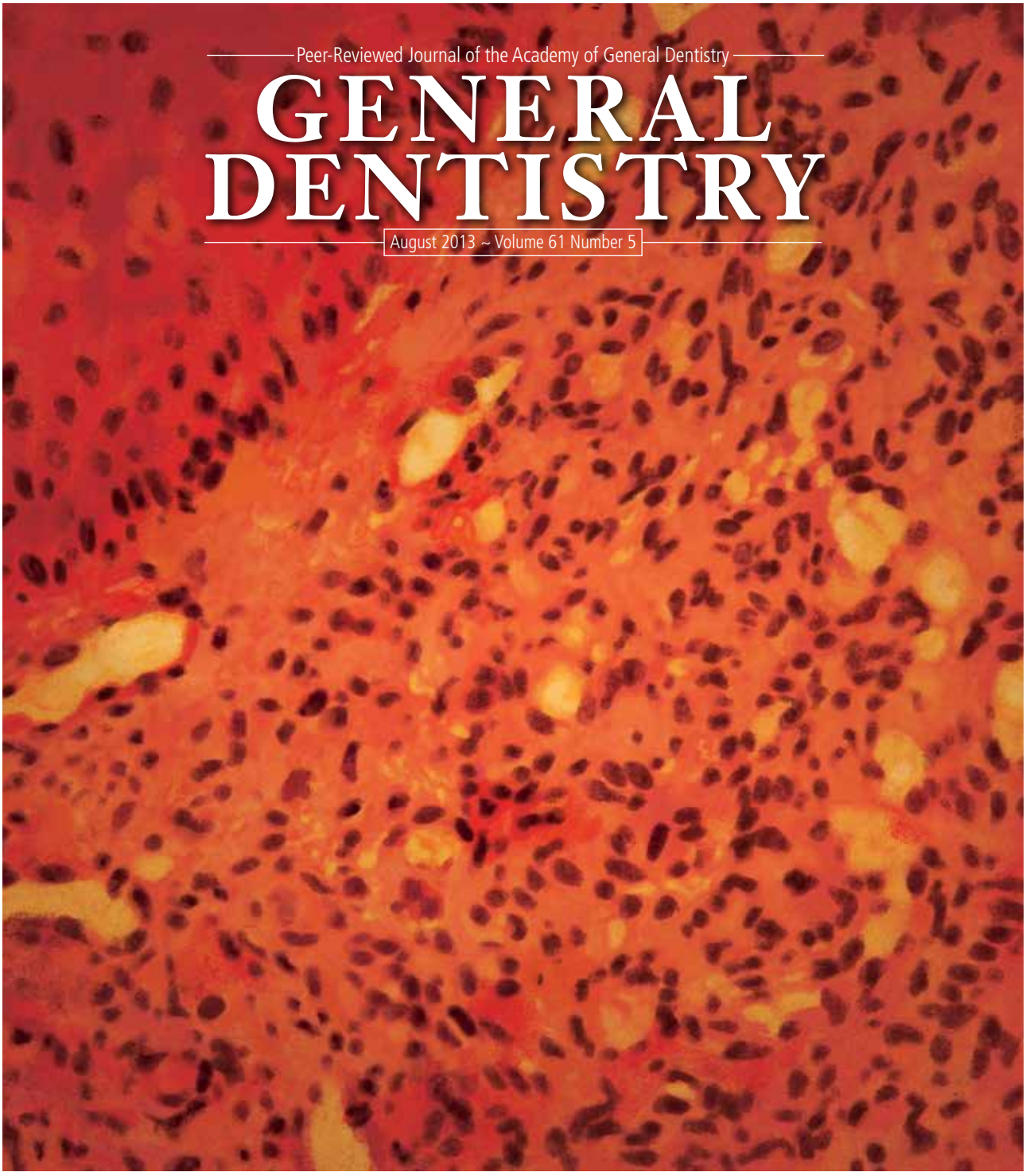
Peer-Reviewed Journal of the Academy of General Dentistry

GENERAL DENTISTRY

August 2013 ~ Volume 61 Number 5



ORAL MEDICINE, ORAL DIAGNOSIS, ORAL PATHOLOGY ■ ENDODONTICS ANESTHESIA AND PAIN CONTROL ■ PERIODONTICS ■ WWW.AGD.ORG

BlueSkyBio.com

BIO | View

FREE Patient Education App

- Available for iPad and Android tablets
- App includes detailed videos demonstrating common dental procedures
- Draw, add photos, text, and icons, to photos or to screens in the videos

ANDROID APP ON Google play

Available on the App Store

Compatibility
Innovation Value

AGD on Facebook

Academy of General Dentistry™

Like the AGD Facebook page and gain access to breaking general dentistry news, AGD event photos, important links, and more!

Keep the conversation going with the AGD on all of your favorite social media sites—and be a part of the latest general dentistry news as it's happening!

HandsOnTraining®

INSTITUTE

Register Today!

YOUR #1 CHOICE FOR HANDS-ON TRAINING

Costa Mesa, California | Houston, Texas | Pittston, Pennsylvania | London, Ontario, Canada

6 DAY Contemporary Esthetics & Restorative Dentistry

LIVE

Dr. Paresh Shah
DMD, MS, Cert. Esthetic Dentistry

8 & 11 DAY Mini Residencies In Implant Dentistry

LIVE

Dr. Ken Hebel
BSc, DDS, MS

6 DAY Endodontic Solutions

LIVE

Dr. Gary Glassman
DDS, FRCD

For Information, Call: 1-888-806-4442 or go to handsontraining.com

Products

NEW DentalEd

A Revolutionary Resource for Dentistry

DentalEd course content works with iPad®

Available on the App Store

View Sample content on our website

AGD MASTERSHIP

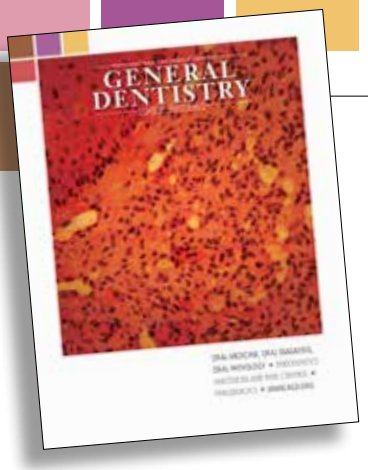
Academy of General Dentistry PACE Program Approval for Continuing Education

Approved PACE Program Provider FAGD/MAGD Credit

Approval does not imply acceptance by a state or provincial board of dentistry or AGD endorsement. (1/1/2011) to (12/31/2014) Provider AGD ID #217896

4 Volume Manual Set

700 pages.
3000 pictures with text



Cover image adapted from *Pyogenic granuloma on the tongue: a pediatric case report* on p. 27

Contents

Departments

6 **Editorial** Helping a grieving patient

8 **Minimally Invasive Dentistry** Continuing education holds the key to minimally invasive biomimetic dental successes

12 **Restorative Dentistry** Mounted diagnostic casts: the entry into comprehensive care

16 **Public Health** An introduction to forensic dentistry

18 **Ethics** What's wrong with this picture?

22 **Pediatrics** Parental presence

24 **Esthetics** Minimally invasive dentistry and its impact on esthetic restorative dentistry

78 **Oral Diagnosis** Bluish discoloration of alveolar ridge. Radiolucency of anterior mandible.

79 **Answers** Oral Diagnosis

Clinical articles

27 **Oral Medicine, Oral Diagnosis, Oral Pathology** Pyogenic granuloma on the tongue: a pediatric case report
Marcos Ximenes, MSc
Thaisa C. Triches, MSc
Mariane Cardoso, MSc, PhD
Michele Bolan, MSc, PhD

30 **Endodontics** Using a dental operating microscope for endodontic management of a mandibular central incisor with 3 root canals
Vijayakumar Aswinkumar, BDS
Suresh Nandini, MDS
Natanasabapathy Velmurgan, MDS

SELF -INSTRUCTION

33 **Pharmacotherapeutics** Bisphosphonate-related osteonecrosis of the jaws: a potential alternative to drug holidays
Douglas D. Damm, DDS
David M. Jones, DDS

39 **Self-Instruction Exercise No. 334**

40 **Endodontics** Different ultrasonic vibration protocols and their effects on retention of post-and-core to root canal
Neilor Mateus Antunes Braga, PhD, MD, DDS
Manoel Brito Jr., MD, DDS
Juliana Monteiro da Silva
Lilian Souto Miranda
Jacy Ribeiro de Carvalho Jr., PhD, MD, DDS
Andre Luis Faria-e-Silva, PhD, MD, DDS

43 **Endodontics** Using spiral computed tomography for endodontic management of a mandibular first molar with a middle mesial canal: a case report
B. Gurudutt Nayak, BDS, MDS
Inderpreet Singh, BDS

47 **Endodontics** Coronal reconstruction following anterior teeth traumatism: multidisciplinary treatment
Flavia Cohen-Carneiro, DDS, MSc, PhD
Emilio Carlos Sponchiado Jr., DDS, MSc, PhD
Lucas da Fonseca Roberti Garcia, DDS, MSc, PhD
Fikriye Viga Yurtsever, DDS, MSc, PhD
Danielson Guedes Pontes, DDS, MSc, PhD
Amilen Sena

self CDE 2 HOURS CREDIT *instruction*

Continuing Dental Education (CDE) Opportunities

Earn 2 hours of CDE credit by signing up for and completing the **SELF-INSTRUCTION** exercises based on various subjects.

***General Dentistry* Index of Articles now available online!**

Please visit www.agd.org/gdindex to peruse our Index of Articles. Arranged by topic, this index provides a comprehensive list of all articles published on a particular topic in recent issues and includes PubMed citation information.

SELF -INSTRUCTION

50 **Periodontics** Salivary thiol levels and periodontal parameters assessed with a chromogenic strip
Ahmed Khocht, DDS, MSD
Merriam Seyedain, DMD, MS
Samia Hardan, DMD, MS
John Gaughan, PhD
Jon Suzuki, DDS, PhD

55 **Self-Instruction Exercise No. 335**

56 **Soft Tissue Surgery** Modified frenectomy: a review of 3 cases with concerns for esthetics
Prashant Bhusari, MDS
Shiras Verma
Shubhra Maheshwari
Sphoorthi Belludi, MDS

60 **Operative (Restorative) Dentistry** An evaluation and adjustment method for natural proximal contacts of crowns using diamond dental strips: a case report
Daniel S. Kim, DDS, FAGD
John A. Rothchild, DDS, MAGD
Kyu-Won Suh, DDS, MSD, DSO

64 **Complete Dentures** Rehabilitation of the edentulous maxilla complicated by combination syndrome with an implant overdenture: a case report
Jack Piermatti, DMD, FACP

SELF -INSTRUCTION

70 **Anesthesia and Pain Control** Evaluating complications of local anesthesia administration and reversal with phentolamine mesylate in a portable pediatric dental clinic
Sean G. Boynes, DMD, MS
Amah E. Riley, RDH
Sarah Milbee, BS
Meghan R. Bastin, BSDH
Maylyn E. Price, DMD
Andrea Ladson, RDH

77 **Self-Instruction Exercise No. 336**

e1 **Anterior Composite Restorations** A conservative treatment approach using direct composite resins for anterior teeth eroded by lemon sucking
Vanara Florencio Passos, DDS, MSc, PhD
Andre Mattos Brito de Souza, DDS, MSc
Lidiany Karla Azevedo Rodrigues, DDS, MSc, PhD
Juliana de Campos Fraga Soares Bombonatti, DDS, MSc, PhD
Sergio Lima Santiago, DDS, MSc, PhD

Instructions for Authors

For information on submitting a manuscript for publication in *General Dentistry*, please visit www.agd.org/gdauthorinfo.

Your Prescription for Unbeatable Quality, Service & Value

INCLUSIVE®

Custom Abutments and Bars

$299 COMPLETE ABUTMENT

Inclusive® Custom Abutments are available in titanium or zirconia and are compatible with 10 of the most popular implant systems. Inclusive implant bars and frameworks are precision milled from high-grade titanium alloy. Contact a Certified Inclusive Laboratory below or visit www.inclusivedental.com for more details.

Certified INCLUSIVE® *Laboratories*

CERTIFIED LABORATORY	CITY	STATE	PHONE
Burdette Dental Lab Inc.	Birmingham	AL	800-624-5301
Mobile Dental Design, Inc	Mobile	AL	251-634-2445
Oral Arts Dental Laboratories, Inc.	Huntsville	AL	800-354-2075
Parkway Dental Lab	Opelika	AL	800-239-3512
Dentek Dental Laboratory, Inc.	Scottsdale	AZ	877-433-6835
Kofa Dental Laboratory	Yuma	AZ	928-783-1141
Lakeview Dental Ceramics	Lake Havasu City	AZ	866-499-3388
New West Dental Ceramics	Lake Havasu City	AZ	800-321-1614
A & M Dental Laboratories	Santa Ana	CA	800-487-8051
BDL Prosthetics	Irvine	CA	800-411-9723
Bigler Dental Ceramics, Inc.	Tustin	CA	714-832-9251
Coast Dental Lab	Stanton	CA	714-670-9048
Creative Porcelain	Oakland	CA	800-470-4085
Dental Masters Laboratory	Santa Rosa	CA	800-368-8482
Excel Maxillofacial Prosthetic Laboratory	Simi Valley	CA	805-526-5346
Glidewell Laboratories	Newport Beach	CA	800-854-7256
Great White Dental Lab	Santa Maria	CA	800-441-3522
High Precision Dental Laboratory	Torrance	CA	877-523-4241
Iverson Dental Laboratories	Riverside	CA	800-334-2057
NEO Milling Center	Cerritos	CA	562-404-4048
Nichols Dental Lab	Glendale	CA	800-936-8552
Noel Laboratories, Inc.	San Luis Obispo	CA	800-575-4442
Precision Ceramics Dental Laboratory	Montclair	CA	800-223-6322
Riverside Dental Ceramics	Riverside	CA	800-321-9943
Williams Dental Laboratory	Gilroy	CA	800-713-5390
Elite Dental Arts	Wilmington	DE	302-994-1466
Autry Orthodontic Appliances	Panama City Beach	FL	850-230-6696
Biotech Dental Prosthetics	Palm Beach Gardens	FL	800-564-0556
Carlos Ceramics Dental Lab	Miami	FL	305-940-4040
Hennessy Dental Laboratory	Riviera Beach	FL	800-694-6862
Knight Dental Group	Oldsmar	FL	800-359-2043
William Scott Dental Studio	Palm Beach Gardens	FL	561-775-7720
Colonial Dental Studio	Davenport	IA	800-397-1311
Artistic Dental Studio	Bolingbrook	IL	630-679-8686
Oral Image Dental Studio, Inc.	Chicago	IL	877-235-9740
Prosthotech	Sugar Grove	IL	630-466-8333
Ragle Dental Laboratory, Inc.	Champaign	IL	800-742-3629
Vitality Dental Arts	Arlington Heights	IL	800-399-0705
Eurodent Dental Lab	Overland Park	KS	800-298-9589
Arcari Dental Laboratory	Wakefield	MA	781-213-3434
PDL, Inc.	Kingston	MA	800-924-6025
Apex Dental Milling	Ann Arbor	MI	866-755-4236
Artistic Dental Lab	Allen Park	MI	800-437-3261
Trachsel Dental Studio	Rochester	MN	800-831-2362
Las Vegas Digital Dental Solutions	Las Vegas	NV	800-936-1848
Elegant Dental Laboratories	Brooklyn	NY	877-335-5221
Smiledent Dental Studio	Mt. Kisco	NY	914-276-0218
ROE Dental Laboratory	Garfield Heights	OH	800-228-6663
Applegate Dental Ceramics	Medford	OR	541-772-7729
Ceramicraft Dental Lab	Bend	OR	541-318-7808
Albensi Laboratories	Irwin	PA	800-734-3064
DeLux Dental Laboratory	Reading	PA	800-541-5642
Innovative Dental Arts	North Huntingdon	PA	866-305-5434
Sherer Dental Laboratory	Rock Hill	SC	800-845-1116
Shoolbred Dental Laboratory	Anderson	SC	864-261-3861
Crystal Dental Ceramics	Richardson	TX	972-680-1660
Dental Dynamics Laboratory Inc.	Arlington	TX	800-640-8112
Natural Arts Dental Laboratory	San Antonio	TX	800-322-6235
Oral Designs Dental Laboratory, Inc.	San Antonio	TX	800-292-5516
PCB Dental Lab	Richardson	TX	972-671-3894
Broadway Dental Lab	Taylorsville	UT	801-955-4878
Treasure Dental Studio	Salt Lake City	UT	800-358-6444
Art Dental Lab	Chantilly	VA	888-645-7541
NexTek Dental Studios	Manassas	VA	800-678-7354
Nu Technologies Full Service Dental Laboratory	Powhatan	VA	804-379-9939
The Point Dental Studio, LLC	West Point	VA	804-337-5477
Ziemek Aesthetic Dental Lab	Olympia	WA	866-943-6357

INTERNATIONAL LABS SERVICING THE U.S.

Smith-Sterling Dental Laboratories	Cartago	Costa Rica	800-479-5203
Smile Designs	Guelph	ON, Canada	519-836-1100

3004964_01

e5 **Tooth Whitening/Bleaching** The effect of baking soda when applied to bleached enamel prior to restorative treatment
Bhenya Ottoni Tostes, MSc
Rafael Francisco Lia Mondelli, DDS, PhD, MSc
Ynara Bosco de Oliveira Lima-Arsati, DDS, PhD, MSc
Jose Augusto Rodrigues, DDS, PhD, MSc
Leonardo Cesar Costa, DDS, PhD, MSc

e10 **Periodontics** Non-drug induced gingival enlargement
Michelle L. Moffitt, RDH
Robert E. Cohen, DDS, PhD

e14 **Dental Materials** Optimal depth of cure for nanohybrid resin composite using quartz tungsten halogen and new high intensity light-emitting diode curing units
Saijai Tanthanuch, DDS, MSc
Prapansri Ruengsri, DDS
Boonlert Kukiattrakoon, DDS, MSc

e18 **Dental Materials** Microleakage of 3 single-bottle self-etch adhesives having different solvents
Cigdem Elbek Cubukcu, PhD
Ece Eden, PhD
Tijen Pamir, PhD

Coming next issue

In the September/October issue of *General Dentistry*

- Influence of periodontal biotype in the presence of interdental papilla
- Effects of mixing technique on bubble formation in alginate impression material
- Management of phenytoin-induced gingival enlargement: a case report

In the September issue of *AGD Impact*

- The cost of dentistry today: understanding your practice's finances
- AGD 2013 Annual Meeting & Exhibits wrap-up

Meet our new columnists

In addition to our regular contributors, *General Dentistry* is honored to welcome new columnists covering **Esthetics, Pediatrics, Public Health,** and **Restorative Dentistry.** In this issue, read the new Esthetics column, *Minimally invasive dentistry and its impact on esthetic restorative dentistry,* by Wynn H. Okuda, DMD, FICD, FICOI, on p. 24. Jane A. Soxman, DDS, Diplomate, ABPD, our new Pediatrics columnist, covers the question of *Parental presence* during children's dental appointments on p. 22. An inaugural Public Health column by Larry N. Williams, DDS, stresses the importance of dental recordkeeping in *An introduction to forensic dentistry* on p. 16. And in his first Restorative Dentistry column, Roger A. Solow, DDS, covers *Mounted diagnostic casts: the entry into comprehensive care* on p. 12.

GENERAL DENTISTRY

General Dentistry
211 E. Chicago Ave., Ste. 900
Chicago, IL 60611-1999

888.AGD.DENT (888.243.3368)
www.agd.org

Email: generaldentistry@agd.org
Fax: 312.335.3442

Back Issues and Change of Address
Members, call 888.AGD.DENT (888.243.3368) and ask for a Member Services representative. Nonmembers, call Derria Murphy (ext. 4097).

Mailing Lists
For information about ordering AGD mailing lists, call Derria Murphy (ext. 4097).

Disclaimer
The AGD does not necessarily endorse opinions or statements contained in essays or editorials published in *General Dentistry*. The publication of advertisements in *General Dentistry* does not indicate endorsement for products and services. AGD approval for continuing education courses or course sponsors will be clearly stated.

General Dentistry (ISSN 0363-6771) is published bimonthly plus an additional issue in August for 2013 by the AGD, 211 E. Chicago Ave., Suite 900, Chicago, IL 60611-1999. AGD members receive *General Dentistry* as part of membership.

Periodicals postage paid at Chicago, IL and additional mailing office. POSTMASTER: Send address changes to *General Dentistry*, 211 E. Chicago Ave., Suite 900, Chicago, IL 60611-1999. Email: subscriptions@agd.org.

Canadian mailing information: IPM Agreement number 40047941. Change of address or undeliverable copies should be sent to: Station A, P.O. Box 54, Windsor, Ontario, N9A 6J5, Canada. Email: subscriptions@agd.org.

The nonmember individual subscription rate for *General Dentistry* is $100 for the print version, $100 for the online version, and $175 for print and online versions; the nonmember institution rate is $300 (add $20 for Canada and $50 for outside the U.S. and Canada). Single copies of *General Dentistry* are available to nonmember individuals for $15 and nonmember institutions for $18 (add $3 for orders outside the U.S.).

Academy of General Dentistry™

Your voice for excellence through education and advocacy

Helping a grieving patient

Many things are taught in dental school, but coping with a grieving patient is not one of them. You may find yourself standing by feeling helpless as you watch a grieving patient struggle to cope with the death of a loved one. It's a horrible feeling not knowing what to do or say, or how to treat a grieving patient. Everyone grieves differently, so what works for one person may not be the answer for another. Still, there are ways we can offer comfort that are nearly universal, and hold true for both patients and friends who have lost a loved one, or whose loved one is suffering from a debilitating illness or trauma.

Before attempting to console patients, we must observe how they are handling their grief, since everyone copes with grief differently and experiences the stages of grief on a different schedule. Watching them to see how they are coping, and what they need at any given point in time, is the best way to help them. What they need in the initial days following the death of a loved one may not be the same things they need from you in four weeks, four months, or four years.

We can increase our empathetic knowledge in dealing with grieving patients by knowing the stages of grief. According to the Kubler-Ross model of the grieving process, sooner or later, not always in the same sequence and according to each individual's timetable, a grieving person goes through five stages of grief: denial, anger, bargaining, depression, and finally, acceptance.

Denial is the stage of grief during which your patient will probably still be in shock and disbelief, numb, or unable to comprehend that this could be happening. I recommend that as a dentist, you should use a soft, comforting approach, with as little treatment as possible during this stage.

During the *anger* stage, the patient might direct their anger toward God or another deity, specific people who are perceived to have caused the death, other people who still have their loved ones alive and possibly, anyone who innocently crosses their path. This anger may be volatile, hostile, or more subdued. Your patient may only confide how angry they are to certain people. This anger stage also involves feelings of frustration, helplessness, and hurt, as well as jealousy, bitterness, resentment, hatred, and/or fear. Give this stage as much time as possible to play itself out before starting any extensive dental treatment with your patient.

Bargaining is the stage where your patient may attempt to negotiate with a higher deity or even with themselves. It is a temporary state, during which they are struggling to cope with what must be done. They may say or think things like, "God, if you just let me live to see my children graduate from high school," or "If I can get through this week, everything will be okay." Bargaining helps a grieving individual take one step at a time.

Depression is the stage that usually lasts the longest, and is potentially the most dangerous. It can involve feelings of hopelessness and despair, and may manifest itself in several different ways, such as a disinterest in things or activities previously enjoyed, excessive sleeping or sleeplessness, nightmares, disorganization, difficulty concentrating, real physical pain, shortness of breath or panic attacks, disproportionate fears, or other seemingly unrelated changes. Making a solid plan of dental treatment during this stage is extremely difficult, and this may be the time your patient needs your professional understanding the most.

Acceptance is the final stage of grief. This is the healing part of the grieving process. During this stage, your patient will begin to recognize that their life should go on, reorganize their life as it will be without their loved one, and start to function in a state that will come to be their new "normal."

As dentists, we assume many roles, and grief counselor may be one of them. As humans, our strongest psychological need is to feel there is some significance in our lives. Lonely, grieving people may feel as though they no longer count, and as professionals, we can try to bring some joy into their lives just by showing them that they do. A helpful tool for you and your patients to understand the five stages of grief can be found at: http://grief.com/the-five-stages-of-grief.

Roger D. Winland, DDS, MS, MAGD
Editor

AGD Member Savings & Offers

Academy of General Dentistry™

The AGD Member Savings & Offers program (formerly the Benefits Plus Program) works with various organizations to provide AGD members with special savings and exclusive offers on high-quality products and services. These savings and offers have been selected by the AGD Group Benefits Council and are exclusive to each category.

Insurance Products

Dentist's Advantage
PROFESSIONAL LIABILITY & PRACTICE PROTECTION

Receive 10 percent premium credits on professional liability and malpractice protection insurance. Additional premium credits are available for AGD Fellows and Masters.
888.778.3981

HBi
Hagan Barron Intermediaries

Life, disability income, office overhead expense, and health insurance.
877.280.6487

Liberty Mutual INSURANCE

Save on auto and home insurance.
877.477.3320

Personal Products

AVIS / Budget

Save on car rentals.
avis.com/agd
budget.com/agd

Financial Products

Bank of America

Save 50 percent on administrative fees for professional financing.
800.497.6076

POWERED BY WorldPay

Receive 30-plus basis point pricing for credit card processing.
866.304.8852

Choose from three different AGD Visa® Platinum credit card options, including a rewards card.
888.922.1822 (Use code 11114)

Brought to you by Capital One®

CareCredit℠
Making care possible...today.

AGD members save $170 when they enroll with CareCredit. Call 866.247.0062. Already accept CareCredit? Call 800.859.9975 to connect with your Practice Development Team for training and tools to help your practice.

Practice Management Products

Lighthouse 360

Save 10 percent on the monthly fee for automated patient communications.
888.906.1905

The Online Practice
One Click To Your Market.

Save 50 percent on the monthly fee for the Gold Package practice website service and up to 25 percent on monthly fees for social media and online visibility services.
888.932.5560

ZOLL®

Receive an AED Plus® defibrillator, including pulse oximeter (a $500 value), for only $1,545.
888.851.8584

To take advantage of these member savings and exclusive offers, be sure to identify yourself as an AGD member when you contact these AGD Member Savings & Offers companies.

The AGD Member Savings & Offers program is subject to change without notice.

For more information about the AGD Member Savings & Offers program, visit *www.agd.org/savings* or call 888.AGD.DENT (888.243.3368).

Continuing education holds the key to minimally invasive biomimetic dental successes

Mark I. Malterud, DDS, MAGD

As a former Dental Education Council Chair for the Academy of General Dentistry (AGD), I had the honor, pleasure, and opportunity to read the AGD's Charge to which conferees were to respond in order to receive their Mastership in the AGD. The following is a key component of the Charge: *G.V. Black, the father of modern dentistry, once said, "The professional person has no right to be other than a continuous student."* This quote is even more valid in today's world, when technologic advancements in materials and techniques are coming at us at breakneck speeds, and we need to constantly assess whether they hold a valid place in our practices. As a general dentist, you may implement one of these advancements, only to find that you chose an option that was flawed; yet if you wait too long to choose a new advancement, you may find that you had inadvertently deprived your patients of a new quality procedure, possibly even a new standard of care. Continuing Education (CE) provides us with a solid foundation from which we can make sound decisions to guide us through the many advances in technology.

The following case illustrates the importance of CE in providing the practitioner with the ability to resolve the unique issues that arise in their offices. As this column is about minimally invasive biomimetic dentistry (MIBD), those tenets are always at the foundation of the decision-making process as to how to proceed with care. What triggered this column was a realization I had while working on a treatment plan. I found that there was no specialist to whom I could refer my patient who could address the full range of care necessary to resolve a dilemma. Who other than a general dentist, with a well-rounded continuing education background, could have adequately helped this patient?

A 17-year-old female patient, accompanied by her mother, presented to our office for a new patient exam and a prophylaxis, with no chief concerns and a noncontributory health history. It had been "a couple of years" since the patient had been to a dentist, so the decision was made to conduct a full examination, including caries-detecting bitewing X-rays, before the prophylaxis. Upon examination, it was noted that tooth No. 2 had what appeared to be an ectopic or possibly supernumerary tooth to its buccal sitting over the distal portion of the tooth. The tooth had surface demineralization and there was no mobility (Fig. 1). Probing of the area showed that there was a lack of attachment and bone over the buccal of tooth No. 2, and that the anomaly in fact may be attached or fused to that tooth.

The decision was made to take a cone beam computed tomography (CBCT) X-ray of the patient to confirm that the anomaly was actually attached to tooth No. 2. The CBCT would also confirm whether there were other issues that might have a bearing on future decisions made for the patient's treatment. The CBCT showed that the aberration projecting from tooth No. 2 was an anomalous cusp that emerged from the distal portion of the mesial buccal root in the area of the buccal furcation. The nerve and vascular supply of this anomalous cusp emanated from the mesial buccal root (Fig. 2-4).

Many options were considered in this unique situation that would allow this young patient to have a fully functioning tooth, hopefully for the rest of her life. In looking at the

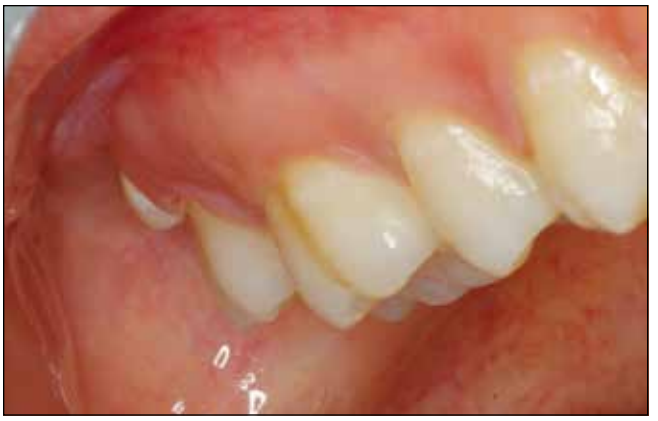


Fig. 1. Tooth No. 2 as it appeared at initial examination, showing demineralization of the enamel and a projection buccal to the tooth.

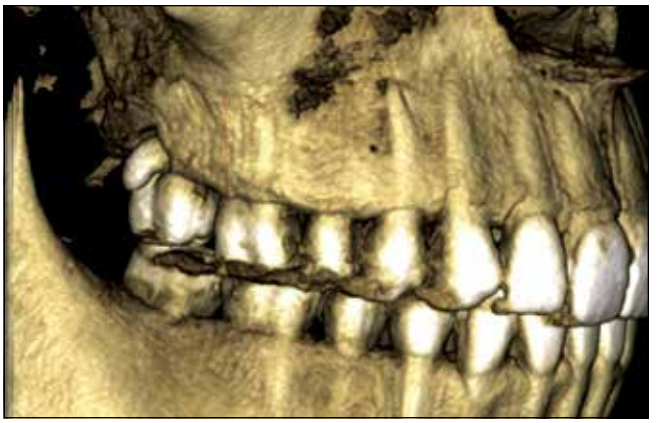


Fig. 2. CBCT of the anomalous cusp showing the missing bone on the buccal of tooth No. 2.

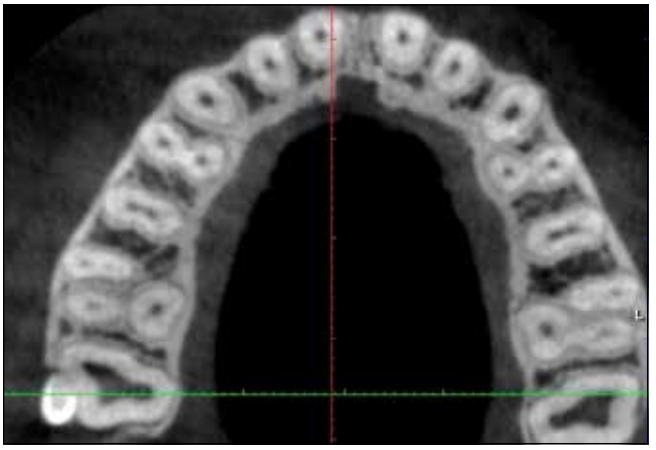


Fig. 3. CBCT showing the sharing of the innervation with the canal of the mesiobuccal root.

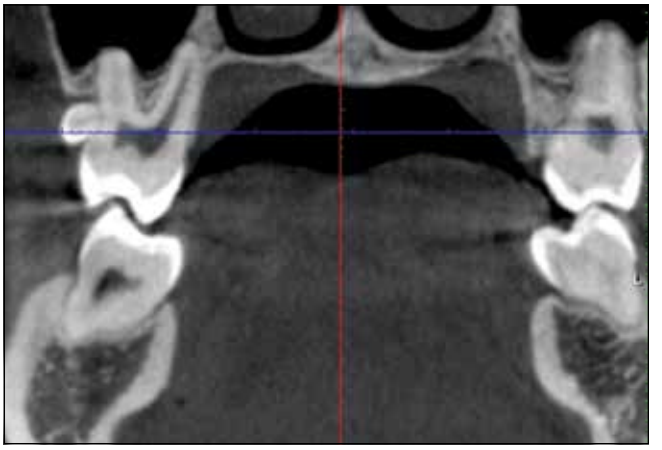


Fig. 4. The root tips are up in the sinus and no pulpal pathology was noted.

options, I thought of numerous specialists who I could call in to help with the situation. A periodontist could deal with the lack of bone on the buccal of tooth No. 2. An endodontist could work on the proper treatment of the shared pulpal vascularity and innervation. If needed, an oral surgeon could extract and place an implant. None of these options seemed to fully address that we were facing a restorative issue, with the need for resection of the anomalous cusp and a filling. Endodontic and periodontic intervention would also be required before the tooth could heal. I concluded that a well-trained general dentist who has studied widely, such as an AGD Master, was probably this patient's best chance at getting a successful outcome. In order to obtain the results we needed, we had to break down each of the individual issues at hand.

The most logical way to look at the treatment sequence was to start with the restorative option. Leaving the cusp in its current state was not an option, as there were already smooth surface caries and a cleft between the tooth, as well as the concern that the anomalous cusp could not be adequately cleaned. The amputation of the cusp and subsequent filling of the area would be crucial for creating root form contours that could allow proper healing, and set up the area for more root coverage with bone and soft tissue. Controlling hemorrhaging would be crucial to the success of the restoration, so a very fast-setting restorative material, that would be biocompatible with soft and hard tissue healing, would have to be employed. A new, highly biocompatible, restorative material that is easy to handle and has a multiple modality of polymerization (including self cure, light cure, and heat cure) would be used. In this case, we used Activa (Pulpdent Corporation) material that was placed into and over the root, creating an ionic bond to the tooth root surface similar to that of a glass ionomer.[1,2]

As the amputation of the supernumerary cusp would expose a nerve, some form of a pulp cap, or possibly a full root canal, would be required. Recent research has shown that intentional mechanical exposure of nerve tissue with a sterile procedure can be successfully treated while maintaining pulpal vitality with a number of different materials, including MTA (DENTSPLY Tulsa Dental Specialties), TheraCal LC (Bisco, Inc.) and Biodentine (Septodont, Inc.).[3-7] As the area would require a flap procedure to expose the root and allow amputation, control of hemorrhaging would make it hard to keep the area isolated, so the light cure and immediate set of the TheraCal LC made it a more user-friendly option to avoid the contamination issues of unset materials.

As the area could potentially be contaminated during the process, we employed ozone gas to disinfect the surface area, as well as to stimulate healing and enhance the bond.[8-11] Once the TheraCal LC was in place and hardened, we could immediately place the restorative covering of that prepared portion of the root, and proceed to the final contouring and smoothing of the root to make the area confluent with the surrounding root anatomy with the anomalous cusp gone. A smooth surface would allow the reattachment of the gingiva, and potentially create some bone fill in the furcation.

If the restoration and pulp capping were successful and the healing monitored, we would have to decide (via a CBCT scan) if there was enough bone on the buccal to go back, flap the area, graft bone into the site, and place a resorbable membrane. We would consider leaving the area alone if there was a firm attachment around the tooth with no appreciable pocketing. Time and healing was needed to decide on whether future treatment is necessary.

The procedure in this study was accomplished after careful consideration and a full discussion, with full informed consent from the patient and her mother. The area was anesthetized with 2% Lidocaine with 1:100,000 epi to control localized bleeding, and a full thickness flap was developed to access the area (Fig. 5). As noted in the CBCT, the anomalous cusp came off from the distal aspect of the mesiobuccal root, so access for using an electric handpiece was limited. A long shank surgical round bur was used to reach back into the area.

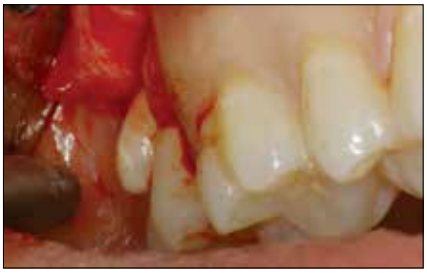


Fig. 5. Full thickness flap exposing the entire anomalous cusp of tooth No. 2.

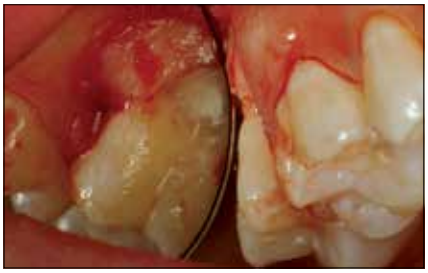


Fig. 6. The pulp-capping material in place and sealed well.

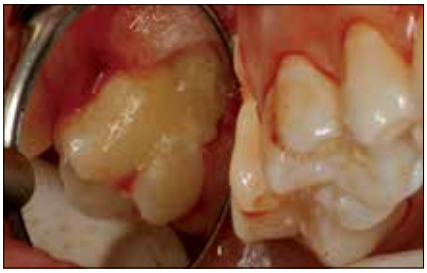


Fig. 7. The area after immediate placement of the restorative material used to cover the pulp cap and restore the full contour of the root.

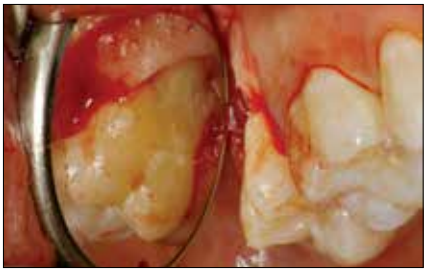


Fig. 8. Flap is replaced and sutured coronally, with a modified sling suture used to hold the tissue coronally and approximate the releasing incisions.

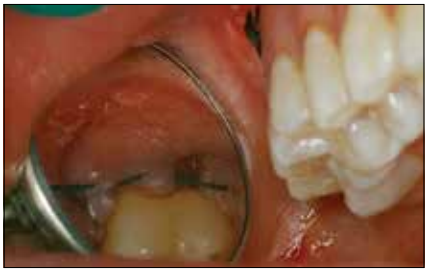


Fig. 9. Suture removal after 10 days healing. Tissues appear healthy, although the final smoothing of the tissue contours has not yet occurred.

Once the anomalous cusp was removed, it was confirmed that the pulpal tissue was breached, so a new sterile round bur was used to create a preparation that dropped into the root, not so deep as to damage the main nerve traversing the canal of the mesiobuccal root, but deep enough to add in both the direct pulp cap and a restorative cover of the capping material. At that point, the area was rinsed thoroughly with ozonated water to remove any debris left in the area, then 100 mg/ml ozonated oxygen was flooded into the area to disinfect the surface. The pulp-capping material was immediately placed over the non-bleeding pulp horn, and cured with a high intensity curing light (Fig. 6). The area was still clear of hemorrhage, so the filling material was placed over the pulp-capping material and was cured also with the high intensity curing light (Fig. 7). The excess filling material was removed and smoothed to contour, and the area was rinsed thoroughly again with ozonated water to remove debris, the flap was replaced slightly coronally, and sutured with a sling suture and 3-0 silk suture (Fig. 8).

Postop follow-up calls were placed at the end of the first day, Day 2, and Day 5, with the patient responding that she had no postoperative issues. At Day 10, the sutures were removed, the tooth was asymptomatic, and the tissues were healing well (Fig. 9). At 3 weeks, the patient returned for her usual hygiene visit, and the tooth was tested with an ice test and percussion; full vitality and normal responses were noted for all the upper right teeth, including tooth No. 2.

The object of this case presentation was to illustrate the importance of being no less than a continual student, as G.V. Black ascribed in his quote from the turn of the last century. The idea of this being a team effort involving all the specialists would create a nearly impossible situation, as they all would have to assemble at one spot to perform each of their specialized portions of the procedure, and this alone could become cost prohibitive. This also would put these specialists in a situation where they are out of their own office environments and probably their comfort zones. My contention holds that the best person to help with this care is a well-trained and well-read general dentist who can perform each of the individual procedures needed to satisfy the needs of the situation in their own environment.

