicular to the occlusal forces directed occlusogingivally, for example, pulpal and gingival walls.

## Cavosurface Angle Margin and Cavity Margin

Cavosurface angle is formed by the junction of a prepared cavity wall and external surface of the tooth. The acute junction is referred to as cavity margin or cavosurface margin.

## Line Angle

It is a junction of two surfaces of different orientations along the line and its name is derived from the involved surfaces.

## Point Angle

It is a junction of three plane surfaces or three line angles of different orientation and its name is derived from its involved surfaces or line angles.

For simple **class I cavity preparation** involving only occlusal surface of molars eight line angles and four point angles have named as follows (Fig. 31.6):

**Line angles**
- Mesiobuccal line angle
- Mesiolingual line angle
- Distobuccal line angle
- Distolingual line angle
- Faciopulpal line angle
- Linguopulpal line angle
- Mesiopulpal line angle
- Distopulpal line angle

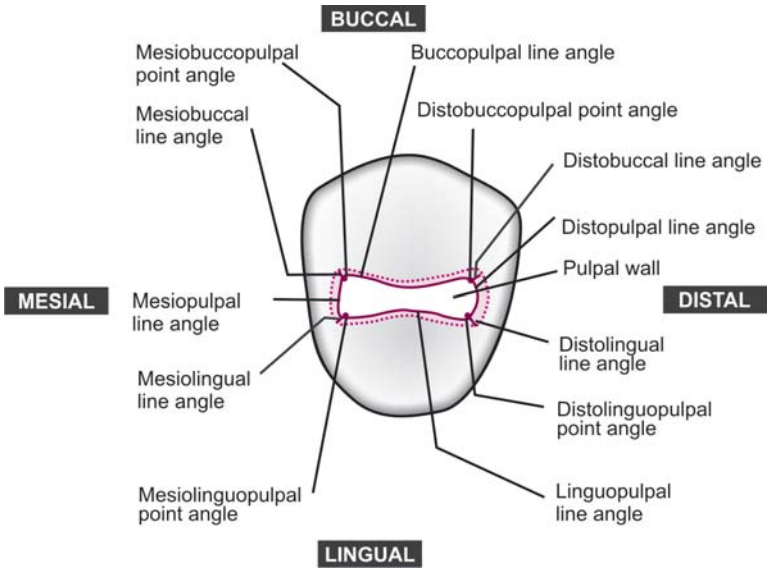



**Fig. 31.6:** Line angles and point angles of class I cavity involving occlusal surface

**Point angles**
- Mesiobuccalpulpal point angle
- Mesiolinguopulpal point angle
- Distobuccalpulpal point angle
- Distolinguopulpal point angle.

For **class II cavity preparation** (mesioocclusal or disto-occlusal) 11 line angles and 6 point angles are as follows. The following is the nomenclature for mesio-occlusal cavity (Fig. 31.7).

**Line angles**
- Distofacial
- Faciopulpal
- Axiofacial
- Faciogingival
- Axiogingival
- Linguogingival
- Axiolingual
- Axiopulpal
- Distolingual
- Distopulpal
- Linguopulpal

**Point angles**
- Distofaciopulpal point angle
- Axiofaciopulpal point angle
- Axiofaciogingival point angle
- Axiolinguogingival point angle
- Axiolinguopulpal point angle
- Distolinguopulpal point angle

For **class III cavity preparation** on anterior teeth 6 line angles and 3 point angles are as follows (Fig. 31.8).

**Line angles**
- Faciogingival
- Linguogingival
- Axiogingival
- Axiolingual
- Axioincisal
- Axiofacial

**Point angles**
- Axiofaciogingival point angle
- Axiolinguogingival point angle
- Axioincisal point angle

For **class IV cavity preparation** on anterior teeth 11 line angles and 6 point angles are as follows (Fig. 31.9).

**Line angles**
- Faciogingival
- Linguogingival
- Mesiofacial
- Mesiolingual
- Mesiopulpal
- Faciopulpal
- Linguopulpal
- Axiogingival
- Axiolingual
- Axiofacial
- Axiopulpal

**Point angles**
- Axiofaciopulpal point angle
- Axiolinguopulpal point angle
- Axiofaciogingival point angle
- Axiolinguogingival point angle
- Distofaciopulpal point angle
- Distolinguopulpal point angle

For **class V cavity preparation**, 8 line angles and 4 point angles are as follows (Fig. 31.10).

**Line angles**
- Distofacial
- Axiogingival
- Axioincisal

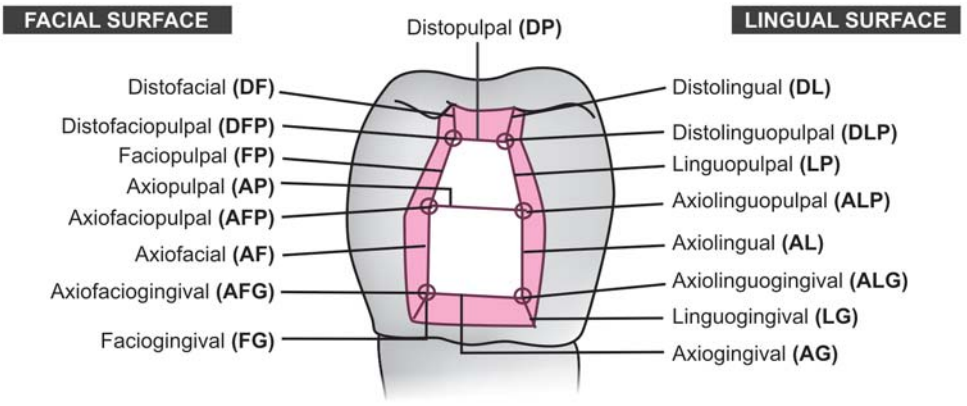



**Fig. 31.7:** Line angles and point angles of class II cavity

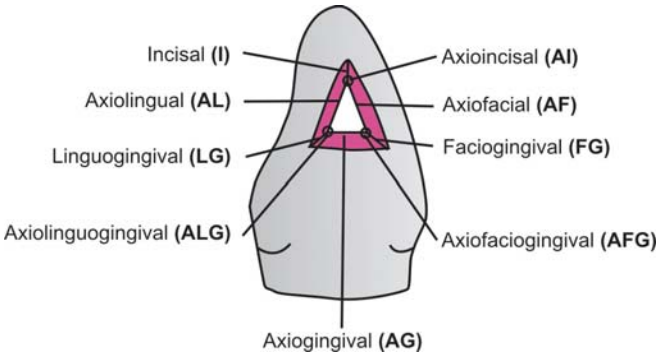



**Fig. 31.8:** Line angles and point angles of class III cavity

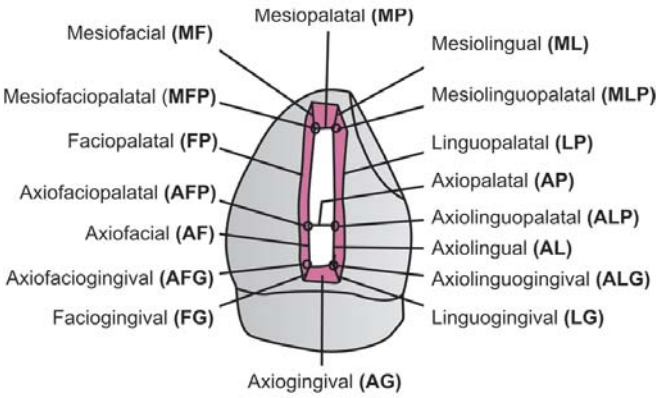



**Fig. 31.9:** Line angles and point angles of class IV cavity

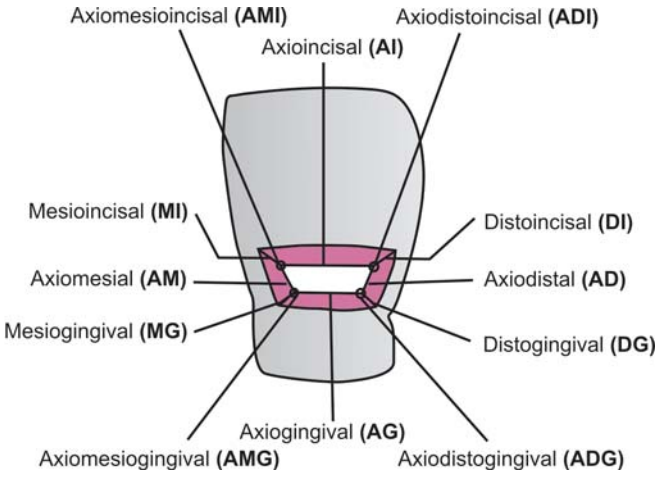



**Fig. 31.10:** Line angles and point angles of class V cavity

| | |
|---|---|
| | - Axiomesial<br>- Axiodistal<br>- Mesioincisal<br>- Mesiogingival<br>- Distoincisal<br>- Distogingival |
| Point angles | - Axiodistogingival point angle<br>- Axiodistoincisal point angle<br>- Axiomesiogingival point angle<br>- Axiomesioincisal point angle |

*During cavity preparation Black had suggested following precautions:*

1. Provision for definite mechanical retention in the cavity.
2. Extension into nearby deep pits and fissures for prevention of recurrent caries.
3. Removal of infected and affected enamel and dentin from all surfaces.
4. Removal of even healthy tooth structure to gain access and good visibility.
5. Cavosurface margins must be at self cleansing areas.

With the following changes the designs of the cavities have become most conservative and Black's concepts have been totally revolutionized.

1. The development of tooth colored, adhesive, fluoride releasing restorative materials which make adjacent tooth tissues caries resistant.
2. More liking for tooth colored restorative materials.
3. Satisfaction even with shorter life of esthetic restoration.
4. Routine use of improved and new diagnostic aids.
5. Better oral hygiene maintenance.
6. Softer food rich in refined carbohydrates.
7. Use of preventive measures like fluoridation of water supply, fluoride toothpaste, fluoride gel, proper brushing and flossing, etc.
8. Realization of the fact that the remineralization of uninfected demineralized dentin takes place hence it can be left as such.
9. Acid etching followed by bonding provides retention sufficient to hold back the restorative materials.

## OBJECTIVES OF TOOTH PREPARATION

1. Removal of all the defects with protection of pulp.
2. To locate the margins of restoration conservatively.
3. To allow for esthetics and functional placement of restorative material.
4. To make cavity such that cavity and restoration can withstand the forces of mastication.

## WHAT ARE BASIC STEPS IN TOOTH PREPARATION?

Basic tooth preparation is divided mainly into two stages:

### Stage I: Initial Tooth Preparation Steps

1. Outline form and initial depth.
2. Primary resistance form.
3. Primary retention form.
4. Convenience form.

### Stage II: Final Tooth Preparation Steps

5. Removal of any remaining enamel pit or fissure, infected dentin and/or old restorative material, if indicated.
6. Pulp protection, if indicated.
7. Secondary (additional) resistance and retention form.
8. Procedures for finishing the external walls of the tooth preparation.
9. Final procedures: cleaning, inspecting and sealing.

Under special conditions these sequences are changed.

## INITIAL TOOTH PREPARATION STEPS

### Outline Form and Initial Depth

The outline form means extending the cavity margins to the place they will occupy in the final cavity preparation. This defines the external boundaries of the prepared cavities. **The following factors guide the outline form and initial depth form.**

a. Extension of carious lesion.
b. Proximity of the lesion to other deep structural surface defects.
c. The esthetic consideration.
d. The relationship of approximating and opposing teeth.
e. Susceptibility to caries.
f. The restorative material to be used.

**Factors guiding the outline form and depth in occlusal cavities.**

a. Remove all caries and cavity margins are extended to healthy tooth structure.
b. All unsupported enamel rods are removed from stress bearing areas.
c. Extension for prevention- All deep pits and fissures within 0.5 mm of the cavity should be included and if the thickness of wall between two cavities is less than 0.5 mm.
d. Avoid ending cavity margins in high stress areas like cusp tip and crest of the ridges.
e. Margins are extended so as to facilitate all procedures.
f. Due to esthetic reasons cavity should be made as conservatively as possible.

The cavity depth must be atleast 1.5 to 2.0 mm vertical from the cavosurface margin to the pulpal wall and should be, at least 0.2 to 0.5 mm in dentin to provide adequate strength to resist fracture due to occlusal forces.

### Outline of Proximal Cavities

Outline of proximal cavities is controlled by the following factors:

a. Extent of the caries on the proximal side.
b. Dimensions of the contact area in the carious tooth.
c. Caries susceptibility of the patient.
d. If nonfluoride releasing restorative material is to be used then the cavity margins should be in a self cleaning area.
e. Age of the patient.
f. Position of gingiva and chances of future recession.
g. Masticatory forces likely to fall on restorative material.
h. Conservative proximal box is made because of esthetic reasons.

## ENAMELOPLASTY

Enameloplasty is the careful removal of sharp and irregular enamel margins of the enamel surface by 'rounding' or 'saucering' it and converting it into a smooth-based groove or pit which may be easily cleaned and allow conservative placement of margins.

The following factors govern the cervical/gingival/root/outline of the buccal and lingual cavities:

1. Size of the lesion guides the cervical outline of the cavity.
2. Restorative material—Selection of restorative material affects the shape of the cavity.
3. Age—In younger patients cavity margin is kept in gingival sulcus, in older patients having gingival recession the cavity margin is kept supragingivally.
4. Contour of the buccal/lingual surfaces affect design of the cervical cavities.
5. Oral hygiene, forces of mastication, pattern of occlusal contacts also affect the design of cervical cavity.

## Primary Resistance Form

Primary resistance form is that shape and configuration of cavity walls to enable a placement of restorative material, so that both the tooth and restoration best withstand the stresses of masticatory forces without fracture.

For obtaining the resistance form the followings must be followed:

a. Make a box-shaped cavity (Fig. 31.11).
b. Establish a flat floor.
c. Provide adequate thickness of restorative material to prevent the fracture of both the remaining tooth structure and restoration.
d. Restrict the extension of external walls to allow strong ridge areas with sufficient dentin support.
e. Inclusion of weakened tooth structure.
f. Slight rounding of internal line angle to reduce the stress in tooth structure to increase the resistance to fracture.
g. Capping of cusp.

## Primary Retention Form

Primary retention form is the form, shape and configuration of the prepared cavity that resists the displacement or removal of restoration from the cavity under all types of tilting and tipping masticatory forces.

The retention form is affected by the type of the restorative material used.

### *Amalgam*

Retention is increased in amalgam restoration by the following:

a. Converging (about 2 to 5%) the dentinal walls towards the tooth surface.
b. Giving slight undercut in dentin near the pulpal wall (Fig. 31.12).
c. Conserving the marginal ridges.

### *Castings*

Retention is increased in cast restorations by the following:

a. Parallelism of the walls.
b. To prevent tilting of restoration in all types of class II cavities the occlusal extension must be sufficient even if there is no occlusal caries.
c. Secondary retention in the form of coves, skirts and dentin slot without undercut.
d. To prevent tipping movements in class I compound (class I division 3, 4 and 5) and all types of class II, specially in MOD (class II division 5) cavities, reverse bevel is given.

### *Composites*

In composites retention is increased by micromechanical bonding between the etched and primed prepared tooth structure and the material.

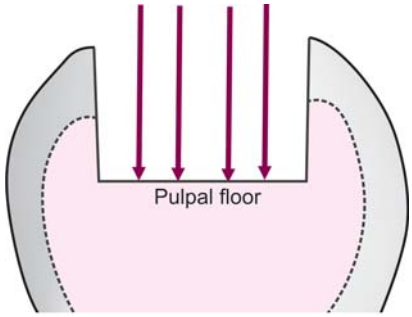



**Fig. 31.11:** Class I cavity in which flat pulpal floor provides good resistance form

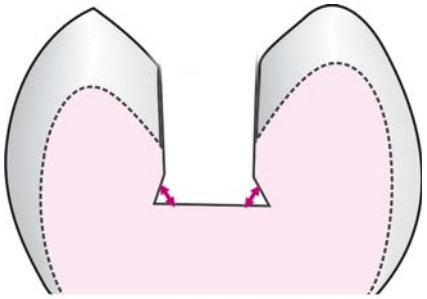


**Fig. 31.12:** Undercut dentinal walls used for retention

*Direct Gold*

Elasticity of dentin and starting point in dentin provide retention in direct gold fillings by proper condensation.

### Convenience Form

The convenience form is that form which facilitates and provides sufficient visibility, accessibility and ease of operation in preparing and restoring the tooth.

## FINAL STAGES OF TOOTH PREPARATION

Removal of any Remaining Enamel Pit or Fissure, Infected Dentin and/or Old Restorative Material, if Indicated.

- After the establishment of external and internal outline form, any remaining carious tooth structure or defective restorative material left in tooth may be removed completely with the protection of pulp.
- Infected and discolored dentin must be removed.
- The pulpal and axial wall should be established as initial cavity preparation and if a small amount of carious lesion remains, only this lesion should be removed, leaving concave, rounded area in the wall.
- In the large cavities with soft caries, the removal of carious dentin is done early in initial cavity preparation.

### Pulp Protection, if Indicated

The bases and the liners are used to protect the pulp. When thickness of the remaining pulpal dentin is less pulpal injury is caused by the following:

1. Heat produced by high speed burs with less effective coolants.
2. Cutting dentinal odontoblastic fibrils when exposed to irritating materials may result in degeneration of the affected odontoblasts.
3. Some restorative materials, produce exothermic heat during setting reaction or have some ingredients which may irritate the pulp.
4. Galvanic currents due to fillings of dissimilar metals or alloys in the same oral cavity.
5. The ingress of microorganisms and their noxious products through microleakage and dentinal tubules irritate the pulp.

If the thickness of the remaining dentin over the pulp is less than 2 mm the pulp protection must be done using liners, varnishes and bases depending upon the amount of dentin left and the restorative material to be used.

### Secondary (Additional) Resistance and Retention Forms

For some cases additional mechanical resistance and retention forms are adopted which are as follows:

*Grooves*

- These are mostly prepared in the walls of the proximal surfaces at the axiobuccal and axiolingual line angles.
- More than one groove per wall should be avoided as they may weaken the wall.
- All grooves must be in one direction and plane having at least 0.5 mm dentin around each groove.

*Slots or Internal Boxes*

- These are 1.0 to 1.5 mm deep box like grooves prepared in dentin to increase the surface area.
- These are prepared in occlusal box, buccoaxial, linguoaxial and gingival walls.

*Locks*

These are prepared mostly for amalgam class II restoration in the proximal or occlusal box of class II cavity.

*Pins*

They are used in all types of restorations like amalgam, composite and cast restorations.

*Skirts*

They extend the preparation around the line angles of the tooth.

In cast restorations skirts are prepared, to increase the total surface area of the preparation.

*Coves*

These are small conical depressions in healthy dentin to provide additional retention.

*Beveled Enamel Margins*

Bevelling of the cavity margins increases the surface area thereby the retention in cast gold/metal and composite restorations.

*Enamel Wall Etching*

Etching results in microscopic roughness, which increases the surface area and provides micro-mechanical retention.

*Dentin Conditioning (Etching and Priming)*

Etching and priming of the dentin surface done in some restorative materials increases the retention.

*Adhesive Luting Cements*

Adhesive luting cements increase the retention of indirect restorations.

### Procedures for Finishing the External Walls of the Tooth Preparation

The finishing of the cavity walls is done for the following:

a. To create the better marginal seal between restorative material and tooth structure.
b. To provide maximum strength to both tooth structure and restorative material.
c. For strong location of the margins.
d. For proper degree of smoothness of the margins.

During finishing of the cavity walls and margins principles of paralleling the direction of enamel wall should be adhered. The finishing of cavity wall is guided by knowledge of enamel structure and careful testing of the margins with hand instruments.

### Final Procedures; Cleaning, Inspecting and Sealing

The final debridement of the cavity has following three objectives:

a. Freeing of all cavity or preparation walls, floors and margins from enamel and dentin chips resulting from excavation and grinding.
b. Drying the cavity/preparation walls, floors and margins before insertion of the restorative materials.
c. Sterilization of cavity walls with very mild alcohol free disinfectant is done.

## EXPLAIN TUNNEL CAVITY PREPARATION AND RESTORATION

When small carious lesion is present only on the proximal surface of posterior tooth and the adjacent tooth is present and is healthy and when caries susceptibility index is low, tunnel cavity preparation may be considered.

To reach the caries a tunnel is prepared starting from occlusal surface undermining but preserving the marginal ridge. The preparation of tunnel is started from the occlusal pit of carious side on the occlusal surface with the help of a small round bur, after protecting the adjacent tooth with metal strip. The tunnel is directed approximately at about 45° angle towards the carious lesion. After approaching the lesion with round bur, then with tapering fissure bur the access is slightly widened.

After this matrix band is properly adapted and wedge is placed, and restorative material is condensed from the occlusal opening avoiding any void.

### Precautions

- The angulation of the bur should be predetermined.
- After cutting upto dentino-enamel junction radiograph should taken along with the bur present in the tunnel preparation to ascertain the correction of the angulation of the bur before proceeding further.
- Constant angulation of the bur has to be maintained because the tunnel should be in a straight line to facilitate excavation of the caries and condensation of the restorative material.

### Advantages

- Maximum possible healthy tooth tissues are preserved.
- Strength of the tooth and the proximal contour is maintained.
- Contact area is maintained.
- Chances of overhanging restoration are minimized as minimum area of the proximal surface is cut.
- Minimum restorative material is used.

### Disadvantages

- Limited indications.
- It is almost a blind procedure as visibility is poor.
- Marginal ridges although not cut, become weak.
- Complete removal of caries lesion on proximal side is difficult.
- On proximal surface the marginal adaptation of restorative material may not be perfect.
- Finishing of the proximal margins is difficult and may not be perfect.

## HOW TO MAKE DISTRIBUTION OF FORCES IN VARIOUS CLASSES OF RESTORATIONS?

### Class I and Class VI Restorations

- In case of plastic materials like amalgam restorations, if floor is not flat and is concave then the forces acting on the tooth will rotate the restoration on both the sides.

- In case of cast restorations the pulpal floor is flat and side walls are slightly diverging occlusally to prevent the rotation of restoration under the forces acting on it.

### Class II and Class IV Restorations

- Here stresses mostly act on marginal ridges.
- Axiopulpal line angle in both class II and IV restorations should be slightly rounded to increase the strength of material by increasing the bulk at this line angle.
- In MOD preprations, the length of axial walls should be kept as far as possible equal on the both sides for balancing the forces acting on it.

### Class III Restorations

- Only transverse forces act in rotation of these restorations.
- Lingual lock in the dentin is given to minimize the stresses.

### Class V and Class VII Restorations

- Transverse forces mainly act in the cervical region which rotate the restorations.
- A restorative material that is adhesive in nature should be used to prevent the rotation of restoration in case of class V and VII cavities.

## WHAT IS RESTORATION?

Restoration is defined as the prosthesis or filling material used to restore or replace a tooth, portion of tooth, multiple teeth or other oral tissues.

### Classification

*Based on Longevity*

*Temporary*: They are placed for limited period, from days to months and are placed in teeth until permanent restoration is placed.

*Permanent*: They are long lasting restorations for damaged teeth.

*Based on Fabrication*

*Direct*: They are placed and formed intraorally to restore teeth e.g. amalgam, GIC, Composites.

*Indirect*: They are formed extraorally in form of prosthesis which is used to replace missing tooth structure or teeth.

### Indications of Restorations

- Caries
- Repair of old restorations
- Esthetics
- To restore form and function
- To restore fractured teeth.

## HOW DO PHYSICAL AND CLINICAL PROPERTIES OF THE RESTORATIVE MATERIALS AFFECT THEIR SELECTION?

### Dimensional Stability

After the placement of the restoration in the cavity, changes in the dimension of the restorative materials take place due to setting reaction or due to thermal expansion or contraction.

### Percolation

It is one of the consequences of difference of thermal expansion and contraction between material and tooth. Percolation gives rise to marginal leakage.

The more is the difference between linear coefficient of thermal expansion, more will be percolation and more will be the marginal leakage. Therefore, such restorative material should be selected which have linear coefficient of thermal expansion as near to as that of tooth.

### Strength

The restorative material must have sufficient strength to sustain the masticatory forces. During mastication, occlusal surfaces of the posterior teeth receive maximum stress, so the restoration in these areas requires material of high strength.

### Adaptability

An ideal restorative material should have both chemical and physical bonding to the tooth structure. Acid etching, use of liners and sound manipulation helps in increasing the adaptability of the material.

### Abrasion Resistance

Abrasion resistance is determined by the application of abrasives on the surface of the restoration. Abrasion resistance to wear and fracture is required more for the occlusal surfaces of posterior teeth and incisal edges of the anterior teeth.

### Thermal Conductivity

The material should have low thermal conductivity so as to avoid pulpal irritation. As the cavity becomes deeper and closer to pulp, protection becomes very important. Liners and bases are placed between deep dentin and the restoration to provide pulp protection.

### Resistance to Tarnish and Corrosion

The material should be resistant to tarnish and corrosion so as to prevent the degradation of the restoration surface.

# 32 Basic Instruments of Operative Dentistry

## GIVE CLASSIFICATION OF OPERATIVE DENTAL INSTRUMENTS

Dr GV Black classified the operative instruments according to their use and function into following six classes:

### Cutting Instruments

They are of two types:

*Hand*

- Hatchets
- Chisels
- Hoes
- Excavators and others.

*Rotary*

- Burs
- Diamond abrasive points stones
- Disks and others.

### Condensing Instruments

*Pluggers*

- Hand
- Mechanical.

### Plastic Instruments

- Spatulas
- Carvers
- Burnishers
- Packing instruments.

### Finishing and Polishing Instruments

### Hand

- Orange wood sticks
- Polishing points
- Finishing strips.

*Rotary*

- Finishing burs
- Mounted brushes
- Mounted stones
- Rubber cusps
- Impregnated disks and wheels.

### Isolation Instruments

- Rubber dam
- Saliva ejector
- Cotton roll holder
- Evacuating tips and equipment.

### Miscellaneous Instruments

- Mouth mirrors
- Explorers
- Probes
- Scissors
- Pliers and others.

## WHAT ARE PARTS OF A HAND CUTTING INSTRUMENT? GIVE BLACK'S INSTRUMENT FORMULA?

### Parts of Hand Cutting Instrument

A hand instrument is composed of three essential parts (Fig. 32.1):

1. Handle or shaft
2. Shank
3. Blade or nib.

*Handle or Shaft*

The handle is used to hold the instrument. They are available in various sizes and shapes, which is helpful for better grasping and developing pressure.

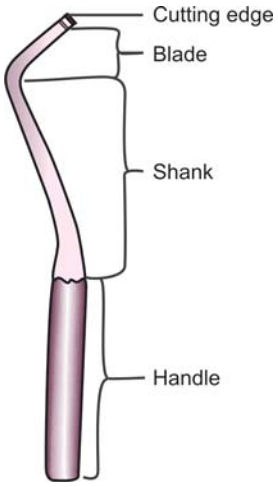



**Fig. 32.1:** Parts of hand cutting instrument

*Shank*

It connects the handle with the working point or nib of the instrument. The shank may be straight or may be bent for better control of the working point when force is applied. According to the number of angles, the instruments are classified as (A) straight, (B) mono-angle, (C) biangle (D) triangle.