To be a continual student, such as an AGD Master, enables the dentist to be better prepared to handle unique situations, such as the one just outlined, and work toward a successful outcome. By utilizing many procedures that follow along the lines of a MIBD treatment philosophy learned as a continual student, the patient is set up for healing. Time will tell if this will give the long-term success that we desire. The patient and the dentist can rest assured that everything possible was done in a timely manner and the success of the procedure was due to the level of education and skill of the practitioner.

As general dentists, we are only as capable as what we learn and apply from our many CE experiences. Choose your mentors wisely, and get a broad base of education and experience, such as becoming an AGD Master. Even the AGD Mastership isn't an endpoint, but a goal to strive for in your lifelong learning experience.

Author information

Dr. Malterud, a 1983 graduate of the University of Minnesota, is in general practice in St. Paul, Minnesota. He has lectured and published on MIBD for more than 17 years.

References

1. Parmeijer OH, Zmener O. Histopathological evaluation of a RMGI cement, auto and light cured, used as a luting agent. A subhuman primate study. Pulpdent Corporation. 2011.
2. Pameijer CH, et al. Biocompatibility of two RMGI experimental formulations in subcutaneous connective tissue of rats. Pulpdent Corporation. 2011.
3. Gandolfi MG, Siboni F, Prati C. Chemical-physical properties of TheraCal, a novel light-curable MTA-like material for pulp capping. *Int Endod J.* 2012;45(6):571-579.
4. Wang Y, Suh BI. Effects of adhesives on calcium-release, pH and bonding of TheraCal. *J Dent Res.* 2012;91(Spec Iss A):Abstract No. 264.
5. Gandolfi MG, Suh B, Siboni F, Pratt C. Chemical-physical properties of TheraCal pulp-capping material. *J Dent Res.* 2011;90(Spec Iss A): Abstract No. 2521.
6. Gandolfi MG, Siboni F, Taddei P, Modena E, Prati C. Apatite-forming ability of TheraCal pulp-capping material. *J Dent Res.* 2011;90(Spec Iss A): Abstract No. 520.
7. Hebling J, Lessa FC, Nogueira I, Carvalho RM, Costa CA. Cytotoxicity of resin-based light-cured liners. *Am J Dent.* 2009;22(3):137-142
8. Huth KC, Jakob FM, Saugel B, et al. Effect of ozone on oral cells compared with established antimicrobials. *Eur J Oral Sci.* 2006;114(5): 435-440.
9. Huth KC, Quirling M, Lenzke S, et al. Effectiveness of ozone against periodontal pathogenic microorganisms. *Eur J Oral Sci.* 2011;119(3):204-210.
10. Schmidlin PR, Zimmermann J, Bindl A. Effect of ozone on enamel and dentin bond strength. *J Adhes Dent.* 2005;7(1):29-32.
11. Bojar W, Czarnecka B, Prylinski M, Walory J. Shear bond strength of epoxy resin-based endodontic sealers to bovine dentin after ozone application. *Acta Bioeng Biomech.* 2009;11(3):41-45.

Manufacturers

Bisco, Inc., Schaumburg, IL
800.247.3368, www.biscoinc.com

DENTSPLY Tulsa Dental Specialties, Tulsa, OK
800.662.1202, www.tulsadentalspecialties.com

Pulpdent Corporation, Watertown, MA
800.343.4342, www.pulpdent.com

Septodont, Inc., Lancaster, PA
800.872.8305, www.septodontusa.com

Mounted diagnostic casts: the entry into comprehensive care

Roger A. Solow, DDS

Comprehensive care can be defined as the education, diagnosis, and treatment of patients so that all factors causing disease and discomfort are eliminated and only minimal effort is needed to maintain health.[1] Dentists must have an in-depth understanding of the patient's status before any discussion of problems, solutions, and fees. Typically, a restorative dentist completes the interdisciplinary case, so it is critical that all planning is done to facilitate a predictable restorative result. Thus, specialist communication and treatment coordination become additional responsibilities for the restorative dentist.

Diagnosis is the first and most important aspect of dentistry, as all predictable treatment is based on correct diagnosis. A comprehensive exam consists of a preclinical interview, clinical examination, appropriate imaging, and mounted diagnostic casts. The patient's decision to accept comprehensive care is based on their examination experience. Dentists only have one opportunity to make a great first impression by demonstrating their knowledge, caring attitude, and thoroughness.

In his classic text, Dawson ascribes the causes of breakdown of the dentition to microbial factors and excess physical force problems.[2] Diagnostic casts that replicate the structural and functional relationships of the dentition are essential for analyzing the effects of adverse forces and planning appropriate solutions (Fig. 1). If these casts are to have clinical significance, they must accurately portray the intraoral situation. Mounted diagnostic casts show the arc of closure and chewing excursion occlusal interferences (Fig. 2 and 3). An intraoral assessment of the occlusion when the patient closes or chews on articulating ribbon is not an accurate way to evaluate occlusal problems.[3] Patients are programmed by the protective neuromuscular response, mediated by periodontal mechanoreceptors, to avoid arc of closure interferences and do not accurately identify these teeth. Also, natural teeth intrude and allow marks to occur on adjacent teeth. Teeth on stone casts do not intrude and show the actual interference. Duplicate mounted casts can be trial-equilibrated, and a diagnostic wax up performed to visualize the final restoration. These casts are measured to quantify the size of interferences and restorations for precise treatment planning.[4,5] A clear matrix over these casts generates provisional restorations to preview the planned result intraorally (Fig. 4-7). Implant surgical guides can also be fabricated from these casts (Fig. 8). These "before and after" casts provide a 3-dimensional preview of the benefits of the proposed treatment. Discussion of problems and solutions with these casts creates a learning experience for the patient and specialist, and develops a unique connection with the dentist.

Many interdisciplinary cases would benefit from orthodontic correction prior to restoration. Patients can ask for a restorative solution without understanding the possibility or value of placing the roots in the correct position in order to attain the best long-term periodontal health and the most natural esthetic results. When the restorative dentist incorporates model surgery along with a diagnostic wax up, the advantage of creating the best foundation for restorative work becomes apparent to the patient (Fig. 9 and 10).

The original preoperative cast is always preserved to illustrate the initial problems, and to compare with the alterations on duplicate casts. The duplicate cast can have teeth sectioned with a saw or disc, and then repositioned with baseplate wax to simulate the gingiva. The dentist can measure the mesial-distal

Fig. 1. Mounted diagnostic casts on a semi-adjustable articulator.

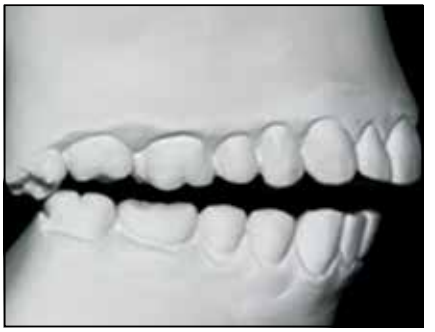


Fig. 2. Arc of closure interference on the hypererupted third molar with the casts mounted in centric relation (CR).

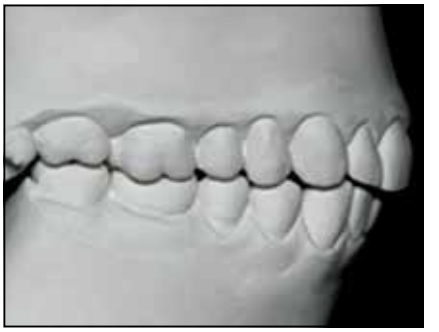


Fig. 3. The casts in maximum intercuspation. Note the significant vertical and horizontal dimension of the shift from CR to maximum intercuspation.

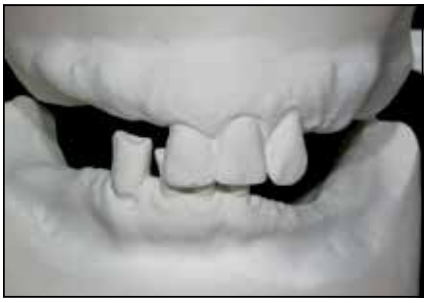


Fig. 4. Preoperative casts mounted in CR.

Fig. 5. Diagnostic wax up on duplicate casts mounted in CR with the same facebow and CR record.

Fig. 6. Maxillary cast with microfill composite resin provisional shells generated from a clear matrix over the diagnostic wax up.

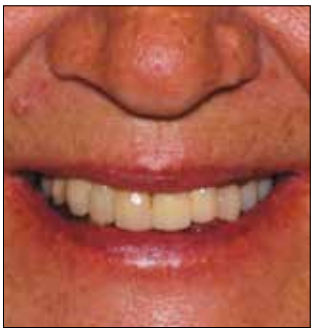


Fig. 7. Full facial view of the composite resin shells relined with acrylic resin intraorally.

Fig. 8. Surgical guide fabricated on a duplicate cast of the diagnostic wax up.

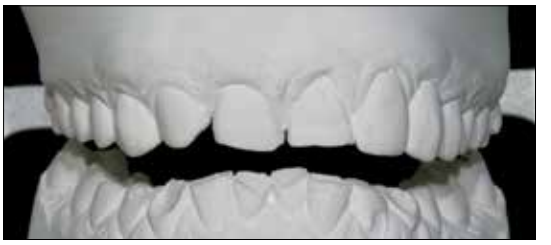


Fig. 9. Preoperative diagnostic casts mounted in CR and opened to show the mandibular incisal plane. Note the wear facet patterns and abfractions. Site No. 6 is a porcelain crown on a loose primary canine. Site No. 7 is a permanent canine. Site No. 10 is a porcelain bridge retainer on a permanent canine.

and buccal-lingual dimensions compared to an adjacent tooth as each tooth is moved, or use wax occlusal records to measure the changes.[4] This specific information is discussed with the orthodontist to confirm that the proposed change is realistic and predictable, without incurring the deleterious effects of gingival recession, apical root resorption, or excessive interproximal reduction.

A restorative-orthodontic consultation should be based on a problem list that specifies the precise change from the preoperative condition to the ideal result visualized on the diagnostic workup casts. The restorative dentist who presents a case to the specialist with thorough information on who the patient is (preclinical interview), what the extraoral and intraoral problems are (clinical examination), what is underlying these problems (appropriate imaging), and the structural relation of the dentition (occlusal analysis) will have a very different discussion than a consultation without this information. There is learning on both sides of the conversation when working through cases where this complete diagnosis has been presented. This creates a special relationship that promotes future referrals (in both directions) between the restorative dentist and the specialist.

Technique

Mounted diagnostic casts require a semi-adjustable articulator to closely replicate the arc of closure and mandibular excursions. The 3 steps to create these models are facebow transfer, centric relation (CR) and protrusive records, and impressions of both dental arches.

The facebow records the radius of the mandibular closure, so that casts reflect the patient's actual closure. Earbows with an arbitrary hinge axis are commonly used instead of true hinge axis facebows, and incorporate minimal error if the CR record is taken at a small open dimension.[6] If a large increase in vertical dimension is treatment-planned, a hinge axis facebow is more accurate. The earbow is used to mount the maxillary cast and determines both the anterior-posterior as well as the horizontal position in the articulator. If the plane of the ear canals is not parallel to the interpupillary plane, there will be a distortion in the cant of the maxillary cast.[7] The dentist should observe the actual position of the maxillary teeth relative to the interpupillary line and correct any error generated by the earbow by loosening and rotating the bitefork prior to mounting (Fig. 11).

The CR record is the most critical step in the procedure, since it determines the occlusal relationship. An anterior deprogrammer

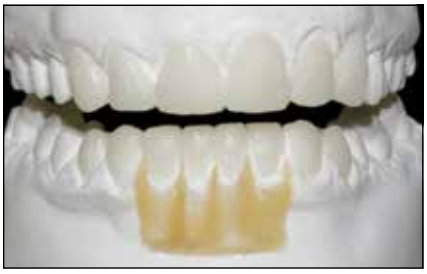


Fig. 10. Duplicate mounted casts with model surgery and wax up. Note the corrected incisal planes and dominance of the maxillary central incisors compared to the adjacent lateral incisors.

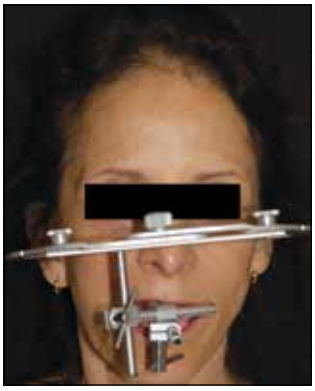


Fig. 11. Earbow demonstrating a pronounced difference between the interpupillary and external auditory meatus levels.

Fig. 12. Custom anterior deprogrammer with CR dot.

or bite stop facilitates a predictable and accurate CR record.[8-10] This author uses a custom, maxillary anterior deprogrammer, made from SNAP acrylic resin (Parkell, Inc.) with Dawson bimanual guidance.[11] Once a predictable arc of closure is obtained, the deprogrammer is marked with ribbon against the opposing incisor, with no other teeth contacting (Fig. 12). The dentist verifies that each closure—with light or firm bimanual guidance—contacts this mark. A vinyl polysiloxane record (Blu-Mousse, Parkell, Inc.) of this closure is taken with the incisor on the mark and is used to mount the mandibular cast against the maxillary cast. After mounting, the deprogrammer is placed on the maxillary cast and the mandibular cast incisor must contact the intraoral mark to verify the intraoral relationship.

The protrusive record is used to adjust the condylar guidance to improve the accuracy of mandibular excursions on the casts. A sheet of pink baseplate wax is softened and folded in 4 layers. The wax is gently pressed against the maxillary arch and then cut back so that it covers only the posterior teeth. The patient is instructed to protrude the jaw 5-7 mm from maximum intercuspation and gently close into the record. On removal, the wax is then chilled under cold water. After the casts are mounted in CR, the condylar controls are loosened and the casts are seated into the record. The articular eminence incline is rotated to touch the condylar ball and the controls are tightened.

Maxillary and mandibular full arch impressions are taken to replicate the dentition. Alginate or vinyl polysiloxane materials can be used. Orthodontic wax placed along the periphery of the tray helps to capture alveolar ridge contours that could influence implant planning. Alginate is less expensive and is accurate in making duplicate models if repoured within 45 minutes.[12] The casts are poured with vacuum mixed white dental stone and mounted with white plaster.

After setting, any excess plaster beyond the mounting ring is cut back, additional plaster is added to the mounting, and smoothed with a wet finger. After set, a smooth finish is obtained with 180 grit waterproof sandpaper. Mounted casts should have a professional appearance that conveys the dentist's attention to detail.

The arc of closure interference is identified with 8 µm shimstock (Hanel, Almore International, Inc.) and then only that site is marked with 20 µm Accufilm (Parkell, Inc.). This avoids any smearing of ink on other teeth that would obscure the interference mark or detract from the esthetics of the casts, as usually happens when a marking ribbon is used to identify the contact.

Discussion

There are alternative ways to obtain CR records. Wax records with bimanual guidance, preformed anterior stops, and leaf gauges can be used with success. Preformed stops are secured by bite registration material. These can be uncomfortable to dislodge from the teeth and are difficult to accurately replace on the mounted cast. Leaf gauges can distalize the condyles if the patient bites too hard and do not help to verify the mounting. One advantage of the custom anterior deprogrammer is that a single operator can use bimanual guidance without an assistant to take the record. Vinyl polysiloxane is preferable to wax for CR records, as it is more accurate and doesn't distort with temperature during shipping. Hands-on courses are essential to develop the knowledge and skills to predictably take accurate CR records.

Interdisciplinary care can be the most rewarding aspect of a restorative dental practice. Mounted diagnostic casts and duplicate casts for the proposed treatment facilitate a realistic discussion of all treatment options with specialists. The treatment plan can then be organized and shown in a 3-dimensional model to the patient. For many patients, this approach is the first time they understand what is best for them in the long term, and why a comprehensive restoration is their best investment.

Author information

Dr. Solow is in private practice in Mill Valley, California, and a member of the visiting faculty at the Pankey Institute, Key Biscayne, Florida.

References

1. Solow, RA. Occlusal bite splint therapy. In: Becker IM, ed. *Comprehensive occlusal concepts in clinical practice.* 1st ed. Hoboken, NJ: Wiley-Blackwell; 2011:169.
2. Dawson PE. *Evaluation, diagnosis, and treatment of occlusal problems.* 2nd ed. St. Louis: CV Mosby; 1989:4.
3. Roth RH. Temporomandibular pain-dysfunction and occlusal relationships. *Angle Orthod.* 1973;43(2):136-153.
4. Solow RA. Preorthodontic implant placement in the planned postorthodontic position: a simplified technique and clinical report. *Gen Dent.* 2012;60(4):e193-e203.
5. Solow RA. Equilibration of a progressive anterior open occlusal relationship: a clinical report. *J Craniomandib Prac.* 2005;23(3):229-238.
6. Weinberg LA. An evaluation of the face-bow mounting. *J Prosthet Dent.* 1961;11:32-42.
7. Gracis S. Clinical considerations and rationale for use of simplified instrumentation in occlusal rehabilitation. Part 1: mounting of the models on the articulator. *Int J Periodontics Restorative Dent.* 2003;23(1):57-67.
8. Becker I, Tarantola G, Zambrano J, Spitzer S, Oquendo D. Effect of a prefabricated anterior bite stop on electromyographic activity of masticatory muscles *J Prosthet Dent.* 1999;82:22-26.
9. McKee JR. Comparing condylar positions achieved through bimanual manipulation to condylar positions achieved through masticatory muscle contraction against an anterior deprogrammer: a pilot study. *J Prosthet Dent.* 2005;94(4):389-393.
10. Karl PJ, Foley TF. The use of a deprogramming appliance to obtain centric relation records. *Angle Orthod.* 1999;69(2):117-124; discussion 124-125.
11. Solow RA. The anterior acrylic resin platform and centric relation verification: a clinical report. *J Prosthet Dent.* 1999;81(3):255-257.
12. Haywood VB, Powe A. Using double-poured impressions to fabricate bleaching trays. *Oper Dent.* 1998;23(3):128-131.

Manufacturers

Almore International, Inc., Portland, OR
800.547.1511, www.almore.com

Parkell, Inc., Edgewood, NY
800.243.7446, www.parkell.com

An introduction to forensic dentistry

Larry N. Williams, DDS

The fictional and real crime dramas seen on television and read about in books sometimes involve the use of forensic dentistry for identification purposes. This type of identification is often dramatized in such a way to lead the layperson to think this is very straightforward. As a dentist who has been involved in several cases while in the military, I can attest that forensic dentistry is an exacting process that requires concentration and methodical tenacity. In the process of educating the uninformed dental community and the general public about dental forensics, it is necessary to remove the television dramatics while instilling the necessary dedication. We will look at the basics of forensic dentistry and work to help the reader see the benefits of getting involved in this necessary part of our profession.

First, we need to explore what is meant by the term *forensic dentistry* (sometimes referred to as *forensic odontology*). According to *Mosby's Medical Dictionary,* forensic dentistry (odontology) is the branch of dentistry that deals with the legal aspects of professional dental practices and treatment, with particular emphasis on the use of dental records to identify victims of crimes or accidents.[1] This definition denotes a very important "emphasis" of what makes forensic dentistry possible—the use of dental records.

Without accurate and complete dental records, the possibility of forensic dental identification is next to impossible. A "complete" dental record (quality serial bitewing radiographs, panorex (if possible), accurate charting, and all restorations documented—especially recent ones) greatly enhances the ability of the dentist performing the forensic identification on a possibly known victim to use radiographs and restorations as potential identification markers. Other activities that are made possible by an accurate and detailed dental record of the potentially known victim include charting dental and cranial features, radiographic documentation of these features, and writing a forensic report regarding these findings.

Tips for maintaining an effective forensic dental record include limiting abbreviations, keeping up-to-date records, having records written in legible ink, and not erasing errors (it is recommended to line out and initial). Always remember that your last entry may be the deciding factor that helps identify a deceased victim.

Here is an example of forensic dentistry in action. A plane crash occurs, and there is a manifest of known passengers.[2] Due to severe burns and blast damage, many of the normal means of identification are rendered useless. The dentists of these passengers are contacted and dental records are requested. A trained forensic dentist can then use these provided records and radiographs to begin the identification process. The antemortem records are compared to the postmortem records and the identification process begins. The physical comparison of autopsy results and antemortem dental radiographs and records completes the process, wherein the dentist renders either an opinion of a positive identification, a possible identification, no identification, or inconclusive results.[3]

However, the case may sometimes involve an unidentified person that requires identification. This would involve a dental examiner to document dental findings and develop leads that may help in identification. The use of postmortem radiographs and dental charting can be used to help identify the unknown person via communication with dentists that may have provided treatment. The conditions of the body can make the process challenging. The body may be intact, or the remains may be decomposed or skeletonized. The victim may have been killed as a result of a high-energy accident, biological event, or homicide. In many cases, the basic information about the unknown victim may be submitted to national, state, and local dental publications to assist in obtaining a lead.

A new aspect of forensic dentistry now involves the use of pulpal DNA. Due to the relative protection of the hardened tooth structure, the pulpal DNA may be intact (even in a putrefied body) to be used in the identification process. Based on current technology, it is possible to distinguish one individual from all others with a high level of confidence, by starting with only ≤1 ng of target DNA. The amount of DNA that can be recovered from a molar tooth with a pulp volume of 0.023-0.031 cc is approximately 15-20 mg. Mitochondrial DNA can be found in ground dentin.[4]

Another aspect of forensic dentistry involves the use of the human dentition in identifying an assailant that left a bite mark. The identification of bite marks on victims can involve the comparison of bite marks with the teeth of a suspect, and the use of salivary DNA left behind in the bite mark. Bite mark analysis involves measurements of the distance from cuspid to cuspid, tooth alignment, dimensions of the teeth, spacing of the teeth, missing teeth, and patterns due to wear.

This identification tool has been used in some very high profile cases. One of the most dramatic was the use of a bite to identify the serial killer, Ted Bundy. The steps taken to convict him were very difficult, due to the number of years involved and the loss of some of the evidence. Due to the inherent difficulties and exacting legal procedures involved, the American Board of Forensic Odontologists has created the *ID and Bitemark Guidelines.*[5,6] With the growing importance of dentistry in the area of forensics, the American Dental Association has a detailed *Dental Records* guidelines to assist and guide the dental team.[7] The ADA encourages the cooperation of dentists who get requests to provide dental records in forensic investigations. A key component of the guideline is the importance of dealing with forensic dentistry issues under the Health Insurance Portability and Accountability Act (HIPAA).[8] Dentists who are covered under the HIPAA generally may release dental records or make disclosures without patient permission when presented with a valid, properly-served warrant, court order, subpoena, or administrative request.

The Federal government has instituted the Disaster Mortuary Operational Response Team (DMORT).[9] It is a program in the National Disaster Medical System, and is a federal level response team designed to provide mortuary assistance at mass fatality incidents. DMORT works under local jurisdictional authorities such as coroner/medical examiner, law enforcement, or emergency managers. DMORT responds in a mass fatality only when requested by a municipality through appropriate federal channels.

In large-scale fatalities, DMORT members may help to identify victims by examining recovered dental remains. DMORT team members that are called in to help local authorities might contact a dentist to obtain antemortem patient information, or to clarify previously gathered information. It is the DMORT team who also has the difficult job of deciphering illegible handwriting, obsure abbreviations, and unclear codes or acronyms. DMORT must also sometimes translate foreign languages and abridged summaries in the records in order to make positive identifications.

In my 30-year career as a Navy dental officer, I have been involved in the forensic identification of military members killed while serving on active duty. The records used in the forensic process were legible and the radiographs were diagnostic. This made the identifications very straightforward. Even with the electronic dental records, it is very important to remember to accurately document the dentistry being done. In closing, please remember that the quality of your records makes a huge impact on the forensic process.

For readers who want to learn more about the role of forensic dentistry, please visit the following websites for additional information:

- Disaster Mortuary Operation Response Team: http://ndms.dhhq.health.mil
- American Board of Forensic Odontology: http://www.abfo.org

Author information

Dr. Williams is an assistant professor, Midwestern University College of Dental Medicine, Illinois.

References

1. *Mosby's Medical Dictionary.* 8th ed. Philadelphia, PA: Elsevier Inc.; 2009.
2. Bush M, Miller R. The crash of Colgan Air flight 3407: advanced techniques in victim identification. *J Am Dent Assoc.* 2011;142(12):1352-1356.
3. Bowers CM. Forensic Dental Evidence: An Investigator's Handbook. 2nd ed. Philadelphia, PA: Elsevier Inc; 2011.
4. Boles TC, Snow CC, Stover E. Forensic DNA testing on skeletal remains from mass grave: A pilot project in Guatemala. *J Forensic Sci.* 1995;40(3):349-355.
5. Pretty IA, Sweet D. Adherence of forensic odontologists to the ABFO bite mark guidelines for suspect evidence collection. *J Forensic Sci.* 2001;46(5):1152–1158.
6. The American Board of Forensic Odontology. *ID and Bitemark Guidelines.* Available at: http://www.abfo.org/resources/id-bitemark-guidelines. Accessed: June 17, 2013.
7. American Dental Association Council on Dental Practice, Division of Legal Affairs. *Dental Records.* 2010. Available at: http://www.ada.org/sections/professionalResources/pdfs/dentalpractice_dental_records.pdf. Accessed June 17, 2013.
8. U.S. Department of Health and Human Services. *Health Insurance Portability and Accountability Act (HIPAA).* Available at: https://www.cms.gov/Regulations-and-Guidance/HIPAA-Administrative-Simplification/HIPAAGenInfo/downloads/HIPAALaw.pdf. Accessed June 17, 2013.
9. U.S. Department of Homeland Security. Disaster Mortuary Operational Response Team (DMORT). Available at: http://www.phe.gov/Preparedness/responders/ndms/teams/Pages/dmort.aspx. Accessed June 17, 2013.

What's wrong with this picture?

Toni M. Roucka, DDS, MA ▪ Evelyn Donate-Bartfield, PhD

James Bartka, a fourth year dental student at Acme Dental School, was beginning to panic. His clinical board exam for licensure was in 1 week, and he still did not have a patient for the Class III resin portion of the exam.

James was doing everything he could to find a patient. He talked with other students, asked his relatives, and checked all of his existing patients' records looking for an appropriate patient. Finally, after days of hovering in the school's Radiology Department, he came across the "perfect lesion" in a new patient, Ms. Williams. The lesion was radiographically but not clinically visible, and extended half the distance to the dentin-enamel junction, so it fit the regional board's selection criteria. James was happy, but getting the patient to show up for the exam was the next challenge. If the patient did not keep the appointment, it would mean that James would not be able to be licensed or take a job he was scheduled to start. Instead, he would have to put everything on hold and take the exam again several months later. Taking the exam later would be complicated, because it would involve finding and transporting patients to take the exam in an unfamiliar city; this could cost thousands of extra dollars that James did not have.

Ms. Williams, James' proposed patient, was a 23-year-old woman who was struggling financially. She knew she needed dental work, and she was hoping to get treatment when she became eligible for dental insurance at her job. Unfortunately, she began to experience mild discomfort and knew she couldn't wait any longer. She came to the dental school because she knew she could not afford a private dentist. Her chief complaint was discomfort with cold and chewing in the lower right quadrant; the class III lesion James found on the radiograph was on tooth No. 8.

James had Ms. Williams assigned to him for patient care and scheduled a comprehensive examination. In addition to the carious lesion on tooth No. 8, the clinical findings included a moderately sized occlusal carious lesion on tooth No. 31 (the source of the cold sensitivity), similar lesions on teeth No. 14 and 19, and a larger, class III lesion on tooth No. 10. She also needed a prophylaxis, and localized scaling and root planning for some mild generalized calculus buildup. While reviewing the findings, James realized that she might also qualify for the periodontal portion of his exam. He already had another patient lined up for that section, but Ms. Williams could certainly serve as a backup patient. James did not want to fail because he did not have a patient for the exam, so like other students in the class, he would schedule a backup. If it turned out that he did not need Ms. Williams, she could serve as an examination patient for another student if necessary.

When the comprehensive exam was completed, James presented Ms. Williams with her treatment plan. He explained that she could have the lesion on No. 8 treated "free of charge" if she agreed to sit for his board examination the next week. He also told her he would pay her an additional $200 "for her troubles" if she agreed to help him out with this important exam. He admitted to her that there would be no time to treat her sensitive tooth (No. 31) prior to the boards, but he promised he would get to it the week following the exam.

Ms. Williams felt fortunate to not only get a free restoration and possibly a free cleaning, but also to be paid for her time. Moreover, the sensitivity on tooth No. 31 was only there when eating or drinking cold foods. It hadn't really been bothering her long, and she thought she could put up with the pain for a while longer, at least until James would have time to see her.

When James explained the fees for the rest of the treatment, however, she was a bit disappointed. The total treatment plan cost was more than she could afford. The $200 she would receive for participating in the dental board exam would barely cover treatment of the painful tooth. Nevertheless, she was grateful that one filling would be done for free. All things considered, it seemed like a win-win situation for both of them. Ms. Williams agreed to sit for James' board exam. James emphasized the importance of Ms. Williams coming to the appointment and being there on time.

The day of the board exam arrived, and Ms. Williams was there bright and early. Immediately upon her arrival at the school, she could feel the tension in the air. The board candidates were nervous and the atmosphere was different than what she had experienced during her initial exam. James greeted her and escorted her into the clinic. As he sat her down in the dental chair, he said, "Thanks again for coming. My future depends on this examination, so I really appreciate your help." Ms. Williams began to feel uncomfortable. She realized that she had no idea what she was getting herself into when she agreed to do this. Would there be any faculty supervision for this "test"? What if something went wrong? She wanted to rethink her decision to participate, but felt it was too late. She knew that she had already paid for the X-rays and comprehensive examination, and there was no other way she was going to get care elsewhere because she couldn't afford it. James nervously administered the anesthetic.

What's wrong with this picture?

Using live patients for dental licensure exams has been debated for decades. Dental educators find that the exam experience is seldom positive, is sometimes tolerable, but is usually problematic for a number of reasons which are central to dentistry's professional values. Dental educators teach students to consider a patient's overall oral health when planning treatment, and to work on creating long-term partnerships with their patients. During licensing exams, they see this treatment model distorted. They not only witness the difficulty that board exam candidates have with finding "suitable" patients for the clinical boards, but are also supposed to assist them in the process. Sadly, in the course of finding and managing clinical

board patients, ethical lapses can occur.[1,2] While the exact frequency of ethical missteps related to licensing exams is hard to quantify, having any ethical problems associated with a part of dentistry's educational process should be a matter of grave concern. The licensing process itself appears to set up a situation for ethically problematic behavior to occur: the nature of the exam is not conducive to comprehensive care, and the stakes are extremely high. Did James do anything wrong in the way he handled Ms. Williams and this situation? Could he have managed the case differently? This case illustrates just some of the ethical issues of concern when using live patients for dental licensure examinations.

Approximately 5000 new dentists graduate from dental schools in the United States and Puerto Rico every year.[3] The vast majority of these students will take a patient-based licensure exam. The scenario we describe in this case could occur in dental schools across the nation every year and we, as a profession, permit this process.

There was a time when dentistry was unregulated and nonstandardized. Anyone with an interest and a few tools could call themselves a dentist. During this period, from approximately the mid-1600s to the mid-1800s, on-the-job apprenticeships or proprietary schools were the way "dentists" were educated.[4] Without standardized training, the public was at risk and needed protection against incompetent practitioners. The first dental practice acts appeared in 1868 in Kentucky, New York, and Ohio. Licenses were issued automatically to dental school graduates.[4] Over time, licensing became more sophisticated and standardized. In 1933, the first Dental National Board Examination was issued and with it came the birth of modern day dental licensing and professional regulation.[4]

Dentistry needed this regulation to protect the public and the profession back then, and while the protection of the public is always a concern and one of the functions of professional self-regulation, it is hard to justify the use of live patient examinations in obtaining this goal. Dental schools are highly regulated and standardized. Accreditation by the Commission on Dental Accreditation (CODA) sets high standards for dental education, and closely regulates both the curriculum and educational outcomes. Change in the way we grant initial licensure is long overdue. In 2003, Dr. Arthur Dugoni stated:

> *The dental schools of this country are charged with educating a competent practitioner and this is evaluated regularly by the Commission on Dental Accreditation and by the student's passage of Part I and Part II of the National Boards. I believe that this state (California) and this nation would be better served by the elimination of initial licensure examinations, and granting licensure to graduates who have passed Part I and Part II of the National Boards, and have been certified as competent by the deans and faculty of their respective schools.*[5]

California now offers an alternative route to initial licensure that does not involve the use of live patients in a clinical examination.[6] The American Dental Association (ADA) and the American Dental Educators Association (ADEA) have also both passed resolutions to eliminate the use of live patients in the initial clinical licensure examination process—the ADA in 2000 and 2005, and the ADEA in 2011—so why is the profession still allowing live patient exams?[7-9]

In this case, James is only doing what he needs to do in order to navigate the patient-based clinical licensure examination system. James did not fail ethically; the exam failed him. The first failure came when James was forced to try and find a suitable patient for the exam. The exam forced him to treat patients not as recipients of oral health care, but as objects needed to complete an exam. Thus, "hovering" in the radiology department to find a patient with a "perfect lesion" is a violation of the principles of *respect for autonomy* and *justice* for the patients in question.[10,11] Without the patients' knowledge, James is rummaging through records to find lesions that will serve his purpose. This exercise blinds him to the patients whose radiographs indicate that they are in desperate need of treatment; James is *only* concerned about patients who will serve *his* needs right now; he has tunnel vision for the upcoming exam requirements. The fiduciary underpinning needed for a professional relationship takes a back seat to the licensing examination.

Concerns about the risks of exam candidates performing potentially unnecessary treatment or providing treatment outside of a comprehensive treatment plan are discussed in the literature.[1,2,10] In this case, James finds a lesion that is clinically acceptable for his exam, but is this lesion one that should be restored at all? Ms. Williams is a healthy 23-year-old female whom James is meeting for the first time. He has no prior radiographs on her to know whether or not this lesion is arrested or if there are active caries, and this is important, because an arrested lesion should not be restored. He has also not worked with her enough to know about her oral health habits, or how compliant she has been—or will be—with treatment. He chooses to prepare and restore tooth No. 8, an incipient class III lesion, over the larger lesion on tooth No. 10, which in private practice (and in a comprehensive care model for a regular dental school clinic patient), would normally be given priority. If James were to attempt to restore tooth No. 10 for his exam, the caries on this tooth may dictate a preparation that is larger than the exam-defined "ideal," and cause him to fail for not following proper exam protocol. This scenario could happen if an unexpected complication occurs and his nerves get the best of him. James knows he is capable of managing any carious lesion at this point in his young career, but for this exam, he needs to minimize the chances of anything going wrong, because the stress will be high enough already due to the high stakes nature of the exam. Again, unlike what his professors have taught him since he arrived at school, the underlying message is that the live patient exam has its own set of rules.

Possibly the worst aspect of this case is that James is postponing the treatment of the painful tooth No. 31—the chief complaint—so that he can restore tooth No. 8 for his exam, despite the fact that tooth No. 8 arguably does not need treatment at all. Furthermore, by restoring tooth No. 8, James has now committed Ms. Williams to a restoration on tooth No. 8 for the rest of her life. Concerns have been raised that delaying treatment or "shelving" patients in order to have them available for licensure exams are encouraged by live patient exams.[1,2,12] Again, is this the message that we wish to give young professionals as they enter their lives of service to the dental profession?

Other ethically problematic actions that this case illuminates are the potential for subtle patient coercion or manipulation to participate, along with problems in getting a fully informed consent to treatment.[1,2,10-12] In this case, Ms. Williams admittedly has limited funds available for dental care. Many patients come to dental schools seeking care for that reason. Ms. Williams may not understand the difference between an incipient lesion and one that is larger; she only knows she has some "cavities" that need to be restored. She believes the benefit to her participation in the board exam is the free filling, possibly a free cleaning, and the $200. She has no idea that tooth No. 8 may not need a restoration at all. James can rationalize paying her the $200 because it would help her to pay for her filling on tooth No. 31 if she wishes, or enable her to buy something else she may need or want. On the surface, James believes he is doing her a service, as well as furthering his own goals. Helping Ms. Williams pay for her needed dental work may appear altruistic, but is it really a beneficent act? Vulnerable patients such as Ms. Williams, who are economically challenged and in acute need of services, may feel pressured when making treatment decisions. There are also subtle social pressures that patients can experience when they learn of the student's situation and their desperation to find patients.

Convincing patients to accept certain treatments undermines the informed consent process and can take advantage of the patient's vulnerable state.[11] In this case, Ms. Williams has convinced herself that her pain in tooth No. 31 is not that bad, and she can wait in order to receive the free restoration and the $200. Importantly, informed consent should be a product of a dentist-patient relationship where treatment decisions are made with the desired outcome being the best oral health care for the patient. In the case of live patient board exams, this goal is distorted. Even if the patient benefits from the treatment, their oral health needs are not the priority in this examination. Again, this is contrary to what dental students are taught throughout their dental school education.

Another ethical consideration for patients participating in clinical board exams is the stressful atmosphere of the exam itself. This high stress environment can deleteriously affect a student's performance, and can also affect the patient's experience of the appointment.[1,2,10] As described above, Ms. Williams could "feel the tension in the air." The high stakes nature of the exam puts the candidate under a lot of pressure to pass. Failing, along with causing great personal disappointment and shame, can mean thousands of dollars to retake the exam, facing the daunting task of finding more qualified patients, and delaying the start of a residency program or job. With Damocles' sword dangling in the background, we ask the most inexperienced members of the profession to perform delicate, irreversible procedures on live patients. This situation is hard for dental students, but more seriously, shows a lack for respect for their patients.

Does the use of live patients for clinical licensure exams treat patients like "guinea pigs?"[11] Patients have irreversible procedures performed on them by students, without customary levels of supervision, in an atmosphere where the candidate would rather be anywhere but there treating that patient! It is uncomfortable for patients to spend hours in a tense environment, sitting with a rubber dam in their mouth, having work performed on them by an unlicensed individual. As Chiodo & Tolle so eloquently stated in 1996, "A patient treated like this in a dental practice probably would not return to that provider. In fact, the sequence of treatment during the state board examination, if repeated in private practice, would border on malpractice."[13] Again, if our goal is to teach students about the need for comprehensive and informed treatment, and the importance of developing a patient-dentist partnership aimed at the patient's optimal oral health, this picture is far from that ideal.

Those in our profession who remain in favor of using live patients in clinical dental licensure examinations will argue that the perceived ethical issues involved in conducting such exams are necessary for ensuring the safe practice of dentistry for our citizens. They hold that third party examiners and live patients are essential to the process, and graduation from an accredited dental school alone is not enough to safeguard the public.[14,15] It's important to think clearly about this issue. The profession has an interest in making sure all dentists are competent, but that does not justify the use of any means to obtain this outcome. Alternative ways to ensure students' competence have been suggested. Moreover, there are questions as to whether the use of live patients in dental board exams actually effectively assesses student competency and protects the public. In fact, the "snapshot in time" approach to testing has been accused of being unreliable, invalid, and inconsistent across the different testing agencies.[16-19] There is a need for alternative mechanisms to be explored and their outcomes tested.

The time has come for our profession to deal once and for all with the problems the licensure process creates, and to devise a new, nationally accepted means to ensure that dental graduates are competent and safe dental practitioners. While some states are making significant strides in that direction, the wheels are turning slowly. Dentists are trusted professionals because they put their patients first. It's our responsibility as a profession to make it happen now. We owe it to ourselves, our future colleagues, our dental schools, and the public. Are you with us?

Author information

Dr. Roucka is a Fellow of the American College of Dentists, is President-elect of the American Society for Dental Ethics, and has an M.A. in Bioethics from the Medical College of Wisconsin. She is currently an assistant professor and program director, General Dentistry, Marquette University School of Dentistry, Milwaukee, Wisconsin. Dr. Donate-Bartfield has a Ph.D. in clinical psychology from the University of Wisconsin-Milwaukee, and an M.A. in Bioethics from the Medical College of Wisconsin. She teaches Behavioral Sciences at the Marquette University School of Dentistry.

References

1. Feil P, Meeske J, Fortman J. Knowledge of ethical lapses and other experiences on clinical licensure examinations. *J Dent Educ.* 1999;63(6):453-458.
2. Buchanan RA. Problems related to the use of human subjects in clinical evaluation/responsibility for follow-up care. *J Dent Educ.* 1991;55(12):797-801.
3. American Dental Association 2010-11 Survey of Dental Education, Academic Programs, Enrollment and Graduates - Volume 1. 2012:48.
4. Dugoni A. Licensure and credentialing--position paper. *J Dent Educ.* 1991;55(12):789-791.

5. Dugoni A. Protection of the public. *J Calif Dent Assoc.* 2003;31(11):801-803.
6. Dental Board of California. How to Become a Licensed Dentist in California. Available at: http://www.dbc.ca.gov/applicants/dds/become_licensed.shtml. Accessed June 17, 2013.
7. American Dental Association, Ethical Considerations When Using Patients in the Examination Process. Available at: http://www.ada.org/sections/educationAndCareers/pdfs/ethics_clinical_exam.pdf. Accessed June 17, 2013.
8. Valachovic R, American Dental Education Association. Making Waves, One State at a Time. Charting Progress. 2011. Available at: http://www.adea.org/uploadedFiles/ADEA/Content_Conversion_Final/about_adea/ADEA_CP_July_2011.pdf. Accessed June 17, 2013.
9. American Dental Association, Clinical license exam process eyed. 2010. Available at: http://www.ada.org/news/3915.aspx. Accessed June 13, 2013.
10. Hasegawa TK. Ethical issues of performing invasive/irreversible dental treatment for purposes of licensure. *J Am Coll Dent.* 2002;69(2):43-46.
11. Hasegawa TK Jr, Matthews M Jr. Dental clinical examining board dilemma. *Tex Dent J.* 1995;112(12):44-46.
12. Formicola AJ, Shub JL, Murphy FJ. Banning live patients as test subjects on licensing examinations. *J Dent Educ.* 2002;66(5):605-609; discussion 610-611.
13. Chiodo GT, Tolle SW. An ethics perspective on licensure by state board examinations. *Gen Dent.* 1996;44(1):18-20, 22, 24-25.
14. Cole JR 2nd, Maitland, RI. A response from the American Association of Dental Examiners. *J Am Coll Dent.* 2002;69(2):47-49.
15. American Association of Dental Examiners. The impact of the elimination of the use of human subjects in the clinical licensure examination process by 2005 from the dental and dental hygiene licensure communities' perspective. A position statement of the American Association of Dental Examiners in response to ADA Resolution 64H. 2001. Available at: https://www.dentalboards.org/positionstatements/LivePatient.pdf. Accessed June 13, 2013.
16. Ranney RR, Gunsolley JC, Miller LS, Wood M. The relationship between performance in a dental school and performance on a clinical examination for licensure: a nine-year study. *J Am Dent Assoc.* 2004;135(8):1146-1153.
17. Ranney RR. What the available evidence on clinical licensure exams shows. *J Evid Based Dent Pract.* 2006;6(1):148-154.
18. Chambers DW. Board-to-board consistency in initial dental licensure examinations. *J Dent Educ.* 2011;75(10):1310-1315.
19. Jenson LE. Is it ethical to involve patients in state board examinations? *J Am Coll Dent.* 2002;69(2):39-42.

Parental presence

Jane A. Soxman, DDS, Diplomate, ABPD

Is parental presence during children's dental appointments a good idea or not? That is the question. Children under 4 will most likely fare better with parents alongside them as they undergo dental treatment. After age 4, most children can comfortably separate from the parent for treatment. Ultimately, the decision will be made according to your preference or your feelings regarding the benefit of being or not being present. Many dentists have a distinct preference for parental presence. I have found that not only restorative, but also preventive care visits typically go more smoothly, and are completed in less time, without the distraction of a parent. If you choose to have a parent accompany a child, ground rules need to be established prior to the appointment. The parent should have a clear understanding of your individual preferences. Parents who are coming from another practice may have routinely accompanied the child for treatment and naturally expect to be present. Parents are always present for a medical appointment, so many believe that their presence is also expected during the dental visit. The decision depends on the parents: there are those who choose not to be present, and others who demand to attend treatment.

I have found that an *undivided attention* explanation is the most acceptable reason for parents to remain in the reception room. I tell the parent that we want to give their child our undivided attention, and that we want the child's undivided attention. The door to the room where the child is getting treatment will remain open, and the parent can briefly, quietly check on the child, as long as the child does not see the parent. I stress that if I feel the parent's presence would be beneficial, the parent will be invited to accompany the child for the procedure. Any time a child is crying loudly, and can be heard in the reception room, the parent is brought into the room so that he or she can see what is occurring. A child crying can be upsetting, not only to the parent, but also to any other parent or child in the reception area. Hysterical children or strong avoidance behavior may also require parental involvement.

Whether to separate the parent and child in the reception room, or after the child is seated for treatment, is also an individual preference. In my experience, I have found separating in the reception room is the better choice. I tell parents that when the child is permitted to separate, two inferences are made to the child: first, that the parent trusts the dentist and staff, and second, that the parent believes that the child is capable of undergoing treatment without the parent present.

Contemporary parents often play an active role in their children's lives, sharing most experiences with their children. They want to see firsthand what is occurring. Parental presence may provide an opportunity for more explanation and a relaxed conversation if the child's behavior permits. Increased familiarity with dental procedures usually results in decreased parental apprehension; that translates to the child. Additionally, the parent may gain an appreciation for the challenges of managing a fearful child or a child with strong avoidance behavior. A parent experiencing an over-reaction by the child, such as when a child says "ouch" when he or she is only being gently touched with a gloved hand, better understands that even with minimal stimulation, anxiety or apprehension may elicit an unwarranted reaction.

If a parent does accompany the child at the treatment, I tell him or her, "You are my Silent Partner and your mere presence will provide support." Discuss the silent cues of distress in the parent's body language that should be avoided. A parent should not raise his or her voice in an attempt to be heard by a child who is crying or loudly protesting. When they're with the child during treatment, parents are not permitted to use cell phones. Parents are not to repeat our requests to the child, nor are they to make any statement about the procedure's length of time. After informed consent is obtained, a parent who is present may assist with immobilization, if necessary.

Noncompliance with the discussed expectations, or overt anxiety on the part of the parent may suggest that the other parent may fare better. As a rule, fathers typically do better with compliance and a "you can do it" attitude. I have been amazed by the differences in behavior depending on the accompanying parent. If things are going well with the parent who has been with the child for treatment, compliment his or her teamwork, enhancing our success for a less stressful visit for the child. Invite him or her to return for the next visit to ensure continuing familiarity and consistency. A parent's frame of mind typically has a profound influence, not only on the child's comfort level, but also on whether or not the procedure will be completed. Only one parent may accompany the child during the treatment. This policy may avoid parents disagreeing and talking, as well as a general state of disruption.

Parents of children with special needs may offer methods to achieve cooperation or cues for tolerance level, especially for autistic children. For any age, a parent may want to be present for the first visit in your practice, particularly if previous dental visits have been difficult. Some children may be much older for a first visit, having no prior experience with any dental office, so this parent may wish to accompany his or her child during the treatment.

Although the majority of parents prefer to be present, some do not. Before going into a long dissertation about your guidelines for parental presence, ask how the parent feels about being present for treatment. After a few visits, many parents are comfortable with permitting the child to separate in the reception room or will accompany the child at the beginning of the treatment, and then return to the reception room after administration of local anesthesia.

If a parent is present and things are rapidly going south due to the parent's constant interjections, comments, talking on a cell phone, or if the parent becomes the "court of appeals" with a litany of back and forth bargaining and manipulation,

a predetermined plan should be in place for the parent to leave the room. A statement such as, "Mommy is going to go out and look at a magazine now," or another previously discussed gesture may be used. The front desk or other staff should be aware of this possibility and accompany the parent to the reception room if there is any hesitation, assuring the parent that the child is in good hands. Sometimes the receptionist must be the gatekeeper, distracting parents or involving them in conversation.

A cooperative child who is undergoing treatment without a parent present can demonstrate or "model" for a parent who feels the child cannot cooperate for treatment without their presence. This modeling requires permission from the parent of the child who is modeling.

Establishing trust is paramount. Communication builds trust. The practice philosophy regarding parental presence may be provided in a simply stated and brief written form. If this information is also verbally supported by the dentist, it is much more likely to be understood and compliance is increased.

Parental presence often requires as much guidance as treating and guiding the behavior of a child. Taking care of the developing psyche is our greatest obligation to our youngest patients, but taking care of the parents is also essential, and often the key to a successful visit.

Author information

Dr. Soxman is a general practice residency seminar instructor, and maintains a private practice in Allison Park, Pennsylvania.

Minimally invasive dentistry and its impact on esthetic restorative dentistry

Wynn H. Okuda, DMD, FICD, FICOI

One of the goals of dentistry is to develop new approaches in restorative dentistry that will reduce the amount of tooth removal during treatment. With advances in material science and restorative techniques, we are able to attain these ideals and recreate nature with minimal removal of tooth structure. The latest developments in minimally invasive dentistry (MID) and its impact on esthetic restorative dentistry will be discussed (Fig. 1 and 2).

Current advances in minimal intervention esthetics

The most conservative of all esthetic restorative procedures is one that involves no tooth removal at all. Minor blemishes on smooth surfaces of facial enamel can be an esthetic problem depending on the severity. From decalcification and enamel mottling to congenital defects, interference in the formation of enamel and/or demineralization of the enamel matrix can result in an unaesthetic appearance of the smile and dentition.[1]

Normal enamel has the appearance of a lustrous surface that reflects light from the surface and subsurface. Along with that, different aspects of tooth structure will reflect, refract, and absorb wavelengths of light at different degrees. However the reflection and scattering of light from the surface and the subsurface should be relatively the same.[2,3] When this is the case, the enamel and the dentition will have a natural appearance. The appearance of the teeth is altered when there is a disturbance in the enamel matrix.

There are now several choices for correction of decalcified enamel and unaesthetic white spots. Enamel microabrasion and remineralization techniques using Recaldent CPP-ACP (such as MI Paste and MI Paste Plus, GC America, Inc.) has proven to be a minimally invasive approach to corrections.[4-6] The developments in micro-invasive technology allows for minimally invasive treatment of these lesions (Fig. 3 and 4). In addition, for treatment of enamel decalcification and incipient decay—up to the first third of dentin—infiltration therapy can be used to reinforce demineralized areas through the capillary action of resin (such as Icon, DMG America).[7-9] This modality of treatment assists in restoring decalcified enamel. The infiltration of resin impregnates the voids left by the decalcification and aids in restoring the optical nature of the treated area resulting in a natural esthetic result, without any tooth removal.

For carious lesions that go beyond the incipient stage, minimally invasive treatments are available for correction as well. Using the latest in composite resin technology, minimally invasive correction of Class I, II, III, IV, and V lesions is now attainable. In addition, with the latest generation of nanohybrid composite resin, long-lasting composite resin veneer restorations that mimic the strength and beauty of natural dentition can be attained.[10]

One of the challenges of esthetic dentistry is the creation of predictable color harmony between the restorative material and natural tooth structure. In natural dentition, different aspects of tooth structure will reflect, refract and absorb wavelengths of light at different degrees (such as enamel rods, dentinal tubules, dentin-enamel junction, etc.) Therefore, for an esthetic material to be successful, it must reflect, refract, and absorb light similar to tooth structure.[11,12]

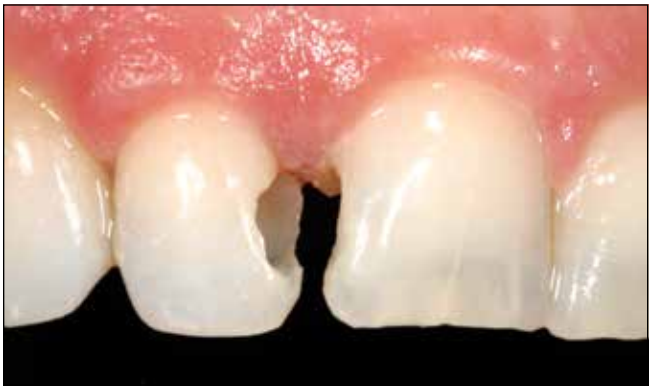


Fig. 1. Patient presents with missing restorations in central and lateral incisors.

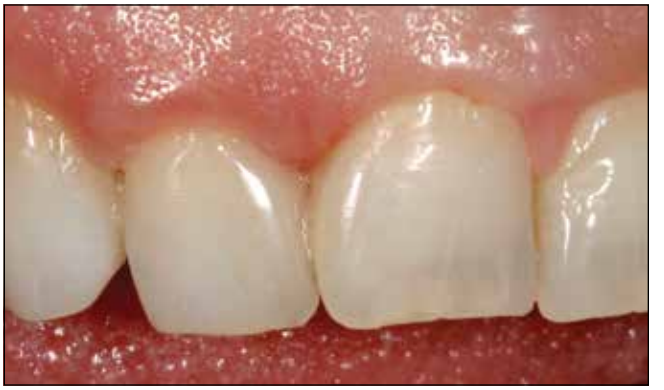


Fig. 2. Composite resin restorations can exhibit great chameleon effect, color blending, and improved esthetics.

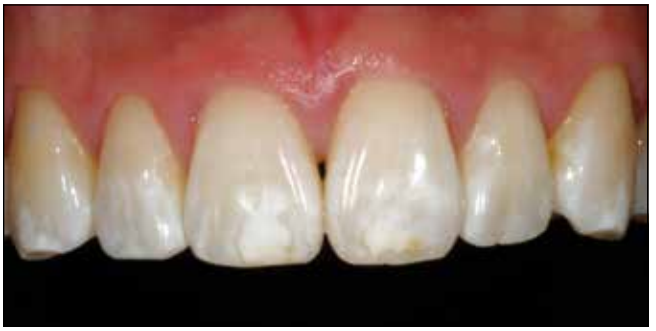


Fig. 3. Dentition affected by moderate decalcification of anterior teeth.

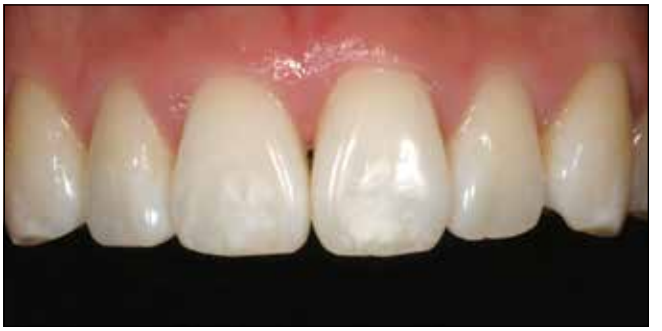


Fig. 4. Natural recalcification of dentition achieved.

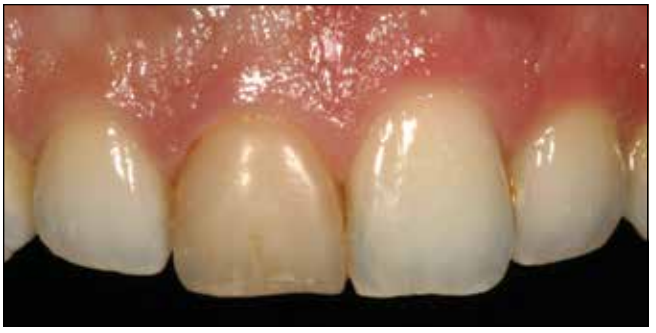


Fig. 5. A failing composite restoration along the central incisor (tooth No. 8).

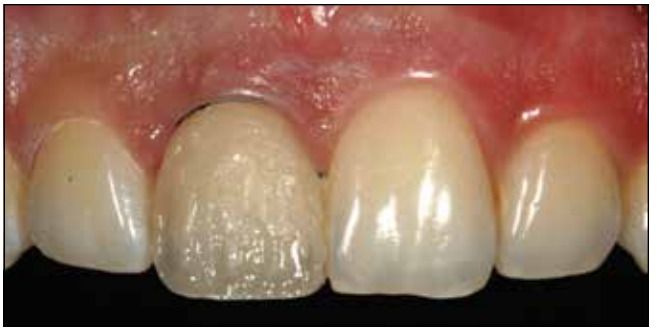


Fig. 6. Internal anatomy sculpted to create a natural characterization.

When the composite resin is able to match the optical properties of the surrounding teeth, a chameleon effect is achieved that renders the restoration "invisible." The latest nanohybrid composite resins (such as Kalore, GC America, Inc.; Renamel Universal, Cosmedent; and Esthelite Sigma, Tokuyama Dental America, Inc.) achieve great success because the physical properties mimic the properties exhibited by natural dentition.

Minimally invasive dentistry application

Case study

A 26-year-old male patient presented with a failing composite resin restoration on the central incisor (tooth No. 8) (Fig. 5). It was proposed to have a composite resin veneer restoration placed, using an MID approach.

There are several factors necessary to attain a successful composite resin restoration. Proper understanding of composite resin shade selection, and preparation design and sequence of composite resin layering are important in attaining an accurate blending of the composite resin to the existing tooth. A correct finishing and polishing technique is equally essential in obtaining optimal esthetic results.[13,14]

Shade selection is always done prior to start of treatment. This allows for the proper shade layering sequence. Several composite resin shades were directly placed on the tooth to determine colors that would best match the adjacent teeth.

Total removal of the failing restoration and decay was performed. For minimally invasive purposes, a caries detector (Caries Detector, Kuraray America, Inc.) was used only to remove the infected caries. Minimally invasive burs (Micro Prep Kit, Komet USA, LLC) were used, as they are important to minimize tooth removal. A slight chamfer margin was created along the free gingival margin, so that optimal blending could be attained.

Prior to bonding and to restoring the tooth, the enamel was etched with 37% phosphoric acid (Select HV Etch, Bisco, Inc.). A dentinal adhesive (All Bond SE, Bisco, Inc.) was placed, blown thin for 10 seconds with compressed air, and light cured for 20 seconds. Using one of the latest generation of nanohybrid composite resins (Kalore) a sequence of composite resin layering was done to create a natural depth of shade that mimics the adjacent central incisor. To eliminate the shine-through of light, an opacious dentin shade (A-02, Kalore) was placed in areas where dentin was lost. Then, using a freehand sculpt technique, universal shade A-1 was carefully sculpted over the opacious dentin shade, with an emphasis of placing internal anatomy to simulate natural dentition (Fig. 6). After placement of subtle characterizations with tints and color modifiers (Kolor + Plus, Kerr Corporation), a neutral translucency (Kalore NT) was used as the final layer.[15,16]

After final light curing, esthetic contours were refined using aluminum oxide finishing discs (Sof-Lex, 3M ESPE) and composite finishing burs (Q-Finishers, Komet USA, LLC) (Fig. 7). Finally, a micro-diamond polishing paste (Diamond Polish, Ultradent Products, Inc.) brought out the surface luster of the nanohybrid

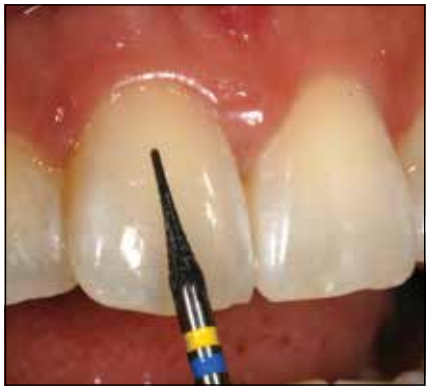


Fig. 7. Finishing with aluminum oxide discs and finishing burs.

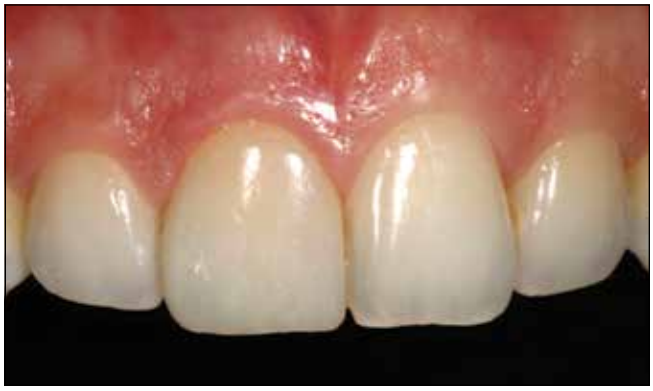


Fig. 8. Using the correct principles of color selection, prep design, color layering, characterization, finishing, and polishing, esthetic success can be achieved with composite resin veneer restorations.

composite resin veneer. By using proper technique and state-of-the-art dental materials, natural color, contour, and finish were achieved (Fig. 8).

Conclusion

In the development of MID, it is important to explore progressive ideas in order to preserve the natural dentition. With advances in innovative materials, new and improved clinical techniques are developed to elevate patient care. These tooth-conserving methods could replace traditional treatment as a new standard in restorative care. Using a creative approach to dentistry helps us provide our patients with new levels of excellence.

Author information

Dr. Okuda is an international speaker on the topic of cosmetic dentistry and the founder of the *Okuda Educational Institute for Innovative Dentistry* in Honolulu, Hawaii, where he also has a private practice.

References

1. Mount GJ, Ngo H. Minimal intervention: a new concept for operative dentistry. *Quintessence Int.* 2000; 31(8):527-533.
2. Sieber C. Voyage: visions in color and form. *Quintessence Int.* 1991;22:775-782.
3. Ubassy G. *Shape and Color: The Key to Successful Ceramic Restorations.* Hanover Park, IL: Quintessence Publishing Co., Inc.;1993.
4. Muia PJ. *The Four-Dimensional Tooth Color System.* Hanover Park, IL: Quintessence Publishing Co., Inc.;1985.
5. Reynolds EC. Remineralization of enamel subsurface lesions by casein phosphopeptide-stabilized calcium phosphate solutions. *J Dent Res.* 1997;76(9):1587-1595.
6. Sato T, Yamanaka K, Yoshi E. The caries prevention potential of a tooth-coating material containing casein phosphopeptide–amorphous calcium phosphate (CPP-ACP) [abstract]. IADR General Session, Goteborg, Sweden. 2003:100.
7. Reynolds EC, Cain CJ. Webber FL, et al. Anticariogenicity of calcium phosphate complexes of tryptic casein phosphopeptides in the rat. *J Dent Res.* 1995;74(6): 1272-1279.
8. Meyer-Lueckel H, Paris S. Improved resin infiltration of natural caries lesions. *J Dent Res.* 2008;87(12):1112-1116.
9. Garcia-Godoy F, Summitt JB, Donly KJ. Caries progression of white spot lesions sealed with an unfilled resin. *J Clin Pediatr Dent.* 1997;21(2):141-143.
10. Paris S, Meyer-Lueckel H, Kielbasa AM. Resin infiltration of natural caries lesions. *J Dent Res.* 2007;86(7): 662-666.
11. Mitra SB, Wu D, Holmes BN. An application of nanotechnology in advanced dental materials. *J Am Dent Assoc.* 2003;134(10):1382-1390.
12. Terry DA. Direct reconstruction of the maxillary anterior dentition with composite resin: a case report. *Pract Periodontics Aesthet Dent.* 1999; 11(3):361-367; quiz 368.
13. Duarte S Jr, Perdigao J, Lopes M. Composite resin restorations—natural aesthetic and dynamics of light. *Pract Proced Aesthet Dent.* 2003;15(9):657-664; quiz 666.
14. Fahl N Jr, Swift EJ Jr. The invisible Class IV restoration. *J Esthet Dent.* 1989;1(4):111-113.
15. Fahl N Jr, Denehy GE, Jackson RD. Protocol for predictable restoration of anterior teeth with composite resins. *Pract Perio Aesthet Dent.* 1995;7(8):13-21.
16. Crispin BJ, Hobo S, Hewlett ER, et al. *Contemporary Esthetic Dentistry: Practice Fundamentals.* Hanover Park, IL: Quintessence Publishing Co., Inc.;1994.

Manufacturers

Bisco, Inc., Schaumburg, IL
800.247.3368, www.bisco.inc.com

Cosmedent, Chicago, IL
800.6216729, www.cosmedent.com

DMG America, Englewood, NJ
800.662.6383, www.dmg-america.com

GC America, Inc., Alsip, IL
800.323.7063, www.gcamerica.com

Kerr Corporation, Orange, CA
800.537.7123, www.kerrdental.com

Komet USA, LLC, Rock Hill, SC
888.566.3887, www.kometusa.com

Kuraray America, Inc., New York, NY
800.879.1676, www.kuraraydental.com

Tokuyama Dental America, Inc., Encinitas, CA
877.378.3548, www.tokuyama-us.com

Ultradent Products, Inc., South Jordan, UT
888.230.1420, www.ultradent.com

3M ESPE, St. Paul, MN
888.364.3577, solutions.3m.com

Pyogenic granuloma on the tongue: a pediatric case report

Marcos Ximenes, MSc ▪ Thaisa C. Triches, MSc ▪ Mariane Cardoso, MSc, PhD ▪ Michele Bolan, MSc, PhD

Pyogenic granuloma (PG) is a rare, benign, vascular, hyperplasic, soft tissue lesion caused by diverse factors, including traumatic injuries. This article presents a case involving the surgical removal of PG on the tongue of a 4-year-old boy who had difficulty with speech and eating because of the tongue lesion. The parents reported that the child had the habit of nibbling on and sucking his tongue. The lesion was excised, and histopathological analysis confirmed the diagnosis of PG; however, because the child continued to nibble and suck on his tongue, the lesion recurred. A second surgery was performed with the same histopathological diagnosis. At a 1-year follow-up, the child had ceased his tongue habits, and no recurrence was seen.

Received: February 28, 2012
Accepted: June 27, 2012

Pyogenic granuloma (PG) is a rare, benign, vascular, hyperplasic, soft tissue lesion. It is characterized by a proliferative inflammatory reaction and is caused by various chronic, low-intensity factors, including traumatic injuries.[1-4] Clinically, characteristics of PG include a bump with soft consistency; and a painless, exophytic mass, generally with a smooth or lobular surface and sessile or pediculate insertion.[3,5] Multiple surrounding lesions may be present.[2] The color of PG ranges from pink to purplish red, with a tendency toward an ulcerated surface, depending on its location and exposure to traumatic irritation. Hemorrhaging may occur spontaneously or following slight trauma.[2,6]

The anterior gingival region is the location affected most frequently in the oral cavity; however, the tongue, mucosa and lips may be affected also.[1,2,6] Treatment consists of complete surgical excision and removal of local irritating factors.[1,7,8] A diagnosis of PG is only possible through a histopathological analysis of the biopsied tissue.[1,4,8]

This article presents a case involving the surgical removal and recurrence of a PG located on the dorsum of the tongue in a pediatric patient.

Case report

A 4-year-old boy presented with difficulty speaking, eating, and chewing due to a lesion on the tongue. The clinical examination revealed the presence of an exophytic lesion on the right side of the dorsum of the tongue, with a lobular surface, sessile base, well-defined borders, and a verrucous, erythematous appearance (Fig. 1). Patient history revealed that the child exhibited good general and oral health, but had the habit of biting and sucking on his tongue.

Treatment involved the surgical removal of the lesion under local anesthesia and orientation regarding abandoning the habits of biting and sucking on his tongue. After the lesion was excised, the material collected (measuring 8 mm x 6 mm x 4 mm) was taken for an anatomopathological examination.

Microscopically, the lesion consisted of a mucosal fragment lined with parakeratinized stratified squamous epithelium with areas of acanthosis (Fig. 2). A proliferation of endothelial cells and neovessels was observed in the lamina propria in association with the intensive inflammatory infiltration of mono- and polymorphonucleated leukocytes. Areas of hemorrhaging confirmed the histological diagnosis of PG.

Due to the persistence of the patient's tongue habits, the lesion recurred (Fig. 3) after 1 month and another surgery was performed. The material was sent for histopathological analysis, which revealed a fragment of mucosa. This fragment was lined partially with a squamous epithelium that had an area ulceration covered with fibrino-leukocyte exudate. In the connective tissue of the lamina propria, lobular aggregations of endothelial cells formed small capillary vessels associated with the inflammatory infiltration of mononucleated leukocytes; there also were polymorphonucleated leukocytes in the region of the ulcer. The lesion was diagnosed as a recurrence of PG.

The patient received psychological orientation regarding his tongue-biting habit. At a clinical follow-up 1 year after this second surgery, the patient had abandoned his habit and there was no sign of lesion recurrence. The tongue exhibited a regular shape with a normal surface and no signs of alteration (Fig. 4).

Discussion

PG occurs most frequently between the second and third decades of life.[4-6] The incidence of PG is higher among females; this is attributed to hormonal alterations that occur mainly during pregnancy and menopause.[1-3]

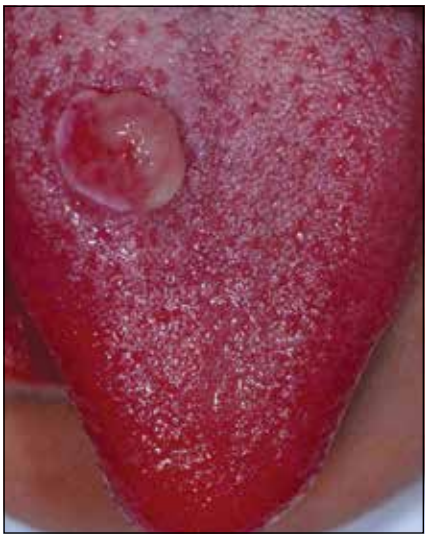


Fig. 1. An exophytic lesion on the right side of the dorsum of the tongue.

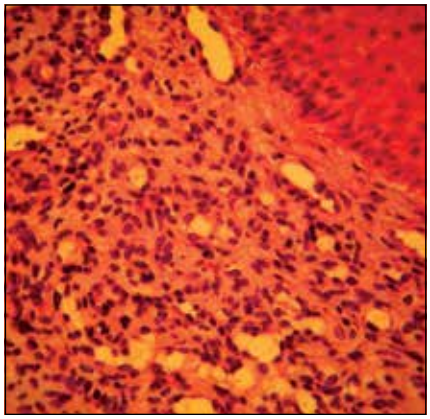


Fig. 2. Endothelial cell proliferation and neovascularization with intense inflammatory infiltration of leukocytes (H&E staining; original magnification 400X).

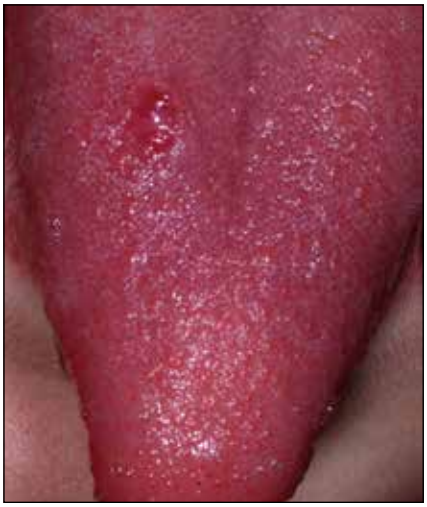


Fig. 3. A recurrence of the lesion on the tongue 1 month after the initial excision. The lesion has the same clinical characteristics as the previous injury.

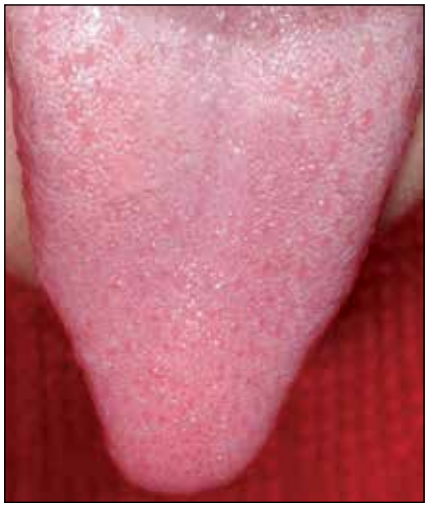


Fig. 4. The patient's tongue at a follow-up examination 1 year after the second surgery.

In the present study, the PG was on the dorsum of the tongue of a 4-year-old boy. Oral PG is well-documented in the literature, however, its occurrence on the tongue in children is rare and often has an atypical appearance from a lesion on the gums and on other parts of the body, due to the tongue being more vascularized.[3] There is a consensus in the literature that trauma is the main etiological factor of oral PG, which is characterized as a reactive lesion.[1,9] In the present case, the lesion appeared a number of weeks after the child had developed the harmful habit of biting and sucking his own tongue.

Local irritation as the likely cause of PG suggests a number of situations that are common to the oral cavity, including trauma from brushing, biofilm- and calculus-induced irritation, rough surfaces and prominent margins of restorations, natal and neonatal teeth, previous tooth extraction, exfoliating primary teeth, apical fenestration, and pacifier sucking.[2,5,6] However, the authors found no reports in which the local irritation was caused by the harmful habit of biting and sucking the tongue.

The clinical examination of the lesion suggested PG, which was confirmed by the histopathological analysis, corroborating the findings described by other authors.[1,2,4,6] Conditions that must be considered when making a differential diagnosis include inflammatory gingival hyperplasia, giant cell peripheral granuloma, capillary hemangioma, metastatic carcinoma, Kaposi's sarcoma, melanoma, lymphoma, hemangioendothelioma, hemangiopericytoma, leiomyoma, peripheral ossifying fibroma, infection by cytomegalovirus, and gingival lesions caused by bacilli.[1,5-9] These conditions were ruled out in the present case by histopathological analysis.

Microscopically, both of the lesions analyzed had similar characteristics that were typical of PG, such as an inflamed, vascularized area and intensive endothelial neoformation associated with granulation tissue. The difference between the patient's 2 lesions was the ulcerated surface on the second lesion due to his persistent tongue-sucking habit. Histologically, there was an absence of parakeratin and the presence of polymorphonucleated cells (neutrofils) in the second lesion, which indicated an acute inflammatory process. According to histological analysis, the first lesion showed a proliferation of endothelial cells and neo-vessels, while the recurrence exhibited only aggregated lobular endothelial cells forming small capillary vessels.

There are a number of treatment options for PG; the one most commonly employed is surgical excision performed at the base of the lesion with a margin of safety.[1,4,6-8] Surgical excision has a lower rate of recurrence; in addition, this method allows for histopathological analysis and can be performed on lesions of any size.[4,7,9] In the present study, surgical excision led to an immediate improvement and allowed the child to regain his speaking and eating habits.

Recurrence is rare (14%-16% of cases) and is related to the persistence of local irritating factors and the partial removal of the lesion.[3,7] Removing the base of the lesion and vigorous curettage of the granulation tissue are recommended, as is eliminating any local irritants to avoid recurrence.[7,8] The lesions can sclerotize if not excised completely; however, recurrence is rare, even in cases of incomplete excision.[10]

In the present case, the persistence of the patient's tongue-sucking habit led to the recurrence of a lesion with the same characteristics as the initial lesion. A second surgical intervention and psychological accompaniment proved effective, as there was no further recurrence at 1-year follow-up examination.

Summary

This case shows the efficacy of surgical removal of PG as a treatment, and highlights the importance of monitoring due to possible recurrences, especially those

patients that still have the presence of the etiology, which in this case was the habit of nibbling and sucking the tongue.

Author information

M. Ximenes and T. Triches are postgraduate students, School of Dentistry, Federal University of Santa Catarina, Brazil, where Drs. Cardoso and Bolan are professors, Pediatric Dentistry.

Acknowledgments

The authors wish to thank Dr. R. Areal for her valuable contribution in conducting psychological treatment for the patient and his family during the follow-up performed, and to Dr. A. Oenning for her help with the histopathological analysis.

References

1. das Chagas MS, Pinheiro Rdos S, Janini ME, Maia LC. Pyogenic granuloma: lobular capillary hemangioma in the upper lip of a 24-month-old child: case report. *J Dent Child.* 2009;76:237-240.
2. Epivatianos A, Antoniades D, Zaraboukas T, et al. Pyogenic granuloma of the oral cavity: Comparative study of its clinicopathological and immunohistochemical features. *Pathol Int.* 2005;55(7):391-397.
3. Jurkiewicz BD. Rare case of pyogenic granuloma of the tongue in an 8-week-old infant. *Eur Arch Otorhinolaryngol.* 2005;262(6):453-455.
4. Lin RL, Janniger CK. Pyogenic granuloma. *Cutis.* 2004; 74(4):229-233.
5. Aguilo L. Pyogenic granuloma subsequent to injury of primary tooth: a case report. *Int J Paediatr Dent.* 2002; 12(6):438-441.
6. Shenoy SS, Dinkar AD. Pyogenic granuloma associated with bone loss in an eight-year-old child: a case report. *J Indian Soc Pedod Prev Dent.* 2006;24(4):201-203.
7. Aguilo L, Bagan JV. Pyogenic granuloma subsequent to apical fenestration of a primary tooth. *J Am Dent Assoc.* 2002;133(5):599-602.
8. Ramirez K, Bruce G, Carpenter W. Pyogenic granuloma: case report in a 9-year-old girl. *Gen Dent.* 2002; 50(3):280-281.
9. Al-Khateeb T, Ababneh K. Oral pyogenic granuloma in Jordanians: a retrospective analysis of 108 cases. *J Oral Maxillofac Surg.* 2003;61(11):1285-1288.
10. Willies-Jacobo LJ, Isaacs H Jr, Stein MT. Pyogenic granuloma presenting as a congenital epulis. *Arch Pediatr Adolesc Med.* 2000;154(6):603-605.

Using a dental operating microscope for endodontic management of a mandibular central incisor with 3 root canals

Vijayakumar Aswinkumar, BDS ▪ Suresh Nandini, MDS ▪ Natanasabapathy Velmurgan, MDS

Endodontic management of teeth with aberrant root canal morphology can be challenging. This article presents a case in which multiple angulated radiographs and a dental operating microscope clearly revealed the presence of 3 root canals in a right mandibular central incisor with 2 different canal patterns. This case report emphasizes the importance of utilizing a dental operating microscope to understand unusual root canal morphology.

Received: October 14, 2012
Accepted: March 11, 2013

The success of endodontic therapy depends on the knowledge of root canal morphology and its variations.[1] The morphology of the permanent mandibular central incisor has been reviewed extensively in the literature.[1-5] The root canal anatomy of the mandibular central incisor usually has been described as a single root with a single canal. The most common variation involves the presence of an additional lingual canal, which has been reported in 26.0%-36.3% of cases.[4-6] The majority of these canals will join and exit through a single foramen.[1-3] A 1998 study by Mauger et al assessed the canal anatomy of 100 mandibular incisors at different root levels and reported that 98%-100% of the teeth had a single canal in the apical third.[7] Of the various comprehensive mandibular central incisor in vitro studies in the dental literature, only 2 have reported mandibular central incisors with 3 root canals.[1,5] Caliskan et al reported an incidence of 1.96% in 100 mandibular central incisors, while in a Turkish population study by Sert & Bayirli, of the 100 and 200 mandibular central incisors (separated by gender of subject) analyzed, the incidence of 3 root canals was reported to be 1.96% and 1.5%, respectively.[1,5] A thorough literature search revealed no clinical reports concerning mandibular incisors with 3 root canals.

This case report presents a case involving a mandibular central incisor with 3 root canals (type XV canal pattern) and its successful endodontic management with the aid of a dental operating microscope.

Case report

A 58-year-old female patient reported to the postgraduate clinic of the Department of Conservative Dentistry and Endodontics, Meenakshi Ammal Dental College, Chennai, India, with a chief complaint of pain in the anterior mandible. Patient history revealed dull, continuous pain in the right mandibular central and lateral incisors (teeth No. 25 and 26) for the past month. The patient's medical history was noncontributory. Clinical examination revealed that teeth No. 25 and 26 had a large proximal restoration and were tender on percussion. Palpation of the buccal and lingual aspect of the teeth did not reveal any tenderness. The teeth were not mobile and periodontal probing around the teeth was within physiological limits. No response was elicited in either tooth with an electronic pulp tester (Digitest, Parkell, Inc.) or a thermal pulp vitality testing method (DENTSPLY Maillefer). A preoperative radiograph revealed a large proximal restoration close to the pulp space, with periodontal ligament widening in relation to the right mandibular central and lateral incisors (Fig. 1). Based on clinical and radiographic findings, both teeth were diagnosed with pulpal necrosis and symptomatic apical periodontitis.

The teeth were anesthetized with 1.8 mL (30 mg) of 2% lignocaine containing 1:200,000 epinephrine (Xylocaine, AstraZeneca), followed by rubber dam isolation. Single buccal and lingual canals were identified in tooth No. 25 during access cavity preparation; however, examination with a surgical operating microscope (Seiler Revelation, Seiler Instrument, Inc.) revealed an additional canal between the buccal and the lingual canals (Fig. 2). Initially, this additional canal was negotiated using a C+ file ISO 8 (DENTSPLY Maillefer). An apex locator (Root ZX, J. Morita USA, Inc.) was used to determine the working length of each of the 3 canals; the lengths were later confirmed using a radiograph. Canals were then pre-enlarged, using 2% stainless steel hand K-files up to ISO 15 size (MANI, Inc). A WaveOne file (DENTSPLY Tulsa Dental Specialties) was used to clean and shape the root canals. Canals were irrigated with a 2.5% sodium hypochlorite and normal saline solution. Final irrigation was performed using a 17% EDTA solution. A calcium hydroxide paste was used as an intracanal medicament for 1 week.

The patient was found to be asymptomatic at a subsequent appointment, which took place one week later. Calcium hydroxide paste was removed using ultrasonics. The canals were dried with absorbent points and obturation was performed using cold lateral compaction of gutta percha and a resin

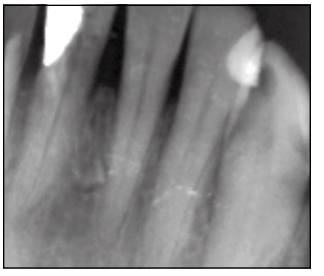


Fig. 1. A preoperative radiograph of tooth No. 25.