If shank has more than one bends it is termed as contra-angled.

*Blade or Nib*

Blade or nib is the working point. For cutting instruments, the working point is called blade, while for non-cutting instruments, the working part is termed the nib.

## Instrument Formula

**Dr. Black** prescribed following nomenclature for the instruments.

1. Order—function of the instrument, e.g. excavator, condensor.
2. Suborder — position, mode or manner of use, e.g. hand condensor.
3. Class — design or form of the working end, e.g. hatchet, spoon excavator.
4. Sub-class — shape of the shank, e.g. binangle, contra-angle.

These names are combined to give a complete description of the instrument.

The formula consist of a code of three or four numbers separated by dashes or spaces which describe the dimensions and angulation of the hand instrument (Fig. 32.2).

- The first number of the formula indicates width of the blade or primary cutting edge in tenths of a millimeter (10 = 1.0 mm).
- The second number represents the angle formed by the primary cutting edge and central axis of the instrument handle in clockwise centigrade. If the cutting edge is at right angle to the length of the blade, then this number is omitted.
- The third number represents the length of the blade in millimeters.
- The fourth number represents the angulation which the blade forms with the long axis of the handle in clockwise centigrade.

*Bevels in Cutting Instruments*

- There is a **single bevel** in most of the hand cutting instruments that forms the primary cutting edge.
- If two additional cutting edges extend from the primary cutting edges, then the instrument with secondary cutting edges is called ***bibeveled instrument***.
- **Right and left sided instrument:** Single-beveled direct cutting instruments such as enamel hatchets are made in pairs having bevels on opposite sides of the blade. The primary cutting edge is held downwards and pointing away. If bevel is on the right

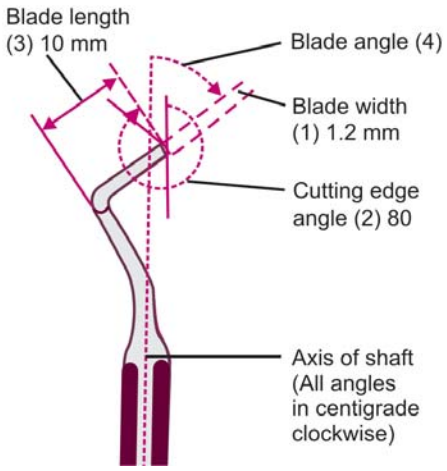



**Fig. 32.2:** Diagrammatic representation of instrument formula

side of the blade, the instrument is right sided and if bevel is on the left side of the blade the instrument is left sided.

- **Mesial and distal bevel:** If the inside of the blade curvature or the primary bevel is not visible then the instrument has a distal bevel and if the primary bevel can be seen the instrument has a mesial or reverse bevel.

## VARIOUS TYPES OF HAND-CUTTING INSTRUMENTS?

### Chisels

Used to cleave the hard tissues of tooth.

*In Straight Chisel*

- The cutting edge is perpendicular to the long axis of the handle.
- Used for gingival restorations of the anterior teeth.

*In Angled Chisels*

- Primary cutting edge is in a plane perpendicular to the long axis of the shaft (Fig. 32.3).
- Have mesial or distal bevel.
- Used for anterior proximal restorations, smoothing proximal walls and gingival walls for full coverage restorations.

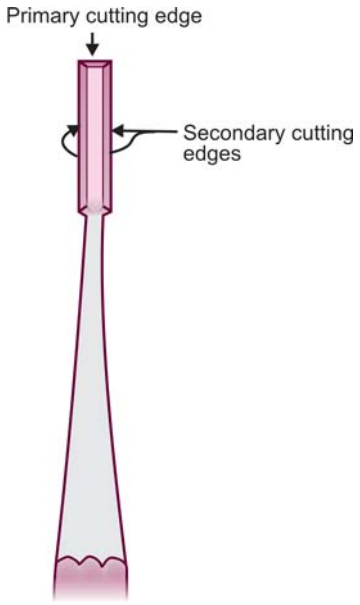



**Fig. 32.3:** Bibeveled chisel

### Hoe

- Modified chisel in which the angle of the blade is greater than 12.5° centigrades.
- Used with a pull motion.

### Hatchet

- A paired instrument in which the blade is perpendicular to the long axis of the handle.
- Used in a chopping motion to refine line and point angles.

### Angle Former

- A type of excavator.
- Monangled with the cutting edge sharpened at right and left angles to the long axis of the blade.
- Used with a push or pull motion for making retentive forms in direct filling gold restoration.

### Spoon Excavator

- Cutting edge is rounded.
- Used to remove caries, etc.
- Used in the spooning or scooping action from the carious teeth.

### Gingival Marginal Trimmer

- It is like the hatchet, but the blade is curved and the cutting edge is other than right angle to the axis of the blade (Fig. 32.4).

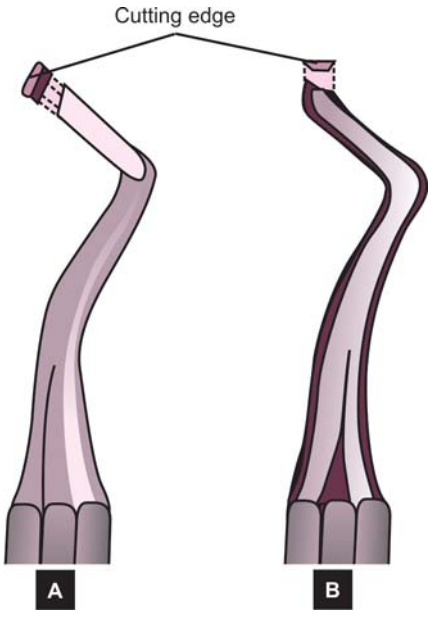



**Fig. 32.4:** GMT cutting edge is other than right angle to axis of the blade

- Available in two pairs forming a set of four.
- In each pair it has right and left beveled instrument.
- If cutting edge makes an acute angle with that edge of blade away from the handle, it's a distal GMT.
- If cutting edge makes an acute angle with that edge of blade nearer to the handle, it's a mesial GMT.
- When the second number of the formula is 75 to 85, it is used on mesial margin and when 90 to 100, it is used for distal margin.
- Used to give bevel in gingival enamel margin of proximo-occlusal preparations.
- For beveling gingival floor.
- For forming sharp angles in the cavity.

### Cleoid and Discoid

- Blades are claw like in cleoid and sharp circular in discoid.
- Used for removing caries and carving amalgam or wax patterns.

### Knives

- Blades are thin designed in various sizes and shapes.
- Used for trimming excess filling material and contouring the surface of the restoration.

## WHAT ARE DIFFERENT TYPES OF INSTRUMENT GRASPS?

Basic instrument grasps are:

1. Modified pen grasp
2. Inverted pen grasp
3. Palm and thumb grasp
4. Modified palm and thumb grasp.

*Modified Pen Grasp*

- The instrument is held between the thumb and the first and middle finger, while the tip of the ring finger and little finger are placed as a rest on a nearby tooth surface.
- The pad of the middle finger should rest on the shank of the instrument. The first finger is positioned above the middle finger on the same side by bending at the second joint from the fingertip. The positioning of the fingers in this manner creates a triangle of forces or tripod effect, which enhances the instrument control (Fig. 32.5).

**Fig. 32.5:** Modified pen grasp

- It is most commonly used in mandibular teeth.
- Here the palm of the operator is facing away from the operator.

*Inverted Pen Grasp*

- In this grasp the palm faces towards the operator, while the finger positions are the same as for the modified pen grasp.

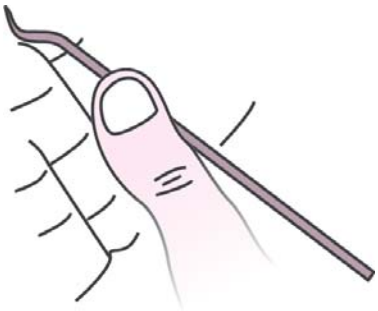


**Fig. 32.6:** Inverted pen grasp

- This grasp is most commonly used for preparing cavity in the anterior teeth by lingual approach. (Fig. 32.6).

*Palm and Thumb Grasp*

- The shaft of the instrument is placed on the palm of the hand and grasped by the four fingers to provide firm control, while the cushion of the thumb is free of instrument to control movements and provide rest on a nearby tooth of the same arch or on a firm and stable structure (Fig. 32.7).
- Used for holding a handpiece while cutting incisal retention for a class III cavity in maxillary incisor.

**Fig. 32.7:** Palm and thumb grasp

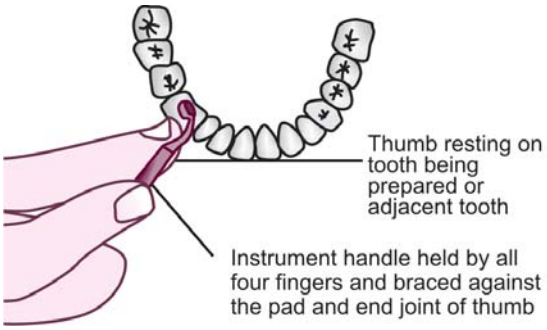



**Fig. 32.8:** Modified palm and thumb grasp

*Modified Palm and Thumb Grasp*

- The instrument is held like the palm grasp but the pads of all the four fingers press the handle against the distal area of the palm as well as the pad and first joint of the thumb.
- This grasp is used when it is feasible to rest the thumb on the tooth being prepared or the adjacent tooth (Fig. 32.8).

## Finger Rests

The finger rest serves to stabilize the hand and the instrument by providing a firm rest to the hand during operative procedures.

A. *Intraoral finger rests*
   - *Conventional*: In this the finger rest is just near or adjacent to the working tooth
   - *Cross arch*: In this the rest is obtained by the tooth of the opposite side but of the same arch.
   - *Opposite arch*: In this the rest is obtained by the tooth of the opposite arch.
   - *Finger on finger*: By the index finger or thumb of non-operating hand the rest is obtained.

B. *Extraoral finger rest*: It is used mostly for maxillary posterior teeth.

*Palm up*: The rest is established by resting the back of the middle and fourth finger on the lateral aspect of the mandible on the right side of the face.

*Palm down*: The rest is obtained by resting the front surface of the middle and fourth fingers on the lateral aspect of the mandible on the left side of the face.

*Guards*: These are hand instruments and other items such as wedges which are used to protect soft tissues from contact with the sharp instruments.

## WHAT ARE ROTARY CUTTING INSTRUMENTS?

Rotary cutting instruments are those instruments which rotate on an axis to do the work of abrading and cutting on tooth structure

To measure the rotational speed of an instrument the term revolutions per minute [rpm] is used.

a. *Ultra low speed* (up to 1000 rpm): Used only for finishing with abrasive disks and for drilling holes for implants in the bone.
b. *Low or slow speed* (1000 to 10,000 rpm): This speed is used for refinement of the preparation and finishing and polishing procedures.
c. *Medium speeds* (12,000 to 25,000 rpm): The early handpieces were electric driven
d. *High speeds* (50,000 to 1,50,000 rpm): The instrument has an air turbine which uses compressed air as the power source.
e. *Ultra high speed* (2,00,000 to 3,00,000 rpm): In air turbine handpieces, compressed air is used.
f. *Super ultra high speed* (above 3,00,000 rpm): High speed air turbine.

## Characterstics of Rotary Instruments

*Speed*

- It is surface feet per unit time of contact that the tool has with the work to be cut.
- It can ultra high, high, medium, low or ultra low depending upon RPM.

*Pressure*

- Pressure is force per unit area.
- Pressure is directly proportional to heat generation
- Instrumentation pressure should not be more than four ounce when using high speed and twelve ounce when using low speed.
- Using the same force, smaller tools exert more pressure than the larger ones.

*Heat production*

If the pulp temperature is elevated by 11°F, destructive reaction will occur even in a normal, vital periodontal organ.

That "heat" is a function of:

a. RPM, i.e. more the RPM more is the heat production.
b. Pressure: Whenever the RPM's are increased, pressure must be correspondingly reduced.
c. Surface area of contact, more the contact between the tooth structures and revolving tool, the more is the heat generation.

*Vibrations*

Vibrations which are measured by their amplitude or their capacity and frequency (the number/unit time).

They are an indication of eccentricity in rotary instruments.

In addition affecting the pulp tissues, vibration can create micro-cracks in enamel and dentin.

*Patient Comfort*

Intermediate application of pressure, use of coolants and use of sharp instruments decrease patient discomfort.

*Power Source*

Most commonly used power source is air turbine.

## PARTS AND DESIGN OF ROTARY CUTTING INSTRUMENTS

The rotary instruments burs and abrasive points consist of three parts (Fig. 32.9).

1. *Shank*: This part fits and accepts the rotary motion from the handpiece.
2. *Neck or shaft*: It connects the shank to the head. The function of the neck is to transmit rotational and translational forces to the head.

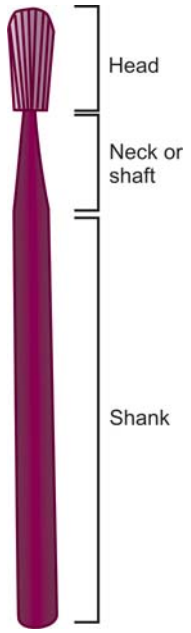



**Fig. 32.9:** Parts of a rotary cutting instrument

3. *Head*: It is the working part of the instrument to which cutting edges or points are attached.

## Classification of Burs

*According to Composition*

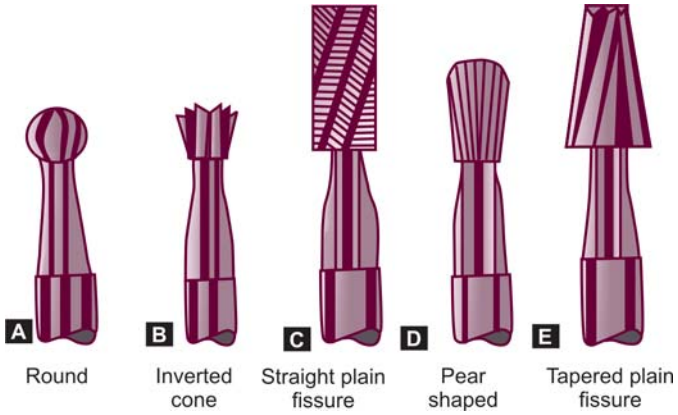
- Steel
- Tungsten carbide.

*According to Shape of Bur Head (Fig. 32.10)*

a. *Round bur* is used for initial entry into the cavity, removal of caries, preparation of retention grooves
b. *Straight plain or flat fissure* is used for extension of the cavity preparation
c. *Inverted cone* is used for providing undercuts in the cavity
d. *Tapered plain fissure* is used for inlay and crown preparations
e. *Pear shape*: Provides rounded line angles and point angles required for composites restorations.

*According to Length of Head*

- Long
- Short
- Regular




**Figs 32.10A to E:** Different shapes of bur heads

*According to Handpiece*

They are designed for:
- Straight handpiece
- Contra-angle.

*According to Mode of Attachment to the Handpiece*

- Friction grip type
- Latch type.

## Design of Bur Blade

*Bur Tooth*

- It is cutting edge or blade.
- Usually number of bur teeth are 6-8 in cutting burs
- It has two surfaces:
  - Tooth face, that is side of tooth on leading edge
  - Back of the tooth, that is side of the tooth on the trailing edge.
- Land refers to the plane surface immediately following the cutting edge.
- Chip space is the space present between successive blades of the bur. It provides an exit for removal of debris and creates a clearance angle.

Rake angle, clearance angle and edge angle are the three important angles, measured in relation to the radial line of the blade.

## Rake Angle (Fig. 32.11)

- Rake face and clearance face are the two sides of the blade.
- Rake angle is the angle that face of bur tooth makes with the radial line.
- When the rake face is ahead of the radius, the rake angle is said to be negative.
- When the rake face is behind the radius, the rake angle is said to be positive.
- When radius and tooth face coincide with each other, rake angle is said to be zero.

## Clearance Angle

- It is the angle between back of the bur tooth and the tooth surface.
- Clearance angle prevents the bur edge from digging into the tooth structure.

**Table 32.1: Standard Bur Head Sizes – Carbide and Steel (1955 to Present) Head diameters in mm**

| HEAD | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| In mm | 0.5 | 0.6 | 0.8 | 1.0 | 1.2 | 1.4 | 1.6 | 1.9 | 2.1 | 2.3 | 2.5 | 2.8 | 3.0 | 3.3 |
| SHAPES | | | | | | | | | | | | | | |
| Round | ¼ | ½ | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | |
| Wheel | | 11½ | 12 | 14 | 16 | | | | | | | | | |
| Inverted cone | | 33 ½ | 34 | 35 | 36 | 37 | 38 | 39 | 40 | | | | | |
| Plain flat fissure | | 55 ½ | 56 | 57 | 58 | 59 | 60 | 61 | 62 | | | | | |
| Round crosscut | | | | 502 | 503 | 504 | 505 | 506 | | | | | | |
| Straight fissure crosscut | | | 556 | 557 | 558 | 559 | 560 | 561 | 562 | 563 | | | | |
| Tapered fissure crosscut | | | | 700 | 701 | | 702 | | 703 | | | | | |
| End cutting fissure | | | | 957 | 958 | 959 | | | | | | | | |
| Round finishing | | | | A | B | C | D | | 200 | 201 | 202 | 203 | | |
| Oval finishing | | | | | | | | | 218 | 219 | 220 | 221 | | |
| Pear finishing | | | | | | | | | 230 | 231 | 232 | | | |
| Flame finishing | | | | 242 | 243 | 244 | 245 | 246 | | | | | | |

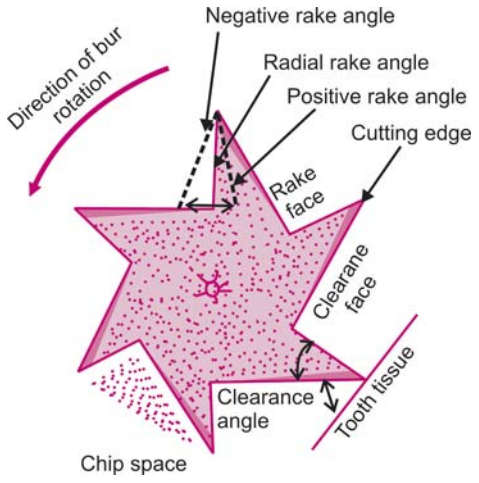



**Fig. 32.11:** Design of a bur blade

- *Primary clearance* angle is the angle between land and the tooth surface.
- *Secondary clearance* angle is the angle between back of the bur tooth and the tooth surface.
- *Radial clearance* angle is the angle formed when back surface of the bur tooth is curved.

## ENUMERATE FACTORS AFFECTING CUTTING EFFICIENCY OF BURS

### Rake Angle

- More positive the rake angle, greater is cutting efficiency of bur
- A negative rake angle produces a chip which is smaller and moves directly away from the blade edge
- A positive rake angle produces a chip which is larger and moves directly away from the blade edge.

### Clearance Angle

- An increase in clearance angle reduces the blade angle, thus reducing the bulk of bur blade
- Larger clearance angle reduces early dulling of the bur.

### Crosscuts

- Crosscuts are the notches in the blade edge to increase cutting efficiency at low and high speed
- They reduce the total length of bur blade that is cutting at a time, this increases the force per unit area, and thus reduce the pressure required to start cutting.

### Number of Blades

- As the number of blades decrease, magnitude of force at each blade increases, thus thickness of chip removed by each blade increases.
- Fewer number of teeth decrease the chance of bur clogging
- Fewer the number of blades, more is the tendency for vibration.

### Influence of the Load

- Load is the force exerted by the dentist on the bur head, not the pressure induced in the tooth during cutting
- Load should be from 60-120 gm for high speed, 1000-1500 gm for low speed.

### Heat Treatment

- It is used to harden the bur and thereby preserves the cutting edge of blade
- This is not needed for carbide burs.

## WHAT ARE USES OF LOW AND HIGH SPEED ROTARY INSTRUMENTS?

### High speed

*Uses*

- For tooth preparation
- For removal of old restorations

*Advantages*

- Faster removal of tooth structure
- Better control and ease of instrumentation
- Many teeth can be prepared in single appointment
- Patient comfort

*Disadvantages*

- If care is not taken, it can injure adjacent hard and soft tissues
- Excessive removal of tooth structure can occur
- Spread of aerosols.

### Low Speed

*Uses*

- For tooth cleaning
- For finishing and polishing
- For post space preparations
- For removal of caries.

*Advantages*

- Less heat generation
- Better tactile sensation.

*Disadvantages*

- Ineffective
- Time consuming
- More discomfort to patient.

## WHAT PRECAUTIONS SHOULD BE TAKEN WHILE WORKING WITH ULTRASPEED CUTTING INSTRUMENTS?

### Pulpal Precautions

Trauma to the pulp during cavity preparation may occur due to mechanical vibration, improper cavity form and heat generation during cutting. If air is used alone, it unnecessarily desiccates the dentin and damages the odontoblast. Use of air-water spray not only cools but also moistens the tissues, lubricates and cleans the rotary cutting instruments.

### Condition of Burs and Rotary Instruments

All the burs and rotary instruments should be perfectly centric, eccentric bur can destructively damage the surrounding dental tissues and the handpiece.

### Other Soft Tissue Precautions

Lacerations may occur in the lips, tongue, cheeks and floor of the mouth if proper precautions are not taken.

During cutting procedures, sudden movement by the patient due to gagging, swallowing or coughing can result in soft tissue injury.

While removing the rotating air turbine handpiece, wait for the instrument to stop.

### Ear Precautions

The noise emitted by air turbine handpieces ranges from 75 to 100 decibels and the frequency is above 2000 cycles per second. In protective measures, sound proofing of the room with sound absorbing materials can be done, or ear plugs may be used.

### Inhalation Precautions

Oral inhalation of aerosols and vapors by the patient can be avoided by the use of rubber dam. For prevention disposable masks must be used by dentist.

### Eye Precautions

To protect the eyes glasses should be worn by the patient and the dental personnel.

## DENTAL ABRASIVE STONES

- Abrasives are used to smoothen the tooth surface by grinding.
- Abrasive particles are held together by means of a binder.
- Most commonly used binder is ceramic binder, used to bind diamond points.
- For better efficiency of abrasive, its hardness should be more than the hardness of the work.
- An abrasive should be irregular in shape to prevent rough surface.
- More irregular is the surface, more is the abrasive efficiency.
- Larger the particle size, deeper will be the scratches on the work, faster the work will be worn away.

### Types

*Mounted Dental Stones*

- In these, the abrasive head is permanently welded to shank and the attachment part
- They are available in latch or friction grip form.

*Unmounted Dental Stones*

- In these, the abrasive head is supplied separately, and may be mounted on mandrel
- They are available in various shapes i.e. cone, round, v shape, inverted cone or cylinder type.

## Abrasives used in Dentistry

*Diamond*

- Diamond is the hardest and having least wear rate among all the materials.
- It can abrade all materials hence called as 'superabrasive'.
- Diamond is the most effective abrasive, especially for enamel.

*Synthetic Diamond*

- It is produced by heating graphite at or above 2000°C under a pressure of 90 kilograms in presence of catalyst.
- Used as abrasives for manufacturing diamond abrasive points, burs, wheels, saws, etc.

*Tungsten Carbide*

- Slightly less hard than diamond.
- Used for making various cutting tools used in industry and dentistry.

*Silicone Carbide or Carborundum*

- Silicone carbide is very hard and brittle abrasive.
- Manufactured by fusing sand and coke at 2000°C.
- Its cutting efficiency is low.
- Used in manufacture of grinding stone of different sizes.

*Alumina*

- Used to manufacture coated and bonded abrasive, etc.

*Garnets*

- These are silicates of aluminum, cobalt, iron, magnesium and manganese and are very hard.
- Used in grinding metal alloys and plastics.

*Pumice*

- Pumice is a siliceous material and light yellow or light gray in color.
- Used for polishing natural teeth, restorations, acrylic denture and appliances, etc.

*Chalk*

- It is calcium carbonate which is a very fine white abrasive used for soft metals, acrylic resins, enamel, amalgam and gold foils.
- Chalk is used as mild abrasive in toothpastes and powders.

## SHARPENING OF DENTAL INSTRUMENTS

### Advantages

- Less trauma to patient.
- Increased operator efficiency.
- Control over instrument.
- Decreased operator fatigue.
- Increased quality and preciseness in cavity preparation.
- Less pain with use of sharp instruments.

### Principles

- Always sharpen clean and sterilized instruments.
- Establish the proper bevel angle (45-60°) and desired angle of the cutting edge to the blade before placing the instrument against the stone and maintain these angles during sharpening.
- Use light stroke or pressure against the stone to decrease the frictional heat.
- Use a rest or guide whenever possible.
- Remove a little metal from the blade as possible.
- Lightly hone the unbeveled side of the blade after sharpening to remove the fine bur that may be created
- Sharpening stone should be clean and free of metal cuttings.
- Sterilize the instrument after sharpening.

### Technique

It is of three types:

1. Stationary sharpening stone technique.
2. Mechanical sharpening technique.
3. Handpiece sharpening technique.

*Stationary Sharpening Stone Technique*

- Sharpening stones are available in the form of grits and different shapes.
- Grits can be in the form of (i) coarse, (ii) medium, (iii) fine.

- Various shapes are (i) flat, (ii) cylindric, (iii) grooved, (iv) tapered.
- Also called as OILSTONES because of applying a coating of oil on the stone during sharpening.
- Most frequently used technique.
- These stones are made up of different materials such as (i) Arakanas stone, (ii) Aluminum oxide, (iii) Silicon carbid, (iv) Diamond.
- Arakanas stone is commonly used material in dental practice.
- Silicon carbide is commonly used for grinding wheels and sandpapers. And commonly known as industrial abrasive.
- Aluminum is commonly used in manufacturing of sharpening stones.
- Diamond is mainly used for sharpening of carbide and steel instruments.

*Mechanical Sharpeners*

- This instrument moves a hone in a reciprocating motion at a slow speed, instrument is held at an appropriate angle supported by a rest.
- Aluminum oxide hones of different shapes and coarseness are available for this.

*Handpiece Sharpening Stones*

- Here aluminum oxide and silicon carbide stones are mounted on straight and contra-angle handpieces
- Commonly used for sharpening hand instruments.


# The Operating Field

## GIVE DIFFERENT POSITIONS FOR PATIENT AND OPERATOR

- The comfortable position of operator causes less physical strain and fatigue and reduces the chances of developing musculoskeletal disorders.
- A desirable position for the operator is one in which the operator is seated with his back resting on back rest of the stool and with his feet flat on the floor, legs relaxed and relatively together and thighs parallel to the floor.
- The most common patient positions for conservative dentistry are almost supine or reclined at 45°.
- In a supine position, the patient's ankles and chin should be at the same level. The supine position enables the operator's forearm to be parallel to the floor when working in the operative field.