Fig. 2. Access opening showing 3 root canal orifices in tooth No. 25 and 2 canals in tooth No. 26. (B: buccal, L: lingual, MBL: mid-buccolingual)

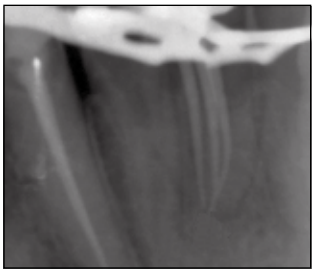


Fig. 3. A postobturation radiograph of teeth No. 25 and 26.

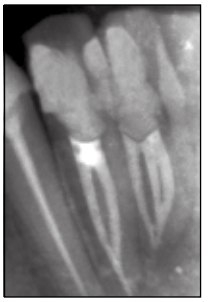


Fig. 4. Tooth No. 25, showing 2 separate exit portals.

sealer (AH Plus, DENTSPLY Maillefer) (Fig. 3). The tooth was restored with a posterior composite resin core (Filtek P60, 3M ESPE). The patient was asymptomatic during a 3-month follow-up period. Tooth No. 26 (which was also treated endodontically), had one buccal canal and one lingual canal; endodontic treatment for tooth No. 26 was similar to that for tooth No. 25. The patient was asymptomatic during the 3-month follow-up period.

Discussion

Although anomalies related to mandibular central incisors have been reported in the literature (including dens invaginatus, fusion, and gemination), the presence of a second (lingual) root canal is the most common.[8-10]

Failure to identify extra canals has been reported as the second most common reason for the failure of endodontic treatment.[11,12] Multiple angulated preoperative radiographs make it possible to identify complex anatomies of the root canal system and thus reduce the incidence of missed canals during routine endodontic therapy.[13,14]

Recent studies have suggested using cone beam computed tomography (CBCT) to better understand aberrations in the root canal anatomy.[13-15] While CBCT requires less radiation than conventional CT, it uses a dose of radiation that is higher than regular conventional intraoral radiographs.[16] Surgical operating microscopes are indispensible in the field of endodontics. A 2008 study by Matherne et al suggested using both CBCT and a surgical microscope to diagnose various aberrations in the root canal anatomy.[17]

In the present case, an additional canal was found between the buccal and the lingual canals in tooth No. 25; the authors referred to this as the *mid-buccolingual (MBL) canal,* which was clearly distinguishable during examination by using a surgical dental operating microscope, and was also visible on multiple angulated radiographs.

In the present case report, the buccal and MBL canals both appeared to have a single exit portal, while the lingual canal had a separate portal. These exit portals were confirmed by exploring each canal individually with a K-file. Because the file placed in the MBL canal did not reach the full working length, it was concluded that the buccal and MBL canals had 1 common exit portal, whereas the lingual canal had a separate path from the orifice to the exiting foramina (Fig. 4). This pattern of root canal configuration has been classified by Sert & Bayirli as a Type XV canal pattern.[1] Tooth No. 26 had 2 root canals that shared a single exit portal. This pattern was also observed by Green.[18] The canal pattern of tooth No. 26 was classified by Vertucci as a Type II canal pattern.[2]

Summary

The present case describes the successful endodontic management of a mandibular central incisor with 3 root canals. It also highlights the importance of using a surgical operating microscope to better understand unusual root canal morphology.

Author information

Dr. Aswinkumar is a postgraduate student, Department of Conservative Dentistry and Endodontics, Meenakshi Ammal Dental College and Hospital, Meenakshi University, Chennai, India, where Dr. Nandini is a reader, and Dr. Velmurgan is a professor and head, Department of Conservative Dentistry and Endodontics.

References

1. Sert S, Bayirli GS. Evaluation of the root canal configuration of the mandibular and maxillary permanent teeth by gender in the Turkish population. *J Endod.* 2004;30(6):391-398.
2. Vertucci FJ. Root canal anatomy of the mandibular anterior teeth. *J Am Dent Assoc.* 1974;89(2):369-371.
3. Pineda F, Kuttler Y. Mesiodistal and buccolingual roentgenographic investigation of 7,275 root canals. *Oral Surg Oral Med Oral Pathol.* 1972;33(1):101-110.
4. Boruah LC, Bhuyan AC. Morphologic characteristics of root canal of mandibular incisors in North-East Indian population: an in vitro study. *J Conserv Dent.* 2011; 14(4):346-350.
5. Caliskan MK, Pehlivan Y, Sepetcioghlu F, Turkun M, Tuncer SS. Root canal morphology of human permanent teeth in a Turkish population. *J Endod.* 1995;21(4):200-204.
6. Ingle JI, Bakland LK, Baumgartner J, eds. *Ingle's Endodontics.* 6th ed. Hamilton, Ontario: BC Decker, Inc.; 2008.
7. Mauger MJ, Schindler WG, Walker WA 3rd. An evaluation of canal morphology at different levels of root resection in mandibular incisors. *J Endod.* 1998;24(9): 607-609.
8. Beltes P. Endodontic treatment in three cases of dens invaginatus. *J Endod.* 1997;23(6):399-402.
9. Goncalves A, Goncalves M, Oliveira DP, Goncalves N. Dens invaginatus type III: report of a case and 10-year radiographic follow-up. *Int Endod J.* 2001;35(10):873-889.
10. Brown P, Herbranson E. *Dental Anatomy & 3D Interactive Tooth Atlas: Version 3.0, An Interactive DVD-ROM.* Carol Stream, IL: Quintessence Publishing Co.; 2005.
11. Grossman IL, Oliet S, Del Rio E, eds. *Endodontic Practice.* 11th ed. Philadelphia: Lea and Fabringer; 1988: 145-151.
12. Song M, Kim HC, Lee W, Kim E. Analysis of the cause of failure in nonsurgical endodontic treatment by microscopic inspection during endodontic microsurgery. *J Endod.* 2011;37(11):1516-1519.
13. Kottoor J, Velmurugan N, Sudha R, Hemamalathi S. Maxillary first molar with seven root canals diagnosed with cone-beam computed tomography scanning: a case report. *J Endod.* 2010;36(5):915-921.
14. Kottoor J, Hemamalathi S, Sudha R, Velmurugan N. Maxillary second molar with 5 roots and 5 canals evaluated using cone beam computerized tomography: a case report. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.* 2010;109(2):e162-e165.
15. La SH, Jung DH, Kim EC, Min KS. Identification of independent middle mesial canal in mandibular first molar using cone-beam computed tomography imaging. *J Endod.* 2010;36(3):542-545.

16. Ludlow JB, Davies-Ludlow LE, Brooks SL, Howerton WB. Dosimetry of 3 CBCT devices for oral and maxillofacial radiology: CB Mercuray, NewTom 3G and i-CAT. *Dentomaxillofac Radiol.* 2006;35(4):219-226.
17. Matherne RP, Angelopoulos C, Kulild JC, Tira D. Use of cone-beam computed tomography to identify root canal systems in vitro. *J Endod.* 2008;34(1):87-89.
18. Green D. Double canals in single roots. *Oral Surg Oral Med Oral Pathol.* 1973;35(5):689-696.

Manufacturers

AstraZeneca, Wilmington, DE
800.236.9933, www.astrazeneca.com

DENTSPLY Maillefer, Tulsa, OK
800.924.7393, www.maillefer.com

DENTSPLY Tulsa Dental Specialities, Tulsa, OK
800.662.1202, www.tulsadentalspecialties.com

MANI, Inc., Toshigi, Japan
81.028.667.1811, www.mani.com.jp

J. Morita USA, Irvine, CA
800.831.3222, www.morita.com

Parkell, Inc., Edgewood, NY
800.243.7446, www.parkell.com

Seiler Instrument, Inc., St. Louis, MO
800.489.2282, www.seilerinst.com

3M ESPE, St. Paul, MN
888.364.4577, solutions.3m.com

self CDE 2 HOURS CREDIT instruction

Bisphosphonate-related osteonecrosis of the jaws: a potential alternative to drug holidays

Douglas D. Damm, DDS ▪ David M. Jones, DDS

In 2011, the American Dental Association Council on Scientific Affairs released an update by their expert panel on managing the care of patients receiving antiresorptive therapy for the prevention and treatment of osteoporosis. In this report, the panel found no study results that confirmed the effectiveness of *drug holidays* to prevent antiresorptive agent-induced osteonecrosis of the jaws without increasing the risks of low bone mass. The purpose of this article is to provide suggestions for a pattern of patient care for individuals who desire or require an invasive surgical procedure of the jaws, but who also have a skeleton that is at risk for osteoporotic fracture.

The authors reviewed pertinent literature related to basic bone histology, the pharmacokinetics of the aminobisphosphonates (nBP), diagnostic criteria for osteopenia/osteoporosis, and clinical applications of the antiresorptive agents. The skeletal system demonstrates a mixture of resting surfaces (osteocytes, 85%), resorbing surfaces (osteoclasts, 2%), and forming surfaces (osteoblasts, 10%-12%). Deposition of nBP is not uniform, and is highly concentrated in areas of bone remodeling.

A full understanding of bone remodeling and the pharmacokinetics of nBP allow for the modification of the antiresorptive therapy and the timing of the oral surgical procedure in a manner that minimizes the prevalence of osteonecrosis while at the same time continuing to protect the patient's skeleton from osteoporotic fracture. The lack of support for drug holidays by the ADA's expert panel is strongly consistent with the science behind bone remodeling and nBP pharmacokinetics. In spite of this, creative interdisciplinary patient care has the potential to dramatically reduce the prevalence of bisphosphonate-related osteonecrosis (BRON), while at the same time continuing to protect the skeleton of the osteoporotic patient. Creative interdisciplinary patient care may prove to be an effective intervention to reduce the prevalence of BRON of the jaws.

Received: January 7, 2013
Accepted: April 29, 2013

Key words: oral and maxillofacial pathology, bisphosphonate-related osteonecrosis, aminobisphosphonate, jaw, drug holiday

In 2011, the American Dental Association (ADA) Council on Scientific Affairs released their most recent update related to the management of patients receiving antiresorptive therapy, such as aminobisphosphonates (nBPs) for prevention and treatment of osteoporosis.[1,2] In contrast to the ADA document, the two landmark publications that initially highlighted Bisphosphonate-Related Osteonecrosis (BRON) concentrated on cancer patients utilizing the IV formulations, and little guidance existed on the management of patients utilizing bisphosphonates for prevention and therapy of osteoporosis.[3,4] The ADA must be commended for convening an expert panel to expand on the early investigations of BRON and create the standard of care where none previously existed.

Among the many changes in these recent ADA updates, one of the most controversial is the removal of support for *drug holidays.* Since nBPs are known to concentrate in sites of bone remodeling, the lack of support for drug holidays was surprising to many.[3,4] The expert panel was well aware of the pharmacokinetics of nBPs, but also understood that drug holidays have the potential to increase the skeletal-related risks of low bone mass. Osteoporosis cannot be taken lightly. Of patients who suffer a hip fracture, 20% of women and 30% of men will not survive the event, and 75% never regain full function.[5,6]

The purpose of this article is to provide suggestions for a pattern of patient care for individuals who desire or require an invasive surgical procedure of the jaws, but also have a skeleton that is at risk for osteoporotic fracture. This topic is very complicated, and requires an in-depth discussion of the basic histology of bone, skeletal remodeling, and the pharmacokinetics of the antiresorptive agents. In addition, a short case is included, which hopefully will demonstrate the adverse effects of invasive procedures in patients whose antiresorptive therapy is not modified appropriately to minimize gnathic complications.

Any understandable discussion of the pharmacokinetics of the nBP must be interwoven with a review of the basic histology of bone.[7] Within hours of intake, 50% of nBP is removed unmetabolized by the kidneys with the remainder deposited in the skeleton. Eighty-five percent of the skeleton consists of resting bone and demonstrates quiescent osteocytes within their lacunae (Fig.1). Osteocytes have a low affinity for nBP, with the medication loosely bound to resting bone, and removed from these surfaces within days. The resorbing surfaces of bone represent only 2% of the skeleton and are identified by the presence of osteoclasts within their resorptive lacunae (Fig. 1). The cells demonstrate 8 times the affinity for the medication. In spite of this high affinity, the vast majority of the medication is liberated from these cells over days to weeks, with the medication being recycled into the blood for distribution once again to the skeleton or excretion by the kidneys.

The forming surfaces of bone comprise 10%-12% of the skeleton, and are defined by the presence of osteoblasts (Fig. 1). These cells demonstrate 4 times the affinity for nBP. Unlike the osteocytes and osteoclasts, the osteoblasts do not release the medication, but incorporate it into the bone by affixing nBP to newly deposited osteoid. The buried nBP remains within the bone until osteoclasts remodel the area and release the medication for recycling to the skeleton and kidneys. Once recycled back into the blood, the medication tends to be attracted to areas of high metabolic activity, due to the increased affinity of the

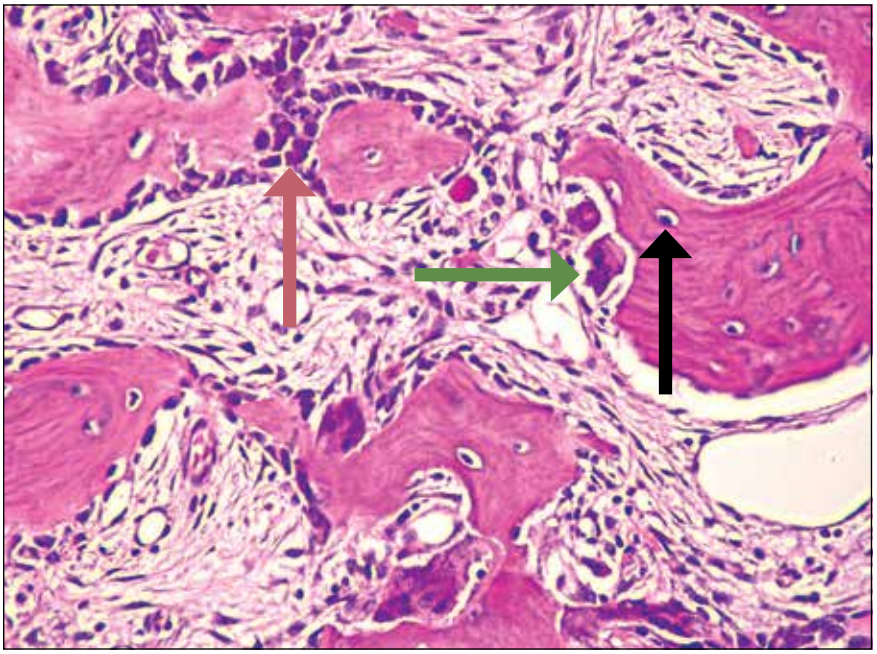


Fig. 1. Histopathologic image of remodeling bone. Note the osteocyte (black arrow), osteoclast (green arrow), and osteoblast (orange arrow). (H&E stain, magnification 20X)

cells involved in active remodeling. Once deposited into the newly formed bone, the medication has a half-life of approximately 10 years, and continues to be recycled upon each remodeling. It is critical for one to understand that the deposition of nBP in the skeleton is not uniform and tends to be highly concentrated in areas of remodeling.[7]

The effects of nBP on the crucial osteoclasts vary with the local concentration of the medication.[7] With low deposition, the ability of the osteoclasts to accomplish bone mineral resorption and collagen degradation is diminished. With increasing nBP deposition, osteoclastic differentiation from the stem cell pool is inhibited; ultimately, osteoclastic apoptosis is induced. Since the majority of the skeleton consists of resting bone with relatively low deposition of the drug, the desired pharmacologic effect of reduced resorption with increased bone mass is achieved in most sites that are not undergoing significant remodeling.

The nBP pharmacokinetics is only half of the story, and one must understand the basics of bone remodeling to design an appropriate pattern of patient care. When the bone is disturbed, as in an extraction site, or in preparation for implant placement, the surgical defect fills with extravasated blood, leading to formation of a hematoma. An inflammatory phase follows clot formation. During this time, the inflammatory cells remove bacteria and foreign debris from the surgical site. Macrophages within the infiltrate release growth factors that activate fibroblasts and endothelial cells, leading to formation of granulation tissue. Pluripotential mesenchymal cells form collagen and, ultimately, woven bone. This immature bone gains full strength only after complete remodeling.[8]

Final remodeling is accomplished by a cell packet known as the *basic multicellular unit* (BMU).[8,9] This unit is an organized synergism, in which osteoclasts, osteoblasts, osteocytes, and the local vascular supply work in an organized and tightly controlled pattern. The BMU is a discrete and narrow "cutting cone" that burrows through the immature woven bone and replaces it with well-organized and strong lamellar bone. Numerous BMU cones traverse the woven bone in the healing surgical site to accomplish final remodeling. Each BMU consists of a leading phalanx of osteoclasts that resorb the woven bone, and these octeoclasts are followed by newly formed blood vessels and osteoblasts. The osteoblasts advance centripetally around the central vascular supply, and fill in the resorptive defect with well-organized lamellar bone. Despite the attention on the osteoclasts and osteoblasts, angiogenesis also is an important component of bone remodeling. The BMU is a moving structure, and requires continual replacement of osteoclasts and osteoblasts at exactly the correct time and place in an ever-changing location. In addition to transporting needed cells to the site, the vascular system supplies bone components to the area, and assists in the removal of degradation products. All the while, new growth of blood vessels, nerves, and connective tissue must occur at the proper rate as the BMU progresses through the healing bone.

The life span of the involved cells in a BMU mandates frequent replacement. The average life span of an osteoclast is only 2 weeks.[8] Osteoblasts have a life span of 1-3 months, unless incorporated into the newly formed bone.[8] Those incorporated into the bone become osteocytes, which are permanent cells, and have the potential to live as long as the organism itself. Most osteocytes live until removed from the bone during remodeling, and demonstrate a life span which varies from a few years to decades.[8-10] The remodeling period is defined as the shortest period of time when, after disturbing the bone, a new steady-state can be guaranteed to exist.[11] Although the time period varies from 2-8 months, 4 months is the normal remodeling period in the human skeleton.[8,12]

The basic knowledge of bone remodeling is critical to planning presurgical and postsurgical antiresorptive therapy. The following case report will demonstrate the adverse outcomes associated with failure to develop an interdisciplinary approach to patient care in individuals receiving antiresorptive therapy and undergoing an oral surgical procedure.

Case report

In 2004, a 70-year-old female presented for comprehensive dental care. At that time, she reported a diagnosis of osteoporosis in the late 1990s, at which point she began therapy. Since that diagnosis,

the patient had changed physicians and attempts to obtain a more detailed medical history were unsuccessful. At this presentation, she utilized weekly oral risedronate for her osteoporosis. A 2004 panoramic radiograph revealed a normal trabecular pattern (Fig. 2).

In February of 2007, she presented with root decay and pulpal involvement of the right mandibular second bicuspid, and was referred to an endodontist for therapy. Despite attempts at conservative therapy, serious periapical inflammatory disease developed and led to extraction of the tooth, an associated hospitalization, and extended antibiotic therapy. A panoramic radiograph taken shortly after the extraction in March 2007 continued to demonstrate an appropriate trabecular pattern (Fig. 3). The right mandibular first molar was slightly mobile and tender. Following removal of the second molar pontic, the mobility and sensitivity of the first molar resolved. In late August and early September, a new 3-unit bridge was delivered to replace the right mandibular second bicuspid.

In October 2007, the patient returned with a complaint of significant pain in the mandible, which extended from the anterior dentition all the way around to the newly placed prosthesis. A night guard was constructed, but failed to reduce the associated dental discomfort. In January of 2008, the pain continued to be problematic. The clinical presentation and vitality testing of the entire anterior dentition were within normal limits, despite the significant sensitivity of these teeth. A return trip to the endodontist was recommended in an attempt to rule out the mandibular first molar as the primary focus of infection. Although no obvious periapical inflammatory disease was noted, the constant pain led to a second referral to an oral and maxillofacial surgeon, who extracted the mandibular first molar in March of 2008. In spite of this intervention, the dental discomfort continued, involving the entire anterior and right body of the mandible.

In June 2008, an additional follow-up panoramic radiograph was obtained (Fig. 4). In this radiograph, the explanation of the chronic oral discomfort was obvious. The trabecular pattern of the medullary areas of the mandible was atypical, with a diffuse patchy radiopacity which extended from the left mandibular cuspid to the right posterior body of the mandible. In addition, the remodeling of the extraction site of the second bicuspid was incomplete after a period of 15 months. When the radiographic pattern was combined with the 8-month history of unexplained odontalgia, the diagnosis of BRON, Stage 0, was made. Following the BRON diagnosis, the risedronate was discontinued by the patient's attending physician in July 2008. Over the next few months, the widespread dental discomfort slowly resolved.

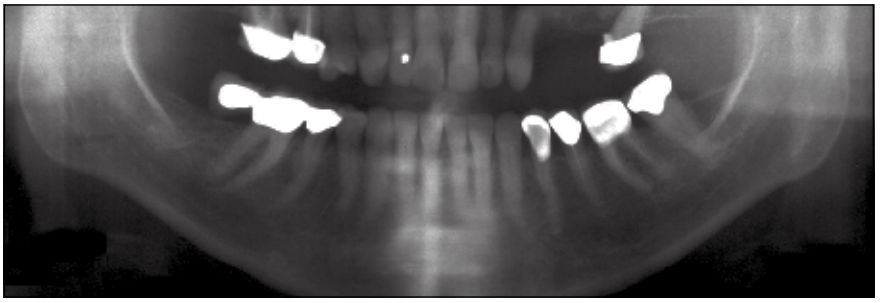


Fig. 2. 2004 panoramic radiograph. Note the normal trabecular pattern.

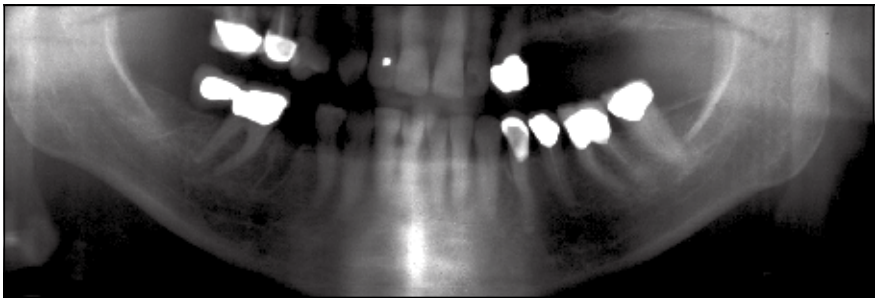


Fig. 3. 2007 panoramic radiograph taken shortly after extraction of the right mandibular second bicuspid. Note the trabecular pattern remains largely unaltered.

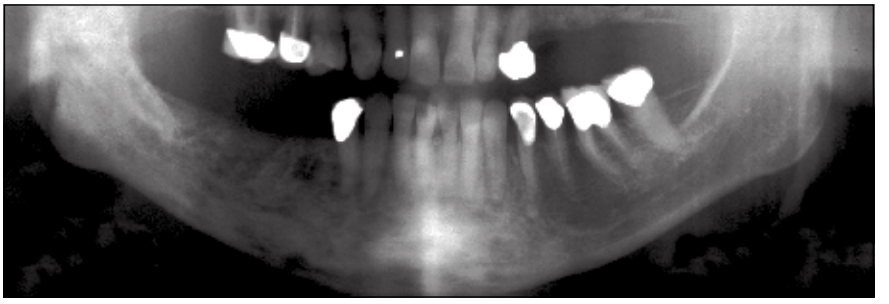


Fig. 4. 2008 panoramic radiograph. Note the diffuse patchy radiopacity of the anterior and right body of the mandible, with incomplete remodeling of the previous extraction site of the second bicuspid.

Discussion

In the 2008 panoramic radiograph, the patchy radiodensity supported the diagnosis of osteonecrosis, even though exposed necrotic bone was not evident. In ischemic-damaged bone, where dead bone abuts living marrow, layers of new bone are applied to the surface of the dead bone. This double layering of bone is responsible for the patchy radiodensity noted in the current patient. One must question how extraction of the right second bicuspid and first molar can lead to an altered bone pattern that extends from the left mandibular

cuspid to the right posterior body of the mandible. The osteocytes within this bone have the potential to live for decades, and should not have undergone necrosis without provocation. As mentioned in the discussion of bone remodeling, the vascular supply is a critical component of bone homeostasis. In all likelihood, the extraction led to increased mandibular concentrations of nBP, which are known to block appropriate angiogenesis. Without the ability to maintain an appropriate vascular supply, ischemic damage occurred, leading to extensive loss of bone vitality. As described in the discussion of nBP pharmacokinetics, the medications are concentrated into sites of active bone remodeling. It is proposed that this adverse outcome could have been avoided if the serum was clear of nBP at the time of the extractions. If no drug was present in the serum, then none could be concentrated into the bone during the period of bone remodeling associated with healing of the surgical site.

What is an appropriate presurgical and postsurgical period for the serum to be free of nBP? A 6-month drug holiday (3 months presurgical and 3 months postsurgical) has been suggested in previous position papers, but the nBP pharmacokinetics and basic bone remodeling process do not support these time frames.[13] Once nBP reaches the serum, renal excretion quickly eliminates 50%, with the remainder deposited in the skeleton. The osteocytes have a low affinity and quickly release the medication. Osteoblasts incorporate the drug into the bone, where it is inert until released by future remodeling. The only reservoir for the medication is the osteoclasts, and they continue to release the drug for a few weeks. Since the life span of an osteoclast is 2 weeks, the only nBP available for release after 2 weeks would be the nBP passed from the original osteoclast to the subsequent generation, along with a small amount released from the bone. With this knowledge, it would be expected that the majority of free nBP within the serum would be minimal at 2 weeks, and extremely low at 2 months (equal to 4 times the life span of an osteoclast). Therefore, a 2-month drug free period prior to an oral surgical procedure seems more than adequate.

Since nBP concentrates in areas of active remodeling, an appropriate postsurgical drug-free period also is critical. This period should be extended until the bone has returned to a normal lamellar pattern, without an increased number of osteoclasts and osteoblasts. As described previously, the bone remodeling period varies from 2 to 8 months, with 4 months being typical. With this knowledge, the recommended postsurgical drug-free period should be at least 4 months, with 8 months being even safer. However, an osteoporotic patient cannot be removed from their protective therapy for 8 months while the bone heals. The risks of hip and vertebral fracture outweigh the concerns related to BRON; fortunately, safe alternatives exist, and will be discussed later in the article.

A review of bone mineral density (BMD), as it relates to osteoporosis would help all dentists as they discuss the possibility of surgery with their patients.[14] The World Health Organization (WHO) utilizes the dual energy X-ray absorptiometry scan (DXA, or DEXA), to define osteoporosis.[15] The results are compared to an arbitrary norm and reported as *T-scores.* Bone densities between -1.0 to -2.5 standard deviations below the norm are classified as *osteopenic,* while those that are ≤-2.5 are diagnosed as *osteoporotic.*[15]

Due to the significant morbidity and mortality associated with osteoporotic hip and vertebral fractures, antiresorptive therapy is strongly recommended for patients with confirmed osteoporosis. The therapy for patients with osteopenia is less well-defined. To lessen the confusion, the WHO established an online *Fracture Risk Assessment* tool (FRAX) (www.shef.ac.uk/frax), through the University of Sheffield, England. This short online assessment calculates a patient's 10-year risk of a major osteoporotic fracture. Therapy is recommended in patients with osteopenia only if the calculation tool predicts a 20% risk of major osteoporotic fracture (hip, shoulder, wrist, and spine), or at least a 3% risk of hip fracture. Use of this tool should be strongly encouraged for all osteopenic patients.

An additional controversy continues for patients who remain osteoporotic after 5 years of nBP therapy. The positive effects of nBP are most noticeable when skeletal concentrations of the drug are low, with greatest gains in bone density occurring during the first few years of use. As the skeletal concentrations of nBP rise, reduced osteoclastic differentiation and increased osteoclastic apoptosis begin to negatively impact the skeleton. In addition to problems encountered within the jaws, physicians are increasingly reporting unusual subtrochanteric and femoral shaft fractures occurring in long-term users of nBP.[16] Such fractures led some physicians to state that current evidence suggests an extended drug holiday should be instituted after 5 years of nBP use.[17] Patients who remain at high risk for fracture should be considered for treatment with alternative therapies, such as teriparatide or raloxifene.[18]

Before presenting a specific pattern for managing osteoporotic patients in need of an oral surgical procedure, a short discussion of 2 medical alternatives to nBP is necessary. Denosumab (Prolia, Amgen, Inc.) is a monoclonal antibody that targets and binds to RANK ligand, which is necessary to allow maturation of osteoclastic precursors into differentiated osteoclasts.[19] This therapy not only inhibits formation of differentiated osteoclasts, but also inhibits the function and survival of previously formed osteoclasts. Denosumab reduces osteoclastic function by 85% within 3 days of administration and obtains maximal reduction within 1 month. After that time, the effect on osteoclasts drops as the concentration of the medication wanes. The half-life is 25.4 days, which means the drug takes 4-5 months to drop to insignificant levels.[19] Although the medication is not incorporated into bone as is nBP, denosumab is known to be associated with osteonecrosis. However, the process tends to respond more readily to intervention than the osteonecrosis that is associated with nBP use.[20,21] Denosumab is available in 2 formulations: Prolia, for osteoporosis that is injected at 6-month intervals, or Xgeva (Amgen, Inc.), which is administered every 4 weeks for cancer patients.[19,22]

Both nBP and denosumab are antiresorptive agents that work by reducing osteoclast formation, increasing osteoclastic apoptosis, and slowing the rate of bone remodeling. Since bone formation only occurs at sites of active bone remodeling, an anabolic agent that increases the number of BMUs would be a much more powerful agent against osteoporosis. Teriparatide (Forteo, Eli Lilly and Company) is an anabolic parathyroid hormone that, when given intermittently, does not decrease the number of BMUs and promotes both an increased number and

increased survival of osteoblasts.[23] This anabolic approach has a much greater ability to increase bone density than the antiresorptive agents that inhibit bone remodeling (and ultimately new bone formation).[24] Forteo is not associated with osteonecrosis, and has been shown to dramatically reduce the healing time in BRON.[25,26]

With the knowledge of the nBP pharmacokinetics, bone remodeling, and the medical alternatives, it is possible to design a pattern of patient care which clears the serum of nBP at the time of bone remodeling and prevents concentration of the drug in surgical sites, but also continues to protect the osteoporotic patient from fracture.

For patients who need or desire an oral surgical procedure and are utilizing nBP, the first step should be review of a recent bone mineral density evaluation. If the results suggest osteopenia rather than osteoporosis, the FRAX website should be utilized to judge the necessity for continued antiresorptive therapy. For patients with osteoporosis or osteopenia that is recommended for continued therapy by FRAX, the following are options which can avoid concentration of nBP into surgical sites without placing the patient's skeleton at risk for fracture.

1. The nBP could be discontinued and replaced with Prolia (denosumab). Once the denosumab therapy is initiated, any elective surgery could be timed to occur 2 months after an injection with Prolia. At this time, 79.9% of the medication would have been degraded. This timing would allow 4 months of healing prior to the next injection. Although some degree of delayed healing would be expected, the effect would be minimal, and unlike nBP, no drug is concentrated into sites of remodeling.
2. The nBP therapy could be replaced with Forteo (teriparatide). This anabolic therapy results in significant new bone growth and most likely would not only eliminate the chance of osteonecrosis but also would shorten the healing time of the surgical site.
3. The oral nBP could be replaced with zoledronic acid (Reclast, Novartis Pharmaceuticals Corporation), administered intravenously on an annual basis.[27] The surgery could be scheduled 2 months after the annual infusion. As mentioned previously in the pharmacokinetics of nBPs and the second paragraph of the Discussion, the serum would be essentially clear of the medication at that point in time and none would be available to concentrate into the sites of osseous remodeling associated with the surgical sites. Once again, such timing would provide adequate time for the serum to clear of nBP prior to the surgery with 10 months of healing prior to the next infusion.

Conclusion

The management strategies described in this article are based on a therapeutic hypothesis, and should not be considered an approved approach to patient care without further studies. In spite of this, the drug pharmacokinetics and physiology of bone remodeling strongly suggest that these alternatives may have the ability to reduce the prevalence of osteonecrosis while consequently continuing to protect the skeleton of the osteoporotic patient. Hopefully, future clinical studies will shed more light on this difficult area of patient care.

Author information

Dr. Damm is a professor, Department of Oral Health Sciences, Division of Oral Pathology, College of Dentistry, University of Kentucky, Lexington. Dr. Jones is in private practice in Chanute, Kansas.

References

1. Hellstein JW, Adler RA, Edwards, E, et al. Managing the care of patients receiving antiresorptive therapy for the prevention and treatment of osteoporosis: executive summary of recommendations from the American Dental Association Council on Scientific Affairs. *J Am Dent Assoc.* 2011;142(11):1243-1251.
2. Hellstein JW, Adler RA, Edwards B, et al. Managing the care of patients receiving antiresorptive therapy for prevention and treatment of osteoporosis: recommendations from the American Dental Association Council on Scientific Affairs. Available at: http://www.aae.org/uploadedFiles/Publications_and_Research/Endodontics_Colleagues_for_Excellence_Newsletter/BONJ_ADA_Report.pdf. Accessed May 6, 2011.
3. Ruggiero SL, Mehrotra B, Rosenberg TJ, Engroff SL. Osteonecrosis of the jaws associated with the use of bisphosphonates: a review of 63 cases. *J Oral Maxillofac Surg.* 2004;62(5):527-534.
4. Marx RE, Sawatari Y, Fortin M, Broumand V. Bisphosphonate-induced exposed bone (osteonecrosis/osteopetrosis) of the jaws: risk factors, recognition, prevention, and treatment. *J Oral Maxillofac Surg.* 2005;63(11):1567-1575.
5. Palmer RM, Saywell RM Jr, Zollinger TW, et al. The impact of the prospective payment system on the treatment of hip fractures in the elderly. *Arch Intern Med.* 1989;149(10):2237-2241.
6. Cummings SR, Melton LJ. Epidemiology and outcomes of osteoporotic fractures. *Lancet.* 2002;359(9319):1761-1767.
7. Kimmel DB. Mechanism of action, pharmacokinetic and pharmacodynamic profile, and clinical applications of nitrogen-containing bisphosphonates. *J Dent Res.* 2007;86(11):1022-1033.
8. Doll B, Aleef M, Hollinger JO. Overview of fracture repair. In: Pietrzak WS, ed. *Orthopedic Biology and Medicine: Musculoskeletal Tissue Regeneration, Biological Materials and Methods.* Totowa, NJ: Humana Press; 2008:39-61.
9. Parfitt AM. Osteonal and hemi-osteonal remodeling: the spatial and temporal framework for signal traffic in adult human bone. *J Cell Biochem.* 1994;55(3):273-286.
10. Knothe Tate ML, Adamson JR, Tami AE, Bauer TW. The osteocyte. *Int J Biochem Cell Biol.* 2004;36(1):1-8.
11. Frost HM. Tetracycline-based histological analysis of bone remodeling. *Calcif Tissue Res.* 1969;3(3):211-237.
12. Martin RB, Burr DB, Sharkey NA. *Skeletal Tissue Mechanics.* New York, NY: Springer-Verlag Inc; 1998:84.
13. Ruggiero SL, Dodson TB, Assael LA, et al. American Association of Oral and Maxillofacial Surgeons position paper on bisphosphonate-related osteonecrosis of the jaws–2009 update. *J Oral Maxillofac Surg.* 2009;67(5 Suppl):2-12.
14. Marx RE, Cillo JE, Ulloa JJ. Oral bisphosphonate-induced osteonecrosis: risk factors, prediction of risk using serum CTX testing, prevention, and treatment. *J Oral Maxillofacial Surg.* 2007;65(12):2397-2410.
15. World Health Organization. Assessment of fracture risk and its application to screening for postmenopausal osteoporosis. Report of a WHO Study Group. *World Health Organ Tech Rep Ser.* 1994;843:1-129.
16. Park-Wyllie LY, Mamdani MM, Juurlink DN, et al. Bisphosphonate use and the risk of subtrochanteric or femoral shaft fractures. *JAMA.* 2011;305(8):783-789.
17. Schneider JP. Should bisphosphonates be continued indefinitely? An unusual fracture in a healthy woman on long-term alendronate. *Geriatrics.* 2006;61(1):31-33.
18. Watts NB, Diab DL. Long-term use of bisphosphonates in osteoporosis. *J Clin Endocrinol Metab.* 2010;95(4):1555-1565.
19. Amgen, Inc. Prolia [prescribing information]. Available at: http://pi.amgen.com/united_states/prolia/prolia_pi.pdf. Accessed May 6, 2013.
20. Diz P, Lopez-Cedrun JL, Arenaz J, Scully C. Denosumab-related osteonecrosis of the jaw. *J Am Dent Assoc.* 2012;143(9):981-984.

21. Smith MR, Saad F, Coleman R, et al. Denosumab and bone-metastasis-free survival in men with castration-resistant prostate cancer: results of a phase 3, randomised, placebo-controlled trial. *Lancet.* 2012; 379(9810):39-46. Comment in: Kyrgidis A, Tzellos TG. Denosumab in castration-resistant prostate cancer. *Lancet.* 2012;379(9828):e50, Author reply: e50-e51.
22. Amgen Inc. Xgeva [prescribing information]. Available at: http://pi.amgen.com/united_states/xgeva/xgeva_pi.pdf. Accessed May 6, 2013.
23 Eli Lilly and Company. Forteo [prescribing information]. Available at: http://pi.lilly.com/us/forteo-pi.pdf. Accessed May 6, 2013.
24. Manolagas SC. Birth and death of bone cells: basic regulatory mechanisms and implications for the pathogenesis and treatment of osteoporosis. *Endocr Rev.* 2000;21(2):115-137.
25. Harper RP, Fung E. Resolution of bisphosphonate-associated osteonecrosis of the mandible: possible application for intermittent low-dose parathyroid hormone [rhPTH (1-34)]. *J Oral Maxillofac Surg.* 2007;65(3): 573-580.
26. Cheung A, Seeman E. Teriparatide therapy for alendronate-associated osteonecrosis of the jaw. *N Engl J Med.* 2010;363(25):2473-2474.
27. Novartis Pharmaceuticals Corporation. Reclast [prescribing information]. Available at: http://www.pharma.us.novartis.com/product/pi/pdf/reclast.pdf. Accessed May 6, 2013.

Manufacturers

Amgen, Inc., Thousand Oaks, CA
800.772.6436, www.amgen.com

Eli Lilly and Company, Indianapolis, IN
800.545.5979, www.lilly.com

Novartis Pharmaceuticals Corporation, New York, NY
888.669.6682, www.us.novartis.com

self CDE 2 HOURS CREDIT instruction

Academy of General Dentistry PACE Program Approval for Continuing Education

Approved PACE Program Provider
FAGD/MAGD Credit
Approval does not imply acceptance by a state or provincial board of dentistry or AGD endorsement
06/01/2010 to 05/31/2014

Exercise No. 334 Pharmacotherapeutics Subject Code 016

The 15 questions for this exercise are based on the article, *Bisphosphonate-related osteonecrosis of the jaws: a potential alternative to drug holidays,* on pages 33-38. This exercise was developed by Thomas C. Johnson, DMD, MAGD, in association with the *General Dentistry* Self-Instruction committee.

Reading the article and successfully completing this exercise will enable you to understand the:
- risks and benefits of a drug holiday;
- pharmacokinetics of amino bisphosphonates (nBP); and
- problems caused by concentration of nBP into surgical sites.

1. What is the percentage of women with osteoporosis who fracture their hip and do not survive?
   A. 10
   B. 20
   C. 30
   D. 40

2. What is the percentage of men with osteoporosis who fracture their hip and regain full function?
   A. 25
   B. 45
   C. 65
   D. 80

3. Within hours of intake, 50% of the dose of an aminobisphosphonate (nBP) is excreted by the kidneys. The remainder is broken down by liver enzymes.
   A. Both statements are true.
   B. The first statement is true; the second is false.
   C. The first statement is false; the second is true.
   D. Both statements are false.

4. Osteoclasts have the highest affinity for nBP, _____ times that of resting bone.
   A. 2
   B. 4
   C. 8
   D. 10

5. The long-term reservoir of nBP is a result of action by which cells?
   A. Adipocytes
   B. Osteocytes
   C. Osteoclasts
   D. Osteoblasts

6. Once deposited, nBP has a half-life of approximately 8 years. Deposition of nBP is uniform, not concentrated.
   A. Both statements are true.
   B. The first statement is true; the second is false.
   C. The first statement is false; the second is true.
   D. Both statements are false.

7. Which of the following effects are observed with low levels of nBP?
   A. Osteoclastic apoptosis
   B. Inhibited formation of new osteoclasts
   C. Diminished osteoclastic collagen degradation
   D. Accelerated angiogenesis

8. Woven bone forms with the initial healing of an osteotomy for implant placement. Numerous *basic multicellular units* (BMUs) or "cutting cones" burrow through the granulation tissue to form the woven bone.
   A. Both statements are true.
   B. The first statement is true; the second is false.
   C. The first statement is false; the second is true.
   D. Both statements are false.

9. A generous blood supply facilitates the formation of new bone in a healing surgical site. nBP will not affect angiogenesis or the actions of the osteoblasts.
   A. Both statements are true.
   B. The first statement is true; the second is false.
   C. The first statement is false; the second is true.
   D. Both statements are false.

10. The patient in the case report was diagnosed with bisphosphonate-related osteonecrosis and had all of the following symptoms or findings except one. Which is the exception?
    A. Radiolucent-radiopaque mixed radiographic appearance
    B. Mandibular pain
    C. Taking oral risedronate
    D. Exposed necrotic bone

11. The patient in the case report had diffuse necrosis of the bone away from the extraction sites. What did the authors state was the cause of this?
    A. nBP's effect on angiogenesis
    B. nBP's effect on osteoclasts
    C. Mucogingival surgery for periodontitis
    D. nBP's effect on osteoblasts

12. The amount of free nBP in the serum should be extremely low after a drug free period of _____ month(s).
    A. 1
    B. 2
    C. 4
    D. 6

13. Patients with osteopenia, who according to the FRAX have a risk of hip fracture of at least _____ %, should have therapy to improve low bone mass.
    A. 3
    B. 5
    C. 10
    D. 20

14. Which of the following increases the number and survival of osteoblasts, thus improving bone density?
    A. Denosumab
    B. Raloxifene
    C. Teriparitide
    D. Zoledronic acid

15. Which of the following is not incorporated into bone, as is nBP, and yet still is associated with osteonecrosis?
    A. Denosumab
    B. Raloxifene
    C. Teriparitide
    D. Zoledronic acid

Answer form is on page 80. Answers for this exercise must be received by July 31, 2014.

Different ultrasonic vibration protocols and their effects on retention of post-and-core to root canal

Neilor Mateus Antunes Braga, PhD, MD, DDS ▪ Manoel Brito Jr., MD, DDS ▪ Juliana Monteiro da Silva ▪ Lilian Souto Miranda
Jacy Ribeiro de Carvalho Jr., PhD, MD, DDS ▪ Andre Luis Faria-e-Silva, PhD, MD, DDS

This study evaluated the effect of different ultrasonic vibration protocols on custom cast post-and-cores' retention to the root canal. Post holes were placed in the root canals of human maxillary canines, and post-and-core sets were luted using zinc phosphate cement. The samples were divided into 5 groups (n = 8). Group 1 (control) received no ultrasonic vibration. For the other samples, the tip of the ultrasonic device was positioned either over the incisal face of the core (Group 2), over the lateral core surfaces and close to the incisal edge (Group 3), over the lateral face of the core but close to the line of cementation (Group 4), or over the lateral face of the core but with the end of the mouth mirror handle positioned on the opposite surface of the core (Group 5).

After a tensile test, data were submitted to 2-way ANOVA and Tukey's tests ($P < 0.05$). The control group showed higher values than all of the groups that were submitted to ultrasonic vibration. Bond strength was similar for Groups 2 and 3. Bond strength was lower in Groups 4 and 5; no statistical difference was observed between these 2 groups. Based on these results, both positioning the tip of the ultrasonic device near the cement line and placing a mouth mirror handle on the opposite surface of the core, are effective ways to reduce the retention of a cast post-and-core within a root canal.

Received: February 10, 2012
Revised: April 30, 2012
Accepted: June 13, 2012

It is necessary to place a post inside the root canal when the remaining crown can no longer provide a restoration with retention and stability. However, despite the mechanical and esthetic improvements that may be obtained by using fiber posts, the cast post-and-core still offers advantages in certain clinical situations, such as when an extensive prosthesis with intraradicular retention is planned.[1] This type of post offers better adaptation to flared or irregularly-shaped canals than prefabricated post systems.[2] In addition, cast post-and-cores have demonstrated high clinical survival rates.[3,4]

Despite the high success rate of endodontic therapy, adverse situations that require endodontic retreatment are fairly common.[5,6] When signs, symptoms, and radiographic images suggest failed root canal treatment, atraumatic and efficient post removal is essential for optimal nonsurgical endodontic management.

Many techniques have been developed to facilitate post removal. Despite the low incidence of fracture during post removal, the use of extractors (such as an Eggler post remover) is of limited use on posterior teeth. By contrast, ultrasonic devices can be used in both anterior and posterior teeth; in addition, applying ultrasonic vibrations to the dental structure during post removal saves time and preserves root integrity.[7-13] As a result, ultrasonic vibration (via drills and other devices) has been the most common method for removing posts.[14]

Despite its safety and efficacy, ultrasonic vibration can interfere with the removal of a cast post-and-core.[9,11,12] There is no consensus in the literature as to whether positioning the tip of the ultrasound device over the core will increase its effectiveness. This in vitro study sought to evaluate the effect of ultrasonic vibration on the retention of cast post-and-cores. The null hypothesis was that the technique of ultrasound application would have no effect on retention.

Materials and methods

This study utilized 40 maxillary human canines with mature apices, unpronounced flattening, roots without curves, and single canals. The crowns were removed to obtain a root that was 15 mm high. The root canal was prepared according to the crown-down technique, using stainless-steel K-files and No. 2, 3, and 4 Gates-Glidden drills (DENTSPLY Maillefer). After all enlargement procedures, samples were irrigated with a 2.5% sodium hypochlorite solution. Using lateral condensation, the prepared root canals were obturated with gutta percha cones and resin sealer (AH 26, DENTSPLY Caulk). The filled roots were stored in relative humidity for at least 72 hours to allow the resin sealer to set.

The roots were placed directly in self-cured acrylic resin cylinders, with the remaining 1 mm of the cervical portion exposed. Post holes were prepared by standardizing the length (at 8 mm), and diameter (at 1.7 mm), and preparation was performed by using a No. 6 largo drill (DENTSPLY Maillefer) with a low-speed handpiece attached to a parallelometer. The root canal impressions were made with self-cured resin acrylic (DuraLay, Reliance Dental Mfg. Co.). A ring was attached to the dowel to facilitate the tensile testing; this ring also made it possible to standardize the core portion and load application.

The post-and-cores were cast with a nickel-chromium alloy and cemented to the root canal using zinc phosphate cement (SS White), which was mixed according to manufacturer's recommendations. A lentulo spiral filler was used to introduce cement into the canal, and the dowel was coated thoroughly before insertion. The dowels were submitted to a constant force of 5 kg (applied to the long axis of the root for 6 minutes), to standardize the cement line.[15] The samples were stored in 100% humidity (at 37°C) for 1 week.

Samples were allocated randomly to 1 of 5 groups (n = 8), according to the specific technique of ultrasound application. For Group 1 (control), no ultrasonic vibrations

were applied. For Group 2 samples, the tip of the ultrasonic device was positioned over the incisal face of the core and parallel to the long axis of the post (Fig. 1). For Group 3 samples, the tip was positioned perpendicular to the long axis of the post and over the lateral core surfaces, close to the incisal edge (Fig. 2). Tip placement in Groups 4 and 5 was similar to that of Group 3; however, the tip was placed close to the line of cementation for Group 4 (Fig. 3). For Group 5 samples, the end of a mouth mirror handle was positioned on the opposite surface of the core (Fig. 4).

All ultrasonic vibrations were applied by the same calibrated operator, using a piezoelectric ultrasonic device with an ST 09 tip (ENAC, Osada, Inc.), at maximum power under water cooling. For Groups 3-5, the vibration was applied to the buccal, mesial, lingual, and distal surfaces of the core, 15 seconds per surface (60 seconds total). For Group 2, the vibration was only applied to the incisal face for 60 seconds. Next, all samples were positioned on a universal testing machine (Model 4411, Instron), and the ring of the core was attached to the load cell (500 N). Tensile load was applied (at a crosshead speed of 0.5 mm/minute) until the cast post-and-core was dislodged. The ultimate tensile strength (in N/mm^2) of each sample was recorded. Statistical analysis was performed using 2-way ANOVA, followed by Tukey's post hoc test at a 95% confidence level.

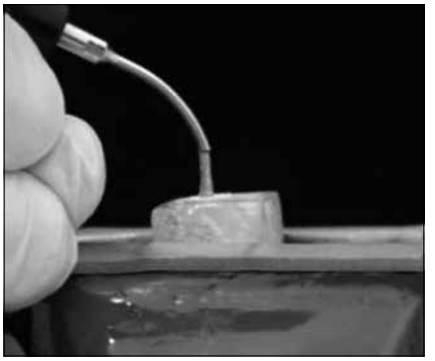


Fig. 1. An example of a tip positioned over the incisal face of the core (Group 2).

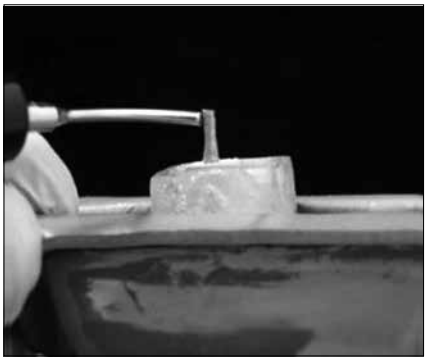


Fig. 2. A tip positioned over the lateral surfaces of the core near the incisal edge (Group 3).

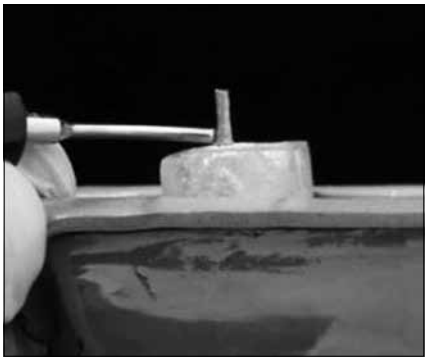


Fig. 3. A tip placed over the lateral surfaces of the core near the line of cementation (Group 4).

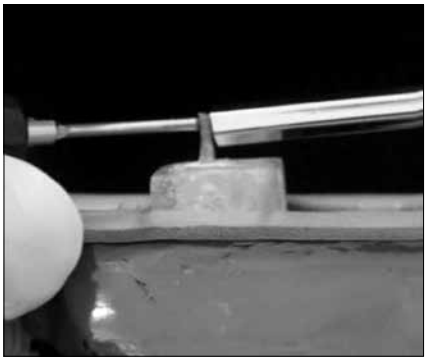
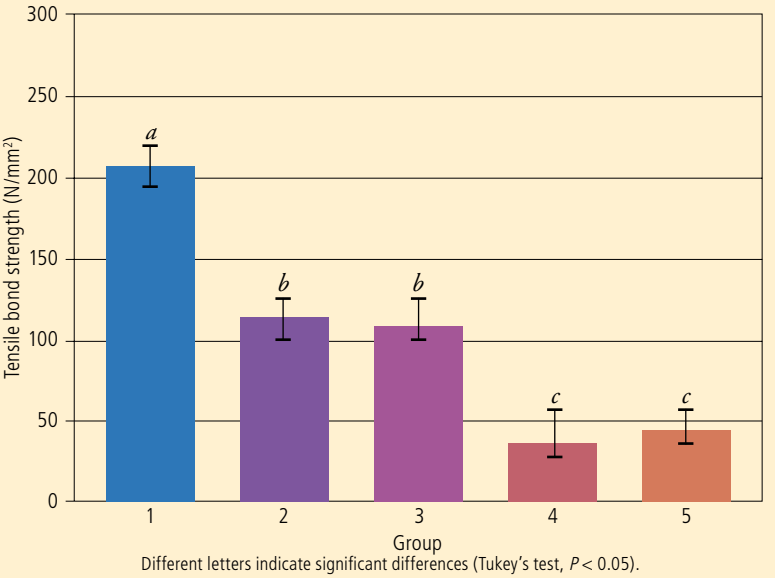


Fig. 4. A tip placed over the lateral surfaces of the core, close to the incisal edge, with the end of the mouth mirror handle positioned on the opposite surface of the core (Group 5).

Results

ANOVA showed a significant effect ($P < 0.001$). The Chart presents multiple comparisons of Tukey's test. Group 1, the control group, presented higher bond strength than the other groups. Groups 2 and 3 presented similar values of bond strength ($P = 0.06$), both of which were higher than the results from Groups 4 and 5; there was no statistical difference between Groups 4 and 5 ($P = 0.99$).

Chart. Comparison of tensile bond strength between groups.



Different letters indicate significant differences (Tukey's test, $P < 0.05$).

Discussion

The most efficient method of using ultrasonic vibration has not been fully elucidated in the literature. In the present study, the best results occurred when the ultrasonic tip was placed near the cement line or the incisal edge, especially with the mouth mirror handle positioned on the opposite side. These approaches were more

effective at reducing cast post-and-core retention to the root canal than the other techniques evaluated; as a result, the null hypothesis was rejected.

Zinc phosphate cement was selected for this study because it has been used successfully to lute cast posts and cores.[4] In addition, an ENAC unit is used frequently during post removal.[8-13] This ultrasonic device has a piezoelectric transducer that transforms electricity into ultrasonic vibrations. Quartz crystals within the transducer are vibrated by the electricity that flows through them. By applying an alternating electrical field across the crystal, the quartz is compressed and released, which causes the tip to vibrate.[16] These ultrasonic vibrations are transmitted through the post, fracturing the cement between the post and the root canal walls to facilitate post removal.[11,13,16]

Placing the tip close to the incisal edge led to higher tensile bond strength values compared to the other modes of ultrasound application, regardless of the face of the tooth where the tip was placed. These results suggest that the direction of tip placement—that is, either perpendicular (over the lateral surfaces) or parallel (over the incisal face) to the long axis—had a secondary interference on the effectiveness of ultrasonic vibration. Conversely, the distance between the tip of the ultrasonic device and the cement line had a significant effect on the fracture of luting material. It is expected that a greater distance will require a higher attenuation of ultrasonic energy. The attenuation of energy is explained by the fact that the ultrasonic wave is converted into heat, and when its direction is changed it affects both the absorption and scattering mechanisms.[17] The present study confirmed that less ultrasonic energy was required when the tip was positioned near the cervical area of the core.

Another interesting result of the present study was the increased effectiveness when a mouth mirror handle was placed on the opposite surface of the core. This technique showed similar post retention values compared to groups where the tip was near the cervical area, compensating for the longer distance from the line of cementation. According to O'Brien, a slight movement of a cast post-and-core during the ultrasonic application can partially absorb the applied energy, thus reducing the amount of energy that reaches the cement.[17] The mouth mirror handle reduced the potential for cast post-and-core movement while increasing the ultrasonic energy available for fracturing the cement, thus the cement layer on the opposite side of the ultrasonic tip usually is destroyed more thoroughly.[11] In most cases, a mouth mirror handle can be placed on the opposite surface of the ultrasound tip on the buccal and lingual sides only, due to the presence of adjacent teeth.[11] An important aspect of this study was the application of ultrasonic vibration for only 60 seconds, a shorter time than is required clinically. Fixing the teeth directly to the acrylic resin cylinder without the use of a periodontal ligament increases the effect of the ultrasonic vibration.[12] Longer times of ultrasonic vibration could promote premature post displacement and impair post retention.

Summary

The outcomes of this study demonstrated that positioning the tip of an ultrasonic device near the cement line or placing a mouth mirror handle on the opposite surface of the core improved the effectiveness of the ultrasonic device in the reduction of the cast post-and-core retention.

Author information

Drs. Braga and Brito Jr. are professors, Department of Dentistry, State University of Montes Claros, Minas Gerais, Brazil. Ms. da Silva and Ms. Miranda are undergraduate students, United Universities of the North of Minas, Montes Claros, MG, Brazil. Dr. Carvalho Jr. is a professor, Department of Dentistry, Faculty of Health Sciences, University of Brasilia, Brazil. Dr. Faria-e-Silva is a professor, Department of Dentistry, Federal University of Sergipe, Aracaju, Brazil.

References

1. Bokman L, Hepburn AB, Kogan E, Friedman M, de Rijk W. Fiber post techniques for anatomical root variations. *Dent Today.* 2011;30(5):106-111.
2. Munoz C, Llena C, Forner L. Oval fiber posts do not improve adaptation to oval-shaped canal walls. *J Endod.* 2011;37(10):1386-1389.
3. Fokkinga WA, Kreulen CM, Bronkhorst EM, Creugers NH. Up to 17-year controlled clinical study on post-and-cores and covering crowns. *J Dent.* 2007;35:778-786.
4. Gomez-Polo M, Llido B, Rivero A, Del Rio J, Celemin A. A 10-year retrospective study of the survival rate of teeth restored with metal prefabricated post versus cast metal post and cores. *J Dent.* 2010;38(11):916-920.
5. Imura N, Pinheiro ET, Gomes BP, Zaia AA, Ferraz CC, Souza-Filho FJ. The outcome of endodontic treatment: a retrospective study of 2000 cases performed by a specialist. *J Endod.* 2007;33(11):1278-1282.
6. West J. Nonsurgical versus surgical endodontic retreatment: "how do I choose"? *Dent Today.* 2007;26(4):74, 76, 78-81.
7. Queiroz EC, Menezes MS, Biffi JC, Soares CJ. Influence of the shape core on custom cast dowel and core removal by ultrasonic energy. *J Oral Rehabil.* 2007;34(6):463-467.
8. Braga NM, Resende LM, Vasconcellos WA, Paulino SM, Sousa-Neto MD. Comparative study of the effect of ultrasound on the removal of intracanal posts. *Gen Dent.* 2009;57(5):492-495.
9. Davis S, Gluskin AH, Livingood PM, Chambers DW. Analysis of temperature rise and the use of coolants in the dissipation of ultrasonic heat buildup during post removal. *J Endod.* 2010;36(11):1892-1896.
10. Brito Jr M, Soares JA, Santos SMC, Camilo CC, Moreira Jr G. Comparison of the time required for removal of intraradicular cast posts using two Brazilian ultrasound devices. *Braz Oral Res.* 2009;23(1):17-22.
11. Garrido AD, Oliveira AG, Osorio JE, Silva-Sousa YT, Sousa-Neto MD. Evaluation of several protocols for the application of ultrasound during the removal of cast intraradicular posts cemented with zinc phosphate cement. *Int Endod J.* 2009;42(7):609-613.
12. Brito-Junior M, Braga NM, Rodrigues DC, Camilo CC, Faria-e-Silva AL. Effect of the simulated periodontal ligament on cast post-and-core removal using an ultrasonic device. *J Appl Oral Sci.* 2010;18(5):528-532.
13. Soares JA, Brito-Junior M, Fonseca DR, et al. Influence of luting agents on time required for cast post removal by ultrasound: an in vitro study. *J Appl Oral Sci.* 2009;17(3):145-149.
14. Castrisos T, Abbott PV. A survey of methods used for post removal in specialist endodontic practice. *Int Endod J.* 2002;35(2):172-180.
15. Queiroz EC, Menezes MS, Biffi JC, Soares CJ. Influence of the shape core on custom cast dowel and core removal by ultrasonic energy. *J Oral Rehabil.* 2007;34(6):463-467.
16. Plotino G, Pameijer CH, Grande NM, Somma F. Ultrasonics in endodontics: a review of the literature. *J Endod.* 2007;33(2):81-95.
17. O'Brien Jr WD. Ultrasound-biophysics mechanisms. *Prog Biophys Mol Biol.* 2007;93(1-3):212-255.

Manufacturers

DENSTPLY Caulk, Milford, DE
800.532.2855, www.caulk.com

DENTSPLY Maillefer, Tulsa, OK
800.924.7393, www.maillefer.com

Instron, Norwood, MA
800.877.6674, www.instron.com

Osada, Inc., Los Angeles, CA
800.426.7232, osadausa.com

Reliance Dental Mfg. Co., Worth, IL
708.597.6694, www.reliancedental.net

SS White, Rio de Janeiro, Brazil
21.2122.9323, www.sswhite.com.br

Using spiral computed tomography for endodontic management of a mandibular first molar with a middle mesial canal: a case report

B. Gurudutt Nayak, BDS, MDS ▪ Inderpreet Singh, BDS

The root canal anatomy of a permanent mandibular first molar has been traditionally described as 2 roots—1 mesial and 1 distal—with 2 canals in the mesial root and 1 or 2 canals in the distal root. Nonetheless, other possibilities exist. The presence of a third canal in the mesial root has been reported to have an incidence of 0%-17%. Conventional radiographs are routinely used to determine root canal anatomy; however, these are 2-dimensional representations of a 3-dimensional object. Advanced diagnostic methods that can provide 3-dimensional data, such as spiral computed tomography (SCT), are very helpful in determining complex morphology. This case report presents the management of a mandibular first molar with 3 mesial and 2 distal canals, confirmed with the aid of both SCT and conventional radiographic methods.

Received: February 22, 2012
Accepted: May 15, 2012

The mandibular first molar is the first permanent posterior tooth to erupt and is the tooth that most often requires root canal treatment.[1] The literature has presented numerous cases of roots and root canals exhibiting considerable anatomic variations and abnormalities.[2-16] The morphology of the mesial canals in mandibular first molars is complex. The literature has reported the presence of a third canal (middle mesial) in the mesial root of mandibular molars with an incidence rate of 0%-17%.[2-16] Such canals are located in the isthmus that connects the mesiobuccal and mesiolingual canals. Pomeranz et al classified the middle mesial canal as an independent canal that originates in a separate orifice and terminates as a separate foramen, a confluent canal that originates as a separate orifice but is apically joined to the mesiobuccal or mesiolingual canal, and as a fin where the instrument can pass freely between the mesiobuccal or mesiolingual canals and the middle mesial canal during cleaning and shaping.[4]

Typically, these multifaceted root canal anatomies have been diagnosed with radiographs at different angulations. However, radiographs have inherent limitations in terms of complete assessment of the root canal system. Newer techniques, such as spiral computed tomography (SCT) are being used to study root canal morphology as a 3-dimensional image. To the authors' knowledge, no clinical reports have described using SCT imaging to identify a middle mesial canal. This case report describes using SCT to detect and manage a mandibular first molar with 3 mesial and 2 distal canals.

Case report

A 31-year-old man had a chief complaint of spontaneous dull pain in the left posterior region of his mandible for the previous 2 weeks. The pain was continuous in nature, and became particularly aggravated when lying down or when consuming anything hot or cold. The patient's case history contained no abnormal data. Clinical examination revealed deep distoocclusal caries in the left first mandibular molar (tooth No. 19), and a preoperative diagnostic radiograph revealed a deep, carious lesion approximating the pulp, with no signs of periapical pathosis or variations in canal anatomy (Fig. 1). Based on radiographic findings and sensitivity tests, acute irreversible pulpitis was diagnosed, and root canal treatment was initiated.

After local anesthesia and rubber dam isolation, an endodontic access cavity was established. The coronal pulp tissue was removed with a spoon excavator and the pulp chamber was flushed with a 3% sodium hypochlorite solution. Four

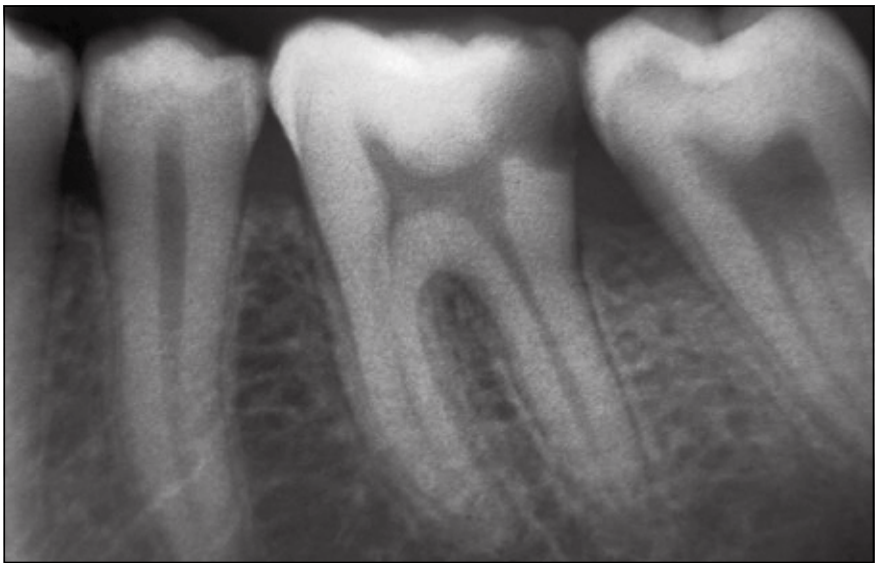


Fig. 1. A preoperative radiograph of the 31-year-old patient.

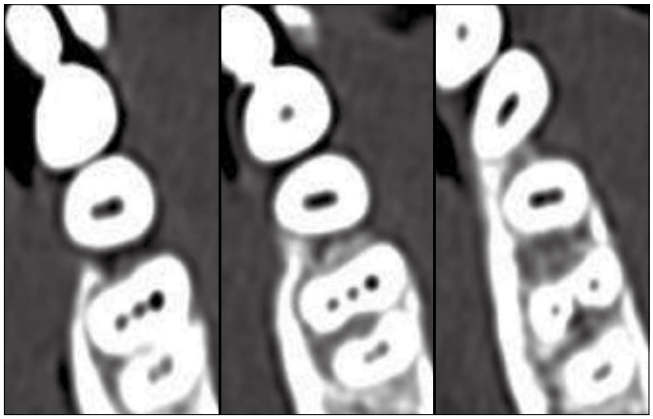


Fig. 2. SCT scan images at the coronal third, middle third, and apical third.

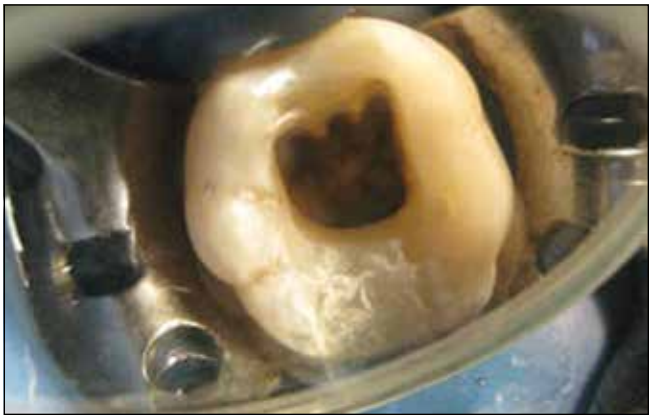


Fig. 3. Access opening, showing 3 distinct mesial root canal orifices.

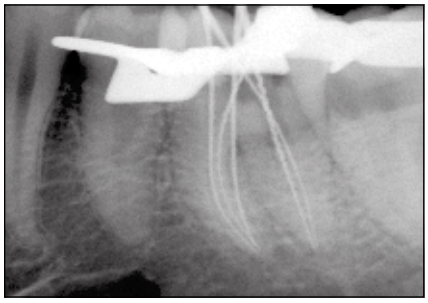


Fig. 4. Radiograph taken to determine working length.

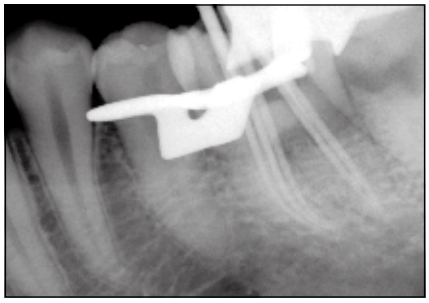


Fig. 5. Radiograph taken to confirm master cone selection.

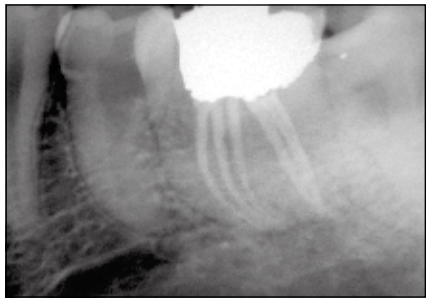


Fig. 6. Radiograph taken after endodontic restoration.

root canal orifices (corresponding to 4 root canals) were detected: mesiobuccal, mesiolingual, distobuccal, and distolingual. Careful examination of the pulp chamber under 2.5X-420 magnifying loupes (Galilean loupes, Lifecare Medical Equipments Co., Ltd.) revealed small hemorrhagic points in the mesial grove equidistant to the mesiobuccal and mesiolingual canal orifices. Inspection with the DG-16 endodontic explorer (Hu-Friedy Mfg. Co., LLC) revealed a "stick" at the same level. A middle mesial canal was suspected. Devitalization paste (Depulpin, VOCO America, Inc.) was placed in the access cavity and the tooth was temporized with a sterile cotton pellet and Cavit (3M ESPE).

To confirm this unusual morphology, SCT imaging (Sensation 64, Siemens Corporation) of the tooth was performed. The patient gave his informed consent, and a multislice SCT scan of the mandible was performed, with tube voltage of 120 kV and a tube current of 390 mA. Contiguous transaxial sectional images of 1 mm thickness were obtained. These images were evaluated at a separate workstation (Siemens Medical Solutions, Siemens Corporation). Horizontal slices of the molar were studied at different levels (the coronal, middle, and apical third of the roots) to determine the canal morphology. SCT scan images confirmed the existence of 5 canals (3 mesial and 2 distal) in the mandibular left first molar. Scan slices revealed the middle mesial canal extending up to the middle third of the root, while being absent in the apical third, suggesting that it might have joined the mesiobuccal canal. The mesiolingual canal was distinct and had a separate foramen. Two distinct distal canals were seen extending up to the middle third; however, the canals appeared to unite at the apical third (Fig. 2).

At the second appointment, the patient was asymptomatic and a size 10 C-Pilot file (VDW, GmbH) was inserted into the orifice of the middle mesial canal with clockwise and counter-clockwise rotational movements to establish canal patency. Three distinct orifices were identified (Fig. 3). Working length was determined using an apex locator (Raypex 5, VDW, GmbH) and confirmed radiographically (Fig. 4). The working length radiograph showed that the middle mesial canal originated from a separate orifice but joined the mesiobuccal canal in the apical third. After manual preparation with a size 15 K-file, the canals were cleaned and shaped with 2 nickel-titanium rotary instruments (VDW, GmbH) in a simultaneous technique. Irrigation was performed using a 3% sodium hypochlorite solution and ethylenediaminetetraacetic acid (Glyde File Prep, DENTSPLY Maillefer). Master cones were selected by placing cones that corresponded to the size of the last finishing file that was used to the working

Table. Prevalence of accessory middle mesial canals in mandibular first molars according to different investigators: review of the literature.

Investigators	Year	Methodology	Number of molars	Prevalence (%)
Skidmore & Bjorndal[2]	1971	Plastic casts	45	0.0
Pineda & Kuttler[3]	1972	Radiography	300	0.0
Pomeranz et al[4]	1981	Clinical	61	11.4
Martinez-Berna & Badanelli[5]	1983	Clinical	1418	1.3
Vertucci[6]	1984	Clearing	100	1.0
Fabra-Campos[7]	1985	Clinical	145	2.7
Fabra-Campos[8]	1989	Clinical	760	2.6
Goel et al[9]	1991	Clinical	60	15.0
Caliskan et al[10]	1995	Clearing	100	3.4
de Carvalho & Zuolo[11]	2000	Extracted teeth	93	17.2
Gulabivala et al[12]	2001	Clearing	139	7.1
Gulabivala et al[13]	2002	Clearing	118	5.9
Sert & Bayirli[14]	2004	Clearing	200	1.5
Ahmed et al[15]	2007	Clearing	100	4.0
Navarro et al[16]	2007	Micro-CT/SEM	27/25	14.8/12.0

CT: Computed tomography.
SEM: Scanning electron microscope.

length (Fig. 5). The canals were dried with absorbent points, and single cone obturation was performed using gutta percha with resin sealer (AH Plus, DENTSPLY International). After postendodontic restoration, a full-coverage porcelain crown was recommended (Fig. 6).

Discussion

Many dentists believe that a given tooth will contain a predetermined number of roots and/or canals. Based on the literature and the present case, the root canal anatomy of the mandibular first molar can be aberrant. Clinicians must be aware when a third canal is present in the mesial root of the mandibular first molar. (Table).[2-16]

Successful endodontic treatment requires understanding the anatomical variations via clinical and radiographic examination of the involved tooth. Using the endodontic explorer for a thorough examination of the pulp chamber floor, troughing the grooves with ultrasonic tips, staining the chamber floor with 1% methylene blue dye, performing the "champagne bubble test" with sodium hypochlorite, and visualizing canal bleeding points can increase the chance of finding an extra canal. The use of magnifying loupes and fiberoptic transillumination also aid in locating extra orifices.

Variations in the mesial root of mandibular first molars can be identified through very careful observation of angled radiographs. However, conventional radiographs and digitally captured periapical radiographs produce 2-dimensional images of 3-dimensional objects, resulting in the superimposition of the overlying structures. Newer diagnostic methods, such as SCT scans, greatly improve access to the internal root canal morphology. By using simultaneous patient translation through the X-ray source via continuous rotation of the source-detector assembly, SCT scans acquire raw projection data with a spiral-sampling locus in a relatively short period. Data can be viewed as conventional transaxial images, such as multiplanar reconstructions, or as 3-dimensional reconstructions. SCT scans make it possible to reconstruct overlapping structures at arbitrary intervals, thus increasing the ability to resolve small subjects.[17] SCT is more expensive than a conventional radiograph. In addition, it utilizes high amounts of radiation dosage; one section produces 0.12 mGy for a scan time of 0.2 seconds. Ten sections per tooth provide a dosage of 1.2 mGy, which is similar to the dose of one panoramic radiograph (1.8 mGy).[18] Radiation doses can be decreased by reducing the tube current and by using a slice thickness of 1.5 mm (instead of 1.0 mm), or using a spiral technique with a pitch factor of more than 1.0. Dosage can also be reduced by limiting the area of the investigation by selecting the maxilla or mandible and excluding all occlusal scans.[19]

In the present case, SCT scanning was pivotal for detecting the middle mesial canal. In keeping with the classifications established by Pomeranz et al, the middle mesial canal was classified as confluent.[4]

Summary

Detecting extra canals may be challenging, but failing to find and properly treat root canals may cause endodontic failure. This case report presented the endodontic management of an unusual case involving a mandibular first molar with 2 roots and 5 canals, while also highlighting the role of SCT scanning as an objective analytical tool for ascertaining root canal morphology.

Author information

Dr. Nayak is a reader, Department of Conservative Dentistry and Endodontics, K.D. Dental College and Hospital, Mathura, Uttar Pradesh, India, where Dr. Singh is a postgraduate student.

References

1. Vertucci JF, Haddix EJ, Britto RL. Tooth morphology and access cavity preparation. In: Cohen S, Hargreaves MK, eds. *Pathways of the pulp.* 9th ed. St. Louis: Mosby; 2006:220.
2. Skidmore AE, Bjorndal AM. Root canal morphology of the human mandibular first molar. *Oral Surg Oral Med Oral Pathol.* 1971;32(5):778-784.
3. Pineda F, Kuttler Y. Mesiodistal and buccolingual roentgenographic investigation of 7,275 root canals. *Oral Surg Oral Med Oral Pathol.* 1972;33(1):101-110.
4. Pomeranz HH, Eidelman DL, Goldberg MG. Treatment considerations of the middle mesial canal of mandibular first and second molars. *J Endod.* 1981;7(12):565-568.
5. Martinez-Berna A, Badanelli P. Investigacion clinica de molars inferiors con cinco conductos. *Boletin de Informacion Dental.* 1983;43:27-41.
6. Vertucci FJ. Root canal anatomy of the human permanent teeth. *Oral Surg Oral Med Oral Pathol.* 1984; 58(5):589-599.

7. Fabra-Campos H. Unusual root anatomy of mandibular first molars. *J Endod.* 1985;11(12):568–572.
8. Fabra-Campos H. Three canals in the mesial root of mandibular first permanent molars: a clinical study. *Int Endod J.* 1989;22(1):39-43.
9. Goel N, Gill K, Taneja J. Study of root canals configuration in mandibular first permanent molar. *J Indian Soc Pedod Prev Dent.* 1991;8(1):12-14.
10. Caliskan MK, Pehlivan Y, Sepetcioglu F, Turkun M, Tuncer SS. Root canal morphology of human permanent teeth in a Turkish population. *J Endod.* 1995; 21(4):200-204.
11. de Carvalho MC, Zuolo ML. Orifice locating with a microscope. *J Endod.* 2000;26(9):532-534.
12. Gulabivala K, Aung TH, Alavi A, Ng YL. Root and canal morphology of Burmese mandibular molars. *Int Endod J.* 2001;34(5):359-370.
13. Gulabivala K, Opasanon A, Ng YL, Alavi A. Root and canal morphology of Thai mandibular molars. *Int Endod J.* 2002;35(1):56-62.
14. Sert S, Bayirli GS. Evaluation of the root canal configurations of the mandibular and maxillary permanent teeth by gender in the Turkish population. *J Endod.* 2004;30(6):391-398.
15. Ahmed HA, Abu-bakr NH, Yahia NA, Ibrahim YE. Root and canal morphology of permanent mandibular molars in a Sudanese population. *Int Endod J.* 2007;40(10):766-771.
16. Navarro LF, Luzi A, Garcia AA, Garcia AH. Third canal in the mesial root of permanent mandibular first molars: review of the literature and presentation of 3 clinical reports and 2 in vitro studies. *Med Oral Patol Oral Cir Bucal.* 2007;12(8):E605-E609.
17. Kalender WA, Seissler W, Klotz E, Vock P. Spiral volumetric CT with single-breadth-hold technique, continuous transport and continuous scanner rotation. *Radiology.* 1990;176(1):181-183.
18. Cimilli H, Cimilli T, Mumcu G, Kartal N, Wesselink P. Spiral computed tomographic demonstration of C-shaped canals in mandibular second molars. *Dentomaxillofac Radiol.* 2005;34(3):164-167.
19. Cotti E, Campisi G. Advanced radiographic techniques for the detection of lesions in bone. *Endod Top.* 2004; 7(1):52-72.

Manufacturers

DENTSPLY International, York, PA
800.877.0020, www.dentsply.com

DENSTPLY Maillefer, Tulsa, OK
800.924.7393, www.maillefer.com

Hu-Friedy Mfg. Co., LLC, Chicago, IL
800.483.7433, www.hu-friedy.com

LifeCare Medical Equipments Co., Ltd., Zhejiang, China
86.574.87252696, www.china-lifecare.com

Siemens Corporation, Washington, DC
800.743.6367, www.usa.siemens.com

VDW, GmbH, Munchen, Germany
918.878.0450, www.vdw-dental.com

VOCO America, Inc., Briarcliff Manor, NY
888.658.2584, www.voco.com

3M ESPE, St. Paul, MN
888.364.3577, solutions.3m.com

Coronal reconstruction following anterior teeth traumatism: multidisciplinary treatment

Flavia Cohen-Carneiro, DDS, MSc, PhD ▪ Emilio Carlos Sponchiado Jr., DDS, MSc, PhD
Lucas da Fonseca Roberti Garcia, DDS, MSc, PhD ▪ Fikriye Viga Yurtsever, DDS, MSc, PhD
Danielson Guedes Pontes, DDS, MSc, PhD ▪ Amilen Sena

This study describes how periodontology, endodontology, and dentistry were integrated for the coronal reconstruction of anterior teeth extensively destroyed by dental trauma. A 15-year-old girl suffered a bicycle accident that resulted in the fracture of teeth No. 8 and 9. Clinical and radiographic examinations confirmed coronal fracture in both teeth, in addition to compromised pulp vitality, invasion of the biologic periodontal space, and loss of coronal space due to mesialization of the neighboring teeth. The protocol consisted of endodontic treatment for the fractured teeth, periodontal surgery to augment the clinical crown and gingival recontouring, intracanal cementation of esthetic glass fiber posts, and coronal reconstruction with resin composite. At a longitudinal follow-up visit 1 year later, clinical and radiographic examinations revealed successful rehabilitation of the fractured teeth.