### Positions for Operator

- For the **right-handed operator**, there are five positions: right front, right and right rear or the 7, 8, 9, 10 and 11 O'clock positions respectively.
- For the **left-handed operator**, there are five positions on left front, left and left rear or and referred to 1, 2, 3, 4, 5 O'clock positions respectively.

*Front Positions*

It facilitates oral examination and work on mandibular anterior teeth, mandibular posterior teeth and maxillary anterior teeth.

*Right or Left Position*

This position facilitates work on the facial surfaces of the mandibular teeth, maxillary right or left posterior teeth and the occlusal surfaces of the mandibular right or left posterior teeth.

*Direct Rear Position*

This position is used for operating on the lingual surfaces of mandibular anterior teeth.

*General Considerations*

- The mandibular occlusal surfaces should be oriented approximately 45° with the floor.
- When operating on the maxillary arch, the maxillary occlusal surfaces should be oriented approximately perpendicular with the floor.
- The design of the stool is important. It should be sturdy and well balanced to prevent tipping or gliding away from the dental chair.
- The backrest of stool should be adjustable up and down as well as forward and backward.
- The upper body of the operator should be positioned so that the spinal column is straight or bent slightly forward.
- The thighs should be parallel to the floor and feet should be flat on the floor.
- The **seated position of the dental assistant** is very slightly higher than the operator and the stool height is 10 to 15 cm higher than the operator's stool for maximum visibility and access.
- The **transfer zone** is located below the patient's chin and several centimeters above the patient's chest, where all instruments and materials are transferred between the operator and the dental assistant.
- The operatory light should be positioned at an arm's length from the operator.
- Lower positions of light are used for the maxillary arch and when using indirect vision and reflecting the light.

## ENLIST THE MEASURES TO BE TAKEN TO FOR INFECTION CONTROL IN DENTAL OPERATORY?

The following procedures should be followed routinely to protect dental personnel and to prevent transmission of infectious diseases from one person to another:

1. Face masks should be worn to protect oral and nasal mucosa from minute droplets of blood and saliva.
2. Gloves should be worn for examining and treating patients.
3. Rubber dam and high-speed evacuation should be utilized to minimize generation of droplets and splatter.
4. Handpieces should be sterilized after use with each patient.
5. Blood, saliva and gingival fluid must be thoroughly and carefully cleaned from material that has been used in the mouth.
6. Dental equipment and surfaces that are difficult to disinfect (light handles or X-ray units) should be wrapped with aluminium foil or clear transparent polythene wrap. The coverings should be removed and discarded and fresh clean wrapping done, after use with each patient.
7. Syringes or needles should never be used again.
8. Eyes should be protected with protective shield or eye glasses.
9. Methods of sterilization should be used.
10. Instruments and surfaces in the operatory should be cleaned.
11. Contaminated disposable materials should be discarded in plastic bags to minimize human contact.
12. To handle used instruments wear protective puncture resistant gloves.
13. For cleaning instrument use an ultrasonic vibrator.

## HOW TO MAINTAIN OPERATORY ASEPSIS?

### Procedure for Preparation of the Dental Chair, Dental Unit and Instruments

*Cleaning of Unit and Instrument after Attending the Patient*

1. After treatment remove chair seat, back and head rest cover with gloves on.
2. Discard cotton rolls and other disposable material into the cover.
3. Aseptically remove and discard disposable gloves and disposable tumbler.
4. Wash hands with soap and water and dry.
5. Put on sterile latex utility gloves.
6. Discard disposable air/water syringe and suction tips into the dustbin.
7. Discard all disposable sharps into sharps container.
8. Remove handpieces and sterilize them.
9. Place all instruments into disinfectant solution.
10. Place into the ultrasonic vibrator.
11. Spray disinfectant on used bottles, containers, tubes and unused burs.
12. Remove and discard plastic drapes from the dental chair and unit, light, tables, trolleys, etc.
13. Uncovered items, controls and switches are cleaned with paper napkin wetted with disinfectant.
14. Wipe operatory floor with disinfectant in disposable towels.
15. Remove utility gloves and wash hands.

*Preparation of Unit for Next Patient*

1. Use as much sterile disposables as possible.
2. Cover chair arms, head rest, back rest and chair seat with disposable sterile polythene sheets.
3. Install sterilized suction tips and handpieces.
4. Set out materials and instruments.
5. Seat the patient and put on sterile mask, eyewear and gloves.

## WHAT IS IMPORTANCE OF ISOLATION OF THE OPERATING FIELD? GIVE DIFFERENT METHODS OF ISOLATION

The following are the **main advantages** of isolation of operating field:

1. A dry and clean operating field.
2. Better access and visibility.
3. Improved properties of dental materials hence better results are obtained.
4. Protection of the patient and operator.

### Different Methods of Isolation of Operating Field

1. To isolate from moisture.
2. To isolate from soft tissues:
   - Retraction of cheek, tongue and lips
   - Gingival retraction.

## Indirect Method

- Patient relaxation
- Local anesthetics
- Drugs.

## Direct Methods

- Rubber dam
- Gingival retraction
- Cotton rolls
- Cellulose wafers
- Throat shields
- High volume evacuators and saliva ejectors.

### *Rubber Dam*

- Rubber dam was introduced by Barnum, a New York dentist in 1863.
- It is a flat thin sheet of latex/non-latex that is held by a clamp and frame which is perforated to allow the tooth/teeth to protrude through the perforations while all other teeth are covered and protected by sheet.

*Advantages*

- It helps in improving accessibility and visibility of the working area.
- It gives a clean and dry field while working.
- It protects the lips, cheeks and tongue by keeping them out of the way.
- It helps to avoid unnecessary contamination through infection control.
- It helps in keeping teeth saliva free while working.
- It improves the efficiency of the treatment.
- It provides protection of patient and dentist.

*Disadvantages*

- Time consumption and patient's objection, as it looks uncomfortable to the patient.
- Patients suffering from asthma, psychological problems, allergy to latex may not tolerate the rubber dam.
- Certain conditions may prevent the use of the rubber dam. These are: (1) incompletely erupted third molar, (2) malposed teeth, (3) teeth that have not erupted sufficiently to receive a retainer (clamp).

*Components of rubber dam*

**Rubber dam sheet**

- The rubber dam sheet is available in size 6 × 6 squares and colors are usually green or black.
- The dark colored rubber dam provides a good contrast with the teeth and reduces light reflection.
- The thickness of rubber dam is 0.15 mm (0.006 inch) (thin), 0.2 mm (0.008 inch) (medium), 0.25 mm (0.010 inch) (heavy) and 0.30 mm (0.012 inch) (extra heavy).
- For better gingival tissue retraction, the heavy (thick) rubber dam is usually employed.

**Rubber dam clamps**

Rubber dam clamps, to hold the rubber dam on to the tooth are available in different shapes and sizes (Fig. 33.1). Clamps mainly serve two functions:

i. They anchor the rubber dam to the tooth
ii. Help in retracting the gingivae.

Rubber dam clamps can be divided into two main groups on the basis of jaw design:

i. Bland
ii. Retentive.

**i. Bland clamps** are usually identified by the jaws, which are flat and point directly towards each other. In these clamps, flat jaws usually grasp the tooth at or above the gingival margin. They can be used in fully erupted tooth where cervical constriction prevents clamp from slipping off the tooth.

**ii. Retentive clasps:** As the name indicates, these clasps provide retention by providing four-point contact with the tooth. In these, jaws are usually narrow, curved and slightly inverted which displace the gingivae and contact the tooth below the maximum diameter of crown.

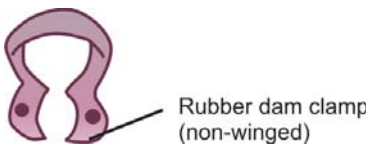



**Fig. 33.1:** Rubber dam clamp

**Rubber dam forceps (Fig. 33.2)**

- Rubber dam forceps are used to carry the clamp to the tooth.
- It is essential that these do not have deep grooves at their tips or they become very difficult to remove once the clamp is in place.

**Rubber dam frame (Fig. 33.3)**

- Rubber dam frames support the edges of rubber dam.
- Young's frame is made up of metal and Endon frame is made up of plastic. Plastic frame does not interfere with X-rays hence preferred over metal frame.

***Rubber dam frames serve following purposes***

- Supporting the edges of rubber dam.
- Retracting the soft tissues.

**Rubber dam punch (Fig. 33.4)**

Rubber dam punch is used to make the holes in the rubber sheet through which the teeth can be isolated. The punch must produce a clean cut hole every time.

**Rubber dam accessories**

- A *lubricant or petroleum jelly* is usually applied on the undersurface of the dam.

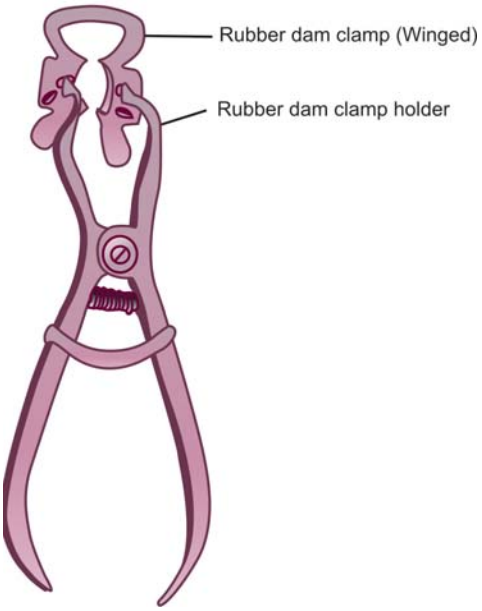



**Fig. 33.2:** Rubber dam forcep

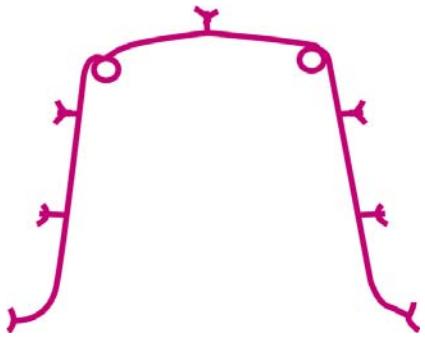


**Fig. 33.3:** Rubber dam frame

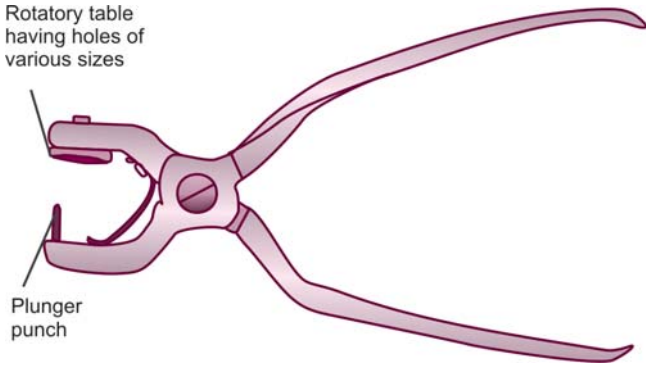



**Fig. 33.4:** Rubber dam punch

- *Dental floss*: It is used as flossing agent for rubber dam in tight contact areas.

**Rubber dam napkin**

- It is a sheet of absorbent materials usually placed between the rubber sheet and soft tissues.
- Absorbs saliva and prevents drooling.
- Reduces allergic reactions by preventing contact between patient's skin and dam sheet material.
- Serves as a drying device for wiping the external surface of face during rubber dam removal.

*Procedure for placement of rubber dam*

Following are the steps for placing the rubber dam:

a. Prior to rubber dam application, the area to be isolated must be clean.

b. With dental floss determine proximal contact area for ease of passage of rubber dam.
c. Rubber dam clamp must be stable upon the teeth and not cause damage to the teeth, to any restoration present in the teeth. Rubber dam clamp forceps carry the clamp to the lingual cervical region first and then are rotated to carry it to the buccal cervical region of the tooth. By this method, four point contacts of the clamp with the cervical area of the tooth are formed.
d. A rubber dam sheet is selected and position of the holes to be punched is established.

Holes punched through the rubber dam should be of the small enough size to permit a snugness around the neck of the tooth and large enough to avoid the possibility of tearing during application of rubber dam.

Spacing present between the two holes should be sufficient to allow the rubber dam to completely encompass the interdental papilla. Insufficient space present between the holes causes slippage of the rubber dam to the mesial or distal of the papilla. Too great spacing between holes allows the excess rubber dam to bunch up within the interdental space.

e. Apply the lubricant to both sides of the rubber dam in the area of punched holes.
f. Winged clamps permit the rubber dam to be stretched over the wings. This facilitates their proper placement A wingless clamp is often applied with the rubber dam, which is already stretched around its bow.
g. Rubber dam passage through the contact area should be started with a single edge and continued with a single thickness.
h. Invert the edge of the rubber dam at each hole present on to the cervical area of the tooth. Completion of the inversion of facial and lingual region of cervical area of the tooth is done by moving the explorer around the neck of the tooth facially and lingually with the tip, perpendicular to the tooth surface or directed slightly gingivally.

The lips and the corners of the mouth should be lubricated with petroleum jelly or cocoa butter. This prevents any abrading action of the rubber dam on these tissues.

*Procedure for removal of the rubber dam*

- Cut away tied thread or tape from around the neck of the teeth.
- Stretch the rubber dam facially and pull the septal rubber away from the gingival tissue and the tooth.
- Free the dam from the interproximal space, but leave the rubber dam over the anterior and posterior anchor teeth.
- The pressure holding the clamp on the tooth is released slowly. Once the retainer is removed by the operator, release the dam from the anchor tooth and remove the dam and frame simultaneously.
- Wipe the patient's lips with napkin immediately after the dam and frame are removed.

## WHAT ARE DIFFERENT METHODS OF GINGIVAL TISSUE RETRACTION?

### Gingival Tissue Retraction (GTR)

GTR is apical and lateral displacement of gingival tissue to aid in visibility and accessibility during subgingival restorative procedures.

*Means of GTR*

1. Physicomechanical means
2. Chemical means
3. Electrosurgical means
4. Surgical means.

*Physicomechanical Means*

It involves mechanical forcing gingival tissue away from tooth in lateral and apical direction.

Method employed are:

- Use of heavy weight rubber dam.
- Placing gingival retraction cords in gingival sulcus.
- Replacement of cotton twigs in gingival sulcus.
- Use of gutta percha and eugenol packs.
- Placement of cotton twills combined with Zinc oxide eugenol.
- Copper band.

*Chemical Method*

- In this method chemicals are placed in gingival sulcus for retraction.
- Commonly used chemicals are:
  - Use of vasoconstrictors like epinephrine and nor-epinephrine.
  - Use of astringents and styptics like alum, aluminium chloride, tannic acid and aluminium potassium sulphate.
  - Astringents like zinc chloride and silver nitrate.
  - These chemicals are carried in site with the help of retraction cords, cotton rolls, cotton pellets.

*Electrosurgical Means*

Here four different types of actions are seen according to amount of energy produced at the electrode end:

- Cutting
- Coagulation
- Fulgerations
- Desiccation.

*Surgical Means*

- Here sharp knife is used to remove gingival tissue surgically.
- Gingivoplasty, gingivectomy or curettage are commonly employed method surgically.

*Absorbents (Cotton Roll and Cellulose Wafers)*

- Cotton rolls and cellulose wafer absorbents are helpful for short period of isolation, for example in examination, polishing and topical fluoride application.
- An advantage of cotton roll holders is that the cheeks, lips and tongue are slightly retracted from the teeth, which enhances access and visibility.
- Cellulose wafers may be used to retract the cheek.
- They must be removed as soon as they become saturated.

*Throat Shield*

- This is particularly important when the tooth being treated is present in the maxillary arch.
- An unfolded gauze sponge, spread over the tongue and posterior part of the mouth is helpful in recovering a restoration like inlay or crown if it is dropped in the oral cavity.

*Additional Methods for Isolation*

i. *Evacuator tip and mouth mirror retraction*
ii. *Mouth prop:* A mouth prop should establish and maintain suitable mouth opening, thereby permitting cavity preparation on posterior teeth.
iii. *Retraction cord:* Retraction cord moistened with a non- caustic styptic may be placed in the gingival sulcus for isolation and retraction in the direct procedures of treatment of cervical lesion, to control the sulcular seepage and/or hemorrhage.

*Drugs*

To control excess salivation, drug like Atropine is used although it is rarely indicated.

# 34 Matrices, Retainers and Tooth Separation

## WHAT ARE REQUIREMENTS OF A MATRIX BAND? GIVE CLASSIFICATION

Matrix band is defined as properly shaped piece of metal or other material, used to support and give form to the restoration during its manipulation. It is held in its place by means of a matrix band retainer which may be a mechanical device, floss, wire, thread or impression materials, etc.

### Requirements

1. *Rigidity*: To withstand the condensation pressure applied during introduction of restoration in the plastic state, and maintain its shape during hardening.
2. *Versatility*: The matrix band should be able to conform to almost any size and shape of tooth.
3. *Comfortable to use.*
4. *Height and contour*: It should not extend more than 2 mm beyond the occlusogingival height of the crown of tooth.
5. *Application*: The matrix band should be such that it can be applied and removed easily.
6. It should be easy to sterilize.

### Functions

- Gives shape to restoration.
- Act as temporary wall during restoration of a tooth.
- Maintains form of restoration during setting of restoration.
- Helps in holding back the gingiva and rubber dam during restoration.

### Classification

*Depending on Method of Retention*

i. Mechanically retained, e.g. Ivory matrix retainers no. 1 and 8, Tofflemire Universal dental matrix band retainer.
ii. Self-retained, e.g. copper or stainless steel bands.

*On the Basis of Transparency*

i. Transparent matrices, e.g. Cellophane, celluloid.
ii. Non-transparent matrices, e.g. Stainless steel.

*Other Classification*

i. Unilateral
ii. Mechanical retainer supported
iii. Wedge supported
iv. Precontoured band
v. Uncontoured band.

## TYPES OF MATRICES AND RETAINERS

Types of matrices and retainers used for various cavities are as follows:

| *Types of cavities* | *Matrices and retainers* |
|---|---|
| **For class II cavities** | Ivory matrix number 1<br>Ivory matrix number 8<br>- Tofflemire matrix<br>- Anatomical matrix band<br>- 'T' shaped matrix band<br>- Retainerless automatrix<br>- Retainerless walser filling matrix |
| **For Class III cavities** | - 'S' shaped matrix band<br>- Plastic matrix strips<br>- Mylar strips |

| | | |
|---|---|---|
| **For Class IV cavities** | - | Plastic strips |
| | - | Aluminium foil |
| | - | Transparent crown form |
| | - | Anatomic matrix |
| **For Class V, VI** | - | Custom made plastic matrix |
| **For direct tooth colored** | - | Plastic matrices |

## NOTE ON MECHANICAL RETAINERS AND MATRIX BANDS

### Ivory Matrix Holder (Retainer) No. 1

- This is most commonly used matrix band holder for MO and DO cavities.
- It is a unilateral matrix.
- Jaws of retainer should engage the gingival embrasure area.

### Ivory Matrix Band Retainer No. 8

- Indicated for cavities involving both proximal sides (MOD cavity) and class II compound cavities having missing walls on more than two surfaces on posterior teeth.
- This retainer provides missing walls by encircling entire crown of the tooth.
- The matrix band is made up of thin sheet of metal so that it can pass through the contact area of the uncut proximal side of the tooth.

### Tofflemire Universal Matrix Band Retainer

- Designed by Dr BF Tofflemire.
- The word 'universal' has been added with its name because it can be used in all types of cavities of posterior teeth.
- This is used mainly due to its advantage of providing all the four walls and easy application and removal.

*Advantages*

- Stable band and retainer.
- Bands of variable heights are available.
- Provides superior contacts and contours.
- Easy application.
- Can be placed facially and lingually.

### Steele's Siqveland Self-adjusting Matrix Holder for Tapering Teeth

- Anatomic adaptation of the matrix band is possible due to Steele's siqveland self-adjusting matrix holder without the help of wedges.
- It is based on the principle of a movable slide which holds and tightens the band in the required position.

## RETAINERLESS MATRIX BAND

These are indicated in tilted and partially erupted teeth and also in patients who cannot tolerate retainers.

### Anatomical Matrix Band

- Pliers are used to contour the band.
- Precontoured anatomic matrix band is placed on cavity side.
- Wedges are then inserted to facilitate adaptation to surface of the tooth.
- Buccal and lingual embrasures are sealed by means of two selfcure acrylic or softened impression compound cones.

### Retainerless Automatrix Band

The matrix is fitted over the tooth with the clip on the buccal aspect. A mechanical device is used to tighten the band.

### T-Shaped Matrix Band

Preformed matrix bands are used with the long arm of the T surrounding the tooth and overlapping the short arm of the T.

### Full Circle or Ring Bands

- Used for mesio-occlusodistal compound cavities and complex cavities.
- Once the proper size of band is selected it can be contoured using pliers, trimmed and finished by finishing stones.
- After condensation is complete, the band can be cut by means of a bur at the same or the next day.

### S-Shaped Matrix Band

- This is ideally used for restoring distal part of canine and premolar.

- The contoured strip is placed interproximally over the facial surface of tooth and lingual surface of bicuspid.
- Wedge and impression compound are used to provide stability.

*Matrices for Class III Direct Tooth Colored Restorations*

1. *Plastic matrix strip:* These are transparent matrix strips. Celluloid strips are used for silicate cements and cellophane strips are used for resins.
2. *Mylar strips:* Mylar strip may be used for composite and silicate restorations.

*Matrices for Class IV Direct Tooth Colored Restoration*

1. *Plastic strip*
   - The strip is folded in 'L-Shape'.
   - The matrix is measured and cut so that one side is as wide as the length of the tooth and the other side is as wide as the width of the tooth.
   - The angle formed when the strip is folded should approximate the tooth corner and support the matrix on the lingual surface.
2. *Prefabricated matrices*
   - *Aluminium foil incisal corner matrix:* These are shaped according to the angles and surfaces of anterior teeth and are prefabricated 'Stock' metallic matrices.
   - *Transparent crown form matrices*: These are 'Stock' plastic crowns and can be adapted to tooth anatomy.

## WEDGES

- Wedge is made of wood, plastic or metal placed interproximally to stabilize matrix band and retainer.
- In cross-section, base of triangle is in contact with interdental papilla, gingival to gingival margin of proximal cavity.

### Function of Wedges

- Wedges separate the teeth.
- Depress the interproximal soft tissues thus minimizing trauma.
- Protect the dam and soft tissue from injury.
- Assure close adaptability and stabilization of matrix band to the tooth.
- Produce separation of the teeth to help compensate for the matrix thickness.
- Prevent gingival 'overhang' of the restoration.

### Classification

*Based on Material*

- Plastic
- Wood
- Metal

*Based on Shape*

- Triangular
- Round

*Based on Modification*

*Unmodified*

- Inserted from lingual side because of larger size of lingual embrasure.
- Round wedge indicated for deep gingival margins because of greater width at its base.
- Triangular wedge indicated for shallow gingival margins because its wedging action is nearer to its gingival margin.

*Modified*

- Prevents distortion of matrix contour.
- Used for wide spacing between the teeth.

### Types

*Wooden*

- Preferred since they can be trimmed by a scalpel to exactly fit each gingival embrasure.
- Absorb water to improve interproximal retention.
- Can be triangular or round.

*Plastic*

Can be molded and bent according to shape of interdental papilla.

### Technique

- Insert the pointed tip of wedge from facial or lingual embrasure whichever is larger, slight gingival to gingival margin of cavity.
- If a proximal restoration involves all of the contact area or extends subgingivally, wedge is inserted in the gingival embrasure after rubber dam application.
- **'Piggy-back' wedging,** i.e. a smaller wedge together with a larger wedge may be used in cases of interproximal tissue recession.
- **Double wedging**, i.e. insertion of two wedges one from facial and other from lingual side. Indicated if proximal box is wide faciolingually.
- **Wedge wedging** is used if concavity on proximal surface is gingival to contact area. It is used to wedge the matrix band tightly, a second wedge is inserted between first wedge and the band.

## TOOTH SEPARATION

### Purpose

- To examine caries in interproximal surface.
- To make teeth restorable by moving them in a desired physiologic position.
- To close space between teeth to promote a balanced arch form.
- To restore to original position of drifted teeth.
- For accessibility during proximal restoration.
- For placing matrix band interproximally.
- For proper restoration of proximal contours.
- For polishing and finishing of restoration.

### Types

Tooth separation may be rapid or slow.

*Rapid or Immediate Separation*

- It is a quick and clinically useful method.
- If excessively used may produce pain due to rupture of the periodontal ligament fibers hence it should be avoided.
- Separation works on the following **two principles**.

1. **Traction principle**
   - Uses mechanical device which engage the proximal surface of teeth to be separated by holding arms.

Examples of separators working on ***Traction principle*** are as follows:

a. *Non-interfering true separator:*
   - Used when continuous stabilized separation is required.
   - Separation can be adjusted as per requirement.
   - Does not interfere with occlusion and functions of teeth.

b. *Ferrier single or double bow separator (Fig. 34.1)*:
   - May be single or double jawed.
   - Impression compound is used to stabilize it.

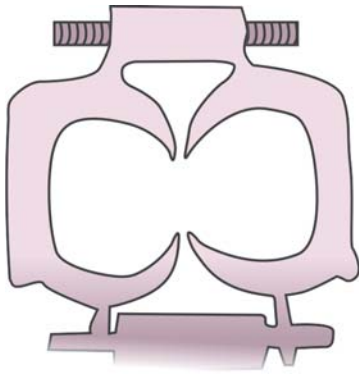


**Fig. 34.1:** Ferrier double bow separator

c. *Ivory adjustable separator*

d. *Wood ward separator*

2. **Wedge principle**

Examples of separators working on ***Wedge principle*** are as follows.

a. *Elliot wedge or separator (Fig. 34.2.):*
   - Also called as the 'crab-claw' separator.
   - Less forceful and requires impression compound for stabilization.

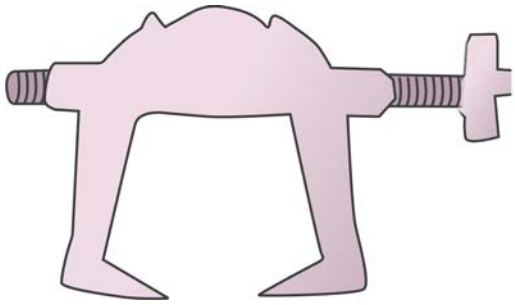


**Fig. 34.2:** Elliot separator

b. *Wedges:*
The wedge is used to stabilize matrix band and retainer. Wedge may be made of wood, plastic or metal.

**Wedges have following functions:**

a. Wedges separate the teeth.
b. They depress the interproximal soft tissues thus minimizing trauma.
c. Assure close adaptability and stabilization of matrix band to the tooth.
d. Produce separation of the teeth to help compensate for the matrix thickness.
e. Prevent gingival 'overhang' of the restoration.

*Slow Separation*

Severely tilted or drifted teeth may be moved by means of slow separation. It occurs physiologically without injuring periodontal ligament fibers.