Received: March 19, 2012
Accepted: July 2, 2012

Key words: dental trauma, treatment, permanent tooth

Tooth fractures in children and adolescents are usually consequences of traffic or bicycle accidents, fights, falls, and/or sports injuries.[1] Maxillary incisors frequently are involved in dental trauma due to their exposed position in the arch.[2,3] When traumatism occurs in anterior teeth, fast and esthetic functional treatment is required.[4,5]

There are situations in which multidisciplinary actions involving different dental specialties are necessary for successful rehabilitatation of the tooth.[5-8] Intracanal posts may be necessary to create central support in cases of complex coronal fractures (that is, when the loss of tooth structure is ≥60%, and the remaining tooth is less than 2.0 mm).[4,5,7]

Metal posts and cores have a modulus of elasticity 10X higher than that of teeth, so they have more rigidity, which causes higher stress at the tooth-cement-core interface, and leads to displacement. Concomitantly, the fabrication of these cores requires intraradicular preparation with dentinal wear; as a result, fractures in the remainder of the tooth are more common.[7]

Prefabricated post systems have been introduced as an alternative treatment option for dental traumatism. Among metal-free posts, glass fiber posts offer esthetics, good translucency, high fatigue and flexural strength, a modulus of elasticity similar to dentin, and good biological compatibility to tooth structure.[7,9-11]

Some studies have reported good clinical performance from fiberglass posts used with direct resin composite restorations, offering a good esthetic result at a low cost to the patient.[12-15] Direct restoration of extensively destroyed teeth is technically difficult, and prognosis is doubtful; however, it can be a conservative alternative to tooth extraction, especially for patients who cannot afford indirect crowns, or in cases in which the crown-root ratio is insufficient for an indirect restoration.[10]

This article presents a case involving teeth extensively destroyed by dental trauma using glass fiber posts and coronal reconstruction with direct composite resin.

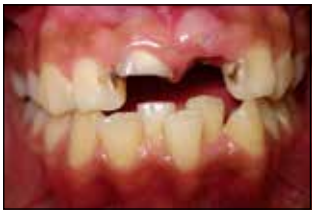
Case report

A 15-year-old girl presented at the Integrated Clinic at the School of Dentistry of the Federal University of Amazonas (FAO/UFAM), having suffered a bicycle accident 6 months earlier that resulted in the fracture of her maxillary central incisors (teeth No. 8 and 9). Clinical and radiographic examinations revealed complex coronal fracture with compromised pulp vitality and invasion of the biologic periodontal space in both teeth (Fig. 1). As a conservative alternative to extraction, the following protocol was proposed: periodontal surgery to increase the clinical crown and gingival recontouring, endodontic treatment of the fractured teeth, intracanal cementation of esthetic glass fiber posts, and coronal reconstruction with composite resin.

The first step was to perform gingivoplasty (specifically, the modified Windman's technique), removing approximately 4 mm of gingival tissue from maxillary canine to canine (Fig. 2). A periodontal flap was folded to perform osteotomy, which allowed for absolute isolation and direct restoration of the fractured teeth (Fig. 3). Case planning did not include fabrication of the indirect restoration, because the extension of the fracture would not allow for adequate recovery of the biologic periodontal space without compromising the crown-root ratio of the teeth.

One week after periodontal surgery, endodontic treatment of the maxillary central incisors was performed under absolute isolation. The canals were debrided using the crown-down technique and filled with gutta percha cones and filling cement (AH26, DENTSPLY Maillefer) using the active lateral condensation technique (Fig. 4).

Twenty-four hours later, absolute isolation and partial unobstruction of the root canal were performed; at that time, approximately two-thirds of the restoration material was removed from the canal to place the posts. Glass fiber posts (Whitepost No. 2, FGM Produtos Odontologicos) were selected, adjusted, and cut at pulp chamber height for each tooth. To cement the posts, a self-adhesive resin cement (RelyX U100, 3M ESPE) was used. RelyX U100 does not require pretreatment of the root canal with



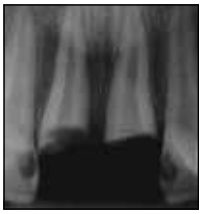


Fig. 1. *Left:* Teeth No. 8 and 9 with extensive coronal destruction. *Right:* Initial radiograph of the teeth reveals the invasion of the biologic periodontal space and unfavorable crown-root ratio.

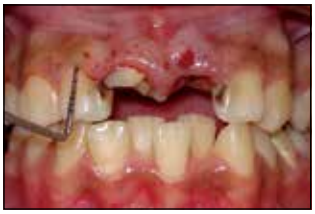


Fig. 2. The patient after the removal of approximately 4 mm of tissue.

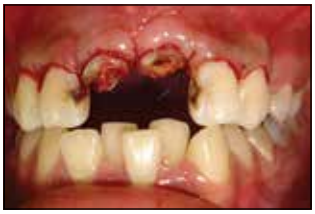


Fig. 3. The patient after periodontal surgery to increase crown and gingival recontouring.

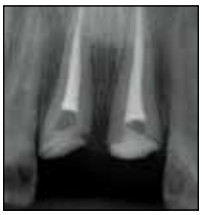


Fig. 4. A radiograph taken after endodontic treatment for teeth No. 8 and 9.

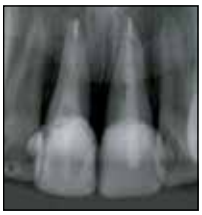


Fig. 5. A radiograph taken before the composite resin was finished and polished.

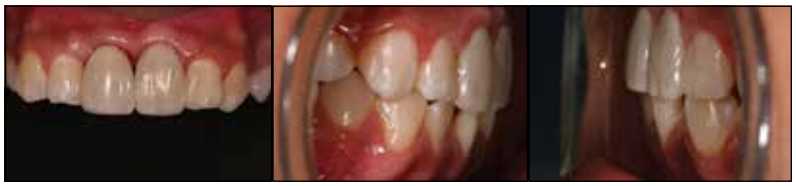


Fig. 6. The patient at a 12-month follow-up visit.

phosphoric acid and an adhesive system. Per manufacturer's instructions, it is applied directly into the root canal after the area is cleansed with 2.5% sodium hypochlorite. During that same visit, the posts were covered with microhybrid composite resin (Natural Look, DFL Industria e Comercio) for the coronal core filling (Fig. 5).

Definite coronal reconstruction was performed using Natural Look resin under absolute trans-surgical isolation by the technique of natural stratification of colors, and was done freehand (without the aid of a silicone barrier).[16] Esthetic improvement of the restorations involved correcting tooth shape and proportion, characterization of surface texture, and final polishing of restorations. Due to fluorosis stains in the adjacent teeth, incisal characterization with opaque white composite resin was needed. Occlusion was verified and adjusted by observing the points of contact in lateral movements and protrusion, and removing the premature contact points. The patient was instructed to avoid excessive masticatory load of these teeth, and guided to follow procedures related to oral hygiene care and routine visits for follow-up and maintenance treatment.

The patient returned for follow-up visits at 7 and 12 months post-treatment; at both visits, the patient showed acceptable esthetic, functional, clinical, and radiographic results (Fig. 6).

Discussion

Traumatism in anterior teeth refers to common lesions that lead to functional, esthetic, and psychological sequelae, frequently requiring multidisciplinary intervention—particularly periodontal therapy and methods used to recover extensively fractured teeth.[4]

The literature has reported that metal-free esthetic fiber posts have been used with satisfactory results and demonstrated advantages compared with metal core posts, including less rigidity with improved distribution of forces transmitted to the tooth, minimizing the risk of root fracture; reinforcement to the remaining tooth structure; the chance to fabricate posts in a single session with no laboratory costs; and improved esthetic properties (such as translucency, refractive index, and transmission of colors, enabling the use of pure ceramic or resin systems).[4,16-19] Fiberglass posts have become a preferred choice for fractured anterior teeth, thanks to the similarities between their biomechanical properties and the properties of dentin.[4,8,13,14,16,20]

The indication for a fiber post is subject to a coronal remainder of at least 2 mm.[21] However, as the present case had no coronal remainder, it was decided to use a direct restorative system with a fiberglass post and resin composite for a trans-surgical restoration of the fractured teeth. The fabrication of a core and crown was not considered, due to the impossibility of recovering the biologic periodontal space and maintaining adequate crown-root ratio. Extraction was avoided by choosing the esthetic glass fiber post and resin composite restoration. Other factors in the choice of treatment included the age of the patient, the desire to preserve the remaining tooth structure, and the patient's inability to afford indirect crowns.[19,21]

In 2005, Grandini et al examined 38 anterior teeth and 62 posterior teeth that had been restored with glass fiber posts and microhybrid resin composite.[16] Teeth with 50% of coronal remainder were included, as were posterior teeth with 2 or 3 coronal walls. The restorations were examined at 6, 12, 24, and 30 months. Clinical and radiographic examinations

confirmed that direct restorations using glass fiber posts and resin composite for direct restorations in endodontically treated teeth with preserved coronal remainders are a conservative option that offers satisfactory clinical results.[16]

A 2012 article by Metha et al examined the use of fiberglass posts and resin composite as an alternative for reconstructing a tooth with more than two-thirds of coronal destruction due to caries.[17] The tooth had broad middle and cervical root thirds, and thin remaining walls, making a cast metal core and prosthetic crown unfeasible. There were no reports of longitudinal follow-up of the case. However, the authors concluded that a glass fiber post and direct coronal reconstruction with resin composite is a satisfactory option (in terms of cost and esthetics) for cases where extraction would be indicated due to the root's fragility.[17,18]

None of the clinical cases reviewed were identical to the present case report, in which fractured maxillary central incisors, without a coronal remainder, were treated by extrapolating the classic indications for fiberglass posts and resin composite restorations. However, there has been an increasing use of currently available esthetic materials, adhesive systems, and restorative techniques to solve dental problems that would normally require more time and intensive surgical procedures.[18,19]

In the present case, a longitudinal follow-up period of 12 months confirmed the efficiency of combining glass fiber posts and resin composite. Longer follow-up periods and longitudinal studies using fiberglass posts in direct reconstructions of extensively fractured teeth without a coronal remainder must be conducted to confirm the longevity of this treatment as a therapeutic option for treating fractured anterior teeth.

Summary

The treatment utilized in this case was a conservative alternative to tooth extraction, especially for patients who cannot afford indirect crowns, or in cases where the crown-root ratio is insufficient to indicate indirect restoration. After 12 months, it was determined that using glass fiber posts and composite resin is a feasible alternative for restoring teeth with extensive coronal destruction, resulting in functional and esthetic recovery of the teeth.

Author information

Drs. Cohen-Carneiro and Sponchiado are professors, Integrated Clinic, School of Dentistry, Federal University of Amazonas, Manaus, Brazil, where Ms. Sena is a graduate student. Dr. Garcia is a postdoctoral student, Ribeirao Preto School of Dentistry, University of Sao Paulo, Brazil. Dr. Yurtsever is a professor, Department of Periodontology, School of Health Sciences, State University of Amazonas, Manaus, Brazil, where Dr. Pontes is an assistant professor, Department of Operative Dentistry.

Disclaimer

The authors report no financial interests in any of the products described in this article.

References

1. Altun C, Tozum TF, Guven G. Multidisciplinary approach to the rehabilitation of a crown fracture with glass-fiber-reinforced composite: a case report. *J Can Dent Assoc.* 2008;74(4):363-366.
2. Flores MT, Andreasen JO, Bakland LK, et al. Guidelines for the evaluation and management of traumatic dental injuries. *Dent Traumatol.* 2001;17(2):49-52.
3. Andreasen FM, Noren JG, Andreasen JO, Engelhardtsen S, Lindh-Stomberg U. Long-term survival of fragment bonding in the treatment of fractured crown: a multicenter clinical study. *Quintessence Int.* 1995;26(10):669-681.
4. Altun C, Guven G. Combined technique with glass-fibre-reinforced composite post and original fragment in restoration of traumatized anterior teeth—a case report. *Dent Traumatol.* 2008;24(6):e76-e80.
5. Floratos SG, Kratchman SI. Surgical management of vertical root fractures for posterior teeth: report of four cases. *J Endod.* 2012;38(4):550-555.
6. Vichi A, Grandini S, Davidson C, Ferrari M. A SEM evaluation of several adhesive systems used for bonding fiber posts under clinical conditions. *Dent Mater.* 2002;18(7):495-502.
7. Naumann M, Koelpin M, Beuer F, Meyer-Lueckel H. 10-year survival evaluation for glass-fiber-supported post endodontic restoration: a prospective observational clinical study. *J Endod.* 2012;38(4):432-435.
8. Rosa R, Hwas A, Melo D, Valandro LF, Kaizer O. Fracture strength of endodontically treated teeth restored with different strategies after mechanical cycling. *Gen Dent.* 2012;60(2):e62-e68.
9. Valceanu AS, Stratul SI. Multidisciplinary approach of complicated crown fractures of both superior central incisors: a case report. *Dent Traumatol.* 2008;24(4):482-486.
10. Creugers NH, Mentink AG, Fokkinga WA, Kreulen CM. 5-year follow-up of a prospective clinical study on various types of core restorations. *Int J Prosthodont.* 2005;18(1):34-39.
11. Turp JC, Heydecke G, Krastl G, Pontius O, Antes G, Zitzmann NU. Restoring the fractured root-canal-treated maxillary lateral incisor: in search of an evidence-based approach. *Quintessence Int.* 2007;38(3):179-191.
12. Queiroz VS, Pizi EC, Soares CJ, Macedo VC, Martins LR. Fracture resistance of composite resin cores with or without prefabricated posts over different substrates. *Gen Dent.* 2011;59(5):e214-e218.
13. Lassila LV, Tanner J, Le Bell AM, Narva K, Vallittu PK. Flexural properties of fiber reinforced root canal posts. *Dent Mater.* 2004;20(1):29-36.
14. Monticelli F, Grandini S, Goracci C, Ferrari M. Clinical behavior of translucent-fiber posts: a 2-year prospective study. *Int J Prosthodont.* 2003;16(6):593-596.
15. Heda CB, Heda AA, Kulkarni SS. A multi-disciplinary approach in the management of a traumatized tooth with complicated crown-root fracture: a case report. *J Indian Soc Pedod Prev Dent.* 2006;24(4):197-200.
16. Grandini S, Goracci C, Franklin RT, Grandini R, Ferrari M. Clinical evaluation of the use of fiber post and direct resin restorations for endodontically treated teeth. *Int J Prosthodont.* 2005;18(5):399-404.
17. Metha D, Gulati A, Basappa N, Raju OS. Esthetic rehabilitation of severely decayed primary incisors using glass fiber reinforced composite: a case report. *J Dent Child (Chic).* 2012;79(1):22-25.
18. Durkan RK, Ozel MB, Celik D, Bagis B. The restoration of a maxillary central incisor fractured with the original crown fragment using a glass-fiber reinforced post: a clinical report. *Dent Traumatol.* 2008;24(6):e71-e75.
19. Sharma D, Garg S, Sheoran N, Swami S, Singh G. Multidisciplinary approach to the rehabilitation of a tooth with two trauma episodes: systematic review and report of a case. *Dent Traumatol.* 2011;27(4):321-326.
20. Fidel SR, Sassone L, Alvares GR, Guimaraes RP, Fidel RA. Use of glass fiber post and composite resin in restoration of a vertical fractured tooth. *Dent Traumatol.* 2006;22(6):337-339.
21. Panduric V, Gabric D, Negovetic-Mandic V. Immediate post-traumatic upper incisor reconstruction using composite resin materials. *Dent Traumatol.* 2008;24(1):108-111.

Manufacturers

DENTSPLY Maillefer, Tulsa, OK
800.924.7393, www.maillefer.com

DFL Industria e Comercio, Rio de Janeiro, Brazil
55.21.3528.6766, www.dfl.com.br

FGM Produtos Odontologicos, Joinville, Brazil
55.47.3441.6100, www.fgm.ind.br

3M ESPE, St. Paul, MN
888.364.3577, solutions.3m.com

self CDE 2 HOURS CREDIT instruction

Salivary thiol levels and periodontal parameters assessed with a chromogenic strip

Ahmed Khocht, DDS, MSD ▪ Merriam Seyedain, DMD, MS ▪ Samia Hardan, DMD, MS ▪ John Gaughan, PhD ▪ Jon Suzuki, DDS, PhD

Periodontitis tends to be associated with bacteria that use sulfate as an energy source and produce thiol compounds that contain sulfhydryl (-SH) groups. This study used a chromogenic thiol-detecting strip to investigate whole saliva -SH concentration (SS) in subjects with and without periodontal disease. Ninety-six subjects were enrolled; all underwent periodontal evaluations, including plaque index (PI), gingival index (GI), probing depth measurements (PD), and attachment levels (AL). Subjects were divided into 3 groups: those who were periodontally healthy (n = 17), those with gingivitis (n = 54), and those with periodontitis (n = 25). Of the 96 subjects, 33% (n = 32) were cigarette smokers. A chromogenic strip was used to collect a whole saliva sample from the mouth. Color reaction was scored based on a color chart.

Good-to-moderate correlations were found between SS scores and PI (r = 0.47, $P = 0.0001$), GI (r = 0.45, $P = 0.0001$), PD (r = 0.42, $P = 0.0001$), and AL (r = 0.30, $P = 0.002$). Analysis of variance showed significant differences in SS scores among the 3 study groups ($P = 0.0001$); post-hoc analysis showed higher SS scores in subjects with periodontitis than in those without ($P = 0.05$). Logistic regression, adjusting for smoking, showed the odds ratio of periodontitis increased by a factor of 12.76 for each increase of one unit of measure of SS. These results indicate that assessing whole saliva thiol levels with a chromogenic strip could be used as a screening test for periodontal diseases.

Received: February 15, 2012
Accepted: June 26, 2012

Conventional periodontal evaluations involve a multitude of clinical and radiographic measures. These tend to be tedious and time-consuming, and therefore are not suited for rapid periodontal disease screening. A number of clinical, biochemical, and microbiological tests have been investigated for rapid screening, but none have seen great success.[1-6]

Periodontal infections tend to be associated with sulfate-reducing bacteria, which produce thiol compounds when sulfate is used as an energy source.[7-9] An increase in thiol compound levels in periodontally diseased pockets is well documented, however, thiol assessment is difficult, and usually involves complicated and/or expensive equipment to assess volatile sulfur compounds.[7-9] A new dry biochemical thiol detection test (SmartBreath QuickCheck, PDx BioTech) employs a strip with a porous pad that has been impregnated with a chromogenic reagent designed to detect thiol compounds that contain sulfhydryl (-SH) groups dissolved in oral fluids.[10] The strip provides a semiquantitative visual assessment of whole saliva -SH concentration (SS). The chromogenic reagent reacts with thiol compounds to form colored complexes, which are scored by using a color chart. Thiol compounds that can be detected by the strip include hydrogen sulfide (HS) and methyl mercaptan (MeSH).[10]

Saliva is a biological fluid that is easily obtained and can provide useful information about a number of pathological conditions.[11] Saliva consists mainly of water, but also contains electrolytes, mucus, enzymes, and immunoglobulins, all of which play important physiologic and defense roles.[11,12] In addition, many oral bacteria and their noxious agents (including thiol compounds) find their way into saliva.[13] Using the thiol strip for salivary analysis of microbial byproducts such as dissolved thiol compounds may offer a novel and simple method of screening for periodontal diseases.

It was hypothesized that thiol compound scores in whole saliva would be elevated among periodontitis patients, and that salivary thiol compound levels would relate positively to measures of periodontal disease. To test these hypotheses, this study used the strip to measure whole saliva thiol levels in subjects with and without periodontal diseases, and examined the relationship between thiol measures in saliva, and clinical measures of periodontal status, at a single point in time.

Materials and methods

This study was conducted at Temple University School of Dentistry (TUSD), Philadelphia, PA. Study protocol and consent forms were approved by the Temple University Institutional Review Board. The study included 3 periodontal status groups: periodontally healthy, gingivitis, and periodontitis. All subjects were recruited from TUSD's patient population, staff, and students.

Subject qualification

Inclusion criteria for this study required patients to be in good general health, 21 years of age or more, able to communicate in English, and to have a minimum of 12 natural usable teeth. Any of the following conditions excluded subjects from eligibility for study participation: medical conditions with a known impact on periodontal status (such as diabetes), medical conditions requiring prophylactic antibiotic coverage, medical conditions that impact salivary function, the use of anti-inflammatory medications, current participation in a dental plaque/gingivitis clinical trial, pregnancy, gross dental caries or other significant oral diseases, and wearing a fixed orthodontic appliance.

The study was advertised by word of mouth to dental patients attending the periodontology clinic at TUSD, as well as to TUSD staff and students.

A total of 100 subjects were screened for the study, with 4 disqualified for not meeting all study criteria; the remaining 96 were enrolled and completed all study evaluations. Characteristics of 24 of the subjects reported in this study were previously described in an earlier study.[14] All subjects were able to communicate in

English. Signed consent was obtained and documented for all subjects before the start of the study.

Questionnaire

Prior to the clinical examination, all subjects were asked to fill out a questionnaire that included questions related to education, income, dental hygiene, dental care, and smoking. However, this study only evaluated those questions related to smoking: the number of cigarettes smoked per day and how many years the patient smoked. The *pack per day* score was calculated for each current smoker.

Oral/periodontal assessments

All subjects received a comprehensive oral/periodontal evaluation that included probing measurements. A single experienced dental examiner performed all dental examinations. The examiner was calibrated and standardized in the use of the clinical evaluation measures employed in the study. To ensure consistency, periodic calibrations were conducted throughout the clinical evaluation phase of the study. The intra-examiner probing measure agreement (that is, probing differences within 1 mm) was 98%. The examiner recorded the plaque index (PI), and the gingival index (GI) around all teeth present.[15,16] Each tooth was scored at 6 sites: mesiobuccal, buccal, distobuccal, mesiolingual, lingual, and distolingual. Surfaces with large restorations and teeth with crowns were not scored.

A conventional periodontal probe (Michigan-O Probe, Hu-Friedy Mfg. Co., LLC) was used for all probing measurements. Probing depth (PD) and bleeding on probing (BOP) were recorded on the same 6 tooth sites noted earlier. The probe was inserted on the buccal and lingual surfaces, parallel to the long axis of the tooth. Interproximally, the probe was placed at a slight angulation, as close to the contact area as possible. The reading was taken (to the nearest mm) at the gingival margin (GM), and the position of the GM to the cementoenamel junction (CEJ) was recorded at the same 6 sites per tooth (again, to the nearest mm). A negative (-) sign was recorded when the gingival margin was coronal to the CEJ and a positive (+) sign was recorded when it was apical. Attachment levels (ALs) were calculated using the formula AL = PD + GM. Only fully erupted teeth were used for these examinations; third molars were not included. Caries and missing teeth were also recorded.

Based on the periodontal findings from these evaluations, each subject was assigned to 1 of 3 periodontal status groups: periodontal health (no loss of clinical attachment and less than 5 sites with a GI score of 2 throughout the mouth), gingivitis (no loss of clinical attachment and 5 or more sites with GI score of 2, with at least 1 site in each quadrant), and periodontitis (at least 1 site or ≥4 teeth with clinical attachment loss of ≥4 mm, with at least 1 affected tooth in each quadrant)

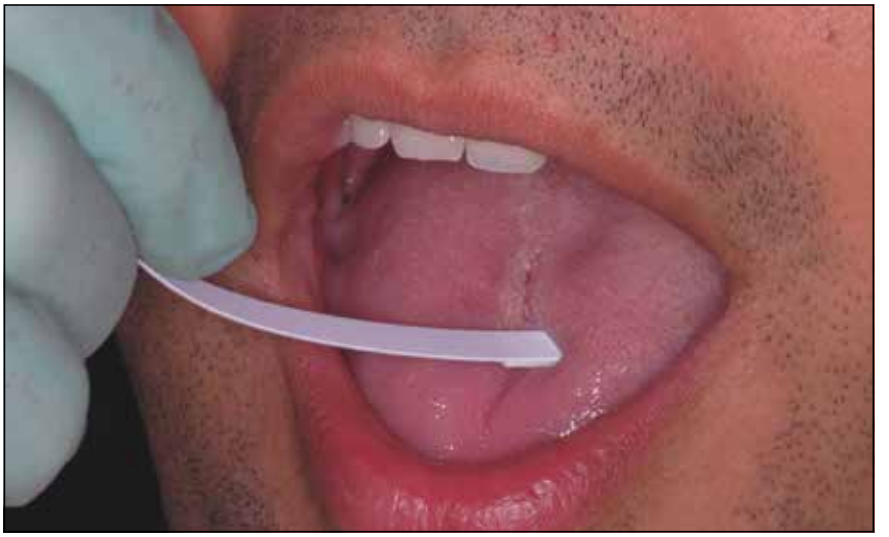


Figure. Saliva sampling with thiol strip. Note that the strip should touch only the saliva, not the tongue.

Thiol-detecting strip

The thiol-detecting strip is formulated to detect thiol concentrations ranging from 0 to 600 μm. It measures the concentration of thiols in saliva directly, and provides a visual signal related to the thiol concentration. The pad on the strip contains a thiol-detection reagent that produces the yellow color of thionitrobenzoate when thiols are present.[10] The intensity of the color on the strip relates directly to the concentration of thiols in the sample. A comparator color chart (with color scores ranging from 0 to 10) is used to score the color change; a score of 0 indicates no color change, and a score of 10 indicates a thiol concentration of ≥600 μm. The comparator color chart allows for rapid visual scoring of a sample's thiol content, without the need for additional equipment. The safety and stability of the reagent, and the sensitivity, selectivity, and reliability of the quantitative color responses have been reported in the literature.[17]

Saliva sampling

Prior to initiating the periodontal measures, a subject was instructed to close the mouth, rub the tongue against the lingual aspects of the gingival margins, pool saliva on the tongue surface, and open the mouth. The padded end of the strip was dipped in the pooled saliva on the tongue surface without rubbing against the tongue (Figure).

After saliva collection, researchers waited 30 seconds for the color reaction to develop on each strip. Strip scoring was performed by a team of 2 blinded evaluators (that is, unaware of the subject's clinical periodontal status). Strip score was determined by comparing the intensity of color change on the strip to the color chart. The score of the color closest to the color on the strip was selected as the strip score. If the color change on the strip was not uniform, scoring was based on the most intense color on the pad. The 2 evaluators scored each strip independently, and the average of the 2 scores was used for data analysis.

To minimize intra-evaluator and inter-evaluator variability, the 2 strip evaluators were calibrated to recognize and agree on the intensity of the color change on the strip and the corresponding color score. Calibration data showed intra-evaluator agreement (same score between first and second readings) of 98% for 1 evaluator and 97% for the other. Inter-evaluator agreement (same score between first and second evaluator) was 94%.

Collected data were entered, and mean scores were computed; statistical software (JMP version 8 for Macintosh, SAS Institute, Inc.) was used for the analysis. Analysis of variance (ANOVA) or chi-square tests were utilized to compare differences in demographic data, clinical data, and strip data between the 3 groups. Pearson correlation and partial correlation were used to examine associations between clinical data and strip scores. Logistic regression analysis was used to determine the prediction of periodontitis based on the strip scores.

Results

For all subjects, the mean age (± SD) was 36.5 (1.57) years, as subjects ranged in age from 22 to 82 years. In addition, 52% of the subjects were male, and 57% were Caucasian. Demographics of subjects by group are summarized in Table 1. Subjects with periodontitis were older than those with gingivitis and those with periodontal health (P = 0.0001); gender distribution was similar between the 3 groups. There was a lower percentage of Caucasians and a higher percentage of smokers among subjects with periodontitis.

Of the 96 subjects in this study, 32 (33%) reported cigarette smoking, and while the percentage of smokers significantly differed between each groups (P = 0.0004), the periodontitis patients had the highest percentage of smokers (64%) (Table 1). The average pack-per-day consumption among smokers in this study was 0.8. No statistical differences were noted between the 3 groups in terms of cigarette consumption.

Clinical parameters by subject group are summarized in Table 2. As expected, analysis of variance (ANOVA) showed significant differences (P = 0.0001) between the 3 groups for all periodontal parameters. Follow-up analysis with the Tukey-HSD test showed the periodontitis group to be significantly higher on all clinical parameters than the group of healthy patients, or those with gingivitis (P = 0.05).

Table 1. Demographic data by subject group.

	Healthy	Gingivitis	Periodontitis	*P*-value
n	17	54	25	N/A
Mean age (SD)	32.17 (3.0)	30.61 (1.68)	52.16 (2.47)	0.0001
Males (%)	70	50	44	0.21
White (%)	64	68	28	0.002
Smokers (%)	35	18	64	0.0004

n = number in group. The *P* value is the probability that the groups differ in either an ANOVA test for means, or a chi-square test for proportions.

Table 2. Mean clinical periodontal data (SD) by subject group (P = 0.0001).

	Healthy	Gingivitis	Periodontitis
n	17	54	25
PI	0.31 (0.09)	0.55 (0.05)	1.11 (0.07)
GI	0.31 (0.04)	0.48 (0.02)	0.78 (0.04)
PD (in mm)	2.33 (0.12)	2.40 (0.06)	3.38 (0.09)
AL (in mm)	0.17 (0.29)	0.10 (0.06)	3.06 (0.24)
% BOP	4.56 (4.32)	13.08 (2.42)	38.15 (3.56)

n = number in group. The *P* value is the probability that the groups differ in an ANOVA test for means.
PI = plaque index, GI = gingival index, PD = probing depth, AL = attachment levels, BOP = bleeding on probing.

Color range of SS was 1 to 6 for all subjects combined. The Chart presents the mean SS score levels by group. Analysis of variance showed significant differences in SS scores among the 3 study groups (P = 0.0001). Post-hoc analysis with Tukey HSD test showed the SS scores of the periodontitis group higher than both the periodontal health group and the gingivitis group (P = 0.05).

Pearson correlation analysis showed a weak association between cigarette smoking (pack/day score) and SS scores (r = 0.35, P = 0.0004), suggesting that cigarette smoking can influence SS scores.

Pearson correlation analyses to determine the association between the periodontal clinical parameters and SS scores are summarized in Table 3. All clinical parameters showed statistically significant weak to moderate associations with SS; PI, GI, and PD produced the strongest associations. Table 3 also summarizes the partial correlations between clinical parameters and SS scores adjusted for cigarette smoking. Adjusted partial correlations were comparable to unadjusted correlations, albeit slightly weaker, indicating that even though cigarette smoking can influence SS scores independently, it does not obscure the relation between SS scores and periodontal clinical parameters. Logistic regression adjusted for smoking showed the odds ratio of periodontitis increase by a factor of 12.76 (95% CL 3.46-67.19; model 1: smoking dichotomous) or a factor of 9.93 (95% CL 2.97-46.97; model 2: pack/day) for each 1 unit increase of the SS score.

Discussion

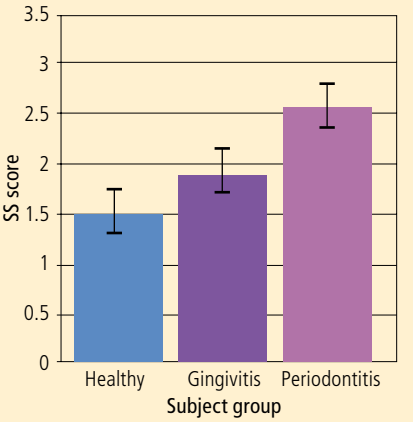
This study used a semi-quantitative chromogenic thiol strip to compare the scores of dissolved thiol compounds in

Table 3. Correlation analysis (r) between salivary thiol strip scores and periodontal measures.

Periodontal Measures	Unadjusted Pearson correlations (*P* value)	Partial correlations, adjusted for smoking (*P* value)
PI	0.47 (0.0001)	0.39 (0.0001)
GI	0.45 (0.0001)	0.39 (0.0001)
PD	0.42 (0.0001)	0.35 (0.0005)
AL	0.30 (0.002)	0.22 (0.02)
% BOP	0.29 (0.003)	0.20 (0.04)

PI = plaque index, GI = gingival index, PD = probing depth, AL = attachment levels, BOP = bleeding on probing.

Chart. Mean (SE) SS scores by group.



Error bars indicate the standard error of the mean. Significance of difference among groups was sought using ANOVA. Ad hoc analysis showed periodontitis > gingivitis and healthy ($P = 0.05$). SS = Whole saliva -SH concentration.

saliva between subjects with and without periodontitis; it also investigated the relationship between salivary thiol scores and clinical periodontal disease. The results showed that periodontitis subjects have higher thiol compound scores than non-periodontitis subjects, as well as a relevant positive relation between the thiol compound salivary scores and clinical periodontal disease.

A number of in vitro experiments have indicated that thiol compounds may play an important role in the pathogenesis of periodontitis, by impairing epithelial and fibroblast cell function, enhancing oxidative stress toxicity, facilitating the penetration of bacterial agents (such as lipopolysaccharides) into gingival tissues, and enhancing interleukin-1 production–subsequently enhancing the production of matrix metalloproteinases and prostaglandin E-2, which are involved in soft and hard periodontal tissue damage.[18-21]

Thiol compounds in oral fluids (saliva and/or gingival fluid) may offer dentists an opportunity to develop a biochemical test for periodontitis. Enzymatic reduction of sulfate—used as a terminal electron acceptor or energy source by anaerobes—is the primary source of thiol compounds (with a free -SH group) present in saliva and gingival fluid. The breakdown of sulfur containing amino acids such as cysteine (yielding HS) and methionine (yielding MeSH) is another source of thiol compounds, as are naturally produced reduced side-chains of cysteine.[7,9,21]

Several clinical studies have investigated thiol compounds and sulfate-reducing bacteria (SRB) in periodontitis patients. Persson used gas chromatography to demonstrate the presence of volatile sulfur compounds (such as HS and MeSH) in periodontal pockets.[8] A 2001 study by Langendijk-Genevaux et al isolated SRB in one or more pockets for 86% of periodontal disease patients.[7] Two years later, Torresyap et al investigated the clinical and microbiological characteristics of periodontal patients and demonstrated that intrapocket sulfide levels reflect SRB levels.[9]

Other studies have examined the relation between oral thiol compound levels and periodontal disease measures. Zhou et al reported an association between experimental gingivitis and increased volatile sulfur compound levels in the gingiva.[22] A 2007 study by Zappacosta et al reported an increase in concentrations of salivary cysteine (the precursor of HS) among periodontitis patients with pocket depths of more than 5 mm.[13] Tsai et al reported increased levels of volatile sulfur compounds in mouth air from patients with chronic periodontitis.[23] Collectively, these studies confirm an association between oral thiol compound levels and periodontal disease, suggesting that oral thiol compound levels may serve as a marker for periodontal disease activity.

The dry chemical strip used in this study was simple to use and easy to interpret. The findings corroborated those reported in the literature and expanded upon their findings by showing that a simple chromogenic test can detect thiol compounds dissolved in biological fluids without the need for expensive and sophisticated equipment. The reported strip scores indicated that patients with periodontitis have elevated thiol compound levels in whole saliva, suggesting that thiol compounds associated with thiol-producing bacteria in the periodontal pockets—as well as those found in microbial biofilm at the dentogingival region and other oral microbial niches (for example, in the tongue)—of periodontitis patients find their way in salivary fluids. The results of the present study also indicate an association between periodontal disease and thiol compounds dissolved in salivary fluids. This indicates that these compounds could be used as a screening test for periodontitis.

The thiol compounds detected by the strip also are associated with halitosis or bad breath. Halitosis could be caused by a variety of intraoral conditions, including periodontal disease, rampant caries, pericoronitis, and/or the type(s) of food consumed. Other conditions—such as cigarette smoking, chronic sinusitis with postnasal drip, and diabetic ketoacidosis—may be involved also.[24,25] This study examined the effect of cigarette smoking on the strip scores and found a positive association between cigarette smoking and the strip color changes. Cigarette smoke contains volatile sulfur compounds that could be detected by a halimeter.[26,27] It is possible that sulfur compounds in cigarette

smoke adsorb onto the oral mucosal tissues and are dissolved in salivary fluids; these levels likely depend on the time elapsed since the last cigarette smoked. The partial correlation analysis performed (adjusted for cigarette smoking) showed that cigarette smoking is associated with SS scores but that does not obscure the association between the SS scores with periodontal disease measures.

Conclusion

The results of this study indicate that the salivary fluids of periodontitis patients contain increased levels of dissolved thiol compounds, and that using a simple chromogenic strip to assess dissolved thiol compounds in salivary fluids has the potential to be a screening test for periodontal diseases.

Author information

Dr. Khocht is an associate professor, Department of Periodontology, Temple University School of Dentistry, Philadelphia, Pennsylvania, where Drs. Seyedain and Hardan are clinical assistant professors; Dr. Suzuki is a professor and chair; and Dr. Gaughan is an associate professor, Biostatistics Consulting Center, Temple University School of Medicine.

Acknowledgments

This study was sponsored in part by PDx BioTech of Lexington, KY.

Disclaimer

The authors have no financial, economic, commercial, and/or professional interests related to topics presented in this article.

References

1. Khocht A, Zohn H, Deasy M, Chang KM. Assessment of periodontal status with PSR and traditional clinical periodontal examination. *J Am Dent Assoc.* 1995; 126(12):1658-1665.
2. Bader HI, Boyd RL. Long-term monitoring of adult periodontitis patients in supportive periodontal therapy: correlation of gingival crevicular fluid proteases with probing attachment loss. *J Clin Periodontol.* 1999;26(2):99-105.
3. Magnusson I, Persson RG, Page RC, et al. A multi-center clinical trial of a new chairside test in distinguishing between diseased and healthy periodontal sites. II. Association between site type and test outcome before and after therapy. *J Periodontol.* 1996;67(6):589-596.
4. Prescher N, Maier K, Munjal SK, et al. Rapid quantitative chairside test for active MMP-8 in gingival crevicular fluid: first clinical data. *Ann N Y Acad Sci.* 2007; 1098:493-495.
5. Andrade JA, Feres M, Figueiredo LC, Salvador SL, Cortelli SC. The ability of the BANA Test to detect different levels of *P. gingivalis, T. denticola* and *T. forsythia. Pesqui Odontol Bras.* 2010;24(2):224-230.
6. Grisi MF, Correa Filho TA, Fanganiello CL, Martins Junior W, Silva-Neto CR, Salvador SL. Relationship between the presence or absence of gingival bleeding and the enzymatic BANA test. *Braz Dent J.* 2001; 12(1):23-26.
7. Langendijk-Genevaux PS, Grimm WD, van der Hoeven JS. Sulfate-reducing bacteria in relation with other potential periodontal pathogens. *J Clin Periodontol.* 2001;28(12):1151-1157.
8. Persson S. Hydrogen sulfide and methyl mercaptan in periodontal pockets. *Oral Microbiol Immunol.* 1992; 7(6):378-379.
9. Torresyap G, Haffajee AD, Uzel NG, Socransky SS. Relationship between periodontal pocket sulfide levels and subgingival species. *J Clin Periodontol.* 2003;30(11): 1003-1010.
10. Ellman GL. A colorimetric method for determining low concentrations of mercaptans. *Arch Biochem Biophys.* 1958;74(2):443-450.
11. Mandel ID. The diagnostic uses of saliva. *J Oral Pathol Med.* 1990;19(3):119-125.
12. Tenovuo J, Grahn E, Lehtonen OP, Hyyppa T, Karhuvaara L, Vilja P. Antimicrobial factors in saliva: ontogeny and relation to oral health. *J Dent Res.* 1987;66: 475-479.
13. Zappacosta B, Manni A, Persichilli S, et al. Salivary thiols and enzyme markers of cell damage in periodontal disease. *Clin Biochem.* 2007;40(9-10):661-665.
14. Hardan S, Khocht A, Suzuki J. A clinical investigation of the association of a biochemical chairside assay and periodontal parameters. *J Clin Dent.* 2011;22(2):36-39.
15. Silness J, Loe H. Periodontal disease in pregnancy. II. Correlation between oral hygiene and periodontal condition. *Acta Odontol Scand.* 1964;22:121-135.
16. Loe H, Silness J. Periodontal disease in pregnancy. I. Prevalence and severity. *Acta Odontol Scand.* 1963;21: 533-551.
17. Burgess-Cassler A, Haley BE, inventors; Alt Bioscience, LLC, assignee. Device for rapid determination of disease-associated thiol compounds. U.S. patent 20090311142. Dec 17, 2009.
18. Yaegaki K, Qian W, Murata T, et al. Oral malodorous compound causes apoptosis and genomic DNA damage in human gingival fibroblasts. *J Periodontal Res.* 2008;43(4):391-399.
19. Ratkay LG, Tonzetich J, Waterfield JD. Antibodies to extracellular matrix proteins in the sera of MRL-lpr mice. *Clin Immunol Immunopathol.* 1991;59(2):236-245.
20. Ng W, Tonzetich J. Effect of hydrogen sulfide and methyl mercaptan on the permeability of oral mucosa. *J Dent Res.* 1984;63(7):994-997.
21. Ratcliff PA, Johnson PW. The relationship between oral malodor, gingivitis, and periodontitis. A review. *J Periodontol.* 1999;70(5):485-489.
22. Zhou H, McCombs GB, Darby ML, Marinak K. Sulphur by-product: the relationship between volatile sulphur compounds and dental plaque-induced gingivitis. *J Contemp Dent Pract.* 2004;5(2):27-39.
23. Tsai CC, Chou HH, Wu TL, et al. The levels of volatile sulfur compounds in mouth air from patients with chronic periodontitis. *J Periodontal Res.* 2008;43(2): 186-193.
24. Bornstein MM, Stocker BL, Seemann R, Burgin WB, Lussi A. Prevalence of halitosis in young male adults: a study in swiss army recruits comparing self-reported and clinical data. *J Periodontol.* 2009;80(1):24-31.
25. Van den Velde S, van Steenberghe D, Van Hee P, Quirynen M. Detection of odorous compounds in breath. *J Dent Res.* 2009;88(3):285-289.
26. Christen AG. The impact of tobacco use and cessation on oral and dental diseases and conditions. *Am J Med.* 1992;93(1A):25S-31S.
27. Rosenberg M. Clinical assessment of bad breath: current concepts. *J Am Dent Assoc.* 1996;127(4):475-482.