*Advantages*

- Absence of tooth soreness.
- Physiological movement of teeth.
- No injury to periodontal ligament fibers.

*Disadvantages*

- Time consuming.
- Repeated application of separating material.

*Materials used for slow separation are*:

- Separating wires.
- Gutta-percha softened and packed between the teeth to be separated.
- Base plate softened and packed between the teeth to be separated.
- Orthodontic appliances.

# 35 The Amalgam Restorations

## PRINCIPLES OF CAVITY PREPARATION FOR AMALGAM RESTORATIONS

### Requirements for Amalgam Restoration

- External outline form consists of smooth curves, straight lines and rounded angles.
- Occlusal cavosurfce angle should be between 85 and 95 degree.
- All unsupported enamel rods must be removed.
- There should be adequate thickness of the material.
- Retention form is made by shaping of the opposing walls strictly parallel or slightly undercut, so that the filling will be retained firmly.
- On the occlusal surface, preparation as dovetail is done to produce retentive features for proximo-occlusal restoration to resist proximal displacement.

### Amalgam Restoration for Class I Cavity Preparations

*Outline Form*

- Class I cavity preparation is started by entering the deepest or most carious pits using a round carbide bur at high speed with air water spray.
- The round bur enters the pits, proper depth of 1.5 to 2.0 mm should be established.
- The plain fissure bur No. 57 is used to provide extension of internal and external outline, extension of occlusal wall to attain the dentino-enamel junction, flatten the pulpal floor, tapering of occlusal walls adjacent to marginal ridges, finishing the enamel to coincide with enamel rod directions (Fig. 35.1).

**Fig. 35.1:** Class I cavity for amalgam restoration

*Primary Resistance Form*

For this:

- Create a box-shaped cavity
- Establish a flat floor
- Provide adequate thickness of amalgam
- Include the weakened tooth structure
- Do rounding of internal line angles.

*Primary Retention Form*

- Converge dentinal walls towards the tooth surface.
- Give undercut in dentin near the pulpal wall.

*Convenience Form*

Which facilitates and provides sufficient visibility, accessibility and ease of operation in preparing and restoring the tooth.

*Final Tooth Preparation*

- Any remaining carious tooth structure or defective restorative material left in tooth is removed completely with the protection of pulp.
- Infected and discolored dentin must be removed.
- The bases and the liners are used to protect the pulp.
- Additional mechanical resistance and retention forms like grooves, slots, box, locks, pins and coves are used whenever required.
- Do the final debridement of the cavity to clean all cavity or preparation walls.
- Sterilize the cavity walls with very mild alcohol.

## Amalgam Restoration for Class II Cavity Preparation (Fig. 35.2)

*Outline Form*

- Using high speed bur enter the pit which is nearest to involved proximal surface, with the long axis of the bur parallel to the long axis of the tooth.
- Depth of initial entry cut is around 2.0 mm, including the pulpal dentin.
- Extend the outline to include the central fissure.
- The isthmus width should be as narrow as possible, but not wider than one fourth the intercuspal tip distance.
- Enameloplasty should be utilized to conserve tooth structure.

*Outline Form of the Proximal Box*

- End of the bur cuts gingivally along the exposed dentino-enamel junction at the expense of two-third dentin and one-third enamel, extending gingivally just beyond the caries or the contact width.

**Fig. 35.2:** Diagrammatic representation of a class II cavity for amalgam

- **Facial and lingual extension**, visualize the completed margins as right angle projections of facial and lingual limits.
- The finish of the gingival margin should be only slightly above the gingival margin.
- The proximal cut is diverged gingivally.
- Faciolingual dimension at the gingival surface is greater than the occlusal surface.
- While the proximal enamel extension is allowed to remain intact, chisel is used to clean away the unsupported proximal enamel and finish the enamel walls and margins.
- Removing any of the remaining enamel and carious dentin on pulpal wall in Class II preparation is accomplished same as a Class I preparation.

*Primary Resistance Form*

For this:

- Establish a flat pulpal floor and gingival walls to resist forces directed along long axis of the tooth.
- Give reverse curve at the junction of occlusal step and proximal box.
- Provide adequate thickness of amalgam.
- Restrict the extensions of walls to allow strong cusp ridges.
- Include the weakened tooth structure.
- Do rounding of internal line angles and axiopulpal line angle.

*Primary Retention Form*

- Occlusal convergence of facial and lingual proximal walls.
- Dovetail design on occlusal step.

*Convenience Form*

Extension of mesial, distal, facial, lingual, proximal and gingival walls facilitates and provides sufficient convenience in preparing and restoring the tooth.

*Final Tooth Preparation*

- Any remaining carious tooth structure or defective restorative material left in tooth is removed completely with the protection of pulp.
- Infected and discolored dentin is removed.
- The bases and the liners are used to protect the pulp.
- Slots' in the gingival floor are used to provide additional retention in an extensive proximal box.
- 'Pot holes' in the gingival floor also provide additional retention.

- Proximal retentive locks are used to maximize the strength of restoration.
- Use GMT for establishing cavosurface margin at gingival margin.
- During final preparation of cavity it should be cleaned with air/water spray or with cotton pellet.
- Inspect the cavity for detection and removal of debris and examine for correction of all cavosurface angles and margins.
- Sterilize the cavity walls with very mild alcohol.

*Reverse Curve (Fig. 35.3)*

- On occlusal surface a reverse curve taking the form of a concave curve is used as a means of conserving the sound tooth tissue, which preserves the triangular ridge of the affected cusp.
- In this flare of the proximal wall leaves the tangent to that outer tooth surface at almost right angles that creates maximum resistance form for the tooth and restoration.
- Significance: It acts as means of preservation of tooth tissue.

## Modifications in Class II Cavities

*Incipient Class II Amalgam Restoration*

- Incipient lesions are small in area and lie immediately below the anatomic contact point.
- The cavity is type of an inverted slot on the side of the tooth.
- Gingival wall is parallel and extends below the lesion into the enamel.
- Location of facial and lingual margins is determined by extent and character of the enamel.
- Cavosurface margins are 90° throughout depth of cavity and are equal in all areas.
- Enamel unsupported by dentin is removed.
- The axial wall is flat or slightly convex.
- Facial and lingual walls have slight undercut to retain the amalgam.
- In the axial wall, grooves are prepared for necessary marginal refinement along the occlusion.

*Class II Slot Cavity Preparation*

- Conservative cavity preparation (Fig. 35.4).
- Carious lesion is approached through the occlusal, buccal or lingual surface.

*Indications*

a. Intact proximal contact
b. Patient with very low caries index
c. Expected life of the tooth is not more than 5 years.

## Amalgam Restoration in Classes III, V and VI Cavity Preparations

*Class III*

- Most commonly done in the distal surface of maxillary and mandibular canines.

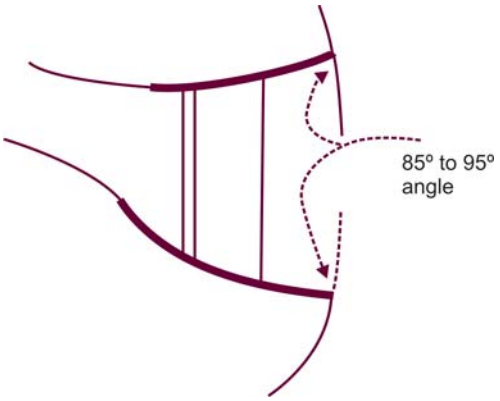



**Fig. 35.3:** Reverse curve in occlusal outline of proximal cavosurface margins in posterior teeth

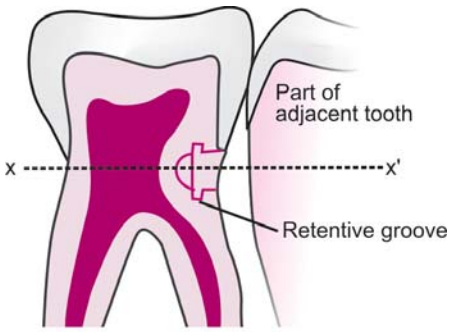



**Fig. 35.4:** Mesiodistal section of tooth showing Class II slot cavity preparation

- A No. 2 bur with penetrates through enamel on distolingual marginal ridge.
- Long axis of bur kept perpendicular to the lingual surface of the tooth.
- The extension is completed when facial, gingival and lingual walls are formed.
- The corners of cavity form are rounded to accept the restoration.
- Cavosurface angle should be about 90° at all margins.
- Axial wall should be uniformly deep into dentin.
- Final cavity preparation involves the removal of any remaining infected dentin, pulp protection, developing retention form and finishing the external walls.
- Lingual dovetail is needed for large preparations, it is prepared only when the preparation of proximal portion is completed because tooth structure needed for isthmus between proximal portion and dovetail might be removed when the proximal outline form is prepared.

*Class V*

- A round bur is used with high speed to establish the outline form.
- The axial wall depth at the occlusal wall is more than at the gingival wall.
- Curved axial wall is formed and this follows the contour of the pulp organ.
- Mesial and distal surfaces walls are prepared perpendicular to the outer tooth surface.
- Occlusal wall is tapered towards the occlusal cavosurface margins to form an obtuse angle of the enamel.
- Retention form is established in dentin of the cervical and occlusal walls to approximate depth (Fig. 35.5).

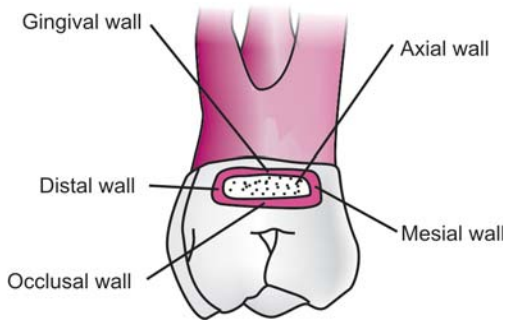



**Fig. 35.5:** Class V prepared cavity (Buccal view)

*Class VI*

- Enter the tooth with the small tapered fissure bur extending to 1.5 mm and prepare a cavosurface margin on enamel
- Retention is created by small undercuts along the internal line angles.

## Finishing and Polishing of Amalgam Restorations

- Finishing and polishing are not done within 24 hours of insertion, since the crystallization of amalgam is not complete.
- Finishing and polishing reduces the surface roughness of the restoration.
- In high copper amalgam restoration, high polishing is not necessary, due to its less susceptibility to tarnish and corrosion.
- A fine pointed, fused alumina stone is used to correct the surface contours.
- The stone is placed on surface so that its long axis is at right angle to the restoration.
- Finishing of proximal restoration begins carefully with cervical margins.
- Discrepancies existing in the gingival area should be removed by using Rhein trimmers.
- A flame-shaped bur should be used in accessible margins to prevent unnecessary removal of restoration.
- For polishing, rubber abrasive point with flour of pumice followed by a high luster agent is used at low speed to produce smooth surface.

## Reasons for Failures of Amalgam Restorations

Most common causes of failure of dental amalgam can be as follows:

1. *Marginal fracture of amalgam*: Takes place due to defective cavity preparation, inadequate condensation and poor edge strength of the amalgam.
2. *Secondary or recurrent caries*: Takes place due to marginal leakage.
3. *Bulk fracture of restoration*: Takes place due to defective cavity preparation.
4. *Tooth fracture*: Takes place due to defective cavity preparation.

5. *Dimensional changes*: Take place in zinc alloys due to moisture contamination.
6. *Discoloration, tarnish and corrosion*: Take place due to improper manipulation and finishing and polishing of filling.
7. *Discoloration of tooth*: Takes place due to percolation of silver salts in the dentinal tubules.

**The reasons for failure** of amalgam restorations can be:

**I. Defective cavity preparation**
- Insufficient occlusal extension.
- *Under extension of the proximal box.*
- *Over extended cavity preparation.*
- Curved or irregular pulpal floor of the cavity.
- Cavosurface angle acute or obtuse rather than being butt joint.
- The sharp axiopulpal line angle.
- Incomplete removal of the carious dental tissues before restoration amalgam.

**II. Improper manipulation of amalgam** may occur in the following forms.
- Improper condensation.
- Delayed use of triturated amalgam.
- Incorrect Mercury Alloy Ratio.
- Under-trituration.
- Overtrituration.
- Contamination during manipulation.
- Defective finishing and polishing.

**III. Faulty matrix adaptation**
- The matrix should be properly made stable before condensation of amalgam.
- The stability of the matrix is a must to avoid distorted restorations, gross marginal excess, overhanging fillings and uncondensed soft amalgam.

**IV. Inadequate cleaning of cavity**

**V. Improper contouring of restoration**
- High points in amalgam filling result in periodontitis or, fracture of the filling or tooth and pain.

**VI. Delayed expansion** in zinc containing alloys causes high and rough filling resulting in high points and fracture of filling or tooth and pain.

**VII. Inadequate pulp protection** may give rise to pain and secondary caries.

**VIII. Continuous leakage around filling** causes post-operative pain and 'Amalgam Blues' which are bluish discolorations of the margins of the cavity.

# 36 Pin Retained Restorations

## WHAT ARE PIN RETAINED RESTORATIONS?

Pins retain the restoration in the prepared tooth structure together and secondly, reinforce the tooth by cross-splinting of weakened cusps.

### Indications

- Grossly mutilated teeth.
- Extended preparations.
- Cores for full coverage restoration.
- Extensive class V restorations.
- Time period and economic factors.

### Contraindications

- In teeth with large pulp chambers.
- Presence of deep subgingival calculus.

### Advantages

- Conservation of tooth material.
- Reduced number of appointments.
- Increased resistance and retention form.
- Economics.

### Disadvantages

- In pulpectomized and pulpotomized teeth pin-retained restorations are contraindicated because the chances of fracture of dentin increase due to its dehydration.
- When minimal dentin is present, fracture lines in dentin or internal stress in dentin may be created while drilling pin holes or during pin placement.
- Microleakage may occur around the pins.
- Pins decrease the tensile and transverse strength of amalgam.
- On misdirection of the bur or pin there, is a risk of perforating into the pulp or the external tooth surface.

## WHAT ARE DIFFERENT TYPES OF PINS?

On the basis of retentive mechanism pins can be classified as (Fig. 36.1):

- Self threading/self shearing pins.
- Friction-lock/friction grip pins.
- Cemented pins.

### Self Threaded Pins

- Pinholes are slightly smaller (0.038 to 0.1 mm) in diameter than the pin diameter.
- The pins are retained due to the mechanical grasp of the threads into the dentin.

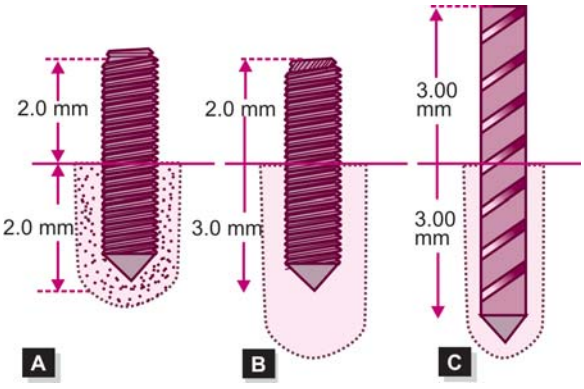



**Fig. 36.1:** Different types of pins (A) Self-threading, (B) Cemented, (C) Friction-locked

*Advantages*

- Superior retention.
- Less depth is required for placement.
- No cementing medium is required.

*Disadvantages*

- The pulpal stress is maximum.
- Stresses on dentin are also maximum.

*Indications*

- For vital teeth.
- Dentin should be properly hydrated.
- When maximum retention is needed.
- When less number of pins are required for retention.

### Friction-Locked Pins

The diameter of the pinhole is 0.025 mm smaller than the diameter of the pin.

By gentle tapping they are placed into dentin and are retained due to resiliency of dentin.

*Disadvantages*

a. The pulpal stress is maximum.
b. Stresses on dentin are also maximum.

*Indications*

- Should be used in vital teeth only.
- Pin should be located at least 2.5 mm away from the DEJ.
- At least 4 mm of dentin should be present around the pin.
- Dentin should be properly hydrated.

### Cemented Pins

- Prepared pinholes should be 0.025 to 0.05 mm larger than the diameter of the pin.
- The depth of hole in dentin should be 3 to 4 mm.

*Disadvantages*

- Needs cementing material for retention.
- Least retentive.
- Pin holes are prepared at the depth of 3-4 mm.

*Indications*

- Ideal for pin retained restorations.
- Good for endodontically treated teeth.
- Used when less amount of dentin is available for pin placement.
- Can be placed in highly mineralized dentin.
- Can be used when pin location is very close to DEJ.

## EXPLAIN MECHANICS OF PIN RETAINED RESTORATIONS

### Stressing Capability of the Pins

*Types of Pin*

a. No or very less stresses occur with cemented pins.
b. Maximum stresses occur with friction grip pins.
c. Intermediate stresses occur with threaded pins.

*Number of Pins*

Excessive number of pins should be avoided. Excessive number of pins:

a. Generate stress in the tooth.
b. Decrease the amount of available dentin between the pins.
c. Decrease the strength of amalgam restoration.

As far as possible one pin must be placed for each missing cusp and one pin for each missing proximal surface.

*Length of Pin into Dentin and Amalgam*

Pin extension of 2 mm into dentin and amalgam provide maximum required retention. Pin extension greater than 2 mm is contraindicated to preserve the strength of dentin and amalgam.

*Site of Pin Placement*

Following factors must be considered.

a. Knowledge of normal pulp anatomy.
b. Pins should not be placed directly below an excessive occlusal load.
c. Pinhole should be atleast 0.5 mm inside the dentin from the dentinoenamel junction.
d. The pins should be positioned at least 0.5 mm from the external surface of the tooth.
e. Pinholes should be located on a flat surface.
f. When more than two pinholes are to be made, they should be placed at different tooth levels.
g. If two or more pins are to be placed, they should be kept apart.

*Pin Size*

Pins are available in four sizes.

| *Name* | *Pin diameter* |
|---|---|
| A. Minuta | 0.38 mm (0.015 inch) |
| B. Minikin | 0.48 mm (0.019 inch) |
| C. Minim | 0.61 mm (0.024 inch) |
| D. Regular | 0.78 mm (0.031 inch) |

Pin size is selected after considering the following factors:

a. Amount of dentin present.
b. Degree of retention required.

*Preparation of Pinhole*

For making pinholes Kodex drill should be used. The drill is made of a high-speed tool steel that is swaged into a color coded aluminium shank. Omni-depth gauge is used to measure the depth of the pinhole.

From the time of insertion till removal, the drill must be kept continuously rotating only in one axis and one direction. This will prevent fracture of the drill in the pinhole and also excessive cutting.

*Bulk of Dentin*

Greater the amount of dentin pulpally, lesser will be the stress generation.

*Type of Dentin*

Greater the dehydration and mineralization of dentin, more will the stresses in dentin.

Stress tolerance is decreased when dentin loses its vitality.

Order of stress tolerance of different dentin are: Primary dentin, secondary dentin, sclerotic dentin and tertiary dentin.

## Retention of the Pins

*Types of Pin*

a. Cemented pins are least retentive.
b. Friction grip pins are 2-3 times more retentive
c. Self threading pins are 5-6 times retentive than cemented pins.

*Surface Texture of Pins*

Threaded and serrated pins have sufficient retention.

*Type of Dentin*

Pin retention decreases in following order in different dentin as: Primary dentin, secondary dentin, sclerotic dentin and tertiary dentin.

*Bulk of Dentin*

Greater the amount of dentin separating pin from pulp and tooth, more will be the retention.

*Number of Pins*

Basically pin placement and its proximation to displacing forces affect the retention.

*Type of Cement*

Retention for various cements in decreasing order is as: Zinc phosphate, polycarboxylate and zinc oxide eugenol cement.

## ENUMERATE FAILURES OF PIN RETAINED RESTORATIONS

- Within the restoration, fracture may occur.
- Pulpal penetration and periodontal perforation.
- Dentin may fracture while placing pins.
- Pin may fracture.
- Pin dentin separation may occur.
- Separation at the interface of the pin and restorative material.
- Broken pins and drills.
- Enlarged pin holes.

To stabilize the pin in larger hole following can be done.

i. Drill the fresh hole.
ii. Redrill a larger fresh hole and insert the larger pin.
iii. Cement the existing pin in place.

## Amalgapin

- They were introduced in 1980 by Shavell.
- Amalgapins are vertical posts of amalgam anchored in dentin.
- The pits prepared in dentin are shallow and little wider than pinholes and are called 'dentin chambers'.
- The post-formed of the amalgam in the dentin chamber is called 'amalgapin' (Fig. 36.2).

*Advantages*

- Increase the retention and resistance.
- Increase the bulk of amalgam.

*Disadvantages*

- Cause greater tooth structure loss.

**Fig. 36.2:** Diagrammatic representation of Amalgampins

# 37 Concepts of Bonding

## NOTE ON ENAMEL AND DENTIN ADHESION

The process by which a restorative material forms a proper union with the tooth surface is known as *bonding* or *adhesion*.

Bonding to the enamel or dentin requires the use of:

### Etchants

- They are chemicals such as phosphoric acid, citric acid or maleic acid which are used for etching, i.e to remove minerals from the surfaces of enamel and dentin by making irregular holes, which increase the surface area.
- They form tags of restorative material by demineralizing the superficial calcium ions (Fig. 37.1).
- A properly etched surface gives a frosty white appearance on drying.
- Etching increases the surface reactivity.
- The acid is gently applied to the prepared enamel and dentin surface. Application of the acid is repeated to keep the area moist for 15 to 30 seconds. The area is then rinsed with water for 5 to 10 seconds.
- Three different micromorphologic patterns are obtained after etching, which are as follows:

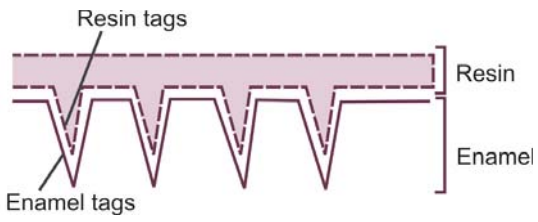



**Fig. 37.1:** Microtags are responsible for micromechanical bonding between resin and the tooth surface

*Type I*: In this pattern there is dissolution of enamel prism cores without affecting the periphery.

*Type II*: In this pattern the peripheries are dissolved.

*Type III*: In this pattern is less distinct, including areas that resemble type I and II patterns, and areas which bear no resemblance to enamel prism.

### Conditioners

Conditioners clean the surface. They also activate the calcium ions making them more reactive.

*Purpose*

- Removes smear layer.
- Opens dentinal tubules.
- Increases dentin permeability.
- Expose collagen fibers.

*Agents used*

- Orthophosphoric acid
- Polyacrylic acid
- Citric acid
- Pumice wash

### Primers

Primers consist of monomers dissolved in water, alcohol or acetone, thus comprising both the hydrophobic (methacrylate group) as well as the hydrophilic groups (hydroxyl or carboxyl groups). Primers ease the flow of resins.

### Bonding Agents

The bonding agents comprises an unfilled resin which also comprises a hydrophilic and a hydrophobic end.

## DENTIN ADHESION

### Conditioning

It is carried out with an objective to alter the dentin as well as the smear layer to promote micromechanical as well as chemical bonding to a dentin adhesive.

*Conditioning by Means of Acids*

Various acids such as 37 percent phosphoric acid, nitric acid, maleic acid, oxalic acid, pyruvic acid, hydrochloric acid and citric acid are used.

*Chelators*

Ethylene diaminotetra acetic acid (EDTA) is the best chelating agent used at a pH of 7.4 for 30 seconds.

*Thermal Conditioning*

Thermal conditioning includes the use of LASER to condition dentin.

### Priming

Primers consist of monomers HEMA and 4-META dissolved in acetone or ethanol. Thus, they have both hydrophilic as well as hydrophobic ends which have affinity for the exposed collagen and resin respectively. For obtaining bond strengths that are optimum the primer should be applied in several coats so that it forms a uniform surface coverage.

### Adhesion Resins/Dentin Bonding Agents

The adhesive resin is a low viscosity, semifilled or unfilled resin which flows easily and matches the composite resin. The penetration of adhesive resins into the microporous collagen of the inter-tubular dentin is known as the *intertubular penetration*. Polymerization with the adhesive parts of the primer give rise to an intermingled layer of collagen and resin known as the *Hybrid layer or Resin reinforced layer* (Fig. 37.2).

## NOTE ON DENTIN BONDING AGENTS

The dentin bonding agents (DBA) should have a hydrophilic end which readily wets and penetrates into the porosities of dentin, reacting with their organic or inorganic components; and a hydrophobic end which bonds to the composite resin. Thus, the adhesive molecule has a bifunctional structure:

M————————R————————T

M → represents the double bond of methacrylate which copolymerizes with composite resin.

R → represents the spacer.

T → represents adhesion to tooth dentin structure either to organic or inorganic part.

On the basis of their evolution, the bonding agents have been divided into *Generations*.

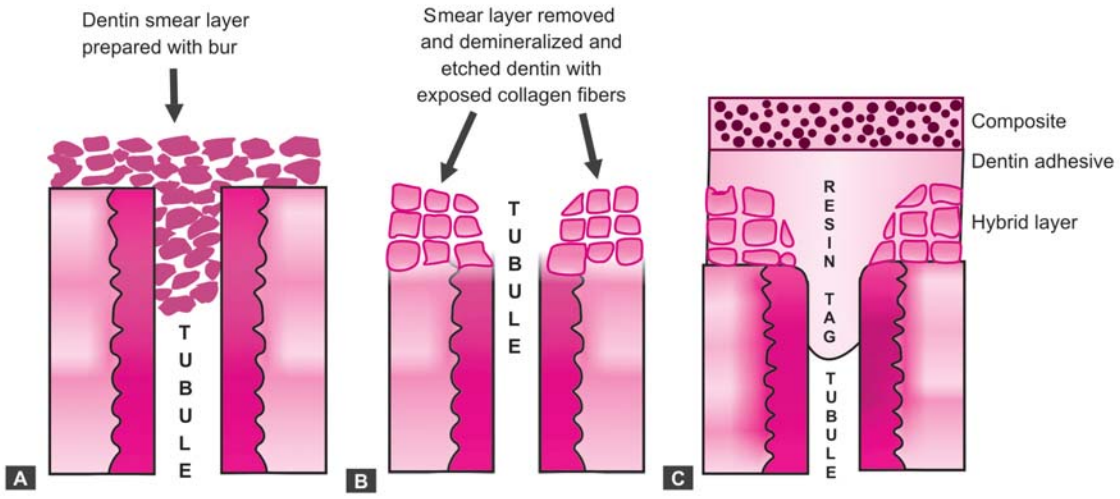



**Fig. 37.2:** Resin bonding: (A) Formation of smear layer during cavity preparation, (B) Etching to remove smear layer and expose collagen fibers, (C) Application of dentin bonding agent, formation of hybrid layer and then application of composite resin

## BONDING GENERATIONS: DEWEY'S CLASSIFICATION

### First Generation Dentin Bonding Agents (DBA)

- Bonding was achieved through chelation of the bonding agent to the calcium component. NPG-GMA (N-phenyl-glycine-glycidyl methacrylate) was used as 1st generation bonding agent.
- Bonding was low, hence was useful only for class III and class IV cavities.
- Low bond strength of 2-3 MPa.

### Second Generation Dentin Bonding Agents

Here the negatively charged phosphate groups in the resin reacted with the positively charged calcium in the smear layer. Examples include—Scotchbond, Bondlite, Prisma Universal Bonding Agent. These products attempted to use the smear layer as a bonding substrate.

*Disadvantages*

- Inadequate bond strengths.
- They did not wet dentin properly.

### Third Generation Dentin Bonding Agents

In third generation DBA, two component primer/adhesive systems were introduced. This was the concept of conditioning and priming before their application. Higher bond strength and reduced microleakage in these decreased with time and did not last long.

### Fourth Generation Dentin Bonding Agents

The fourth generation is characterized by the process of hybridization at the interface of the dentin and the composite.

They consist of:

i. Primers—act as water chaser and enhances adhesive penetration.
ii. An unfilled or filled resin fluid bonding agent:
   - Hydrophobic part: Bis-GMA
   - Hydrophillic: HEMA
   - Acetone based
   - Bond strength was 17-24 MPa.

### Fifth Generation Dentin Bonding Agents

- They have a single component, single bottle.
- These combine the priming and bonding steps but etching is performed separately.
- Application time and number of steps is reduced.
- Bond strengths are almost equal to that of fourth generation adhesives. Example: Prime and Bond, OptiBond Solo, Single Bond (3M).

### Sixth Generation Dentin Bonding Agents

- Since 2000, these single bottle adhesives are available which combine etching, priming and bonding in a single solution and as a single step.
- Since they consist of an acidic solution they cannot be stored and have to be refreshed.
- Examples are Prompt-L-pop and clearfill SE bond.

### Seventh Generation Dentin Bonding Agents (Adhesive Systems)

The seventh generation simplified the multiple of sixth generation materials into a single component, single bottle system. It has disinfecting and desensitizing properties also.

The success or failure of adhesives depends upon several factors described as follows:

i. *Size and shape of lesion*: Small sized cervical lesions show less adhesion as compared to deeper, wedge shaped lesions.
ii. *Arch type*: Adhesion is better in cases of maxillary arch than mandibular arch due to the lesser chances of moisture contamination.
iii. *Age*: With increasing age dentin gets sclerosed and thus adhesives show a greater failure rate.
iv. *Dentin wetness*: Bonding agents with good wetability ensures successful bonding.


# Tooth-Colored Restorations

## DESCRIBE OF TOOTH-COLORED RESTORATIVE MATERIALS

### Silicate Cement

- First translucent material.
- Has tooth matching ability.
- Silicate cement powder is composed of acid-soluble glasses and phosphoric acid, buffering agents and water.
- Recommended for small cavities in the anterior tooth.
- Cavity preparations for it should be of the conventional type.
- They were indicated for restorations of anterior teeth in patients with high caries index in the areas which are not subjected to masticatory forces.

*Disadvantages*

- Poor strength
- Irritation to pulp tissue
- Brittleness.

### Unfilled Acrylic Resins

- Introduced into dentistry in 1940s.
- Available as powder and liquid systems.
- Powder is composed of polymethyl methacrylate polymer and benzyl peroxide as initiator.
- Liquid is methyl methacrylate monomer, hydroquinone as an inhibitor and a tertiary amine as activator.

*Advantages*

- Tooth color matching ability.
- Ease of manipulation.
- Cheaper in cost.

*Disadvantages*

- High polymerization shrinkage.
- High coefficient of thermal expansion (CTE).
- Lack of wear resistance.
- Irritation and injury to pulp.
- Color changes.
- Poor strength and hardness.
- Dimensional instability.

### Glass Ionomer Cements (GIC)

- Introduced in mid-seventies by Mc Lain, Wilson and Kent.
- It is often referred as poly (alkenoate) cement or ASPA (aluminosilicate polyacrylic acid).
- Supplied as a powder-liquid system.
- Powder contains acid-soluble calcium-fluoro-aluminosilicate glass with a higher alumina/silica ratio as compared to silicates. Fluorides of calcium, sodium and aluminum are present as fluxes.
- The liquid contains polyacrylic acid in the form of a co-polymer with itaconic, maleic, or tricarboxylic acid.

*Advantages*

- Esthetically reasonably.
- True chemical bonding with tooth structure.
- Release of fluoride which exhibits anticariogenic properties.
- Biocompatible.
- Coefficient of thermal expansion is close to enamel.
- Less irritating to pulp than silicates and composites.

*Disadvantages*

- Technique sensitive.
- Lack fracture toughness.
- Low wear resistance.
- Sensitive to water content in liquid and in dry environment and are prone to dehydration and cracking if not protected.
- Cannot be finished at the time of placement.

## Composite Resins

The term refers to a three dimensional combination of at least two chemically different materials with a distinct interface separating the components.

*Composition*

- *Resin matrix*: Resin matrix which forms a continuous phase in which filler is dispersed. For example, Bis-GMA or UDMA which is diluted with TEGDMA to decrease its viscosity.
- *Filler* is usually silica. Functions of filler:
  - Increases strength
  - Reduces polymerization shrinkage
  - Increases radiopacity
  - Reduces water absorption
  - Reduces wear resistance.
- *Coupling agent*: Interfacial bonding between the matrix phase and the filler phase is provided by coating the filler particles with silane coupling agents.
- *Activator* is used to produce free radicals.
- *Initiator* is used to initiate the polymerization, e.g. Benzoylperoxide.
- *Inhibitor* is used to stop the polymerization, e.g. Butylated Hydroxy Toluene.

*Indications*

- For class I, II, III, IV, V and VI restorations.
- Pit and fissure sealant.
- Conservative composite restorations.
- Cementation of indirect restorations.
- Periodontal splinting.
- Esthetic improvement procedures:
  - Partial veneers
  - Full veneers
  - Tooth color improvements
  - Diastema closures.

*Contraindications*

- When operating field cannot be maintained dry.
- Where very high occlusal forces are present.
- The restorations that extend up to the root surface.
- Invisible, very small lesions on distal surface of canines where metallic restoration is treatment of choice.
- Patients with high caries susceptibility.

*Advantages*

- Conservation of tooth structure.
- Esthetic.
- Have low thermal conductivity, hence no insulation base is required.
- Can bonded with enamel and dentin.
- Can be finished immediately after curing.
- It is reparable.
- Low microleakage.

*Disadvantages*

- Gap formation on margins may occur, usually on root surfaces.
- More technique sensitive.
- Greater occlusal wear in areas of high occlusal stress.
- High linear coefficient of thermal expansion (LCTE) result in marginal percolation.

*Classification*

*On the basis of size, amount and composition of the inorganic filler*

- Conventional composite resins
- Microfilled resins
- Hybrid composite resins
- Flowable composites
- Packable condensable composites
- Homogenous microfill
- Heterogeneous microfill.

*On the basis of polymerization method*

- Light activated:
  - Ultraviolet light curing
  - Visible light curing
- Chemically activated

*Properties*

- High linear coefficient of thermal expansion (LCTE).
- The size and composition of filler particles determine the smoothness of the surface of a restoration.
- Radiopaque.
- Insoluble in oral fluids.
- Show polymerization shrinkage.

*The configuration factor (C-factor)* is the ratio of bonded surface of the restoration to the unbounded surfaces. The higher the value of C-factor, the greater is the potential for bond disruption due to polymerization shrinkage.

$$\text{C factor} = \frac{\text{Bonded surface}}{\text{Unbonded surface}}$$

For class I restoration = C = 5
For class IV restoration = C = ¼
For class III restoration = C = 2.

## WHAT ARE DIFFERENT TYPES OF COMPOSITE RESINS?

### Conventional Composite Resins

- Average particle size is 8 microns approximately.
- Contain approximately 75 to 80 percent inorganic filler by weight.
- Exhibit a rough surface texture.
- Due to roughness, discoloration and wearing of occlusal contact areas and plaque accumulation take place quickly than other types of composites.

### Microfilled Resins

- Average particle size ranges from 0.01 to 0.04 microns. In these small particle size results in smooth polished surface which is plaque, debris and stain resistant.
- Inorganic filler content of approximately 35 to 60 percent by weight.
- Less susceptible to wear than conventional composite resins.
- Because of less filler content, some of their physical properties are inferior.

### Hybrid Composite Resins

- Average inorganic particle size is 0.4 to 1 micron.
- Inorganic filler content of approximately 75 to 85 percent by weight.
- Physical properties of hybrid are similar to those of conventional composites with the advantage of smooth surface texture.
- Classified based on filler sizes:
  - Hybrid (large filler)
  - Hybrid (mid filler)
  - Hybrid (mini filler).

*Advantages*

- Good strength
- Smooth surface.

*Disadvantages*

- Not suited for heavy stress-bearing areas in posterior teeth.
- Not highly polishable as microfilled.

### Flowable Composites

- Filler content is less about 30 percent by weight.
- Less and narrow filler content increases flow and causes intimate surface adaptation.

*Advantages*

- Good wetability
- Good handling properties
- Easy to use
- At one time it can be used only up to a thickness of 6 mm.

*Disadvantages*

- Inferior physical properties like poor strength and wear resistance.
- It sticks to the instrument, hence difficult to smoothen the surface.
- High stress areas should not be restored with it.

*Uses*

- In very small cavities in low stress or stress-free areas.
- Repair of leaking and defective margins, filling in deep pit and fissure.
- In tunnel cavities.
- Core building.
- Repairing and cementing porcelain restorations.
- For laminations and veneering.

They are **contraindicated** in large class I, class II, class IV and class VI cavities.

### Condensable (Packable) Composites

- Basis of these composites is Polymer Rigid Inorganic Matrix Material (PRIMM), here the components are resin and ceramic inorganic fillers are incorporated in network of ceramic fibers.
- Consistency is like freshly triturated amalgam.
- The composite is carried to the cavity by a carrier and condensed similar to silver amalgam.
- Restorations is light cured for 30 to 40 seconds and finished and polished.

*Advantages*

- Increased wear resistance.
- Due to light conducting property of the individual ceramic fibers depth of cure is more.
- Increased flexural modulus due to presence of more ceramic fibers per unit area.
- Decreased polymerization shrinkage.
- Reduced stickiness because of presence of ceramic fibers.

### Antibacterial Composites

Attempts have been made to incorporate the following caries-resistant antibacterials in the composites.

*Chlorhexidine*

Addition of chlorhexidine was not successful because:

a. Antibacterial activity is temporary.
b. Released materials have toxic affects.

*Methacryloxydecyl Pyridinium Bromide (MDPB)*

It has the following properties:

- Antibacterial property remains constant and permanent.
- Effective against various streptococci.
- Has no adverse effect on the physical properties of Bis-GMA based composites.

*Silver*

- Addition of silver ions in the composites makes them antibacterial.
- Addition of silver into composite without silica gel does not adversely affect its physical properties like depth of cure, compressive strength, tensile strength, color stability, translucency and polymerization.

## POLYMERIZATION METHODS FOR COMPOSITES

### Self-curing Composite Resin

- It is available as a two-paste system composed of a catalyst and a base material.
- One part contains an organic amine accelerator and the other part includes a peroxide initiator.
- Catalyst and base materials are usually mixed in a ratio of approximately 1 : 1.
- Their polymerization process is chemically activated.

### Light-Activated Composite Resins

- Polymerized either by ultraviolet or by visible light.
- Benzoyl methyl ether is an initiator of polymerization when exposed to ultraviolet light and diketones are used as a photochemical initiator.
- They have flexible working time.
- Better resistance to wear and abrasion.
- Reduced porosity.

## WHAT IS CLINICAL TECHNIQUE FOR COMPOSITE RESTORATION?

### Etching of the Prepared Cavity

- A gel etchant is then applied with a syringe or brush to the prepared cavity surfaces, 0.5 mm beyond the cavosurface margins onto the unprepared tooth surface.
- The etchant is left there for 15 seconds, if dentin is included and for 30 seconds if only enamel is involved.
- Wash the area to remove all the etchant for 5 seconds.
- The area is then dried if only enamel has been etched but left moist if only dentin is involved in the cavity preparation.
- The moist dentin has a glistening appearance whereas dried etched enamel exhibits ground glass or frosted appearance.

### Application of Primer and Bonding Agent

- A primer and an adhesive are applied if both enamel and dentin are involved.
- Only adhesive is required for an all enamel cavity preparation.
- If the system does not contain both primer and adhesive, then bonding adhesive is applied after the primer by using applicator tip.
- After that, the adhesive is polymerized with curing light.

### Matrix Application

- Matrix should be applied and stabilized by a wedge before application of etchant, primer and adhesive.
- It should extend one mm beyond the incisal and gingival cavosurface margins.

### Insertion and Curing of Composite

- Light-cured composite is inserted in increments of thickness of about 2 mm each by hand instrument or syringe.
- Then it is cured for 20 to 30 seconds by holding the light source close to but not in contact with the restorative material.
- Longer exposure to light is required for darker and opaque shades.
- Each increment is added and cured till the complete cavity is filled.

### Final Contouring, Finishing and Polishing of Composite Restorations

- The anatomic contours are accomplished by grinding, finishing and polishing the material after polymerization.
- Conventional composites pose greatest difficulty in achieving a smooth surface because of difference in hardness of organic and inorganic phases.
- Microfilled composite materials can be polished to the highest.
- Contouring can be initiated immediately after a light-cured composite material has been polymerized.
- The occlusal surface is shaped with round carbide finishing bur.
- Carbide-tipped carvers are used for removing excess composite along the margins.
- Finishing is accomplished with polishing cups or points after the occlusion is adjusted.
- A final lustre is obtained with polishing pastes that may contain pumice, silica, alumina, tinoxide, etc.
- After the final polishing, a thin layer of glaze is applied to improve surface smoothness.
- Placing of a thin layer of unfilled resin over the finished composite resin is known as '**glazing**'. Its **advantages** are as follows:
  - Improves esthetics
  - Fills surface porosity
  - Creates a smooth glossy surface.

## EXPLAIN TYPES OF TOOTH PREPARATIONS FOR COMPOSITES RESTORATIONS

### Initial Clinical Procedures

- Profound local anesthesia is given before tooth preparation for patient's comfort and reduction in salivary flow.
- Operating site is cleaned with a slurry of pumice to create a site more receptive to bonding.
- The shade of the tooth should be determined before isolation, composite material is selected according to the tooth color.
- The composites are available in enamel and dentin shades, translucent and opaque shades.
- Natural light is preferred.
- Shade selection should not take more than 30 seconds because the fine sensitivity of eyes to differentiate between different shades of similar color is exhausted.
- Final selection must be confirmed by the patient with the use of a face mirror.
- It is better to use the shade of slightly darker side to allow for age-related darkening in color of teeth.
- Isolation of operative field is done with rubber dam or cotton rolls.

### Conventional Class III Tooth Preparation

- The main indication for this type of cavity preparation is damage on the root surfaces.
- The following are important points in conventional cavity preparation:
  - The external walls should be located on sound tooth structure with a cavosurface angle of 90° for butt joint.
  - External walls should be perpendicular to tooth surface.
  - Minimum pulpal depth of axial wall should be approximately 0.75 mm into dentin.
  - Adequate access for removal of remaining infected dentin and old restorative material using spoon excavators or round burs.
  - Calcium hydroxide [$Ca(OH)_2$] liner is used for pulp protection.
  - Grooves may be placed for extra retention in external walls, parallel to tooth surface at least 1 mm from the tooth surface and 0.5 mm deep into dentin.

Retention in such preparation is provided by the following:

- Roughening the surface of prepared cavity.
- Parallelism or convergence of opposing external walls.
- Retention grooves and coves.

## Beveled Conventional Class III Tooth Cavity Preparation

*Indications*

- Replacing an existing defective restoration on crown portion of an anterior tooth.
- When restoring a large carious lesion which will require increased retention form.

*Preparation*

- Area is approached lingually with a no ½, 1 or 2 round bur entering within the incisogingival dimension of lesion close to the adjacent teeth.
- Entry angle should be such that it places the neck portion of the bur far into the embrasure.

Following requirements must be met while preparing a beveled conventional class III cavity, the:

- Shape of the prepared cavity should be similar to the shape of existing lesion and should include friable tooth structure and defects.
- Axial wall depth should be 0.2 mm inside DEJ, pulpally, i.e. 0.75 mm deep gingivally and 1.25 mm deep incisally.
- Axial wall should be convex outwardly.
- External walls should be perpendicular to the enamel surface with all enamel margins beveled.
- The bevel should be about 0.2 to 0.5 mm wide and at an angle of 45° to the external tooth surface.
- All remaining infected dentin or defective restoration should be removed during final cavity preparation using spoon excavator or round bur.
- A calcium hydroxide cavity liner should be placed for pulp protection.
- Bevels should be prepared using flat end tapering fissure diamond bur at cavosurface margins in the areas of centric contacts.
- Areas bearing heavy occlusal forces should not be beveled.
- If the preparation extends gingivally onto the root surface, no bevel is placed on cemental cavosurface margins.
- Retentive groove and coves can be prepared along gingivoaxial line angle and incisoaxial line angle round burs.
- Grooves should be 0.2 mm inside DEJ and 0.25 mm deep without undermining the enamel.

## Modified (Conservative) Class III Tooth Preparation

- Indicated for small and moderate lesions and damages.
- Most conservative type of cavity preparation used for composites.
- The objective is to include only the infected carious area as conservatively as possible by "scooping" out the defective tooth structure.
- Preparation design appears to be 'scooped-out' or 'concave'.

While preparing a class III modified cavity, the following points should be kept in mind:

- Lesion is approached lingually using round bur.
- For smaller preparations, there may not be any definite axial wall depth, and the walls may diverge externally from axial depth in a scoop shape.
- For larger preparations an initial axial depth of 0.2 mm below DEJ is maintained.
- Remaining infected dentin should be removed using small burs or spoon excavators.
- Calcium hydroxide liner should be placed, if indicated.
- Smaller preparations may not require any beveling of margins as they have a beveled configuration from initial tooth preparation.
- Larger preparations require additional beveling or flaring during final tooth preparation.
- The cavosurface margins are beveled using flat end tapering fissure diamond bur to have a width of 0.2 to 0.5 mm and an angle of 45° to external tooth surface.
- Usually, no additional retention groove or cove is required.
- Finally, the cavity should be cleaned and finished.

### Class IV Composite Restoration and Conventional Class IV Preparation

- It is indicated only in those areas that have margins on root surface.
- Here the cavosurface has butt joint.
- Grooves are placed for secondary retention.

### Beveled Conventional Class IV Preparation

- It is used to restore large areas.
- The initial axial wall depth is established at 0.5 mm pulpally to DEJ.
- Bevels are prepared at 45° angle to tooth surface with a width of 0.25 to 2 mm.
- Retentive grooves are made in the same way as in class III beveled conventional preparation.

### Modified (Conservative) Class IV Preparation

- Usually, little or no initial tooth preparation is indicated for fractured incisal corners, other than roughing the fractured tooth structure.
- The objective is to include only the infected carious area as conservatively as possible.
- An initial axial depth of 0.2 mm below DEJ is maintained.

### Direct Class V Composite Restoration and Conventional Class V Preparation

- Indicated if it is completely or mostly located on root surface.
- A tapered bur fissure is used to make entry at 45° angle to tooth surface initially. Later on, the bur's long axis is made perpendicular to the external surface in order to get a cavosurface angle of 90°.
- Axial depth is kept at 0.75 mm into the dentin.
- After this bur is moved mesially, incisally and gingivally for extending the preparation on to sound tooth surface while maintaining a cavosurface margin of 90°.
- Axial wall should follow the contour of facial surface incisogingivally and mesiodistally. During the final tooth preparation, any remaining infected dentin is removed from axial wall using spoon excavator or small bur.
- A calcium hydroxide liner is placed, if necessary.
- Retention grooves are placed along the inciso-axial and gingivo-axial line angles using a flat fissure bur 0.25 mm deep into the dentin.
- The prepared cavity is cleaned finally.

### Beveled Conventional Classes V Preparation

*Indications*

- Replacing defective existing restoration.
- Restoring a large lesion.

*Preparation*

- Preparation should have 90° cavosurface margins which are subsequently beveled.
- The initial axial wall depth should be only 0.25 to 0.5 mm into the dentin.
- Bevel the enamel margins at an angle of 45° to the external surface and to a width of 0.25 to 0.5 mm.

*Advantages*

- Beveling provides enhanced surface for bonding.
- Increased retention.
- Decreased microleakage.
- Conservation of tooth structure, as groove for additional retention can be avoided.

### Modified (Conservative) Class V Tooth Preparation

*Indications*

- Restoration of small and moderate lesions.
- Decalcified and hypoplastic areas located in cervical third of the teeth.

*Preparation*

- Tooth preparation appears 'scooped out' with widely divergent walls.
- Preparation should not extend more than 0.2 mm into the dentin.

### Class I and II Composite Restoration

These types of cavity designs are recommended in class I cavity, where the conservative preparation can be made.

### Class I and II Cavity Preparation

These are similar to silver amalgam restorations but with following differences:

- In small pit and fissure defects conservative modified preparations are recommended. It is characterized by:
  - Less specific in form
  - Scooped out appearance
  - Conservative removal of carious lesions
  - Establishing the beveled cavosurface margins.
- The enamel cavosurface margins are beveled with flame-shaped diamond instruments.
- Intercuspal width is one-fifth the intercuspal distance.
- Walls and floors can be in enamel.
- When a marginal ridge is not supported by dentin, remaining weakened enamel may be left if there is no heavy centric contact on this area. The unsupported marginal ridge will be strengthened by composite restoration due to beveling, etching and bonding procedures between tooth surface and restoration
- These restorations don't require reverse curve configuration.
- The decreased pulpal depth of axial wall in class II cavities allows greater conservation of tooth structures, so the retention grooves are not used.
- Undermined enamel can be retained.
- Class II restoration can be saucer shaped.
- Placing bevel on proximal and occlusal cavosurface margins completes the beveled conventional preparation.

## WHAT IS SANDWICH TECHNIQUE?

- Also called as bilayered restoration.
- Here GIC is placed as intermediate layer between tooth structure and composite material.

### Steps

- Prepare the cavity and place GIC at about 1 mm thickness.
- Etch the surface of GIC and dry it.
- Apply composite resin over it.
- Setting of resin occurs by mechanical interlocking.
- Bonding between GIC and resin takes place through penetration of resin into surface irregularities of etched cement surface.

### Advantages

- Chemical bonding of GIC with tooth surface.
- Anticariogenic property of GIC.
- Durability of composites.
- Esthetics of composites.
- Increased retention of the restoration.

## WHAT ARE STEPS IN CORRECTION OF DIASTEMA?

### Etiology

- Prominent labial frenum.
- Congenitally missing teeth.
- Arch size tooth size discrepancies.
- Supernumerary teeth.
- Tongue thrusting.

### Steps in Diastema Closure

- First of all measurement of the total space between two central incisors is done.
- Isolation of teeth is done by using cotton rolls and retraction cords into gingival crevices.
- Now coarse diamond bur is used to roughen enamel surface, acid etching is performed, rinsed and dried.
- Apply and shape composite with the help of strip, in half of the diastema space measured previously with a caliper.
- Then it is cured.
- Finish with a finishing strip.
- Add and shape composite with the help of strip on another central incisor similarily.
- Unwaxed floss is used to remove any excess composite material in gingival embrasures between two central incisors.

## DISCUSS VARIOUS VENEERS

Veneer is a layer of tooth colored material which is applied on the tooth surface for esthetic purpose.

*Indications*

- Damaged, defective and malformed facial surface.
- Discolored facial surface.
- Discolored restorations.

*Types of Veneers*

*Based on extent of coverage*

- *Partial veneers* are used for the localized damage, defect and discoloration of the tooth, i.e. they involve only a portion of the tooth crown (Fig. 38.1).
- *Full veneers* are used when majority of facial surface or whole of the crown of a tooth is discolored.
  *Types*: Full veneer with incisal overlapping.
  Full veneer with window preparation.

*Based on method of fabrication*

- Direct veneer technique
- Indirect veneer technique.

## Direct Veneer Technique

*Direct Partial Veneer*

*Indications*

- Localized discoloration.
- When entire facial surface is not defective.

*Procedure*

- Cleaning of teeth which are to be veneered.
- Selection of the shade.
- Isolation of the teeth with cotton roll or rubber dam.
- Removal of the defect and tooth preparation.
- Preparation should extend on some sound enamel also.
- Restoration of cavity with composite resins, mostly microfilled.
- Application of composite is as usual, i.e. first acid etching and then application.

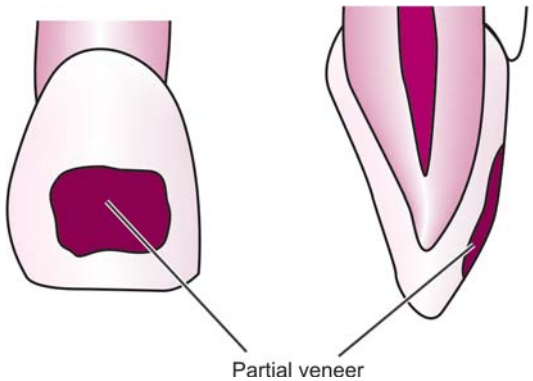



**Fig. 38.1:** Partial veneer involving only localized surface of labial part of the tooth

*Advantages*

- Single appointment.
- Useful for young patients.
- Useful for localized defects.
- Economical.

*Disadvantages*

- More chair side time.
- Require more labor.

*Direct Full Veneers*

*Indications*

- Diastema closure.
- Gross enamel hypoplasia of anterior teeth.
- Grossly tetracycline stained teeth.

*Procedure*

- Cleaning of the teeth.
- Selection of the shade.
- Teeth isolation is done and gingiva is retracted with retraction cords.
- Reduction of tooth is done with coarse round end diamond bur.
- At the proximal side, the preparation should be facial to the contact point.
- Heavy chamfer at the gingival margin is preferable.
- Acid etching, washing and drying.
- Apply composite in increments.
- When adding composites, care should be taken to create proper physiological contour, contact point, and smooth surfaces.

*Advantages*

- Less technique sensitive.
- Last for more time.
- Effective for multiple veneers.

*Disadvantages*

- Expensive.
- Require special tooth preparation.

Tooth Preparation for full veneers is of two types:

*Window Preparation (Fig. 38.2)*

*Indications*

- To preserve functional lingual and incisal surfaces of anterior teeth.
- To prepare maxillary canines in patients with canine guided occlusion.
- In patients with high occlusal stresses.