Manufacturers

Hu-Friedy Mfg. Co., LLC, Chicago, IL
800.483.7433, www.hu-friedy.com

PDx BioTech, Lexington, KY
859.388.9445, periodx.com

SAS Institute, Inc., Cary, NC
800.727.0025, www.sas.com

self CDE 2 HOURS CREDIT instruction

Academy of General Dentistry PACE Program Approval for Continuing Education

Approved PACE Program Provider
FAGD/MAGD Credit
Approval does not imply acceptance by a state or provincial board of dentistry or AGD endorsement
06/01/2010 to 05/31/2014

Exercise No. 335 Periodontics Subject Code 490

The 15 questions for this exercise are based on the article, *Salivary thiol levels and periodontal parameters assessed with a chromogenic strip*, on pages 50-54. This exercise was developed by Daniel S. Geare, DMD, in association with the *General Dentistry* Self-Instruction committee.

Reading the article and successfully completing this exercise will enable you to understand:
- the measurement parameters for periodontitis;
- how thiol compounds are part of periodontitis; and
- how periodontitis is assessed.

1. Periodontitis is associated with bacteria that
   A. are strictly anaerobic.
   B. use sulfate as an energy source.
   C. use carbohydrates as the sole energy source.
   D. are part of a single genus.

2. Periodontal evaluations for this study included all of the following except one. Which is the exception?
   A. Plaque index
   B. Probing depth measurements
   C. DMF Index
   D. Attachment levels

3. Which compound is detected by the test strip?
   A. Methyl mercapten
   B. Inflammatory cytokines
   C. "T" cells
   D. Sulfur oxides

4. Saliva constituents include all of the following except one. Which is the exception?
   A. Electrolytes
   B. Enzymes
   C. Immunoglobulins
   D. Mucopolysaccharides

5. The hypothesis indicated that thiol levels will be elevated in periodontal patients. Salivary thiol levels would be positively correlated to measurable periodontitis levels.
   A. Both statements are true.
   B. The first statement is true; the second is false.
   C. The first statement is false; the second is true.
   D. Both statements are false.

6. Criteria for exclusion from this study included all of the following except one. Which is the exception?
   A. Subjects using anti-inflammatories
   B. Pregnant women
   C. Subjects who are at least 21 years old
   D. Subjects taking antibiotics

7. The thiol-detecting strip detects thiol concentrations
   A. of 650 µm or greater.
   B. in crevicular exudates.
   C. of 0-600 µm.
   D. in thionitrobenzoate.

8. This study showed that periodontal subjects have higher thiol compound scores than non-periodontal subjects. Cigarette smoking was not a factor in measured thiol levels.
   A. Both statements are true.
   B. The first statement is true; the second is false.
   C. The first statement is false; the second is true.
   D. Both statements are false.

9. Thiol compounds play an important role in the pathogenesis of periodontitis because
   A. fibroblast cell function is enhanced.
   B. penetration of bacteria is impaired.
   C. they reduce prostaglandin production.
   D. epithelial cell function is impaired.

10. The enzymatic reduction of sulfate
    A. is the primary source of thiol compounds.
    B. is initiated in the esophagus.
    C. is dependent on aerobic bacteria.
    D. requires essential amino acids only.

11. One study showed that
    A. gingivitis has no effect on volatile sulfur compound levels.
    B. cysteine levels are lower in periodontal patients with deep pockets.
    C. thiol concentrations are age-dependent.
    D. the air in periodontal patients' mouths has measurable volatile sulfur.

12. Cigarette smoking can affect the reading of the color strip changes. This is because cigarette smoke contains sulfur compounds that may be adsorbed into oral mucosal tissues.
    A. Both statements are true.
    B. The first statement is true; the second is false.
    C. The first statement is false; the second is true.
    D. Both statements are false.

13. Of the 96 subjects used in this study, how many were cigarette smokers?
    A. 16
    B. 23
    C. 32
    D. 45

14. All of the following quick tests have been used to test for periodontitis except one. Which is the exception?
    A. Clinical
    B. Biochemical
    C. Microbiological
    D. Immunological

15. For this particular assessment which teeth were specifically eliminated from scoring?
    A. Crowned teeth
    B. Primary teeth
    C. Fractured teeth
    D. Mobile teeth

Answer form is on page 80. Answers for this exercise must be received by July 31, 2014.

Modified frenectomy: a review of 3 cases with concerns for esthetics

Prashant Bhusari, MDS ▪ Shiras Verma ▪ Shubhra Maheshwari ▪ Sphoorthi Belludi, MDS

The maxillary labial frenum is a normal anatomical structure in the oral cavity. An abnormal labial frenum causes localized gingival recession and midline diastema, both of which can interfere with oral hygiene procedures, and eventually affect esthetics. When the frenum maintains its high papillary attachment, frenectomy is the treatment of choice. Though this technique has undergone many modifications, the zone of attachment and esthetics in the anterior maxillary region have been neglected. This article highlights a new frenectomy technique that results in good esthetics, excellent color match, gain in attached gingiva, and healing by primary intention at the site of thick, extensive abnormal frena.

Received: March 29, 2012
Accepted: July 3, 2012

Key words: frenectomy, frenotomy, attached gingiva, diastema

The maxillary labial frenum is a normal anatomical structure in the oral cavity. A *frenum* is a fold of mucous membrane (usually with enclosed muscle fibers) that attaches the lips and cheeks to the alveolar mucosa and/or gingiva and underlying periosteum.[1] As the teeth erupt, alveolar growth generally causes this attachment to assume the adult configuration. An abnormal maxillary labial frenum presents as a thick, broad, fibrous attachment that interferes with the normal function of the upper lip and with oral hygiene, resulting in compromised esthetics, diastema formation, and gingival recession (Fig. 1).[2] An abnormal maxillary labial frenum can be treated by complete excision or via an apical repositioning technique, both of which often heal by secondary intention and may result in the formation of a contracting scar.[3,4] This article presents 3 cases of abnormal maxillary labial frenal attachment treated with a new modified surgical technique in which adjacent attached gingiva in the central incisor region were utilized to achieve a zone of attached gingiva with an excellent color match at the site of the abnormal frenum.

Case reports

Three patients reported to the Outpatient Department of Periodontics, Modern Dental College and Research Centre, Indore, India. The first patient was a 32-year-old woman whose chief complaint was spacing between the maxillary anterior teeth since the age of 6. Examination revealed a broad, thick, hypertrophied labial frenum of papillary-type attachment and a maxillary central diastema between teeth No. 11 and 21. (Fig. 2). The second patient was a 26-year-old male dental student with a broad, thick, hypertrophied labial frenum and median diastema (Fig. 3). The third patient was a 26-year-old man with an apical pull over the gingival margin between teeth No. 11 and 21 due to an aberrant frenal attachment (Fig. 4).

In all 3 cases, the blanching test was performed by pulling the upper lip to reveal all of the teeth were present and had adequate vestibular depth, except in the area of the frenum. At all 3 sites, an adequate amount of attached gingiva was present without any mucogingival problems.

The patients were informed about the techniques that could be used to treat the high frenal attachment and each chose the new frenectomy technique. Treatment planning was built around the patients' esthetic concerns, since traditional excision of wide, thick, hypertrophied frena with high aberrant attachments can leave wide defects and lead to scar formation. Hematological

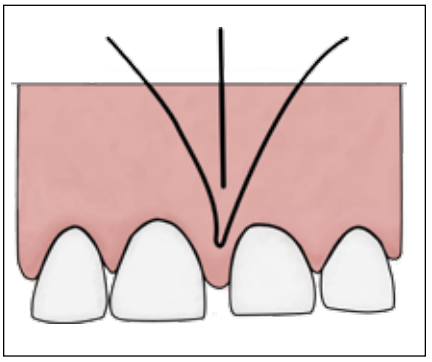


Fig. 1. An illustration of a thick hypertrophied frenum.

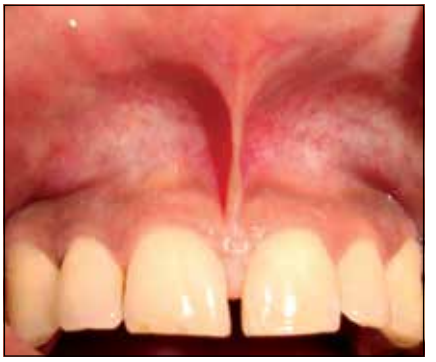


Fig. 2. Photograph of the thick hypertrophied frenum in Case 1.

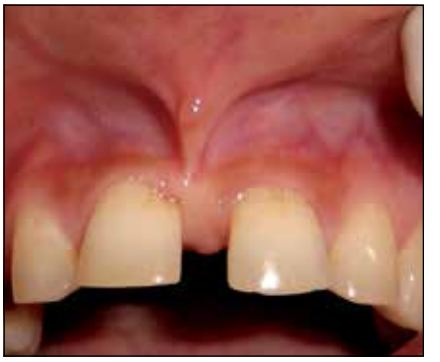


Fig. 3. Photograph of the thick hypertrophied frenum in Case 2.

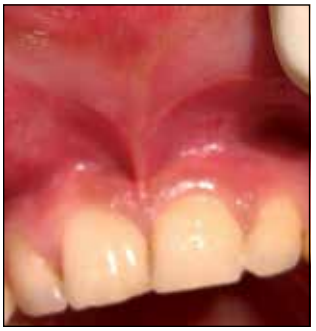


Fig. 4. Photograph of the thick hypertrophied frenum in Case 3.

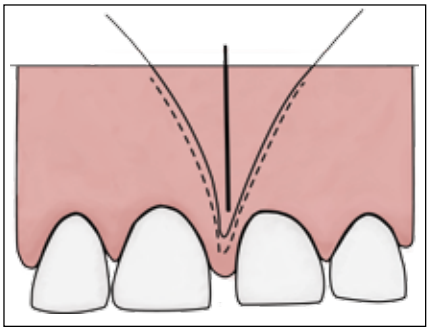


Fig. 5. An illustration of a V-shaped external bevel incision (dotted lines) at the base of the frenum.

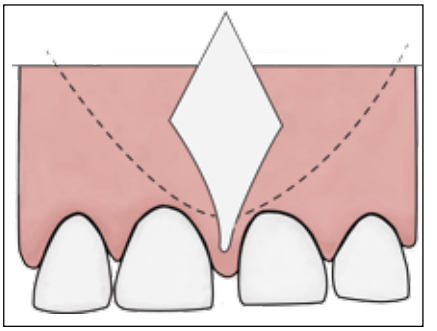


Fig. 6. An illustration of a V-shaped defect and oblique partial thickness incision on adjacent gingiva extending beyond the mucogingival junction.

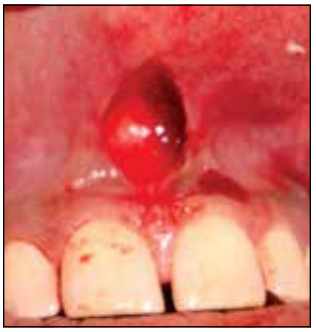


Fig. 7. Photograph of the V-shaped defect and oblique partial-thickness incision made on adjacent gingiva extending beyond the mucogingival junction.

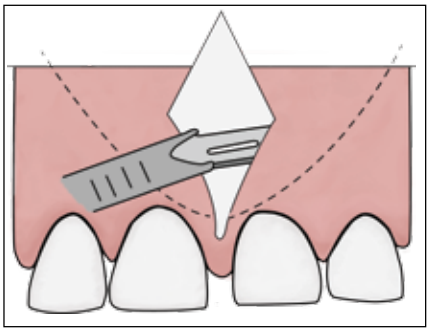


Fig. 8. An illustration of a partial-thickness dissection of attached gingiva in an apicocoronal direction.

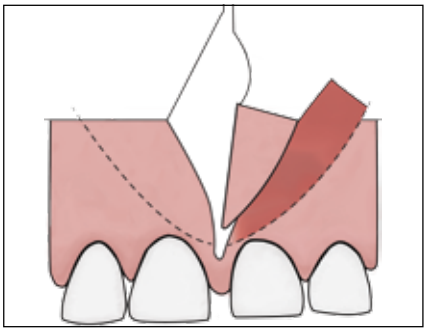


Fig. 9. An illustration of a triangular pedicle of attached gingiva with the free end as apex and the base continuous with the alveolar mucosa.

investigations were within normal limits, and each case's medical history was noncontributory.

Materials and methods

Surgical technique

The maxillary anterior region was anesthetized by local infiltration on buccal and palatal aspects, using 1:200,000 lidocaine hydrochloride with adrenaline. Care was taken not to over-distend the frenum with the solution because it could obscure the anatomic relationships and make removal more difficult.

A V-shaped full-thickness incision was placed at the gingival base of the frenal attachment with an external bevel (Fig. 5). Tissue and periosteum were separated from underlying bone. The initial incision resulted in a V-shaped defect on the gingival side (Fig. 6 and 7). Fibrous tissue attached to the lip was dissected using scissors, and undermining of the labial mucosa was completed. An oblique partial-thickness incision was made to the adjacent attached gingiva, beginning 1 mm apical to the free gingival groove and extending beyond the mucogingival junction (Fig. 8).

The partial-thickness dissection from the medial margin was performed in an apicocoronal direction on the attached gingiva to create a triangular pedicle flap with its free end as the apex and its base continuous with the alveolar mucosa (Fig. 9). To avoid tension, the flap was further undermined and repositioned. A similar procedure was performed on the contralateral side, resulting in 2 triangular pedicle flaps on both sides (Fig. 10). Using 4-0 silk suture (Mersilk, Ethicon, Inc.), these pedicle flaps were sutured to each other at the medial side and laterally with the adjacent intact periosteum of the donor side, completely covering the underlying defect created by the initial frenal excision (Fig. 11 and 12). The area was covered first with tinfoil to avoid suture entrapment in the periodontal dressing (Coe-Pak, GC America, Inc.).

Postsurgical protocol

Analgesics and a 0.2% chlorhexidine mouthwash (Hexidine, ICPA) were prescribed for 5 days. During the first 2 weeks postsurgery, the patients were advised to brush only the noninvolved teeth and to avoid pulling on their lip in the treated area. Pack and sutures were removed after 10 days and the patients were scheduled for regular follow-up visits for the next 3 months.

The 3-month follow-ups revealed a zone of attached gingiva with an esthetic color match in the area that had previously been

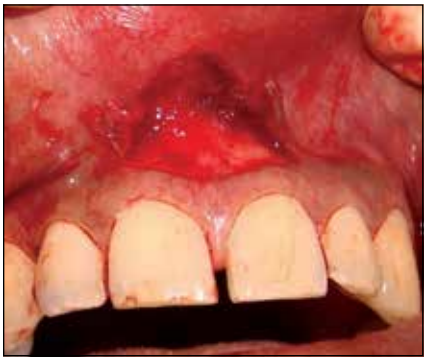


Fig. 10. Photograph of the triangular pedicle flap of attached gingiva with the free end as apex and the base continuous with the alveolar mucosa.

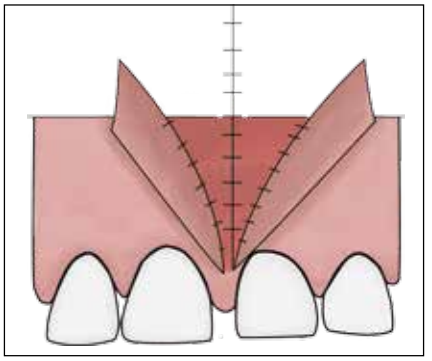


Fig. 11. An illustration of the sutured flaps.

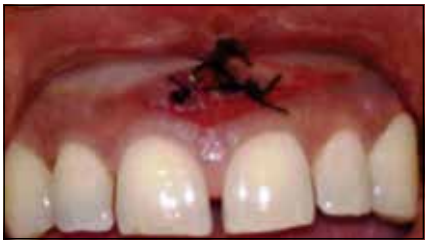


Fig. 12. Photograph of flaps after suturing.

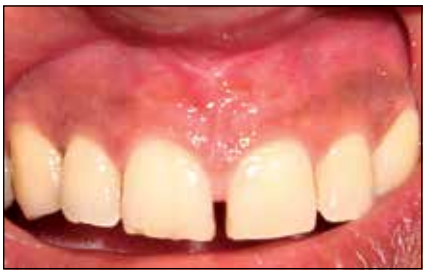


Fig. 13. A new zone of attached gingiva at the previous frenal site, with excellent color match 3 months postsurgery (Case 1).

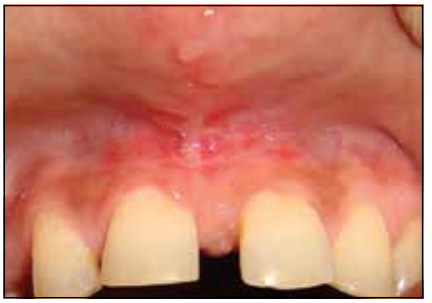


Fig. 14. A new zone of attached gingiva at the previous frenal site, with excellent color match 3 months postsurgery (Case 2).

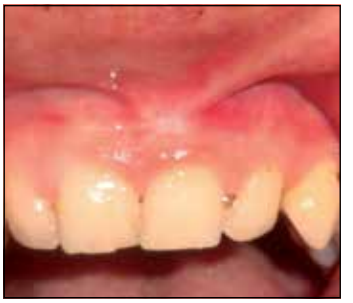


Fig. 15. A new zone of attached gingiva at the previous frenal site, with excellent color match 3 months postsurgery (Case 3).

covered by the abnormal frenum. Normal healing was seen without scarring or complication (Fig. 13-15).

Discussion

Various surgical techniques have been proposed for correcting abnormal maxillary labial frena. The conventional (or simple) frenectomy technique is made with a V-shaped incision (known as Archer incision or diamond-shaped incision) and can result in scarring, which may lead to periodontal problems and an unesthetic appearance.[3]

Z-plasty is a plastic surgery technique that is used to improve the functional and cosmetic appearance of scars.[5] It can elongate a contracted scar or rotate the scar tension line. The middle line of the Z-shaped incision is made along the line of greatest tension or contraction, with triangular flaps raised on opposite sides of the two ends and then transposed. Some complications of z-plasty include flap necrosis, hematoma formation under the flaps, wound infection, trapdoor effect, and sloughing of the flap caused by high wound tension.

Several other procedures have combined frenectomy with a lateral pedicle graft, a free papilla graft, and a free gingival graft taken from the palate.[6,7] The lateral pedicle graft technique also positions the unilateral pedicle at the midline but prevents complete coverage of the wound. A frenectomy followed by a free gingival graft taken from the palate covers the wound area completely but creates the esthetic concern of unsatisfactory color match, with the appearance of a keloid, tattoo-like, or tire-patch appearance at the grafted area.[7,8] In cases with a broad, thick, hypertrophied frenum, simple excision or the modification of V-rhomboplasty fail to provide satisfactory esthetic results.[4,9]

Summary

The frenum technique presented in this article provides a number of advantages, including a gain in attached gingiva (in the region covered previously by the frenum), excellent color match, healing by primary intention, minimal scar formation, and prevention of coronal reformation. This technique may be suitable when anterior esthetics are of primary importance. This technique requires an adequate zone of attached gingiva; however, based on these case reports, it is reliable and easy to perform and provides excellent esthetic results.

Author information

Dr. Bhusari is a professor, Department of Periodontics, Modern Dental College and Research Centre, Indore, India, where Dr. Belludi is a reader, and S. Verma and S. Maheshwari are postgraduate students.

References

1. Carranza FA. Periodontal Plastic and Esthetic Surgery. In: Takei HH, Azzi RR. *Clinical Periodontology.* 10th ed. St. Louis: Saunders Publishing; 2006:1023-1025.
2. Huang WJ, Creath CJ. The midline diastema: a review of its etiology and treatment. *Pediatr Dent.* 1995; 17(3):171-179.
3. Edwards JG. The diastema, the frenum, the frenectomy: a clinical study. *Am J Orthod.* 1977;71(5):489-508.
4. Whinston GJ. Frenotomy and mucobuccal fold resection used in periodontal therapy. *NY Dent J.* 1956; 22:495-499.
5. Chase DC, Laskin DM. Procedures to improve the alveolar soft tissues. In: Laskin DM, ed. *Oral and Maxillofacial Surgery.* Volume II. St Louis, MO: C.V. Mosby Co.; 2006:349-361.
6. Miller PD Jr. The frenectomy combined with a laterally positioned pedicle graft. Functional and esthetic considerations. *J Periodontol.* 1985;56(2):102-106.
7. Breault LG, Fowler EB, Moore EA, Murray DJ. The free gingival graft combined with the frenectomy: a clinical review. *Gen Dent.* 1999;47(5):514-518.
8. Cohen ES. *Atlas of Cosmetic and Reconstructive Periodontal Surgery.* Philadelphia: Lea and Febiger; 1989:189-232.
9. Ito T, Johnson JD. *Color Atlas of Periodontal Surgery.* London: Mosby Wolfe;1994:225-239.

Manufacturers

Ethicon, Inc., Somerville, NJ
877.384.4266, www.ethicon.com

GC America, Inc., Alsip, IL
800.323.7063, www.gcamerica.com

ICPA, Mumbai, India
283.22379, www.icpahealth.com

An evaluation and adjustment method for natural proximal contacts of crowns using diamond dental strips: a case report

Daniel S. Kim, DDS, FAGD ▪ John A. Rothchild, DDS, MAGD ▪ Kyu-Won Suh, DDS, MSD, DSO

The best way to adjust proximal contacts of newly fabricated indirect restorations has been a long-standing unresolved issue in dentistry. Excessively tight contacts cause incomplete seating of indirect restorations and intrusion of adjacent teeth, which leads to patient discomfort, hypersensitivity, and recurrent dental caries at the crown margins. When seating indirect restorations, interproximal relief should be restored as it exists in natural dentition.

This article presents an innovative method of crown seating using diamond strips. This simple, consistent method makes it easier for clinicians to provide comfortable and long-lasting restorations with minimal time and effort. Laboratory technicians utilize diamond strips to provide properly fitting indirect restorations that require minimal adjustment upon clinical delivery. Diamond strips also allow for accurate determination of heavier proximal contacts, allowing dentists to adjust the proximal contact properly in the patients' mouths.

Clinically, restoring natural proximal contacts is a critical factor to the success of indirect restorations. Using this method standardizes proper proximal contact adjustments of laboratory-fabricated indirect restorations between dental labs and dental offices. The method also helps to limit or eliminate the lingering proximal contact issue between clinicians and laboratory technicians.

Received: February 19, 2012
Revised: May 7, 2012
Accepted: June 13, 2012

Key words: proximal contact, interproximal relief, contact adjustment, diamond dental strips, crown seating

Restoring natural proximal contacts is critical to the success of indirect restorations. This restoration directly affects a dentist's ability to achieve complete marginal seating, maintain existing occlusion, and provide patient comfort. Inadequately restored proximal contacts may cause food impaction by open contact, or may cause incomplete marginal seating of indirect restorations by overly tight contact.[1] Dental school curriculums offer surprisingly little instruction on fixing and adjusting tight proximal contacts, and there is little written research on this subject.

In the authors' experience, crowns sometimes must be refabricated due to improper proximal contacts of the final restoration after chairside adjustment. This occurs when the restoration is too tight on one side and opens up on the opposite side. This report presents a clinically proven method for determining and adjusting proximal contact strength by using diamond dental strips. Ideal proximal contacts can be achieved accurately with minimal time and effort, while enhancing patient comfort and functionality immediately upon definitive cementation.

Proximal contacts in the literature

The term *proximal contact area* refers to the area of proximal contour height on the mesial or distal surface of a tooth that touches its adjacent tooth in the same arch.[2] The variants that affect proximal contact are location, tooth type, chewing, and time of day.[3] If a patient has a nocturnal parafunctional habit of clenching or grinding, the interproximal contact would be significantly tighter in the morning upon wakening. Proximal contact location is in fact a physiological entity of multifactorial origin. Dorfer et al measured proximal contact strength with a calibrated metal strip (0.05 mm thick), and reported that the strength varied between teeth, arches, and function.[4]

In natural dentition, small spaces occur between natural teeth at rest, and floss does not properly penetrate these spaces.[3,5-7] A 1987 study by Boice et al reported that a shim stock passed through 90% of natural contacts, regardless of the sex or age of the patient.[6] When restoring natural proximal contacts, the clinician should not intentionally build the contact so tight that it would prevent a 0.0127 mm shim stock from passing through the contact.[6,8] Although there is an association between open contacts and food impaction, open contacts can occur in interproximal sites where contacts are tight, marginal ridges are uneven, when the patient has a lack of adequate escape grooves, and/or prominent opposing cusps.[9]

A properly restored proximal contact should offer passive contact or microscopic clearance that relieves pressure between the proximal contact surfaces of indirect restorations and adjacent teeth. This relief of pressure is referred to as *interproximal relief*.[10] Interproximal space is restored accurately by proper restoration of both the deflecting contours and the occlusal anatomy of the teeth, which prevents food impaction. Proper restoration of interproximal relief allows for complete marginal seating of an indirect restoration, and prevents occlusal interferences.[10] The periodontal ligaments allow for sufficient minor tooth movement during proximal contact adjustment.

Materials and methods

To fabricate an indirect restoration, it is necessary to abrade the proximal contact surfaces of adjacent teeth on working models to compensate for proper proximal contacts. It also is necessary to have a predictable and consistent method for making crowns, with proper measurements of contact tightness.

Dental laboratory technicians use their own techniques to abrade adjacent proximal contacts. These techniques can vary from crown to crown, from technician to technician, and from laboratory to laboratory.

Due to these inconsistencies, the final restoration almost always requires a dentist to perform proximal contact adjustment, which may require extra time for a restoration; this chair time increases if a dentist is placing several restorations. The present study was performed to develop a consistent method for abrading proximal contacts, and to ensure that the laboratory-processed crowns will fulfill dentists' expectations every time.

A section of a stone die with a dowel pin attached was obtained from a used stone model (Heraeus Kulzer), and it was used as a specimen. The section of the stone die block was ground to a rectangular shape (6 mm x 6 mm x 3 mm), with one side rounded to resemble an adjacent proximal contact of a working model. An electronic caliper (Starrett 797, The L.S. Starrett Company) was used to measure the thickness of the block after each abrasion with diamond strips.

The specimen was abraded on the surface of its rounded end by passing the diamond strip once. Using the caliper, the thickness of the specimen was measured (in μ). This procedure was repeated 10 times, and the difference in thickness calculated between each measurement; the differences between reductions (DBRs) were the amount of abrasion. The abrasive surface of the diamond strip was air blown after each use for accuracy. This procedure was repeated in 4 sets, and the median number was chosen from each set of 10 DBRs.

Three different strips were used for this experiment: 15 μ grit, 17 μ grit, and 30 μ grit. (All strips mentioned in this article are manufactured by ContacEZ Company.). The median score for the 17 μ diamond strip was a 0.01 mm reduction per pass, as was the average for the 4 sets. The 17 μ grit, 0.09 mm diamond strip was chosen to abrade the stone die because it consistently abraded 0.01 mm with each pass when controlled finger pressure was applied. The travel distance of the strip movement was 16 mm.

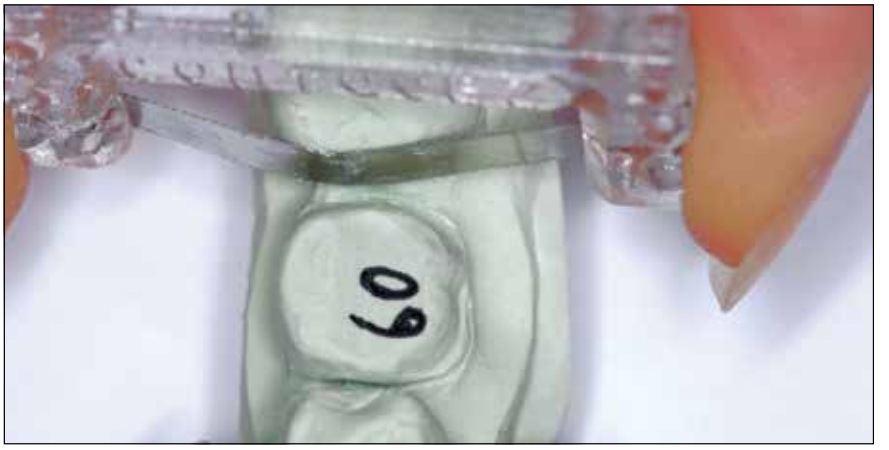


Fig. 1. The proximal surfaces of tooth No. 18 on the working stone model are abraded with a 17 μ grit diamond strip.

Laboratory procedures

Abrade the proximal surfaces of adjacent teeth (stone) on the working model by passing a 17 μ grit diamond strip 6 times (in the authors' experience, using a strip versus a knife produces more consistent, accurate results), reducing the thickness by 0.06 mm. Construct the laboratory-fabricated crown to fit into the space between the 2 adjacent teeth on the stone model. When the crown is made, place it on the working model and pass a thin (0.06 mm) single-sided diamond strip through the interproximal spaces, facing the abrasive surface of the strip toward the bisque-baked crown, until the strip encounters light resistance. Now the crown is ready for glazing.

Adjust the proximal contacts of the glazed crown on the working stone model by passing an ultrafine 0.05 mm diamond strip until the strip encounters light resistance, meaning, the distance between the crown and proximal teeth is 0.01 mm larger than the normal 0.1 mm lateral movement of teeth in natural dentition. Thus, this crown will be seated on the abutment completely with slight resistance.

At this point, the crown fabrication is complete and ready to send to the dental office. Do not rotary polish the proximal contact surfaces of the crown. This procedure eliminates guesswork about the accuracy of a crown's proximal contacts. The clinical seating of the crown will be consistent and accurate.

Evaluation and adjustment

To determine and adjust the proximal contact prior to cementation, place the crown on the abutment tooth and press it to the prepared margin. If there is slight resistance to seating the crown against the prepared margin due to proximal contacts, proceed with the following protocol.

First, lift the crown slightly and insert a 0.05 mm ultrafine or a 0.06 mm fine diamond strip into the interproximal space, with the abrasive side facing the crown. Allow the crown to sit on the prepared tooth, but do not press down yet; instead, simply hold the crown in place and start passing the diamond strip in a buccolingual direction to check interproximal pressure against the strip. Repeat this procedure in the other interproximal space. The diamond strip may move in one direction at the beginning because of the orientation of the diamond particles.

When more pressure is detected on one side than the other, pass the 0.06 mm diamond strip 5-6 times through the side in a buccolingual direction with more pressure. Repeat this procedure until there are equal amounts of light resistance in both the mesial and distal interproximal spaces, indicating that ideal proximal contact for the crown has been attained and that the crown is ready for cementation. If the proximal contact is too heavy, move the crown back to the working model and adjust the side of the closed margin of the proximal contact of the crown by using the 17 μ grit

Fig. 2. A thin diamond strip is passed in a buccolingual direction through the interproximal space between the fabricated crown for tooth No. 19 and the adjacent teeth.

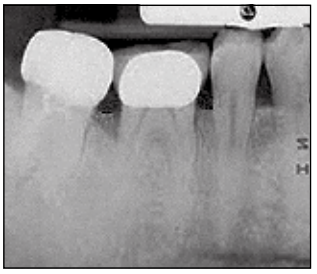


Fig. 3. A radiograph shows complete marginal seating for the crown.

diamond strip with the abrasive side facing the crown. Next, using an explorer, remove the excess resin cement around the crown. Pass an ultrathin (0.04 mm) serrated strip (Serrated Dental Strip I) back and forth gently and buccolingually, to cut and clean out any trapped and remaining resin cement in the interproximal spaces. Pass a single-sided, ultrafine (0.05 mm) diamond strip through the interproximal spaces to polish the contact surfaces of restorations, confirm interproximal relief, and restore a natural finish. Dental floss should pass through the interproximal space with firm resistance (that is, snapping in and out). At this point, the crown seating is considered to be complete with proper proximal contacts.

Case report

A 55-year-old man presented with dental decay under an existing gold crown on Tooth No. 19. A porcelain crown was recommended and the patient consented. The tooth was prepared for the crown and an impression was taken and sent to the dental laboratory for fabrication. On the working model, a diamond strip (LAB Stone Strip) was used to abrade the proximal contacts of the adjacent teeth 6 times (Fig. 1). As shown in the experiment in Materials and Methods, each 16 mm passing of a strip with 17 µ diamond particles reduces the proximal surface of the adjacent stone teeth 0.01 mm in thickness. A porcelain crown (Ceramco, DENTSPLY International) was fabricated (via the conventional laboratory method) to fit the crown into the space between the 2 adjacent teeth (No. 18 and 20).

When the crown was made for tooth No. 19, a thin (0.06 mm) diamond strip (LAB Bisque Strip) was passed through the interproximal space until light resistance occurred and the crown was ready for glazing.

After glazing, the proximal contacts of the glazed crown were adjusted on the working stone model by passing an ultrafine (0.05 mm) diamond strip (until light resistance was felt against the strip. Rotary polishing was not used on the proximal contact surfaces of the crown. Upon completion of fabrication, the crown was sent to the dental office.

In the dental office

The provisional crown (Luxatemp, DMG America) was removed and the porcelain crown was placed on the abutment and seated almost to the margin, indicating that the proximal contact was slightly heavy and needed adjustment. The crown was lifted slightly, and a thin diamond strip (Black Diamond Strip) was inserted into the distal interproximal space with the abrasive side facing the porcelain crown. The strip passed buccolingually through the distal interproximal space a few times (Fig. 2). This procedure was repeated in the mesial interproximal space, revealing additional pressure on the strip, which indicated a heavier proximal contact on the mesial side of the crown. The strip was passed, starting at the mesial interproximal space. The process was repeated until there was equal light bilateral resistance. A periapical radiograph was taken to confirm the complete marginal seating of the crown. Now the crown was ready for cementation.

The crown was cemented with glass ionomer cement (GC Fuji II, GC America, Inc.). The crown was seated with finger pressure and excess cement was removed with an explorer. The remaining excess cement was cut, cleaned, and removed using an ultrathin serrated dental strip (White Strip, 0.04 mm). Dental floss (Reach, Johnson & Johnson) was used to check the interproximal spaces. The floss snapped in and out of the spaces firmly. A periapical radiograph was taken to confirm complete marginal seating of the crown and no residual cement left in the interproximal space (Fig. 3). After the interproximal spaces were cleaned, an ultrafine (0.05 mm) diamond strip was used to polish the interproximal surfaces and restore a natural finish. The ultrafine strip confirmed interproximal relief and proper proximal contacts.[10]

Using a round diamond point, minimal occlusal adjustment was performed and polished using rubber points (Shofu Dental Corporation). At that point, crown seating was complete. The patient reported no pressure from the new crown and said that he felt as comfortable as if it was his own tooth.

Discussion

Excessive tight proximal contacts can be multifactorial and may include parafunctional habits such as bruxing and/or clenching, occlusal discrepancies, crowding, malposition of teeth, and iatrogenic dentistry. Tight proximal contacts can cause not only patient discomfort, but also migration of teeth with consequent crowding and/or repositioning of teeth.[10] When replacing existing dental restorations or restoring virgin teeth, proximal contacts must be restored to appropriate pressure/tightness. There is no true definition of appropriate pressure or tightness for a physiological proximal contact, other than the fact that there is contact between 2 teeth. Typically, appropriate contacts are confirmed by a snapping sound between the teeth when flossing with waxed or unwaxed floss (0.05 mm thick when passing interproximal contacts), by using a shim stock as a guide, or by placing very thin articulation paper or film (0.05 mm) between the contacts. Because lateral mobility of teeth in normal natural dentition is

0.1 mm, the microscopic thickness of the medium can be used to detect and adjust the tightness of a crown's proximal contacts. The goal is to achieve ideal contact, which is passive and without pressure, thus providing the patient with immediate comfort and functionality after crown seating.[10]

Crowns fabricated in the dental laboratory often have heavy bilateral proximal contact. The dentist usually needs to adjust both contacts but first must determine which of the 2 is heavier. An incorrect assessment can result in weak proximal contact on one side, with the heavy proximal contact intact on the opposite side. In such cases, it may be necessary for the laboratory to add porcelain to close the open contact, or to fabricate a whole new crown.

Traditionally, proximal contacts of indirect restorations are adjusted when a dentist holds a restoration between their fingers, using an indicating medium (such as articulating paper), and reducing the heavy contact with rotary instruments. Small restorations are difficult to hold and to see, and can get caught in the folds of gloves or end up on the floor. In addition, incremental adjustments require multiple trials, which can be tedious and time consuming for the clinicians and uncomfortable for the patients.

By contrast, the method described in this article results in consistent placement, as well as patient comfort and functionality. In addition, the complete marginal seating minimizes the need for occlusal adjustment and prevents adjacent teeth movement and extrusion due to excessive interproximal pressure. In mature dentition, the proximal contact should be an area rather than a point.[10] In the authors' experience, most proximal contact surfaces are curved. They become concave or convex by aging due to lateral jaw movement during chewing. The method described in this article also allows dentists to determine easily which proximal contact is heavier and to adjust it properly and immediately in the patient's mouth. Interproximal relief is confirmed easily by using an ultrathin diamond strip (0.04 mm). Ideal proximal contact of restorations can be achieved accurately with minimal time and effort, enhancing patient comfort and functionality immediately upon definitive cementation.

Summary

When seating indirect restorations, interproximal relief should be restored as it exists in natural dentition. This method of proximal contact adjustment uses diamond dental strips to standardize the proximal contact adjustment method of indirect restorations. Thanks to diamond dental strips, laboratory technicians can provide clinicians with consistent indirect restorations that fit properly, and dentists can restore natural proximal contacts and achieve patient comfort and functionality immediately after definitive cementation, with minimal time and effort.

Author information

Dr. Kim is in private practice in Vancouver, Washington. Dr. Rothchild is in private practice in Durango, Colorado; an associate professor, Dental Medicine Emeritus, Capital University of Integrative Medicine, Washington, DC; and an assistant professor, Department of Surgery, Rush University Medical School, Chicago. Dr. Suh is professor emeritus, College of Medicine, Korea University, Seoul, South Korea.

Acknowledgments

The authors would like to thank Carmen Spulber, CDA, for the photographs used in this article, and Ki Duk Ki from Cascade Dental Laboratory for his cooperation in following the laboratory procedures as instructed by the authors.

Disclaimer

Dr. Kim is the inventor and founder of ContacEZ *Restorative Strip System* and has a financial interest in the ContacEZ Company. He received no compensation for writing this article. Drs. Rothchild and Suh have no financial interest in any of the companies mentioned in this article and received no compensation for writing this article.

References

1. Howard WW, Moller RC, eds. *Atlas of Operative Dentistry.* 3rd ed. St. Louis: C.V. Mosby; 1981:127.
2. Sluder TB. Clinical dental anatomy, histology, physiology, and occlusion. In: Studevant CM, ed. *The Art and Science of Operative Dentistry.* 2nd ed. New York: McGraw-Hill;1985:20.
3. DuBois LM, Niles SM, Boice PA. The magnitude of interproximal spaces between adjacent teeth. *Am J Dent.* 1993;6(6):315-317.
4. Dorfer CE, von Bethlenfalvy ER, Staehle HJ, Ploch T. Factors influencing proximal dental contact strengths. *Eur J Oral Sci.* 2000;108(5):368-377.
5. Lindquist JT. *A study of the intra-arch relationships in normal human dentitions* [master's thesis]. Indianapolis: Indiana University School of Dentistry;1951.
6. Boice PA, Niles SM, DuBois LM. Evaluation of proximal contacts with shim stock. *J Oral Rehabil.* 1987;14(1): 91-94
7. Kasahara K, Miura H, Kuritama M, Kato H, Hasegawa S. Observations of interproximal contact relations during clenching. *Int J Prosthodont.* 2000;13(4):289-294.
8. Campagni WV. The final touch in the delivery of a fixed prosthesis. *J Calif Dent Assoc.* 1984;12(2):21-29.
9. Newell DH, John V, Kim SJ. A technique of occlusal adjustment for food impaction in the presence of tight proximal contacts. *Oper Dent.* 2002;27(1):95-100.
10. Kim DS, Suh KW. A proximal contact adjustment and interproximal relief method. *J Prosthet Dent.* 2007; 97(4):244-245.