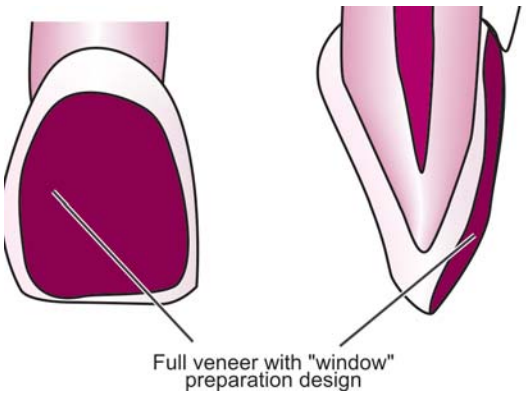



**Fig. 38.2:** Full veneer with incisal lapping veneer

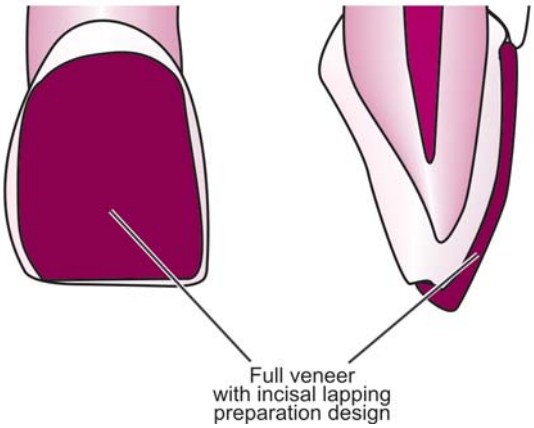



**Fig. 38.3:** Full veneer window preparation technique

*Advantages*

- Saves the functional lingual and incisal surfaces of anterior teeth.
- It does not extend subgingivally or involve incisal edge.
- Decreases the chances of wear of opposing teeth.

### *Incisal Lapping Preparation (Fig. 38.3)*

*Indications*

- Made when crown length is to be increased.
- When incisal defect is severe and restoration is necessary.

*Advantages*

- As tooth preparation is within the enamel, hence no temporary restoration is given.
- Improved esthetics along incisal edge.

## Indirect Veneer Technique

Chair time required for indirect veneer is less.

It requires two less time consuming appointments.

Removal of 0.5 to 1 mm of enamel is done.

Indirect veneers are better for proper contour, contacts and shade.

*Indirect veneers are of the following types*:

a. Processed composite veneers
b. Etched porcelain veneers
c. Castable ceramic veneers.

### *Processed Composite Veneers*

*Advantages*

- Superior physical and mechanical properties.
- Can be bonded to the teeth with a tooth bonding agent.
- Easy to finish and polish.
- Can be easily repaired.
- Processed veneers are made in the cases which show attrition of anterior teeth due to occlusal stress.

*Steps of veneer placement*

- Acid etching.
- Application of bonding agents to the tooth enamel.
- Placement of veneer by using fluid resin bonding medium.
- After placement, finishing and polishing.

### *Etched Porcelain Veneers*

In these porcelain veneers, internal surface is acid etched which forms stronger bond with etched surfaces of tooth.

*Advantages*

- Better retention.
- Less prone to stains.
- Good esthetics.
- Less prone to fractures than other types of veneers.

*Steps*

- After cleaning and shade selection, the isolation of teeth is done.
- Tooth surfaces are prepared with round end diamond bur.
- Preparation should be incisal lapping veneer type.
- Impression is taken in rubber base impression material.
- It is sent to laboratory for veneer formation.
- A completely finished veneer should be seated on clean, dry and isolated prepared tooth.

- Internal surfaces of porcelain veneers are conditioned with silane primer.
- After setting, excess cured resin is carefully removed by BP knife.
- Recontouring and trimming is done if required.

*Castable Ceramic Veneers*

- Commonly used castable ceramic is 'DICOR'.
- These are fabricated for only light to moderate discolorations because it is very translucent material.
- Formed by lost wax technique.
- Preparation of tooth and bonding are like etched porcelain veneers.
- Castable ceramic veneers are not finished with rotary instruments as rotatory instruments cause loss of surface coloration.
- Little marginal finish is required due to good marginal fit of the castable ceramic veneers.

## VENEER FOR METAL RESTORATION

Sometimes, veneers are placed on the facial surface of tooth which has been restored with metal.

### Steps of Making Veneers

- Cleaning of the teeth.
- Shade selection.
- Isolation of the area.
- Preparation includes removal of the metal and enamel.
- Butt joints are made at the cavosurface margin.
- Preparation should not extend on the occlusal surface.
- Grooves are made along the gingivoaxial and linguoaxial angles.
- Enamel surface is beveled to improve esthetics.
- Acid etching of the cavity and then drying is done.
- Placement of composite as usual.
- Finishing of the restoration.

## DESCRIBE REPAIR OF VENEERS IN SHORT

Repair of veneers may be of two types:

1. Veneers on tooth surface.
2. Veneers on the metal restoration.

### Repair of Veneer on Tooth Surface

*Repair of Direct Composite Veneers*

Repaired with the same material by which they have been prepared.

After cleaning, preparation of retentive grooves and roughening the surface composite is applied after acid etching.

*Repair of Indirect Processed Veneers*

i. *Composite:* These are repaired like direct composite veneers.
ii. *Porcelain:*
   - Acid etching with 10% Hydrofluoric acid (HF)
   - Isolation of the tooth
   - Application of coupling agent
   - Application of resin bonding agent
   - Placement of composite, curing and then finishing is done.

### Repair of Veneer on Metal Restoration

*Repair of Metal Veneers*

Repair of these veneers is done in the following steps:

- Cleaning of the tooth followed by shade selection.
- Isolation of the area
- Preparation of the facial surface by removing the remaining material, and creating chamfer finish line.
- Application of acid on the metal surface, rinsing and drying.
- Placing polyester strips and wedges to obtain proper contours.
- Applying resin on the metal surface.
- Placement and curing of composite material.

## EXPLAIN CAVITY PREPARATION FOR GLASS IONOMER RESTORATIONS

### Isolation and Moisture Control

Since GIC is sensitive to water, isolation from saliva, sulcular fluid and gingival bleeding is essential for success of GIC restoration.

### Tooth Preparation

*Mechanical Preparation*

A. *Outline form:*
   a. If not involved in caries, contact areas are not cut to bring the margins to self cleansing areas.
   b. The unsupported enamel is not removed if it is not exposed to heavy masticatory forces.
B. *Retention and resistance form*: The GIC has true or chemical adhesion to enamel and dentin. Thus, major and dovetails are not required at the cost of healthy tooth structure.
C. *Debridement, prophylaxis and isolation*: GIC chemically bonds to the cavity walls, hence the cavity walls must be clean and conditioned.

Tooth surfaces to receive GIC should be absolutely clean and free of contaminants such as debris and saliva.

*Chemical Preparation*

After cavity preparation, surface is chemically prepared to condition for better bonding. Polyacrylic acid 10 to 20 percent is applied for 10 to 20 seconds which produces best conditioning.

### Priming the Tooth Surface

After conditioning the priming is only done for light cure glass ionomers. Priming agents are used for 10 to 30 seconds.

### Mixing of GIC

Mixing should be done at room temperature for 45 to 60 seconds on a cool and dry glass slab or paper pad with the help of a flat and firm plastic spatula.

Working time is one to one and a half minutes for GIC and three minutes for resin modified GIC.

### Restoration

After mixing it is carried in one bulk to the cavity. The filling is contoured and gross excess is quickly removed.

### Finishing and Polishing

The use of matrix produces best finishing. After matrix removal varnish or cocoa butter is applied. Then gross excess is trimmed with sharp hand instruments. Finishing diamond points at very slow speed with petroleum lubricant are used without water coolant. The restoration is finally covered with varnish, bonding agent, petroleum jelly to prevent dehydration.

Final finishing is done after 24 hours using diamonds points, stones, abrasive strips and aluminium oxide disks.

## WHAT IS ATRAUMATIC RESTORATIVE TREATMENT (ART)?

In this technique, the carious tooth tissue with the help of excavators and hand instruments is removed. After excavating, followed by etching and bonding application of glass ionomer cement is done. Hand instruments on the same sitting are used to finish the restorations.

The use of RMGI restorative materials in Class V cavities permits immediate finishing and reduces the rate of microleakage. Conventional glass ionomer materials should be wet finished to prevent desiccation.

### Advantages

a. Less costly.
b. Less time consuming.
c. Can be used in remote rural areas.

# 39 Direct Filling Gold

## NOTE ON DIRECT FILLING GOLD

### Indications

- For small carious lesions.
- For hypoplastic or other defects.
- For limited extension and small cavities like:
  - Class I cavities of all teeth.
  - Class V cavities of all teeth.
  - Class III cavities of all teeth.
  - Class II cavities of bicuspids.
  - Class VI cavities.

### Contraindications

- If limited accessibility.
- If large amount of tooth is destroyed.
- If patient is uncooperative.
- If esthetics is of importance.
- High occlusal stresses.
- Poor periodontal condition.

### Advantages

- Noble metal.
- It provides permanent restoration.
- No cementing medium is required.
- Coefficient of thermal expansion near to the dentin.
- Malleability provides permanent self sealing margins.
- Polished surface is plaque repulsive.
- It does not cause tooth discoloration because of good adaptation to the cavity margins and walls.
- It is insoluble in oral fluids.
- Can be completed in one appointment.

### Disadvantages

- Highly technique sensitive.
- Unesthetic.
- Indicated only in small cavities.
- High thermal conductivity can be a problem in a newly restored tooth.
- The manipulation of gold is difficult and time consuming.

## WHAT ARE DIFFERENT TYPES OF DIRECT FILLING GOLD ?

### Pure Gold

Pure gold is used in dentistry for direct filling in the following forms:

I. Gold foil
   1. Sheet
      a. Cohesive
      b. Noncohesive

II. Preformed gold foils
   1. Ropes
   2. Cylinders (hand rolled and mechanically rolled)
   3. Laminated foils
   4. Strips
   5. Pellets (hand rolled and mechanically rolled)
   6. Platinized
   7. Extraply (Pre-rolled cylinders of foil)
   8. Corrugated

III. Electrolyte precipitated gold powder
   1. Mat gold
   2. Mat foil (Mat gold plus gold foil)
   3. Gold–calcium alloy

IV. Powdered gold—gold powdered and encapsulated—Goldent.

*Gold Foil*

- This is the oldest form of direct filling gold.
- It is made by beating pure gold into thin sheets.
- The size of the sheets is 4 × 4 inch.
- The foils are supplied in books which are separated by thin paper pages.
- The thickness of gold foil is 1.5 micron.
- Before insertion of the foil into the cavity, it is cut, rolled into ropes, cylinders or pellet.
- The pellet size may vary as they are rolled from ½ to 1/128 sections cut from a sheet of foil (Fig. 39.1).
- The rolled pellets can be stored in a gold foil box.
- To prevent the formation of oxide layer on the pellets, cotton dipped in 18 percent ammonia is placed in the gold foil box.
- The advantage with custom-made pellets is that different size and shaped pellets which are more cohesive and require less gold can be made.

*Platinized Gold Foil*

The foil is made up by sand-wiching a sheet of platinum between two sheets of gold foil. The platinum increases the hardness of the restoration, hence, it is used in areas of high occlusal stress like cusp tips and incisal edge of anterior teeth.

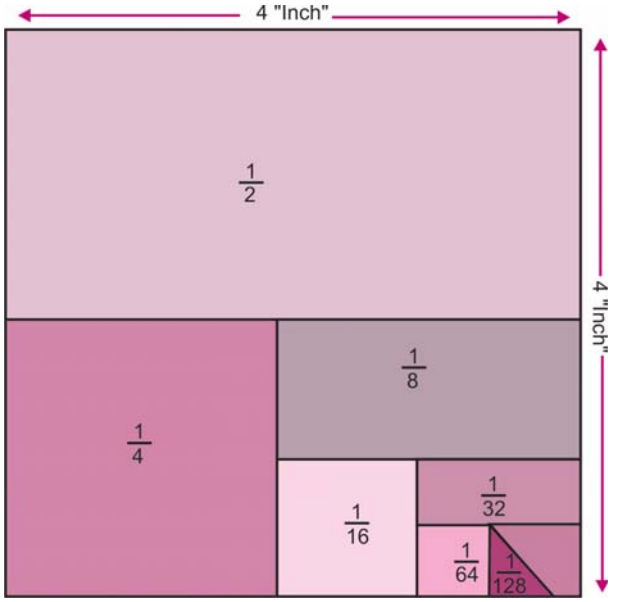



**Fig. 39.1:** Template for pellet size of gold foil. Gold foil sheet is cut according to the required pellet size

*Mat gold*

Pure gold is sintered in an oven, after this, gold is heated slightly below the melting point so that partial fusion occurs. The resultant material is a spongy structure of loosely aligned crystals, which adapt well to the cavity walls.

*Mat Foil*

In this, mat gold is sandwiched between the two cohesive gold sheets

*Electraloy*

In this, mat gold is alloyed with 0.1 to 0.5 percent by weight with calcium. Then this crystalline structure is sandwiched between two gold foils like mat gold. Calcium is added to increase the hardness and strength.

*Powdered Gold or Gold Dent*

It is a combination of atomised and chemically precipitated gold powder embedded in a wax-like organic matrix.

## MANIPULATION OF GOLD

### Degassing or Annealing

- *Degassing* or *annealing* is cleaning of gold surface by heating.
- Degassing is a better term because in annealing, along with the removal of surface contamination, internal stress relief or recrystallization also takes place.
- Degassing is specially required for non-cohesive gold, in which an ammonia layer is placed as a protective coating over the foil by the manufacturer, to prevent other gases and their oxides from contaminating the gold and to prevent clumping of pellets.

### Types

*Bulk method*

- Many gold pellets are heated together.
- The pellets are placed on the mica tray and then heated over open gas or alcohol flame.
- The tray is heated until the gold pellets achieve the temperature above 400°F.

*Advantages*

- Saves time.
- Convenient.

*Disadvantages*

Disadvantages of bulk method are as follows:

- Unused gold may be left and it can be wasted due to contamination.
- There is a danger of over heating.
- It is difficult to select the annealed gold piece that will fit into the cavity.

*Piece Method*

- The gold foil is held in carrier and heated over clean blue flame of absolute or 90 percent ethyl alcohol.
- The flame temperature is about 1,300°F.
- The gold is heated until the metal becomes dull red.

*Advantages*

- Lack of waste.
- One can select piece of desired size.
- Reduces chances of contamination between compaction and annealing.

## EXPLAIN COMPACTION OF GOLD FOIL

The aim of compaction is to:

a. Weld the pieces of gold together.
b. Adapt the gold to the margins of the cavity.
c. Remove the air entrapped in between the gold pieces.
d. Harden the mass by cold working.
e. Strengthen the restoration.

### Types of Condensers

Compaction is done either by hand pressure, hand mallet, automatic mallet, pneumatic mallet, or electromallet. In **hand condensation**, gold is forced into the cavity in a proper direction by condenser.

In **automatic mallet** predetermined force is applied as the force is controlled by a spring fitted inside the mallet. As soon as the desired force is achieved the spring is released.

In **pneumatic condenser (mechanical condenser)**, the no. of compaction strokes are controlled by a rheostat attached to an electric motor, while condensation pressure is regulated by a knob present on the back of hand piece.

The principles involved in compaction of gold are as follows:

1. Weld the gold to make a cohesive mass.
2. Wedge maximum gold into the cavity with minimal air inclusion.

### Compaction Technique

- A gold piece is placed in the corner of the cavity.
- By a condenser malleting is done in the center of the mass (Fig. 39.2) .
- The angle between the face of the condenser and the gold should be between 6 and 12°.
- Line of force should be 45° to cavity walls and floors.
- Forces of condensation should be 90° to the previously condensed gold to avoid loosening or displacement of condensed gold pieces.
- Condensation is done with rocking motion of the instrument from the plane, perpendicular to the plane of the wall (Fig. 39.3).
- *Stepping*: During condensation, as the condenser is moved towards periphery, each succeeding step of the condenser should overlap the half of the previous step.

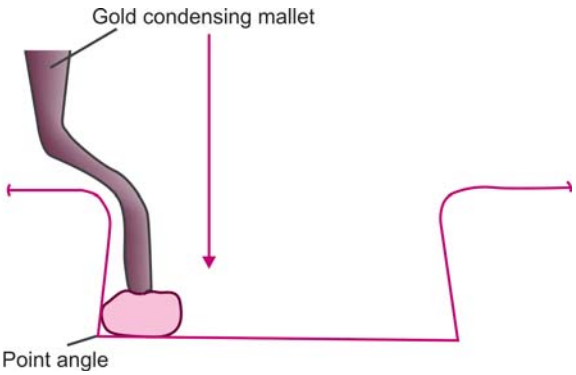
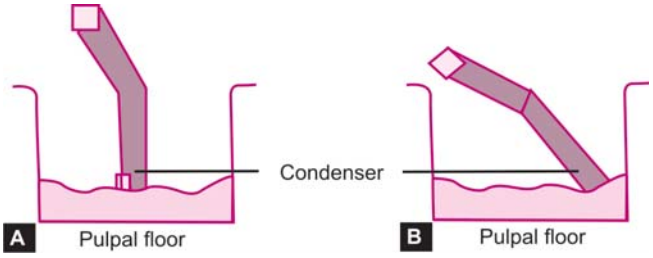



**Fig. 39.2:** First gold pellet being condensed in the starting point angle




**Figs 39.3A and B:** Condensation of direct gold: (A) Condensation against pulpal wall by holding condenser at 90° to the pulpal floor, (B) Condensation at the point angle is done by holding condenser at 45° angle, in such a way that it bisects the line angle and trisects the point angle. Condenser is moved from the center towards the periphery


**Fig. 39.4:** Stepping pattern of one-third overlap of direct filling gold. Condenser moved across the surface of gold in an order of stepping motion. Condensation begins at position 1 and moves to the right after position 2 is moved to the right with overlapping

- Stepping is started at one point and continued in a straight line to another point on opposite side and then back to original side on different straight line (Fig. 39.4).
- Significance of stepping
  - No voids
  - Denser restoration
  - Ensure that every piece of gold has been welded and cold worked
  - Maximal adaptation of gold to the cavity.
- *Bridging*: When an improper building shelf is produced, bridging occurs. That is gold bulges and produces a convexity in the material preventing the condenser from reaching the cavity wall, thus resulting in porosity.
- Bridging can be prevented by uniform placement of gold and adequate condensation using proper line of force.

### Finishing

- A specially designed Spratley burnisher is pressed with pressure over the metal to close the voids.
- During burnishing, gold overlaps the edge of the cavity making it difficult to detect the end of the cavity.
- For polishing in a smooth rubber cup, silica, pumice, metallic oxide compounds are used.

## WHAT ARE PRINCIPLES OF TOOTH PREPARATION FOR DIRECT GOLD RESTORATIONS?

### Class I Cavity Preparation

- Outline form is similar to class I for amalgam but with following differences (Fig. 39.5):
  - Extensions in facial and lingual grooves in molars has pointed ends rather than rounded.
  - Outline form is more rounded than amalgam.
  - Instead of having round corners, there are angular corners at triangular fossa areas.

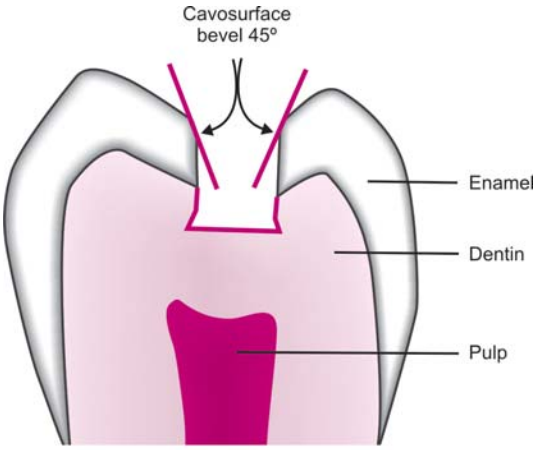



**Fig. 39.5:** Class I cavity prepared for direct gold filling restoration with bevels of cavosurface margins

- The marginal outline form is simple and circular.
- Width of cavity should not exceed one-fifth the intercuspal distance.
- The external walls of the cavity must be parallel with respect to each other.
- Point angles should be angular.
- Mesial and distal walls may be slightly diverging.
- If additional retention is required in the dentin, undercuts are placed in the facial and lingual walls by small inverted cone bur.
- Small bevels of 45° may be placed at the cavosurface margins for easy finishing.

### Class II Cavity Preparation

- Occlusal outline is similar to class I cavity preparation.
- The isthmus and marginal ridge area are very conservative in width.
- The proximal box is slightly smaller than that of amalgam restoration.
- It is a one sided truncated cone type.
- Gingival floor is flat and perpendicular to long axis of the tooth.
- Width of cavity should not be more than one-fifth of intercuspal distance.
- Buccal and lingual walls should be extended for easy manipulation and finishing.
- The gingival margin should be just cervical to the contact areas.
- Retention grooves may be placed in dentin of the proximal and gingival walls.
- All line angles except axiopulpal should be very sharp.
- Retention is provided by sharp line angles and point angles.

## Class III Cavity Preparations

For class III cavity various designs like Ferrier design, Loma Linda design, Ingraham design have been recommended.

*Ferrier Design (Fig. 39.6)*

- In this the lesion is approached from the facial side.
- The preparation is made triangular in shape.
- The incisal margin is kept cervical to the contact area to provide access for instrumentation. It meets the facial and lingual margins in a smooth curve.
- The axial wall is flat in all the directions and is about 0.5 mm deep into dentin.
- The inward sloping dentin of the gingival wall the incisal undercut in the dentin and sharp line angles and point angles provide retention.
- All enamel margins are slightly bevelled to remove only overhanging unsupported enamel rods.

*Loma Linda Design*

- The preparation is done from lingual approach.
- No bevelling of the cavosurface angle is done.
- For retention small grooves are made in three opposite directions (Fig. 39.7).

*Ingraham Design*

- It is used in incipient proximal lesions.
- Shape of the cavity is of a parallelogram, which is mostly confined to the contact area. Lesion is approached from the lingual side with a very small inverted cone bur.

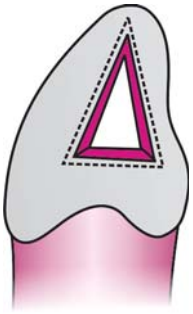


**Fig. 39.6:** Class III cavity design for direct gold restoration

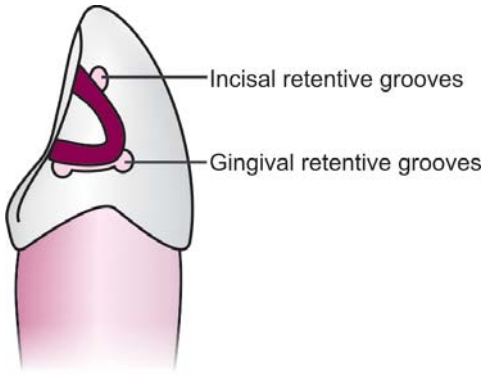



**Fig. 39.7:** Retention grooves in class III cavity

- The gingival margin is straight faciolingually and is at right angle to the long axis of the tooth. It meets the facial margin by making an obtuse angle, while at the lingual margin, the angle is acute.
- For retention, sharp obtuse angles may be made in the facioaxial and linguoaxial line angles into the dentin.

## Class V Cavity Preparation

- The outline form of the cavity for direct gold is trapezoidal (Fig. 39.8).
- As the tooth is narrow in the gingival area, the gingival outline is shorter.

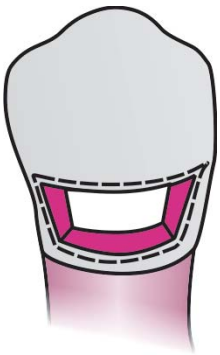
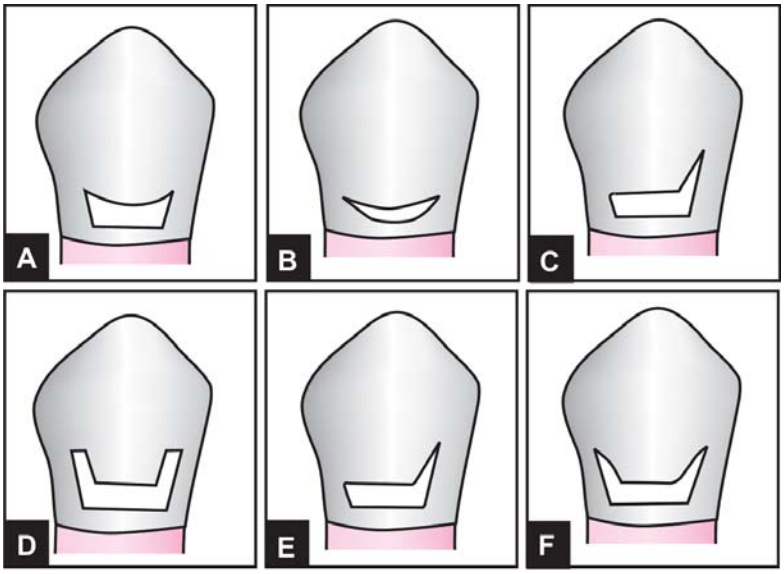


**Fig. 39.8:** Trapezoidal outline form for class V cavity




**Figs 39.9A to F:** Modifications of class V cavity for direct filling gold restoration: (A) To display less gold, curved occlusal outline, (B) Cresentric shaped cavity when height of contour is located apically and esthetics is required (C to F) Trapezoidal form with unilateral step when caries extend on proximal line angle from gingival to occlusal surface. In these trapezoidal form is extended in form of a step or moustache

- The occlusal margin should be straight and parallel to the occlusal surface of the teeth. The mesial and distal margins should be straight and when they meet at the occlusal and gingival margin, the angle formed should be acute and obtuse respectively.
- For retention, convergence is given in the occlusal and gingival walls.
- The acute axio-gingival line angle gives retention.
- Variations in designs of class V restorations for DFG (Figs 39.9A to F).

# 40 Cast Metal Restorations

## WHAT ARE INDICATIONS AND CONTRAINDICATIONS OF CLASS II INLAY AND ONLAY?

### Class II Inlay

Class II inlay essentially involves proximal surface or surfaces of a posterior tooth, usually may involve occlusal surface and also may involve facial and/or lingual surface(s) and caps none or may cap all but one cusp of a tooth (Fig. 40.1).

### Class II Onlay

Class II onlay is a modification of the inlay and involves the proximal surface or surfaces, and may involve facial and/or lingual surface/s of a posterior tooth and caps all the cusps (Fig. 40.2).

*Indications of Metal Inlay and Onlay*

- In extensive proximal surface caries in posterior teeth.
- Root canal treated teeth.
- Tooth requiring extensive restoration.
- To maintain and restore proper interproximal contact.
- Abutment teeth of removable partial dentures.
- In posterior teeth with heavy occlusal forces and attrition.

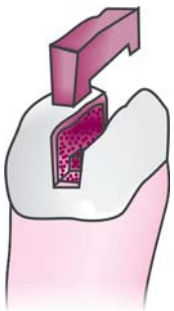


**Fig. 40.1:** Diagrammatic representation of inlay

**Fig. 40.2:** Diagrammatic representation of inlay

*Contraindications of Metal Inlay and Onlay*

- Where esthetics is prime consideration.
- When patient cannot come for second visit.
- Where expected life of a tooth is short.
- For patient of low economic status.

## WHAT ARE PRINCIPLES OF TOOTH PREPARATION FOR CLASS II CAST METAL INLAY?

### Preparation Path

Preparation should have single insertion path opposite to the occlusal load and parallel to the long axis of tooth (Fig. 40.3). This helps in retention of the restoration.

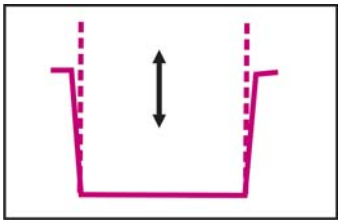
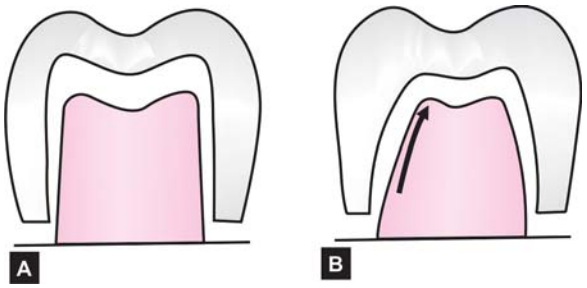


**Fig. 40.3:** Single path of preparation for inlay. It should be parallel to long axis of the tooth

## Inlay Taper

A basic requirement of all cavity preparations for the cast restoration is that the cavity walls must diverge from gingival to occlusal and it may range from 2 to 5° per wall in the line or path of withdrawal (Fig. 40.4).

If cervical to occlusal wall height is more, then degree of occlusal divergence should be increased, for shallow class I or class II preparations the axis of taper is generally parallel to the long axis of the tooth.




**Figs 40.4A and B:** (A) Normal taper of walls provides retention of inlay, (B) More the taper, lesser is the retention

## Bevels

Bevel is defined as the inclination that one surface makes with another when not at right angles.

*Objective* of bevel is to form a metal wedge of 30 to 35° thus enhancing the chance to achieve closure at the interface of cast gold and tooth. By beveling, a strong enamel margin with an angle of 140 to 150° can be produced. In this way, 30 to 40° wedge-shaped margin of cast metal is produced.

The desirable metal angle at the margins of inlays is 30° at the gingival margin and at other margins it should be 40°. Bevels help to maintain the marginal seal of a cast restoration.

### *Types of Bevel (Fig. 40.5)*

According to shape and type of tissue involved, bevels can be:

a. *Ultrashort or partial bevel*:
   - It is beveling of less than two-third of the total enamel thickness.
   - Used to trim the enamel rods from cavity margins.
   - Used in type I casting alloys.

b. *Short bevel*:
   - Beveling of full thickness of enamel wall but not dentin.
   - Used mostly for restorations with type I and II casting alloys.

c. *Long bevel*:
   - Includes full thickness of enamel and half or less than half thickness of dentin.
   - It preserves the internal 'boxed up' resistance and retention features of the preparations.
   - Used in types I, II and III of cast gold alloys.

d. *Full bevel*:
   - Includes full enamel and dentinal wall.
   - It deprives the preparation of its internal resistance.
   - Full bevel should be avoided except in cases where it is a must.

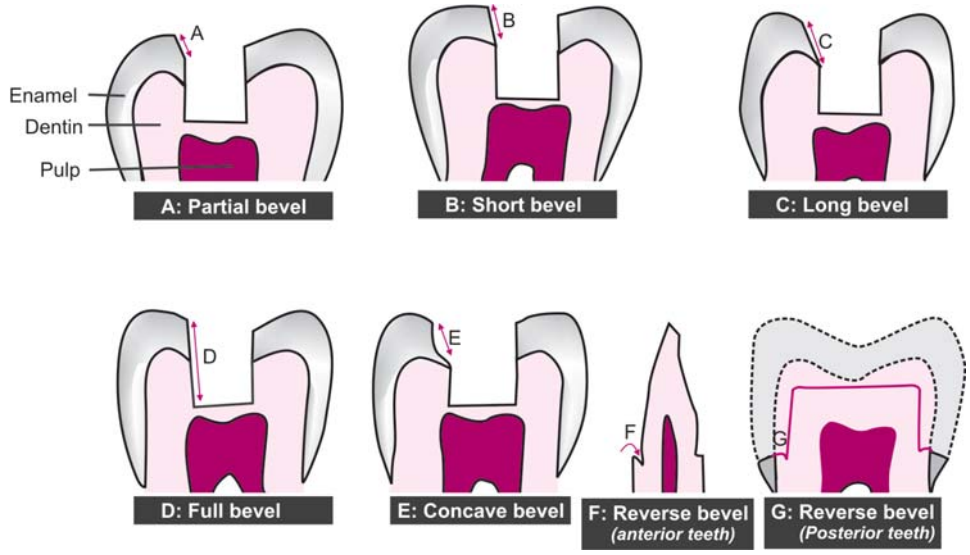



**Fig. 40.5:** Types of bevels

e. *Hollow ground (concave) bevel*:
   - Hollow ground is concave in shape and not a bevel in true sense.
   - The concave bevel is rarely used.

f. *Counter bevel*:
   - Used when capping of the cusps is done
   - It is opposite to an axial wall of the preparation on the facial or lingual surface of the tooth.
   - It has gingival inclination facially or lingually.

g. *Reverse or inverted bevel in anterior teeth*: It is beveling in the reverse or inverted shape given on the gingival seat in the axial wall toward the root in anterior teeth.

h. *Reverse or inverted bevel in posterior teeth*: In posterior teeth in MOD preparations for full cast metal restorations, it is used to prevent tipping of cast restoration in the directions shown with the arrows and to increase the resistance and retention.

### *Functions of Bevels*

- Weak enamel is removed.
- A beveled surface can be easily burnished.
- To increase retention, resistance, esthetics and color matching.
- To improve junctional relationship between the restorative material and tooth.
- The types of margin of tooth preparation depend mainly on the compressive strength, edge strength and tensile strength of the restorative material.
- To maintain the marginal seal.

## Variations in Proximal Margin Design

The design of the proximal margins will vary with the following conditions:

1. The extent of tooth tissue lost/carious/damaged.
2. The location of that loss/carious/damage.
3. The positional relationship with the adjacent teeth.
4. The tooth form.
5. The need for retention form.
6. Convenience.

The box slice, auxiliary slice and modified flare are basic designs used to finish and extend walls and margins of the proximal box.

### *Box Preparation*

- First of all the occlusal retentive preparation is made as dovetail. Then the cavity is made at the proximal side where box preparation is to be done (Fig. 40.6).
- It extends more in the proximal side, proximal enamel including the damaged part is removed.
- Facioproximal groove and linguoproximal grooves are made on the facioproximal wall and linguoproximal wall respectively.

### *Slice Preparation*

- It is conservative cutting of the proximal surfaces to form the extended buccal and lingual finish lines for lap joint (Fig. 40.7).
- Produces sound enamel margins with no unsupported enamel.

### *Auxiliary Slice*

- Auxiliary slice provides external support to weakened tooth surface when it is subjected to high stress during function.
- It is partially made around the proximal line angle, which provides additional tooth support.

*Advantages*

- Minimal tissue is lost, hence resistance form is enhanced.
- Auxiliary slice around the lingual proximal line angle of a tooth will aid in preventing the buccal displacement of a casting.

**Fig. 40.6:** Box preparation

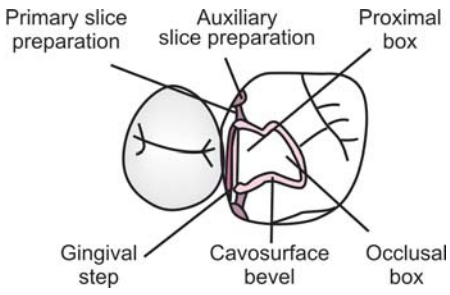



**Fig. 40.7:** Slice preparation and auxillary slice preparation

*Modified Flare Preparation*

- Has the advantages of both box preparation and slice preparation.
- Disking of buccal and lingual walls is done.
- Cavosurface angle is increased (Fig. 40.8).

## Flares

- Flares are concave or flat peripheral portions of the facial or lingual walls.
- They are of **two types:**

*Primary Flare*

It is basic part of circumferential tie and is always directed 45° to the inner dentinal wall proper.

*Functions*

- Weak enamel is removed.
- Improve junctional relationship between the restorative material and tooth.
- Maintain the marginal seal.
- Bring the facial and lingual margins to cleansable and finishable areas.

*Secondary Flare*

- It is a flat plane superimposed peripherally to the primary flare (Fig. 40.9).
- It may have different angulations, involvement and extent depending upon requirement.
- Secondary flare is not given in the areas where esthetics is more important.

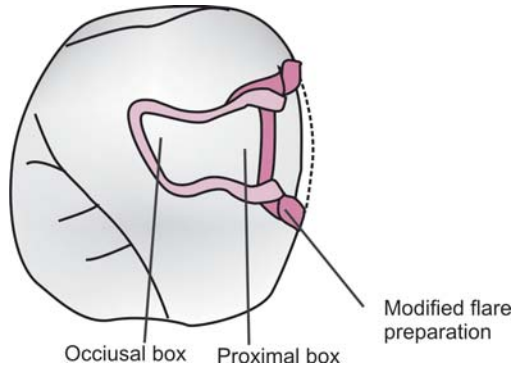



**Fig. 40.8:** Modified flare preparation

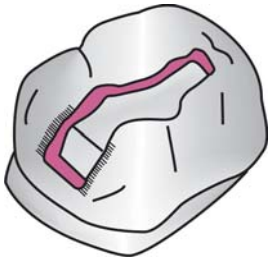


**Fig. 40.9:** Secondary flare

*Advantages*

- The proximal walls having secondary flare encourage self-cleaning as margins are extended into the embrasures.
- Easy finishing of the restoration.
- Beveling of angles help in better burnishing of the metal.
- More blunted and stronger margins are produced.

## TOOTH PREPARATION FOR CLASS II CAST METAL INLAYS

### Initial Cavity Preparation

- Commonly used burs for inlays are No. 271 and 169L carbide burs.
- Throughout the cavity preparation involving occlusal surface for a cast inlay, the cutting instrument should be parallel to the long axis of the tooth and thus the preparation develops a line of withdrawal (Fig. 40.10).
- If longitudinal walls of preparations are short, a maximum of 2° occlusal divergence is desirable.

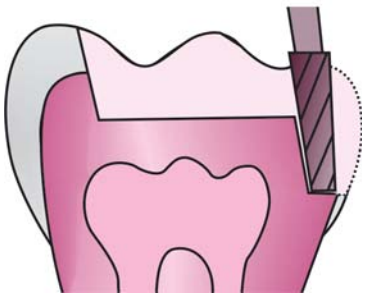


**Fig. 40.10:** Cavity preparation for class II cast metal inlay. Bur should be kept parallel to long axis of the tooth

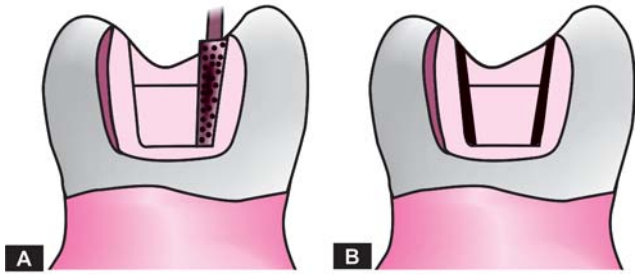
- If cervical to occlusal wall height is more, then degree of occlusal divergence should be increased.
- For shallow class I or class II preparations the axis of taper is generally parallel to the long axis of the tooth.

### Occlusal Step

- Enter the pit closest to marginal ridge with No. 271 bur keeping it parallel to long axis of tooth.
- Maintain bur parallel to long axis of tooth, and extend the preparation to involve pits and fissure.
- Dovetail is prepared by facial and lingual extensions in mesial pit area, it helps in resisting distal displacement of the inlay.
- Maintaining the same depth, extend the occlusal step to distal marginal ridge.
- Widen the preparation to desired faciolingual width for proximal box preparation.

### Proximal Box

- Using the same bur make a proximal ditch by cutting enamel on distal side.
- Mesiodistal width of ditch should be 0.8 mm, that is 0.5 mm in dentin and 0.3 mm in enamel.
- Extend the proximal ditch facially and lingually.
- Maintain the side of bur at specific axial wall depth when preparing proximal box.
- Then make two cuts, one at facial limit of proximal ditch and other at lingual limit extending from the ditch prependicular towards the enamel surface.
- Extend these cuts until bur is through the marginal ridge enamel.
- Plane the distofacial, distolingual and gingival walls using hand instruments.
- Using 169 L bur, shallow retention grooves are made in facioaxial and linguoaxial line angles (Fig. 40.11) .




**Figs 40.11A and B:** Retention grooves made in facioaxial and linguoaxial line angles

### Final Tooth Preparation

- Final cavity preparation takes place according to the case to case modification.
- The deep carious lesion should be carefully removed, preventing pulp exposure.
- The deeper part of the cavity after excavation should be protected by the calcium hydroxide layer and then glass ionomer cement base is placed.
- Occlusal and gingival margins are finally beveled.

## METHODS TO MAXIMIZE RESISTANCE AND RETENTION FORMS IN ONLAYS

1. The minimal amount of taper (2° per vertical wall).
2. The addition of proximal retention grooves.
3. Preparation of facial and/or lingual surface groove extensions:
   - *i. Skirt preparation*:
     - Skirts are thin extensions of the cast metal onlay that extend from the primary flare to a termination.
     - Conservative method to improve retention and the resistance form of the preparation.
     - Include part of the facial and lingual surfaces near the axial angle.
     - Preparation of skirt is done entirely with the slender, flame shaped, fine grit diamond instrument usually, only in enamel
     - Extending into the gingival third of the crown is usually necessary for effective resistance form.
   - *ii. Collar preparation*:
     - Increases resistance and retention form.
     - To provide for a uniform thickness of metal, the occlusal 1 mm of this reduction should be "rolled in" to follow the original contour of the tooth, to reduce the display of the metal and to conserve the tooth structure.
   - *iii. Slot preparation:*
     - Provides the necessary retention.
     - Reduces the display of the metal.
     - Conserves the tooth structure.
     - Reduces the marginal leakage by reducing the linear extention of the marginal outline.
     - Indicated only when enough thickness of dentin is available.
     - Mainly distal and mesial slots are prepared.

## TECHNIQUES FOR MAKING CAST METAL RESTORATIONS

### Interocclusal Records

- Impression of the prepared and adjacent teeth is made by use of an elastomeric impression material that show in the die both the prepared tooth structure and adjacent teeth relationship.
- The occlusal relationship with the opposing arch teeth may be recorded with the occlusal anatomic contours.
- When restoring a large portion of the posterior occlusion with cast metal restorations, the semi-adjustable articulators are used.

### Temporary (Interim) Restorations

- For the time period between tooth preparation and cementing the restoration, the tooth is protected and stabilized by providing temporary restoration made up of resin on the prepared tooth.
- Temporary restorations made up of acrylic resin can be made by indirect and direct methods.
- In indirect method, temporary restorations are fabricated outside the mouth using a cast. Marginal accuracy of indirect is better than the direct technique.

### Final Impression for Cast Fabrication

Requisites for material used for final impression are as follows:

1. It must become elastic after placement.
2. Strength should be adequate.
3. It should have adequate dimensional accuracy.
4. Following impression materials are used for final impression:
   i. Polysulfide
   ii. Silicone (polyvinyl siloxane impression)
   iii. Polyether impression materials
   iv. Agar.

## WORKING CAST AND DIES

### Die Materials

- Dies should replicate the tooth preparation in the most minute details as well as all accessible unprepared area of the tooth.
- Working cast is an accurate replica of the prepared and adjacent unprepared teeth over which cast metal restoration can be fabricated.
- Type IV or V stones are used for making dies and casts because they have superior properties.
- Twice pouring of cast is required for making a working cast with removable dies from an elastic impression.
- The first cast is used to prepare removable dies and the second cast is used to establish intra-arch relationship called 'master cast'.

### Wax Pattern Fabrication

There are two methods for wax pattern fabrication:

A. *Direct wax pattern method:* In which it is prepared in the oral cavity.
B. *Indirect wax pattern method:* In which it is prepared out of the oral cavity.

Direct wax pattern produces better fitting than indirect method. Direct method is possible only in inlays and onlays and is not possible in crowns and bridges, etc.

### Spruing, Investing and Casting

- Sprue pin or sprue former provides a channel for flowing the molten metal.
- Hollow sprue pin filled with inlay wax is better because it provides stronger attachment to the wax pattern.
- Sprue is attached into the bulk portion of the pattern.
- Ideal locations to attach the sprue pin are the marginal ridges of posterior teeth or incisal corners of anterior teeth (Fig. 40.12).

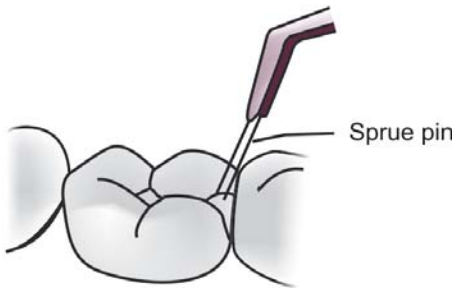



**Fig. 40.12:** Sprue pin should be attached to marginal ridges of posterior teeth

*Washing of Wax Pattern*

- Before investment, wax pattern is washed with soap and water to remove the oil, lubricant and saliva.
- This helps to reduce surface tension and the air bubbles on the surface of wax pattern, thereby reducing bubbles on the casting.

*Investing*

The wax pattern is surrounded by an investment that hardens and forms the mold in which the casting is made.

### Casting Procedure

It includes the burnout for wax elimination, expansion of the investment to compensate for casting shrinkage and placement of the gold alloy into the mold.

### Finishing, Adjusting and Polishing the Casting

- Rough casting should be refined before trying onto the prepared tooth.
- Final occlusal morphology is determined by interocclusal adjustment.
- Occlusion is checked by articulating paper and premature contacts are removed.
- Surface is finished with rubber cup and mild abrasive points.
- Proximal surfaces is finished with felt wheel and polishing compound.
- Intraoral finishing is done by intraoral sand blaster.

### Trying-in the Casting in the Oral Cavity

- Before the 'trying in' procedure, temporary restoration and cement should be completely removed.
- Try the casting on the tooth using light pressure. If it does not seat properly do not force it in the cavity.
- Dental floss is passed through the contact to find out the tightness of the contact and its locations.
- Fine carborundum particles, impregnated rubber disks or wheels are used for adjusting the proximal contact and contours.
- Contact should be prepared by soldering the 'solder' at a proper place if there is no contact.

### Cementation

- The casting should be cleaned thoroughly before cementation.
- Thin layer of cement is quickly applied on the surfaces of the casting and on all tooth preparation surfaces.
- The casting is seated and patient is asked to bite on a small cotton pellet.
- Remnants of set cement are removed.
- Occlusion is rechecked.

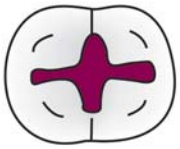
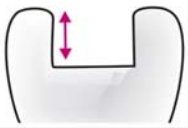
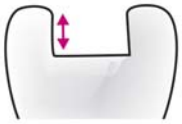
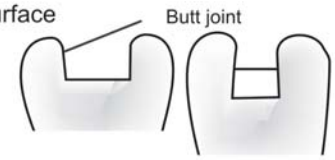
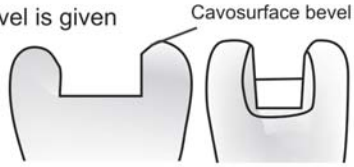
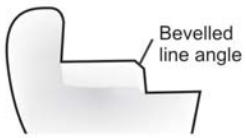
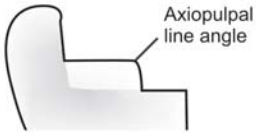
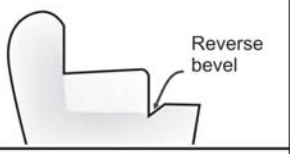
## PIN RETAINED CAST RESTORATIONS

The cast pin channels are prepared by tapering fissure bur having a diameter of about 1 mm with the depth of about 2 to 3 mm.

### Indications for Pin Retained Cast Restorations

- Cuspal fractures where large occlusal inlays and onlays are to be prepared.
- When occluso-gingival height is very short.
- When crown preparation is excessively tapered.
- In full crown preparation when one wall is very short and another wall is very long.
- When the proximal preparation is very long.
- The proximal box of the preparation having one wall very short and opposing wall very long.

## DIFFERENCE BETWEEN CAVITY PREPARATION FOR SILVER AMALGAM AND CAST RESTORATIONS

| Sliver amalgam | Cast restoration |
|---|---|
| 1. (a) Intercuspal width is one-fourth of intercuspal distance<br>(b) Outline form is narrow  | 1. (a) Intercuspal width is one-third of intercuspal distance<br>(b) Outline form is wide  |
| 2. Depth is more in this cavity  | 2. Less depth  |
| 3. Cavity walls converge occlusally  | 3. Cavity walls are parallelt  |
| 4. Buccal and lingual proximal walls converge occlusally  | 4. Buccal and lingual walls are parallel  |
| 5. Butt joint at covosurface margin   | 5. Cavosusface bevel is given   |
| 6. (a) Rounded line and point angles<br>(b) Bevelled axiopulpal line angles   | 6. (a) Well defined line and point angles<br>(b) Rounded axiopulpal line angles   |
| 7. No reverse bevel is given  | 7. Reverse bevel is given   |
| 3. No grooves are given, only locks are given  | 8. Grooves are given in facioaxial and linguoaxial line angles   |

# 41 Restoration of Badly Decayed Posterior Teeth

## WHAT ARE PRINCIPLES FOR RESTORING BADLY DECAYED POSTERIOR TEETH?

### Initial Management

The following preliminary steps are taken prior to finalizing the design:

1. Status of pulp and peridontium should be evaluated.
2. All the frail undermined enamel should be removed.
3. Carious enamel and dentin should be removed.

### Mechanical Evaluation

Mechanical evaluation of lost tooth structure is done for designing the retention-resistance features of the tooth preparation. The following factors are considered.

*Nature and Dimensions of Destruction*

If the stress concentration areas of tooth are lost then special restorative design features including bulk, flat floor and proper fulcrum for the center of restoration.

*Cusp Loss*

Whether a functional or non-functional cusp is involved both create a retention- resistance problem, but it is more with the non-functional cusp as stresses on it are more displacing and destructive than on the functional cusp. Also width and length of cusp lost is very important.

*Loss of Marginal Ridge*

Their partial or complete loss affects the resistance and retention form and thus they should be evaluated. Intact and thick ridges are helpful in resistance form. Complete loss of ridge requires reinforcing protective measures.

*Axial Angle Loss*

Loss of partial or complete axial angle poses a major resistance problem as most of the stresses are concentrated on these areas and also it is difficult to immobilize the restoration without involving external surface of adjacent tooth.

*Junction between Clinical Crown and Clinical Root*

As this is a stress concentration area, the stress condition will be aggravated if there is decrease in tooth bulk in one or more of the three possible directions.

*Evaluation for Occlusal Disharmony*

The stress pattern of cuspal structures should be evaluated so that necessary changes can be made into the design for tooth preparation.

*Abutment for Prosthesis*

Here restoration should be designed such, that it can bear the additional stresses concentrated on the restoration and the remaining tooth structure.

*Splinting*

During an overall treatment, the tooth to be restored can be splinted to another tooth.

*Periodontal Support*

For success of the restoration there should be sufficient tooth support as periodontal tissue and supporting bone are responsible for dissipating most of the occlusal forces acting on the tooth.

*Parafunctional Habits*

Parafunctional habits like bruxism, tobacco chewing, pipe smoking, etc. should be evaluated and necessary changes in the restorative design should be done, if required.

## Biological Evaluation

*Evaluating Stress Patterns in Posterior Teeth*

There are some stress concentration areas in tooth like marginal ridges, oblique ridges and cusps, etc. If they are present in the remaining tooth structure then they should not be disturbed.

*Evaluating Vitality of the Tooth*

A tooth in question should be checked for vitality using various pulp vitality tests.

*Radiographic Evaluation*

It is done to have an idea about nature and dimensions of remaining enamel and dentin and their relationship with pulp.

*Crazing and Surface Deformities*

Craze lines should be evaluated as they can lead to partial or complete fracture.

If surface defects are present, they are involved in the tooth preparation.

*Relation of Gingival Margin Location to Periodontium*

If destruction is located supragingivally then there is no need to alter the periodontium. If destruction is located apically to gingival crevice but suprabony then gingivectomy is performed. If defect is infrabony, then a flap is raised along with osteotomy to expose the defect.

*Badly Mutilated Teeth with Affected or Treated Periodontium*

If furcation is being involved in the area of destruction then it may lead to special designing features. In case of tapering root the tooth prepration for a proximal lesion will have a very thin dentin bridge axially, thus having a chance for pulp exposure, also gingival floor will be narrow, thus reducing the retention.

## Restorative Design Planning

Following principles should be followed in the restorative design.

*Restoration of Total or Partial Cuspal Loss*

Total or partial cuspal loss can be managed by using either amalgam or metal ceramic or cast restorations, depending upon the nature and dimensions of cusp loss.

*Restoration of Lost Axial Angles*

As axial angles are stress concentration areas, materials to be used must be in bulk while replacing axial angles in comparison to other areas. *Auxiliary retentive devices can be used like collars, skirt, reverse secondary flare if casting is to be used as restoration*.

*Management of Lost Marginal Ridges*

Both amalgam and castings can be used to replace lost ridges, but castings are better options.

*Restoration of Crazing*

Management of cracks on enamel depends upon the number and extent of cracks. If there are signs of crack tooth syndrome or if cracks are numerous, they should not be included in the tooth preparation. If cracks are limited and penetrate enamel only, then enameloplasty could be done.

*Retention Features for Badly Decayed Tooth*

Certain rules that should be followed for retentive features like:

a. Recognizing the displacing forces acting on restoration.
b. Retention modes should be used according to the material used for restoration.
c. They should not produce additional stresses on remaining tooth structure.
d. Retention modes should be used along with auxiliary retentive means.

*Resistance Features for Badly Decayed Tooth*

a. Restorative material should be placed in bulk.
b. Planes in tooth preparation should be right angled to bear masticatory load.
c. They should be in harmony with the occlusion.

*Management of Endodontically Treated Teeth*

Cast restorations, pin or posts can be used if coronal tooth tissue is missing in these teeth.

*Management for Periodontically Treated Tooth*

For restoration of periodontically treated teeth, the restorative design should be made, keeping following factors in mind:

a. Gingival margins should be placed supragingivally.
b. Margins should not be placed in the furcation.
c. The gingival margins and finishing lines that come close to a furcation should follow the apico-occlusal curvature of furcation in the horizontal direction.
d. Occulsoapical contour especially facial and lingual axial contour should be less pronounced than usually found in teeth not previously affected with periodontitis.

## SPLINTING

Splinting of teeth is done in order to immobilize a loosened tooth and to share the stresses.

### Provisional Splint

Provisional splint can be of two types:

i. Removable type
ii. Fixed type.

*Intracoronal*

- Amalgam restoration condensed together.
- Amalgam and wire.
- Amalgam, wire and resin.
- Composite resin and wire with or without enamel etching.

*Extracoronal*

- Orthodontic soldered bands.
- Wire and resin retained through enamel etching.
- Brackets and wire.

### Permanent Splint

*Extracoronal*

Partial or full veneer crowns soldered together.

*Intracoronal*

Inlays or onlays soldered together.

### Foundation for Badly Decayed Teeth

Foundation of either amalgam or composite resins is given prior to restoring a badly decayed tooth by cast restorations. Amalgam is more superior material due to following reasons.

a. Indicated in nonvital endodontically treated tooth in which all nonfunctional cusps or half or more functional cusp are to be replaced.
b. Indicated in cases where marginal or crossing ridges are involved.
c. Indicated where more than half of the structure is lost.

## WHAT ARE PRINCIPLES FOR RESTORING BADLY DECAYED ANTERIOR TEETH?

The material of choice for restoring a badly decayed anterior tooth are tooth-colored restorations. Although non-tooth color materials are not used for restoring anterior teeth but there are few exceptions where they can be used. These situations are as follows:

a. The distal of the cuspids.
b. Foundations for cast restoration.

As an anterior tooth has limited tooth structure, thus all the conditions regarding forces acting on tooth; the stress concentration areas and the weakened areas should be evaluated prior to making a choice for restorative material. Other factors that should be considered are as follows:

a. Malocclusion
b. Dimensions and nature of remaining tooth structure
c. Esthetics
d. Phonetics.

We can restore an anterior tooth by using any of the three following choices.

1. Tooth that can be restored by building a foundation and then covering with a reinforcing restoration. They can be used in the following conditions
   a. Where more than 50 percent of the tooth structure is lost.
   b. Where there is loss of two incisal angles together with more than half the proximal surface of the tooth.
   c. Where tooth is to be used as an abutment for fixed prosthesis or partial denture.
2. Porcelain or porcelain fused to cast metal can be used to restore a tooth without foundation build-up.
3. For restoring the tooth with direct tooth-colored materials, the material of choice is composite resins. Factors that should be kept in mind while restoring a tooth with direct tooth-colored materials are:
   a. The tooth should have intact incisal angle.
   b. The preparation should have both labial and lingual walls.
   c. Gingival floor should be created at right angle to the long axis of the tooth.

# 42 Management of Cervical and Noncarious Lesions

## NOTE ON RESTORATION OF CERVICAL LESIONS

**Classification of cervical lesion** is basically based upon the etiology of the lesion.

1. Carious cervical lesion
2. Noncarious cervical lesion
   a. Abrasion lesions
   b. Erosion lesions
   c. Abfraction lesions

### Carious Cervical Lesions

Carious cervical lesions are usually seen in the region of plaque accumulation, i.e. near the gingival or under proximal contacts. The lesions may be shallow saucer-shaped or deep notch shaped.

### Noncarious Cervical Lesion

They include abrasion, abfraction, resorption, etc. These lesions present a variable morphology ranging from shallow grooves to broad dished out lesions, to large notched or wedge-shaped defects.

*Abrasion Lesions*

It refers to the loss of tooth substance induced by mechanical wear other than that of mastication. Abrasion results in saucer-shaped or wedge-shaped indentations with a smooth, shiny surface.

*Erosion Lesions*

It can be defined as a loss of tooth substance by a chemical process that does not involve known bacterial action. The surfaces are smooth, hard and polished.

*Abfraction Lesion (Idiopathic Erosion)*

These are minor irregular cracks or fracture lines or wedge-shaped defects in the cervical region of the tooth. They may result due to excessive masticatory forces on the teeth due to malocclusion. They are most commonly seen on the buccal surfaces of mandibular teeth.

## MANAGEMENT OF CARIOUS CERVICAL LESIONS

### Preventive Management

- Plaque control measures should be taught to the patient along with proper toothbrushing technique.
- Scaling and oral prophylaxis should be done to remove deposits from the teeth.

### Restorative Management

*Restoration of Cervical Lesions using Composite Resins*

Microfilled composites are the material of choice for restoration of cervical lesions as they are clinically very much wear resistant. Also, their low modulus of elasticity may allow microfilled composite restorations to flex during tooth flexure, thus better protecting the bonding interface.

Tooth preparation for composite restoration:

a. Remove the defective tooth structure.
b. Create prepared enamel margin of 90° or greater.
c. Create 90° cavosurface margins on root surface.
d. Roughen the prepared cavity surface.

*Restoration of Cervical Lesion using Glass Ionomer Cement*

Resin modified, light-cured glass ionomers are preferred because of the following reasons:

a. The extended working time
b. Their improved physical properties
c. Esthetic qualities.

Tooth preparation for glass ionomer cements is same as for composite restorations.

*Restoration of Cervical Lesion using Silver Amalgam*

They are generally reserved for the following areas:

a. Nonesthetic areas.
b. For areas where access and visibility are limited.
c. Where moisture control is difficult.

## MANAGEMENT OF NONCARIOUS CERVICAL LESIONS

### Preventive Management

Preventive measures include:

a. Proper tooth brushing using soft bristle toothbrush with less abrasive dentifrices.
b. Use of orthodontic appliances to prevent bruxism and clenching.
c. Correct occlusal disharmony.
d. Restrict acidic and acid producing diet.
e. Correct ill-fitting metal clasps or denture.
f. Topical fluoride application.

### Restorative Management

Noncarious cervical lesion can be restored using either of the restorative material used for carious cervical lesion, i.e. composites, silver amalgam, glass ionomer or direct filling gold. Restoration is done.

a. To maintain the structural integrity of the tooth.
b. To protect pulp.
c. To maintain the gingival health.
d. To prevent caries.

The tooth preparation for a class V abrasion or erosion area usually requires only roughening of the internal walls with a diamond instrument beveling or flaring all enamel margins, and sometimes placing a retention groove in non-enamel area.

## ENUMERATE VARIOUS NONCARIOUS LESIONS AND THEIR MANAGEMENT

a. Attrition
b. Abrasion
c. Erosion
d. Abfraction lesions
e. Localized non-hereditary enamel hypoplasia
f. Localized non-hereditary enamel hypocalcification
g. Localized non-hereditary dentin hypoplasia
h. Localized non-hereditary dentin hypocalcification
i. Discolorations
j. Malformations
k. Amelogenesis imperfecta or hereditary brown opalescent teeth
l. Dentinogenesis imperfecta
m. Trauma.

### Attrition

It is described as a physiological, continuous, age dependent process resulting in loss of tooth structure from forces between contacting teeth.

*Treatment*

- Extraction or endodontic treatment of pulpally involved teeth.
- Parafunctional habits (bruxism, etc.) should be controlled using occlusal splints.
- Diagnosis and resolution of TMJ disturbances.
- Occlusal equilibration by
  a. Selective grinding of teeth.
  b. Creation of adequate overlap between working inclines.
- Restorative modalities: A temporary restoration or a permanent cast alloy restoration should be given according to the planned increase in the vertical dimension.

### Abrasion

It is a pathological process resulting from forces between the teeth and external objects which leads to loss of tooth substance. The most predominantly occurring abrasion is caused due to faulty tooth brushing technique.

*Treatment*

- Determination of the cause.
- Removal of cause.

- Desensitization of lesion.
- If esthetics is not disturbed there is no need to restore very shallow multiple, wide, lesions on non-occluding tooth surface.
- Restoration for esthetically prominent areas should be done using direct tooth colored restorative procedures.

## Erosion

It is defined as the loss of tooth structure resulting from chemico-mechanical acts without any specific role of microorganisms.

*Treatment*

- Removal of the cause.
- Restorative treatment in case of extremely symptomatic or disfiguring lesions.

## Abfraction Lesions

These are wedge-shaped defects in the cervical regions of the teeth due to tensile stresses concentration in these areas.

*Treatment*

- Removal of the etiology.
- Restorations as per requirement.

## Localized Non-hereditary Enamel Hypoplasia

It refers to the localized defects in the crown portion of tooth caused due to injury to ameloblasts during the enamel matrix formative stage.

*Treatment*

- Selective odontotomy can be performed for slight defects.
- Direct tooth colored restorations.
- Metallic or cast restoration.
- Vital bleaching for discolored areas, but after odontotomy and before acid etching.
- Laminates or ceramic veneers.

## Localized Non-hereditary Enamel Hypocalcification

It refers to the localized defects in crown portion of tooth due to injury caused to the ameloblasts during mineralization stage.

*Treatment*

- No odontotomy or restorations requiring etching should be done.
- Vital bleaching, laminated veneering, composite veneering, PFM and cast ceramic crowns can be given.

## Localized Non-hereditary Dentin Hypoplasia

It refers to the localized defects in dentin caused due to the injury to odontoblast cells, leading to deficient or complete absence of dentin matrix deposition. The causes for these defects are same as that for enamel hypoplasia. These lesions are not seen/diagnosed as long as they are covered with enamel. Usually such defects are encountered during tooth preparation procedures.

*Treatment*

Intermediary basing, as it is just an additional dimension to that part of tooth preparation which is going to be restored.

## Localized Non-Hereditary Dentin Hypocalcification

- Refers to localized defects in dentin caused by injury to the odontoblasts during the process of dentin mineralization.
- In these teeth dentin is softer, more penetrable and less resilient for example interglobular dentin.

*Management*

It is same as localized non-hereditary dentin hypoplasia.

## Trauma

Refer to Chapter 23.

## Discolorations

Discoloration of tooth can be:

a. Extrinsic and/or
b. Intrinsic.

*Treatment*

- Scaling, polishing, bleaching, lamination and veneering.
- Intrinsic discoloration due to non-vitality of pulp-root canal system should be treated by endodontic treatment first.

## Malformations

Malformations can be micro or macro type.

*Treatment*

- Direct tooth colored restorations.
- If sufficient enamel is not present or if the tooth is under heavy occlusal stress, PFM or cast ceramic veneering restorations can be given.

## Amelogenesis Imperfecta or Hereditary Brown Opalescent Teeth

It refers to the lesion resulting from genetically determined abnormality in the formative stage of enamel.

*Treatment*

- Selective odontotomy involving esthetic reshaping procedures.
- In deeper defects, restorations, laminations, metallic-based or cast ceramic restorations may be done.

## Dentinogenesis Imperfecta or Hereditary Opalescent Dentin

It refers to the defect resulting from genetically determined abnormality in the formation and/or maturation of dentin matrix, in absence of any obvious systemic or environmental changes.

*Treatment*

- Selective odontotomy.
- Laminations and full veneering.
- Splinting.

# 43 Pulpal Response to Caries and Operative Procedures

## HOW DOES PULP REACT TO DENTAL CARIES?

Dental caries is localized, progressive, decay of the teeth characterized by demineralization of the tooth surface by organic acids, produced by microorganisms. The following defense reactions take place in a carious tooth to protect the pulp:

1. Formation of reparative dentin: More reparative dentin is formed in response to slow chronic caries than to acute caries.
2. Dentinal sclerosis.
3. Inflammatory and immunological reactions:
   - Degree of pulpal inflammation beneath a carious lesion depends on closeness of carious lesions with pulp and permeability of underlying dentin.
   - When the pulp is exposed, bacteria penetrate the infected dentinal tubule and cause beginning of inflammation of the pulp.
   - The early evidence of pulpal reaction to caries is seen in underlying odontoblastic layer.
   - In addition to dentinal changes, antibodies are also produced by the pulp. These antibodies act against the antigenic component of dental caries.
   - Persistence of dental caries provides a continuous stimulus for an inflammatory response in dental pulp.
   - In acute caries, the caries progress more rapidly than the formation of reparative dentin and chronic inflammatory cells become apparent in the pulp tissue.
   - The pulp reacts at site of exposure with infiltration of inflammatory cells.
   - The remainder of the pulp may be uninflamed or if the exposure is present for long time, the pulp gets converted into granulation tissue.
   - As the exposure progresses, partial necrosis of pulp may be followed by total pulp necrosis.

## HOW DOES PULP REACT TO TOOTH PREPARATION?

- The pressure of instrumentation on exposed dentin characteristically causes the aspiration of the nuclei of the odontoblasts.
- Pressure may move some microorganisms from infected cavity floor or wall into the pulp, leading to its irritation.
- ***Heat production*** is the second most damaging factor. If the pulp temperature is elevated by 11°F, destructive reaction will occur even in a normal, vital periodontal organ.
- ***Pressure*** is directly proportional to heat generation. Whenever, the RPM's are increased, pressure must be correspondingly reduced.
- More the contact between the tooth structures and revolving tool, the more is the heat generation and thus destruction in the pulp tissues.
- Desiccation increases the permeability of the vital dentin to irritants like microorganisms or restorative materials.
- ***Vibrations*** which are measured by their amplitude or their capacity and frequency. They are an indication of eccentricity in rotary instruments.
- In addition to affecting the pulp tissues, vibration can create microcracks in enamel and dentin.

## Factors Affecting the Response of Pulp to Irritants

- Cellularity of the pulp
- Vascularity of the pulp
- Age
- Heredity
- Remaining dentin thickness
- Unknown factors.

## Remaining Dentin Thickness (RDT)

- Dentin permeability increases with decreasing RDT.
- RDT of 2 mm or more effectively precludes restorative damage to the pulp.
- At RDT of 0.75 mm, effects of bacterial invasion are seen.
- When RDT is 0.25 mm, odontoblastic cell death is seen.

# 44 Interim Restorations

## NOTE ON INTERIM RESTORATIONS

Interim restorations are temporary or semipermanent restorations which are temporarily used or inserted, cemented or filled until a well-planned, designed restoration is permanently inserted or cemented.

**The interim or temporary restorations should have the following properties:**

1. Nonirritating and protecting the prepared tooth specially dentin and pulp.
2. Protecting and maintaining the health of periodontium.
3. Maintaining the position of the prepared, opposing and adjacent teeth.
4. Provide functions of teeth like esthetic, phonetic and mastication, etc.
5. Sufficient strength to withstand the usual forces in the oral cavity.

**Materials used for interim restorations should have following properties:**

1. Least marginal leakage.
2. Economically priced.
3. Easy and quick manipulation, placement and removal.
4. Fast setting.
5. Good compressive and reasonable tensile strength.
6. Insolubility in oral fluids.
7. Dimensional stability.
8. Sedative to pulp and periodontium.
9. Without any taste or odor.
10. Esthetically acceptable.

**Interim restorations can serve the following purposes:**

1. It can protect the pulp by acting as a barrier.
2. It can be a sedative for a hyperactive pulp.
3. It maintains the position of the tooth in the arch.
4. It protects the gingival tissues surrounding the tooth.
5. To restore the esthetics.

The various types of restorative materials are:

a. Cements
b. Crown forms
c. Customized acrylic restorations.

### Zinc Oxide Eugenol

Zinc oxide eugenol cement is used because of ease of preparation, minimum marginal leakage, retention of dressing and it has a sedative effect on the dental pulp.

### Crown Forms

A. *Stainless steel readymade crowns:* The crown is selected according to the gingival diameter and the metal is made to contact all around the gingival line of the tooth in the gingival space.

B. *Aluminium shell crowns:* An aluminium shell is adapted to the preparation and to secure the shell, luting media is placed in the shell.

C. *Cellulose acetate and polycarbonate crown forms:* The crown forms are made of soft, thin and transparent material and are available in different sizes and shapes. The selected crown is filled with cold cure resin and then seated on the lubricated tooth preparation.

## Customized Acrylic Restorations

The cold cure methyl methacrylate tooth-colored resin is used to produce temporary restorations. The cured resin material is seated with appropriate cement as per situation.

## Limitations of Temporization

1. Temporary crown may fracture under heavy forces.
2. Marginal leakage can take place in temporary restorations.
3. If temporary restorations are placed for longer periods discoloration may take place.
4. Time and expenditure is involved in fabrication of interim coverage crowns required for short-term.

# 45 Finishing and Polishing

## NOTE ON FINISHING AND POLISHING

**Finishing** means removal of surface irregularities, in order to transform an object from rough to a refined form. **Polishing** can be defined as creating a surface layer which can reflect light as good as enamel surface.

### Aims of Finishing and Polishing

- To obtain desired anatomy.
- To achieve proper occlusion.
- To reduce surface roughness and scratches.

### Finishing and Polishing Devices

- *Finishing burs*: Finishing burs are made up of stainless steel or tungsten carbide. They remove excesses of material, creating a smoother surface.
- *Rubber instruments*: They are available in variety of shapes and sizes, e.g. cups, wheels, cones, round, oval, flame, etc.
- *Brushes*: Brushes can be used alone or with abrasive paste. They come in different forms, e.g. wheels, cylinders, cones, etc.
- *Coated disks and strips*: The abrasive particles such as sand, cuttle, garnet are glued to paper, cloth and thin steel discs or strips.
- *Cloth*: Cloth of various softness is used in the final stages of polishing.
- *Felt*: They are used to obtain lustre for different metallic restorations.

### Finishing and Polishing Materials

- *Diamond*: Diamond is the most effective abrasive, especially for enamel.
- *Synthetic diamond*: These are used as abrasives for manufacturing diamond abrasive points, burs, wheels, saws, etc.
- *Tungsten carbide (TC)*: It is used for making various cutting tools used in industry and dentistry.
- *Silicone carbide or carborundum*: Carborundum is used in manufacture of grinding stone, abrasive points, abrasive paper, cones and cloth disks.
- *Alumina*: Alumina is used to manufacture coated and bonded abrasive wheel stones and grinding stones.
- *Garnets*: They are used in grinding metal alloys and plastics.
- *Pumice*: It is used for polishing natural teeth, acrylic denture and appliances, etc.
- *Chalk*: Chalk is used as mild abrasive in toothpastes and powders.

### Benefits of Finishing and Polishing

- Promote oral health by avoiding accumulation of debris.
- Improve function as smooth surfaces minimize the wear rates of opposing teeth.
- Rough surfaces can cause development of high contact stresses which can cause loss of functional and stabilizing contacts between teeth.
- Improves esthetics.

### Finishing and Polishing of Amalgam Restorations

- Finishing and polishing of amalgam restoration is done after the carving is completed.
- After the occlusion is adjusted, the discoid and cleoid finishing instruments can be used to smoothen the accessible areas of the amalgam.

- Final finishing and polishing procedures for amalgam restorations is done after 24 hours with the help of steel finishing bur.
- Polishing is done with the help of coarse, rubber abrasive point.

## Finishing and Polishing of Composite Resins

- It can be initiated immediately after a light-cured composite material has been polymerized.
- Finishing is accomplished with appropriate polishing cups or points after the occlusion is adjusted.
- A final lustre is obtained with polishing pastes that may contain pumice, silica, alumina, tinoxide, etc.

## Finishing and Polishing of Direct Gold Restorations

- The first step in the finishing process is to burnish the gold with the help of burnisher.
- Then a small round finishing bur is used to begin polishing.
- Afterwards a flour of pumice and tin oxide is applied, with a help of soft-rubber cup in slow speed handpiece.

# 46 Microleakage

## NOTE ON MICROLEAKAGE

Microleakage may be defined as 'the ingress of bacteria, its products, toxins, molecules, oral fluids and ions between the margins of the restoration and the walls of the prepared tooth.'

### Consequences

1. Secondary/recurrent caries
2. Pulpal irritation
3. Postoperative sensitivity
4. Marginal discoloration
5. Dissolution of luting cements.

### Factors Contributing to Microleakage

- Greater the difference between coefficient of thermal expansion of tooth substance and restorative material, greater will be the microleakage.
- Polymerization shrinkage: Causes marginal leakage.
- Adhesion: Lack of adhesion gives rise to microleakage.
- Microleakage is also influenced by improper cavity preparation, poor condensation procedures, inadequate cavosurface margins, improper isolation, unfinished margins of a cast inlay, improper fit of crowns exposing a thin cement line all contribute to microleakage.

### Methods to Detect Microleakage

1. *Dye method*: Most commonly used dyes are:
   a. Methylene blue
   b. Crystal violet
   c. India ink
   d. Eosin
   e. Erythrosin
2. *Radioactive isotope method*: Following isotopes are commonly used:
   a. $^{14}C$
   b. $^{32}P$
   c. $^{35}S$
   d. $^{45}Ca$
   e. $^{86}Rb$
   f. $^{131}I$.
3. Chemical tracer method
4. Neutron activation analysis
5. Scanning electron microscopy
6. Bacteriological method
7. Air pressure technique
8. Artificial caries-using acidified gelatin gel technique
9. Electrochemical studies
10. Reverse diffusion method
11. Pain perception.

## MICROLEAKAGE AROUND DIFFERENT RESTORATIONS

### Amalgam

Amalgam restoration is unique in being gradually a 'self-sealing' restoration. In a properly inserted restoration, leakage decreases with age, due to the corrosion products sealing the interface between the tooth and restoration. Microleakage due to dimensional changes in amalgam is nearly minimal.

#### *Methods to Prevent Microleakage in Amalgam Restorations*

- Lathecut or Admixed alloys display less microleakage than spherical alloys.

- Condensation should be performed without any delay after trituration, otherwise there are increased chances of microleakage.
- Varnishes are effective for preventing microleakage.
- Use of bonded amalgam minimize leakage.
- *Gallium amalgam* shows very high wetting ability, and thus is resistant to microleakage.

## Direct Gold Restorations

Direct gold restorations show little or no microleakage due to their insolubility in oral fluids, high malleability and ductility which causes good adaptability to the prepared cavity.

*Methods to Prevent Microleakage in Direct Gold Restorations*

- Optimal pressure should be applied for proper condensation.
- Uniform stepping should be done.
- Condensing force should be directed at right angles to pulp in the center and at 45° near the periphery.
- Burnishing, finishing and polishing also prevent leakage.

## Cast Restoration

The gap between cast restoration and tooth is filled by luting cement. If solubility of cement is greater than 0.04 to 0.10 percent, it causes microleakage.

*Methods to Prevent Microleakage in Cast Restorations*

- Close fitting restorations
- Optimum taper
- Placement of bevels.

## Glass Ionomer Cement

*Methods to Prevent Microleakage in Glass Ionomer Restorations*

- Conditioning of tooth increases bonding and reduces microleakage.
- Lower powder: Liquid ratio increases solubility of cement.
- Coating of vaseline or petroleum jelly prevents any desiccation or moisture contamination which could cause microleakage.

## Composite Restorations

*Methods to Prevent Microleakage in Composite Restorations*

- The size and shape of the cavity should be as conservative as possible.
- Placement of bevels on facial and lingual margins of proximal box prevent microleakage.
- Acid etching on thicker enamel provides micro-mechanical interlocking which reduces microleakage.
- Glass ionomer cements and calcium hydroxide reduce the bulk of composites and thereby reduce polymerization shrinkage.
- Cavity should be filled by placing multiple increments of resin to minimize polymerization shrinkage and microleakage.
- Less microleakage occurs if finishing was done on the next day of insertion.

## NANOLEAKAGE

- Nanoleakage occurs within the nanometerisized spaces, which are around the collagen fibrils.
- These are present in the hybrid layer and are not completely filled by resin.
- Recently new materials have been developed which have better sealing properties thus reducing the leakage.

# 47 Lasers in Dentistry

## WHAT ARE USES OF LASERS DENTISTRY?

- Laser is an acronym for **Light Amplification by Stimulated Emission of Radiations.**
- The common principle on which all lasers work is the generation of monochromatic, coherent and collimated radiation by a suitable laser medium in an optical resonator.
- **Commonly used lasers in dentistry are**:
  - Nd : YAG
  - Er:YAG
  - Argon
  - Gallium-Sa
  - He: Ne lasers
- Most commonly used lasers is Nd:YAG and Er: YAG.

### Soft Tissue Applications

1. Incise, excise, remove or biopsy of tumors and lesions such as fibromas, papillomas and epulides.
2. Vaporize excess tissue as in gingivoplasty, gingivectomy and labial/lingual frenectomy.
3. Remove or reduce hyperplastic tissues.
4. Remove and control hemorrhaging of vascular lesions such as hemangiomas.

### Hard Tissue Applications

1. Vaporize carious lesions.
2. Desensitize exposed root surfaces.
3. Roughen tooth surfaces, in lieu of acid etching in preparation for bonding procedures.
4. To arrest demineralization and promote remineralization of enamel.
5. Debond ceramic orthodontic brackets.

### Use of Lasers in Endodontics

1. *Diagnosis*: Laser Doppler flowmetry (LDF) to test pulp vitality.
2. Pulp capping and pulpotomy.
3. *Root canal treatment*: Application of LASER causes:
   a. Modification of root canal walls
   b. Sterilization of root canals
   c. Root canal shaping and obturation.
4. *Treatment of incomplete fracture*: Lasers are using in repairing incomplete vertical fractures by causing fusion of the fracture.
5. *Apicoectomy*: If laser is used for surgery, a bloodless surgical field should be easier to achieve. If the cut surface is irradiated, it gets sterilized and sealed.
6. Treatment of dentin hypersensitivity.
7. *Sterilization of instruments*: Argon, $CO_2$ and Nd: YAG lasers have been used successfully to sterilize dental instruments.
8. *Bleaching of teeth*: The whitening effect of the laser is achieved by a chemical oxidation process.

# 48 Antibiotic Prophylaxis

## WHAT ARE GUIDELINES FOR ANTIBIOTIC PROPHYLAXIS?

*Antibiotic Prophylaxis Recommended for:*

- Dental extraction.
- Periodontal procedures including surgery, scaling and root planning, probing.
- Dental implant placement.
- Root canal instrumentation beyond apex.
- Initial placement of orthodontic bands but not brackets.
- Intraligamentary local anesthetic injections.

*Antibiotic Prophylaxis not Recommended for:*

- Restorative dentistry (operative and prosthodontic) with or without retraction cord.
- Local anesthetic injections (nonintraligamentary).
- Intracanal endodontic treatment; post placement and build-up.
- Placement of rubber dams.
- Postoperative suture removal.
- Placement of removable prosthodontic or orthodontic appliances.
- Taking of oral impressions.
- Orthodontic appliance adjustment.

**Guidelines for antibiotic prophylaxis for dental procedures**

| *Condition* | *Drug* | *Dose* |
|---|---|---|
| a. General prophylaxis | Amoxicillin | 2000 mg given orally 1 hr before procedure |
| | Ampicillin | 2000 mg given IM or IV 30 min. before procedure |
| b. Allergy to penicillin | Cephalexin | 2000 mg given orally 1 hr before procedure |
| | Clindamycin | 600 mg given orally 1 hr before procedure or IV 30 min before procedure |
| | Azithromycin | 500 mg given orally 1 hr before procedure |

**Cardiac conditions associated with endocarditis in which prophylaxis recommended or not**

| *Prophylaxis recommended* | | *Prophylaxis not recommended* |
|---|---|---|
| *High-risk* | *Moderate risk* | *Negligible risk* |
| Prosthetic heart valves | Rheumatic heart disease | Surgical repair of atrial septal defect |
| Previous bacterial endocarditis | Congenital cardiac diseases | Previous coronary bypass graft surgery |
| Complex cyanotic heart disease | Cadiomyopathy | MVP without valvular regurgitation |
| | Mitral valve prolapse (MVP) | Cardiac pacemakers and implanted defibrillators |

# Index

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