Manufacturers

ContacEZ Company, Vancouver, WA
360.694.1000, www.contacez.com

DENTSPLY International, York, PA
800.243.1942, www.dentsply.com

DMG America, Englewood, NJ
800.662.6383, www.dmg-america.com

GC America, Inc., Alsip, IL
800.323.7063, www.gcamerica.com

Heraeus Kulzer, South Bend, IN
800.435.1785, www.heraeus-dental-us.com

Johnson & Johnson, Skillman, NJ
800.690.1826, www.jnj.com

The L.S. Starrett Company, Athol, MA
978.249.3551, www.starrett.com

Shofu Dental Corporation, San Marcos, CA
800.827.4638, www.shofu.com

Rehabilitation of the edentulous maxilla complicated by combination syndrome with an implant overdenture: a case report

Jack Piermatti, DMD, FACP

The treatment of the edentulous jaws with complete dentures is determined individually and often is unpredictable. Implant-assisted overdentures are a significant improvement over conventional complete dentures in terms of patient comfort and function. *Combination syndrome* refers to a dramatic exaggeration of maxillary alveolar resorption leading to a more complicated rehabilitation. This article reviews how the edentulous maxilla can be rehabilitated with an implant-assisted overdenture. A case report is presented which utilizes a computer-aided design/computer-aided manufactured milled titanium connecting bar to retain a chrome-cobalt based, precision attachment, palateless prosthesis.

Received: April 6, 2012
Accepted: July 23, 2012

Key words: combination syndrome, connecting bar, overdenture prosthesis, CAD/CAM milling, monobloc titanium

Treating edentulous jaws with complete dentures often is difficult, demanding, and frustrating to both doctor and patient. The best results an exacting clinician may obtain might prove only marginally satisfactory to some patients in terms of comfort and function. The literature has reported that masticatory efficiency with complete dentures is dramatically decreased compared to natural dentition or implant-assisted dentition.[1-3] A 2010 Taiwan study by Lin et al of 103 elderly endentulous patients reported that 58% of patients reported dissatisfaction with their dentures, and 51% reported discomfort on chewing.[3] It is reasonable to conclude that denture satisfaction is determined individually, and often is unpredictable.[4]

Various methods and materials have been introduced to improve prosthetic restorations for edentulous patients, including tooth arrangement and occlusal schemes for complete dentures—most commonly, anatomic or semi-anatomic teeth in bilateral balance, cuspless teeth arranged in monoplane format, and lingualized occlusion. While there is a cogent rationale for the use of each, no single occlusal scheme is generally recognized as superior or intended for universal use.[5]

The materials used to construct complete dentures have been modified also, ostensibly to provide better function or comfort. Selecting acrylic or porcelain artificial teeth for complete dentures usually is a clinician's choice and is based more on personal preference than evidence-based science. Many materials have been used for denture teeth, such as porcelain, acrylic, composite, acrylic with metal onlays, and acrylic with amalgam fillings. Many journal articles and textbooks state that the general consensus is that no single material has been shown to have the highest success from the perspective of variables such as patient satisfaction, functionality, and durability. All have advantages and disadvantages.

It has been postulated that porcelain denture teeth cause increased ridge resorption in long-term denture wearers; however, this direct causality has not been demonstrated in the literature.[6] Dentists often use porcelain denture teeth to improve masticatory function; however, this benefit may be anecdotal.[7] The choice of materials for artificial tooth composition, such as feldspathic porcelain, filled composite resin, or acrylic resin, should be case-specific. The dentist must understand anticipated wear patterns to prevent loss of vertical dimension of occlusion, as has been seen when porcelain opposes acrylic resin.[8] In addition, the "clicking" noise heard when feldspathic porcelain denture teeth come in contact during jaw movements needs to be considered. Gold, chromium-cobalt, and various polymers of acrylic resin have been used as denture bases. These metals have been used for their resistance to fracture, improved base-to-tissue adaptation, and their inhibition of microbial colonization.[9] Acrylic has now become the most widely used denture base material due to its simplicity, economy, and ease in repairing or relining. Regardless of the materials used, the techniques employed, or the prosthesis design, patient acceptance of the complete denture—a mainstay for the edentulous patient—has been inconsistent historically. Published data show inconsistent patient satisfaction due to variables such as denture fit, materials used, and occlusion.

The size and shape of the alveolar bases on which the dentures rest is an important factor in determining the success or failure of complete denture prosthodontics. This alveolar process becomes the foundation for dentures: Large, broad, U-shaped, residual ridges provide support, retention, and resistance to displacement during function. When alveolar bone undergoes atrophic changes, the successful function of complete dentures is challenged.[10]

Alveolar bone is unique in that the bone is retained as long as teeth are present. When teeth are extracted, alveolar bone begins the resorption process as a normal sequella of postsurgical remodeling. The maxilla resorbs in a superioposterior direction, and the mandible resorbs in an inferioanterior direction, eventually converting an individual's occlusal scheme from a Class I to a Class III. Tooth loss alters the form of the alveolar bone in 91% of cases.[11]

Combination syndrome is a dramatic exaggeration of maxillary alveolar resorption that leads to a more complicated rehabilitation. This clinical scenario, first described in 1972, relates classically to changes found in the mouth following a

maxillary complete denture that opposes natural mandibular anterior teeth.[12] Continued trauma for the natural teeth against the anterior segment of the denture may result in complete destruction of the alveolar process, extending to the cortical plate of the floor of the nose. The posterior quadrants exhibit full pneumatization of the sinuses bilaterally, with attendant hypertrophy of the entire quadrant—specifically, the overlying soft tissues. The combination syndrome makes conventional denture construction much more difficult, and may preclude implant placement.

Implant-assisted overdenture

Dental implants have shown successful osseointegration in treating edentulism.[13] Implant-assisted overdentures are a significant improvement over conventional complete dentures in terms of patient comfort and function.[2,14,15] The enhanced function manifests in increased bite force, resulting in more efficient mastication. Patients who can chew their food effectively tend to make healthy dietary choices, including fruits, nuts, vegetables, and high quality protein sources.[16]

The implant-assisted overdenture can be divided into 2 broadly defined types with some design overlap. The first is the soft tissue-supported, implant-retained overdenture, a prosthesis that gains its support from the residual bases, similar to a conventional complete denture. These implants provide retention only. The second type is the implant-supported, implant-retained overdenture, a prosthesis that is supported and retained by the dental implants. Typically, a bar/framework is screw-retained to a series of implants. The bar will have retentive elements built in, which pair with the retentive elements in the removable prosthesis. With this type of overdenture, contact with soft tissue is not predicated upon gaining necessary support. As a result, peripheral extension of the prosthesis is not crucial, and actually may be underextended for patient comfort without compromising its functional design.

The implant overdenture differs from a fixed restoration in several ways, some of which are advantageous to patients, particularly those with severely atrophic maxilla. Implant placement in the atrophic maxilla is quite challenging due to the typical alveolar resorptive pattern, which resorbs at the expense of the labial plate in the anterior segment and the buccal plates in the posterior segments. This resorption places the implants toward the lingual and usually in a more apical position; as a result, fixed restorations can be exceptionally large in an inciso-cervical direction and deficient in providing adequate lip support. The overdenture can be made with teeth set further in an anterior direction with increased vertical tooth display. Patients who have lost teeth and significant alveolar support often will exhibit dramatic changes in facial contours which they would like to improve. Implant overdentures can effect that change.

Implant position is less of an issue when an overdenture is planned. Since the prosthesis covers the implants completely, fixture location is not critical, and becomes a function of biomechanics and convenience rather than esthetic restorability. Even compromised angulation becomes less important when the implants are to be connected with a bar/framework.

This type of restoration also offers advantages in terms of maintenance and repair. Generally speaking, any restoration that can be removed from the mouth is easier for patients to clean. In addition, any wear or breakage in the removable prosthesis or the connecting bar can be repaired while the restoration is out of the mouth. The bar is screw-retained normally, and thus can be removed easily, allowing repair, polishing, and maintenance of the retentive elements.

When weighing a patient's restoration options, a removable prosthesis should always be considered during comprehensive treatment planning for the atrophic jaw.

The implant connecting bar

The implant connecting bar is the critical foundation upon which the removable prosthesis rests. Connecting bars generally have been made from prefabricated components joined together or from units created with the typical lost-wax casting technique. More recently, computer-aided design/computer-aided manufacture (CAD/CAM) has made it possible to fabricate connecting bars using industrial custom milling techniques. The computer scanning procedure ensures proper design with ideal bar dimensions for the specific patient situation. A master cast with the proposed overdenture tooth arrangement is scanned into a computer with the appropriate software. An implant-connecting bar is then designed to fit within the confines of the planned prosthesis and the bar is custom-milled to exact specifications using strong, lightweight titanium. The resultant bar is milled from monobloc titanium alloy; that is, it is milled from 1 solid piece of metal to a tolerance of 5 μ, with no seams, porosity, or welding.[17] The CAD/CAM procedure creates different types of bars (such as Hader and Dolder designs), including flat bars that can accept the various types of retentive elements commercially available.

The removable overdenture prosthesis

The overdenture prosthesis provides the patient with comfort, function, and esthetics; however, both short- and long-term success of the overdenture prosthesis depend on adequate implant osseointegration, implant distribution, and connecting bar design. It is naive to expect outstanding results for removable implant restorations without devoting meticulous attention to detail throughout all treatment phases. The overdenture consists of 3 segments: prosthetic teeth, acrylic base, and cast framework.

Prosthetic teeth

Tooth selection for overdenture prostheses is similar to tooth selection for conventional denture prosthodontics. Tooth mold and shade are selected according to standard techniques. Acrylic resin or porcelain may be selected; the choice usually is dictated by the amount of room available for both teeth and supporting acrylic base material.

Acrylic base

The base material usually chosen is acrylic resin, due to its many favorable characteristics. The material is light, strong, and easy to handle and repair. It offers satisfactory esthetics and supports prosthetic denture teeth quite well. Prosthodontics textbooks conclude that the use of acrylic resin in overdenture construction is most widely used due to the reasons cited.

Cast framework

A framework (or *mesostructure*) is integral to the implant overdenture prosthesis. It usually is cast from chromium-cobalt,

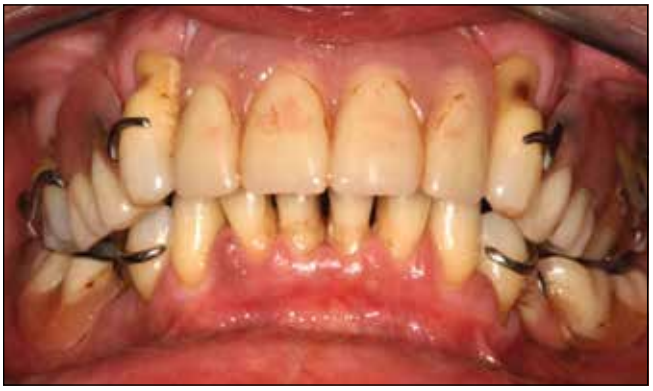


Fig. 1. Preoperative anterior view of the patient, with the prostheses in place.

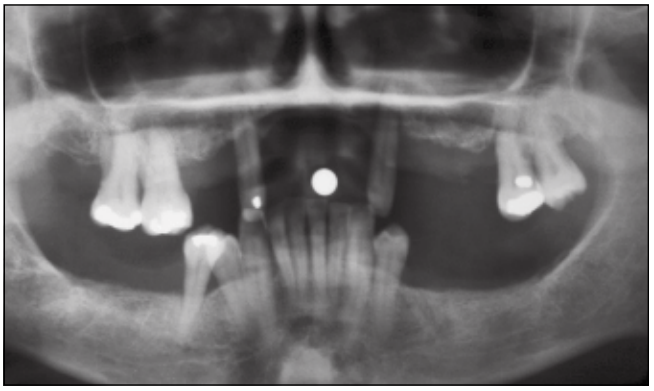


Fig. 2. A preoperative radiograph of the patient.

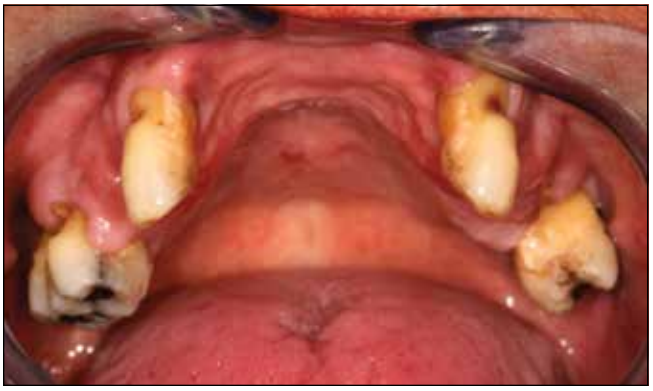


Fig. 3. A preoperative anterior view of the patient without the prosthesis.

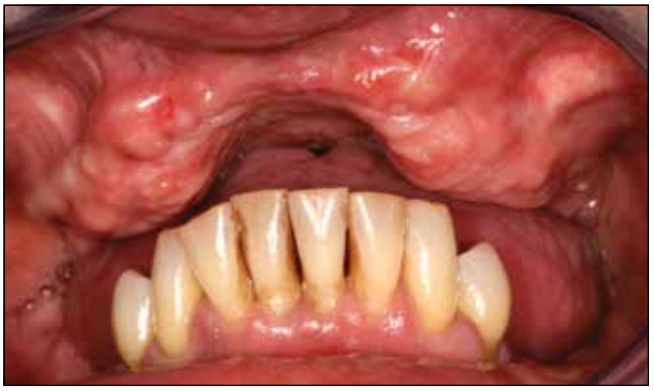


Fig. 4. A clinical view of the patient, post-extraction. Note the significant atrophy of the premaxilla.

an inexpensive, rigid, and biocompatible metal alloy. The cast framework results in a prosthesis that is both fracture-resistant and thin in the palatal areas.

Case report

A 57-year-old woman sought evaluation and treatment for her maxillary arch. Medical history was significant in that she was taking a statin medication for elevated serum cholesterol. Clinical examination revealed a partially edentulous maxilla and mandible with long-term use of removable partial dentures (Fig. 1). The remaining natural teeth in the anterior mandible made solid contact with the maxillary partial denture, resulting in total destruction of the premaxilla. Teeth No. 1, 4, 5, 7-10, 12-14, 17-20, and 30-32 were missing. A Class II skeletal relationship with uneven occlusal plane existed.

Since the remaining maxillary teeth were hopeless and had to be removed, a treatment plan was developed for a maxillary, implant-supported, implant-retained, palateless, removable prosthesis. Since the maxillary occlusal plane would be idealized, the existing mandibular removable partial denture would be replaced with new denture teeth, arranged in a complementary occlusal relationship.

Radiographic examination revealed adequate maxillary bone for implant placement in the posterior quadrants; however, long-term use of the maxillary removable partial denture in contact with the mandibular anterior teeth caused total bony destruction of the premaxilla and precluded implant placement in this area (Fig. 2 and 3).

Diagnostic study casts were made and articulated for case planning. The remaining teeth were removed from the master cast and a complete maxillary denture was fabricated as an immediate prosthesis to be inserted at the time of extractions. All maxillary teeth were extracted in a single surgical appointment (using local anesthesia), with immediate placement of 7 implants (NobelActive, Nobel Biocare USA, LLC).

Fig. 5. The CAD/CAM milled titanium bar on the master cast.

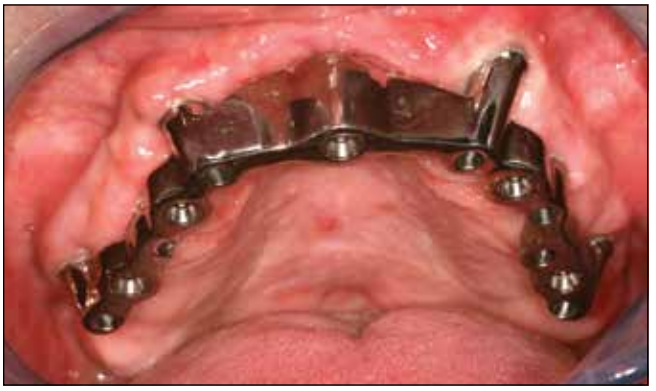


Fig. 6. A clinical view of the titanium bar after fixation.

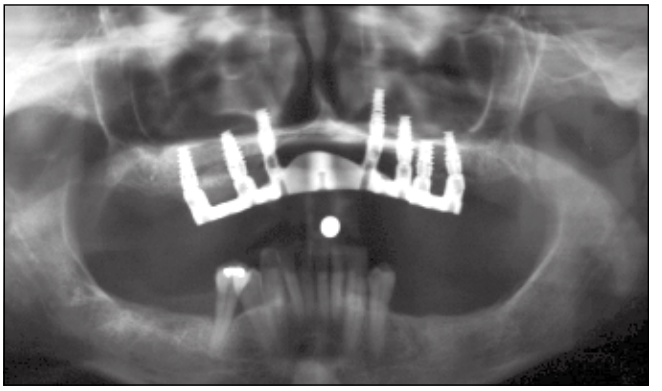


Fig. 7. A radiograph of the CAD/CAM-milled titanium bar after fixation to 7 dental implants.

Fig. 8. The intaglio surface of the chrome-cobalt framework. Note the spring-lock attachments.

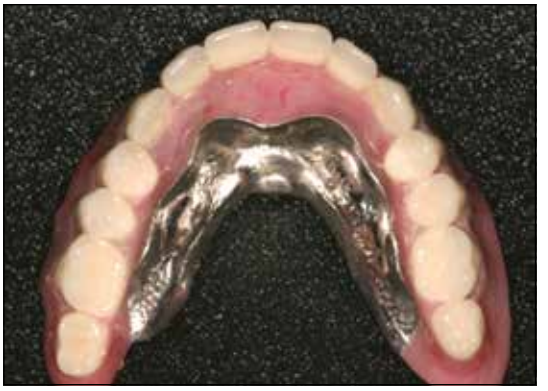


Fig. 9. The occlusal surface of the overdenture prosthesis.

Implants were placed into fresh extraction sites; at that point, mineralized bone allograft (Puros, Zimmer Dental) was placed and covered with resorbable collagen membrane (Bio-Gide, Osteohealth Company). All tissues were closed primarily and an immediate maxillary denture was delivered. The denture was relined with a soft material (MucoSoft, Parkell, Inc.) for patient comfort and the implants were left undisturbed for 4 months, to allow for osseointegration (Fig. 4).

All implants were uncovered subsequently, permucosal collars were placed, and the denture was adjusted accordingly. Following soft tissue healing, 17° multi-unit abutments were torqued into the implants, and an abutment level impression was made with polyether impression material (Impregum, 3M ESPE). The maxillary master cast was poured in dental stone with silicone material to represent soft tissue (Gingifast Rigid, Zhermack, Inc.) and mounted on a semi-adjustable articulator (Hanau Wide-Vue, Whip Mix Corporation).

Preliminary tooth arrangement (on a wax-trial denture) was evaluated for occlusion, vertical dimension, esthetics, and phonetics. The wax-trial denture arrangement and the master cast were scanned using the NobelProcera conoscopic scanner (Nobel Biocare USA, LLC), and the implant connecting bar was designed via CAD. This design included the bar's interface to the multi-unit abutments, as well as 5 receptacles for semi-precision, adjustable, spring-lock stud attachments (Ceka, PREAT Corporation). After the CAD-designed bar passed inspection, it was custom-milled in solid titanium to precise specifications (CAM).

The CAD-CAM implant connecting bar was tried in for verification of passive fit (Fig. 5 and 6). Fixation screws were exchanged for guide screws (Fig. 7). Using a custom tray, the bar was picked up in a light-body impression material (Impregum Garant, 3M ESPE), capturing all soft tissues of the mouth with minimal displacement. After abutment analogs were connected to the implant connecting bar, a new master cast was poured in non-expanding die stone (Resin Rock, Whip Mix Corporation).

Using a refractory cast, the framework of the removable prosthesis was waxed, invested, and cast in chrome-cobalt alloy. Holes were made in the areas of the semi-precision attachments; to ensure absolute passive engagement, each attachment was inserted into the connecting bar and laser-welded to the framework (Fig. 8).

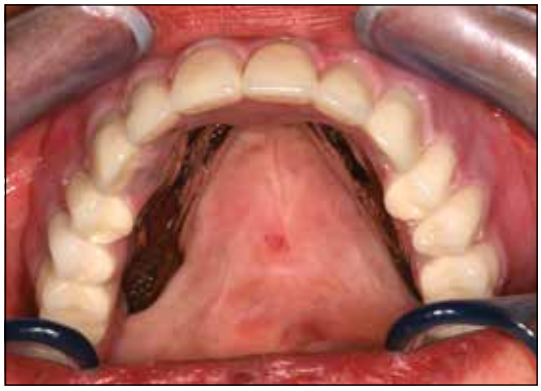


Fig. 10. The overdenture prosthesis after placement in the patient's mouth.

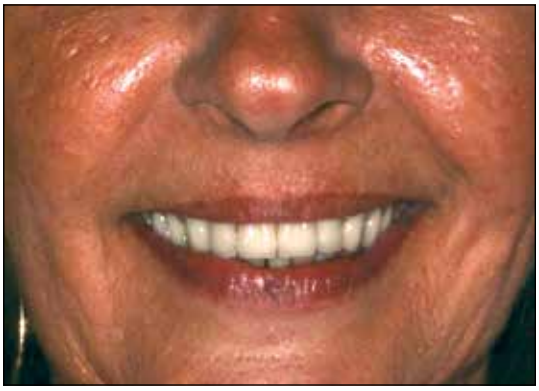


Fig. 11. A postoperative anterior view of the patient after completion of treatment.

The implant-connecting bar was placed into position and fixated to the 17° multi-unit implant abutments. The chrome-cobalt framework was attached to the connecting bar and evaluated for intimate adaptation to the palatal mucosa. Interocclusal records were taken, the case was remounted, and the denture teeth were set and confirmed clinically. Using acrylic resin (Lucitone 199, DENTSPLY International), the denture teeth were processed to the chrome-cobalt framework and the completed maxillary prosthesis was delivered along with a new mandibular removable partial denture (Fig. 9-11).

Summary

This articles offers a review of the rehabilitation of the edentulous maxilla with an implant-assisted overdenture and a case report of complications due to severe destruction from combination syndrome. A CAD/CAM-milled, titanium-connecting bar was fabricated to retain a chrome-cobalt based, precision attachment, palateless prosthesis. The patient enjoyed excellent comfort, function, and esthetics with her restoration. This report highlights the Nobel Biocare CAD/CAM milling process for implant connecting bars, however, Nobel Biocare is not the only company to offer this technology. Many other companies have adopted the same basic CAD/CAM technology.

By using a conoscopic scanner, the bar can be designed to exact specifications with attachments added virtually. After computer visualization and approval, the 5-axis milling of solid titanium is performed, resulting in a connecting bar of unparalleled accuracy without soldering seams or casting porosity that can negatively affect the product's strength and finish.

Following the steps for fabricating a precision attachment connecting bar, and applying sound prosthodontic principles to complete the removable overdenture prosthesis resulted in an exceptional oral rehabilitation.

Author information

Dr. Piermatti is an assistant clinical professor, Postgraduate Prosthodontics, New Jersey Dental School, University of Medicine and Dentistry of New Jersey; and is in private practice, limited to prosthodontics, in Voorhees, New Jersey.

Disclaimer

The author has received compensation for lectures and courses sponsored by Nobel Biocare USA, LLC. The author has no affiliation, compensation, or sponsorship with the other manufacturers or products mentioned in this article.

References

1. Mendonca DB, Prado MM, Mendes FA, et al. Comparison of masticatory function between subjects with three types of dentition. *Int J Prosthodont.* 2009;22(4):399-404.
2. Rismanchian M, Bajoghli F, Mostajeran Z, Fazel A, Eshkevari Ps. Effect of implants on maximum bite force in edentulous patients. *J Oral Implantol.* 2009;35(4):196-200.
3. Lin YC, Chen JH, Lee HE, Yang NP, Chou TM. The association of chewing ability and diet in elderly complete denture patients. *Int J Prosthodont.* 2010;23(2):127-128.
4. van Waas MA. Determinants of dissatisfaction with dentures: a multiple regression analysis. *J Prosthet Dent.* 1990;64(5):569-572.
5. Jokstad A, Turp JC; Working Group 3. Function. Consensus report of Working Group 3. *Clin Oral Implants Res.* 2007;18(Suppl 3):151-167.
6. Mercier P, Bellavance F. Effect of artificial tooth material on mandibular residual ridge resorption. *J Can Dent Assoc.* 2002;68(6):346-350.
7. Shimoyama K, Uchida T, Nagao M, Odagiri K, Shirasaki Y, Tateishi T. Mechanical properties of artificial teeth. *Bull Tokyo Med Dent Univ.* 1993;40(1):13-16.
8. Ghazal M, Hedderich J, Kern M. Wear of feldspathic ceramic, nano-filled composite resin and acrylic resin artificial teeth when opposed to different antagonists. *Eur J Oral Sci.* 2008;116(6):585-592.
9. Perezous LF, Stevenson GC, Flaitz CM, Goldschmidt ME, Engelmeier RL, Nichols CM. The effect of complete dentures with a metal palate on candida species growth in HIV-infected patients. *J Prosthodont.* 2006;15(5):306-315.
10. Boucher C, Hickey J, Zarb G, Swenson MG. *Prosthodontic Treatment for Edentulous Patients.* St. Louis: C.V. Mosby Company; 1975.
11. Abrams H, Kopczyk RA, Kaplan AL. Incidence of anterior ridge deformities in partially edentulous patients. *J Prosthet Dent.* 1987;57(2):191-194.
12. Lynch CD, Allen PF. The 'combination syndrome' revisited. *Dent Update.* 2004;31(7):410-420.
13. Branemark PI, Zarb GA, Albrektsson T. Introduction to Osseointegration. In: Branemark PI, ed. *Tissue Integrated Prosthesis.* Chicago: Quintessence Publishing Co; 1985.
14. Ellis JS, Elfeky AF, Moynihan PJ, Seal C, Hyland RM, Thomason M. The impact of dietary advice on edentulous adults' denture satisfaction and oral health-related quality of life 6 months after intervention. *Clin Oral Implants Res.* 2010;21(4):386-391.
15. Visser A, Raghoebar GM, Meijer HJ, Vissink A. Implant-retained maxillary overdentures on milled bar suprastructures: a 10-year follow-up of surgical and

prosthetic care and aftercare. *Int J Prosthodont.* 2009; 22(2):181-192.
16. Ellis JS, Thomason JM, Jepson NJ, Nohl F, Smith DG, Allen PF. A randomized-controlled trial of food choices made by edentulous adults. *Clin Oral Implants Res.* 2008;19(4):356-361.
17. Drago C, Howell K. Concepts for designing and fabricating metal implant frameworks for hybrid implant prostheses. *J Prosthodont.* 2012;21(5):413-424.

Manufacturers

DENTSPLY International, York, PA
800.226.4283, www.dentsply.com

Nobel Biocare USA, LLC, Yorba Linda, CA
800.322.5001, www.nobelbiocare.com

Osteohealth Company, Shirley, NY
800.874.2334, www.osteohealth.com

Parkell, Inc., Edgewood, NY
800.243.7446, www.parkell.com

PREAT Corporation, Santa Ynez, CA
800.232.7732, preat.com

Whip Mix Corporation, Louisville, KY
800.626.5651, whipmix.com

Zhermack, Inc., Eaton Town, NJ
732.389.8540, en.zhermack.com

Zimmer Dental, Carlsbad, CA
800.854.7019, www.zimmer.com

3M ESPE, St. Paul, MN
888.364.3577, solutions.3m.com

self CDE 2 HOURS CREDIT instruction

Evaluating complications of local anesthesia administration and reversal with phentolamine mesylate in a portable pediatric dental clinic

Sean G. Boynes, DMD, MS ▪ Amah E. Riley, RDH ▪ Sarah Milbee, BS ▪ Meghan R. Bastin, BSDH
Maylyn E. Price, DMD ▪ Andrea Ladson, RDH

This study sought to identify and quantify complications with local anesthetic administration and reversal on consecutive patients seen for comprehensive dental care in a school-based, portable dental clinic, and includes data on the patients seen by the participating portable dental providers. In 923 dental visits where local anesthetic was administered, a standardized form was used to gain further information and identify any complications; this was accompanied by a questionnaire for the student's teacher, in order to quantify the student's distraction and disruption ratings following the dental visit. After statistical analysis of the 923 consecutive cases, the overall complication rate was 5.3%. All of the complications were considered to be mild or moderate, and there were no severe event reports. The complications encountered most frequently (n = 49) were associated with self-inflicted soft tissue injury.

The results of this study indicate that comprehensive care with local anesthesia delivered by a school-based portable dental clinic has a low risk of complications. Whereas safe administration of dental care is achievable with or without phentolamine mesylate as a local anesthetic reversal agent, its use was determined to improve safety outcomes. Three factors appeared to directly increase the incidence of complications: the administration of an inferior alveolar nerve block, attention deficit disorder, and obesity. Teacher evaluations demonstrated that children receiving care by a portable dental team were able to reorient back to classwork and were not disruptive to classmates.

Received: November 2, 2012
Accepted: March 18, 2013

Key words: dentistry, phentolamine, complications, local anesthesia, community health

The relative unavailability of comprehensive oral health care is a serious problem many communities must attempt to solve. Despite improvements in oral health delivery, there still exists a great number of health professional shortage areas, and significant regions of disparity in the U.S.[1-2] A model that was created to improve access to care is the school-based portable dental program. The literature on school-based dental delivery consists mainly of preventive or screening programs, with very few organizations administering comprehensive dental care.[3-4] One of the concerns with the comprehensive care school program model is whether or not the administration of local anesthesia causes significant complications, or has a negative impact on the student's ability to reorient back to classwork.

There are ongoing efforts by chemists and researchers to improve local anesthetic efficacy while decreasing adverse events.[5] Local anesthetics are widely used throughout dentistry, and have a significant safety record. However, there is little documentation on the mild to moderate complications that occur within a "snapshot" of dental care delivery in individual visits. In addition, many of the reviews that are available focus more on the systemic events that relate to anesthetic administration, rather than the peripheral effects on patients receiving local anesthetic.

Phentolamine mesylate (PM) is an alpha adrenergic blocker that competitively blocks pre- and postsynaptic adrenergic receptors. The agent acts within the arterial and venous system to reduce total peripheral resistance, and lower venous return to the heart. As it relates to dental care, PM is used to decrease the duration of soft tissue anesthesia after local anesthetic administration, by increasing the elimination of anesthetic from the localized area.[6-10] A literature search of possible complications or analyses of the safety impact of PM use in active dental practice yielded limited results in the most commonly used Internet search engines.

As a means to address the concerns with the portable comprehensive dental delivery systems in a school-based setting, evaluate the impact of PM use, and enhance existing literature on local anesthesia complication reports, a survey of consecutive patients was completed.

Materials and methods

After being deemed exempt from the CareSouth Carolina Clinical Review Board, a survey-based quality analysis was performed between September 2011 and May 2012 on 923 consecutive local anesthetic dental care patient cases, administered within the CareSouth Carolina's Division of Dental Medicine's (CSCDM) Portable Pediatric Dental Clinic. As part of this study's concept, another prospective questionnaire-based survey was completed by teachers at the conclusion of the CSCDM dental clinic stay.

A standardized form was used to collect data from the dental care team, and a defined group of complications was identified (Table 1). The dental care team was instructed to record any complications occurring from the administration of local anesthetic. Follow-up information was also recorded when applicable. To ensure that complications were reported accurately, a series of identifiable definitions and categories were created. Distinct complications were analyzed, including *hypertension* (defined as 20% above baseline values for systolic or diastolic blood pressure), *hypotension*

(defined as 20% below baseline values for systolic or diastolic blood pressure), *tachycardia* (defined as >age specific maximum value beats per minute), and *bradycardia* (defined as <age specific minimum value beats per minute). Vital signs were taken prior to local anesthesia administration and re-evaluated after injection. *Neuropathy* was defined as any condition involving abnormal function or reaction of the neural components of the head and neck. *Prolonged anesthesia* was defined as any numbness of soft tissue after anesthetic administration beyond the reported normal duration of action that was resolved in 12 hours. *Bleeding related to anesthetic administration* was identified as requiring the application of gauze and pressure. *Trismus* was defined as the inability to open the mouth within the patient's normal limits. For the remaining complication list, standard definitions according to training were accepted.

The dental care team was also directed to record the patient's medical history based on guidelines of the American Society of Anesthesiologists, including age; weight (accompanied by overweight and obese status); procedures performed, including teeth, treatment area and surface information, the anesthetic used and amount, whether PM was administered; and if the injection was completed. Administration of local anesthetic agents included injection types, techniques, and combinations found in 2 widely used textbooks, *Local Anesthesia for Dental Professionals* and *Handbook of Local Anesthesia*.[11,12] For any complication recorded, 3 categories of severity were defined:

- **Mild complications:** Any complication that resolves during the course of standard anesthetic care, or those complications not requiring intervention with a 24-hour follow-up appointment.
- **Moderate complications:** Any complication that resolves in an immediate manner following provider intervention and/or required additional follow-up appointment(s) beyond a 24-hour follow-up.
- **Severe complications:** Any complication that results in extensive pharmacological treatment, complications that require chair-time for 3 days or longer, referral for hospitalization, and/or an incident that requires the submission of a CareSouth Carolina severe adverse event report, or death.

Table 1. Complication listing form used by dental care team.

☐ No complications	☐ Hypertension	☐ Hypotension
☐ Tachycardia	☐ Bradycardia	☐ Heart palpitations
☐ Syncope	☐ Nausea/vomiting	☐ Bleeding (Anes Care)
☐ Hematoma	☐ Trismus	☐ Neuropathy
☐ Mucosal irritation	☐ SII–Lip bite	☐ SII–Tongue bite
☐ SII–Cheek bite	☐ Undesired nerve block	☐ Pain at injection site
☐ Prolonged anesthesia	☐ Other_____	

Participants of the dental care team who administered local anesthesia for this analysis included 2 dentists and a dental hygienist with local anesthesia certification for infiltration injections only. The type of injection and the procedure for administration were determined by the treating dentist according to his/her training. The treating dentist only injected the local anesthetic reversal agent, PM (OraVerse, Septodont, Inc.) when it was deemed appropriate and applicable. This was accomplished by administering a 1:1 ratio of PM to local anesthetic cartridge content (0.4 mg/1.7 mL PM solution/cartridge) at the local anesthetic injection site.[13] The maximum recommended dose of OraVerse is 2 cartridges; this dose was not exceeded. If PM was not administered, the dental care team provided information as to why it was not. It should be noted that CSCDM policies and procedures do not include the administration of PM as a standard order for dispensation in all patients. Delivery of the agent was based on the treating dentist's clinical judgment. The purpose of this analysis was to view a snapshot of dental delivery with local anesthesia and associated adjuncts to care.

In addition to the dental care team participation, a questionnaire was distributed to teachers of 21 schools serviced by CSCDM to obtain information on the student's level of distraction and number of disruptions following the dental visit. A standardized questionnaire was created and distributed by the principal or designee to the teachers at the end of the dental care visit. The form was then collected by the school's central office personnel for delivery to the CSCDM. The questions were developed to gauge disruption and distractions ratings on a numerical (10-point) scale within the classroom after students received comprehensive dental care with local anesthesia. One limitation to this study's design was the omission of data collection for differences between individual children. The questionnaire was designed to provide a general description of the classroom atmosphere.

Data from the complication reports were entered into a JMP Statistical Discovery Software program for analysis. Quantitative evaluations were confined to standard summation, an estimation of means, and a valid percent for identified variables. Additional statistical analyses were performed using Pearson's chi square test and analysis of variance, with $P < 0.05$ considered significant.

Results

A total of 21 school sites were included in this analysis of 923 consecutive local anesthesia patients. The age range of the survey subjects was 3 to 17 years, with a mean age of 8.03 ± 2.64. The gender of the patients in the study was 54% females and 46% males. A pretreatment evaluation includes American Society of Anesthesiologists (ASA) physical status classification reports using the following definitions: ASA I: normal health patient; ASA II: patient with mild to moderate systemic disease, and ASA III: patient with severe systemic disease that limits activity but is not incapacitating. The ASA physical status reports for the subjects of this analysis are: ASA

Table 2. Complication evaluation.

Complication	Occurrences (n = 49)	Overall occurrence rate (n = 923)	Anesthetic reported most often	Mean amount of anesthetic deposited per report (SD)	Mean age (SD)
Self-inflicted injury (Lip bite)	18	1.95%	LIDO (11)	0.98 (0.56)	7.77 (2.66)
Self-inflicted injury (Cheek bite)	8	0.87%	ART 200 (4)	1.40 (0.81)	5.25 (0.89)
Self-inflicted injury (Tongue bite)	2	0.22%	LIDO (1) ART 200 (1)	0.75	7.50 (3.53)
Re-administration/ Inadequate anesthesia	11	1.19%	LIDO (10)	2.05 (1.36)	9.36 (2.29)
Trismus	3	0.32%	LIDO (3)	1.00 (0.25)	13.30 (2.31)
Pain at injection site	3	0.32%	LIDO (3)	0.83 (0.28)	11.00 (1.00)
Prolonged anesthesia	1	0.11%	LIDO	1.00	7.00
Undesired nerve block	1	0.11%	ART 200	0.75	8.00
Hematoma	1	0.11%	LIDO & ART 200	2.00	10.00
Bleeding related to anesthesia administration	1	0.11%	LIDO	1.00	7.00

I: 84.6%; ASA II: 15.3%; and ASA III: 0.1%. The majority of patients (81.9%, n = 923) reported no medical history. Of the 18.1% that reported a medical condition (n = 167), asthma was seen most often (46.1%), followed by attention deficit hyperactivity disorder (ADHD) (22.8%), intellectual and developmental disabilities (IDD) (7.8%), and autism spectrum disorder (6%). The racial makeup of the patients seen during the analyses include the following parental self reports: African American (489, 52.9%); Caucasian American (307, 33.3%); Bi-racial children of Caucasian and African American descent (74, 8%); Hispanic American (39, 4.2%); Asian American (8, 0.9%); and American Indian (6, 0.7%).

Delivery of care

CareSouth Carolina is a federally qualified health center, and its Division of Dental Medicine operates as an anchored integrated system of health care delivery. The CSCDM is comprised of several dental clinics that see all patients, regardless of their ability to pay. The communication between medical and dental personnel is facilitated through medical coding. The CSCDM Pediatric Clinic serves patients (1-18 years) using a portable school-based system of delivery as a means of dental access. After obtaining appropriate parent/guardian consent, the program provides comprehensive dental care within a school's available space by transporting dental equipment from a truck to an empty classroom. This treatment includes oral surgery and basic endodontic treatment, which is performed both during and after school hours, and a parent or guardian must be present. Each pediatric patient is tracked through the school system using the school nurse and/or designated school officials for direct communication. In order to provide a consistent basis of oral health care, the CSCDM returns to these schools at approximate 6-month intervals. The CSCDM includes a fixed site, in which additional dental care is completed. Only the care administered within the schools was considered for this evaluation.

The majority of procedures administered during the period of analysis were restorative (78.7%), followed by oral surgery (9.9%), periodontal/preventive procedures (6.5%), oral surgery and restorative (2.4%), basic endodontic procedures on permanent teeth (0.6%), and additional combinations of care (1.9%). The most commonly administered anesthetics were articaine 4% (ART 200) with 1:200,000 epinephrine (405, 43.9%), lidocaine 2% with 1:100,000 epinephrine (LIDO) (373, 40.4%), articaine 4% (ART 100) with 1:100,000 epinephrine (59, 6.4%), and various combinations of anesthetics used during the same treatment period (9.3%).

The type of injection used most often were standard inferior alveolar nerve block (IANB) (29.6%), maxillary buccal infiltration (27.9%), maxillary infiltration multiple injection sites (13.3%), mandibular infiltration (7.9%), Akinosi injection technique (5.1%), and various additional injection types (16.2%). For the purpose of this analysis, the amount of anesthetic deposited was reported in multiples of 0.25 cartridge administered. A mean of 0.97 ± 0.45 cartridge was administered per patient encounter during the data collection period. Mepivacaine (MEP) 3%, without epinephrine, was the anesthetic with the highest reported amount deposited per patient encounter (1.25 ± 0.55 cartridge), followed by LIDO (1.03 ± 0.48 cartridge), articaine (ART 200) 4% with 1:200,000 epinephrine (0.82 ± 0.34 cartridge), and articaine (ART 100) 4% with 1:100,000 epinephrine (0.79 ± 0.35 cartridge).

Phentolamine mesylate administration

PM was administered to 41.3% (n = 923) of the patients during the analysis period. The primary reasons for not administering PM to patients (n = 542) were when patients were <6 years or weighed <33 lbs, (191, 35.2%), anesthesia was desired postoperatively (91, 16.8%), the area of anesthesia was limited (73, 13.5%), an aversion to or apprehension of a second injection was anticipated (56, 10.3%), the length of time taken by the completion of procedure(s) limited the usefulness of agent (46, 8.5%), medical history (13, 2.4%), and combinations of the preceding (72, 13.3%).

Complication incidence

After statistical analysis of 923 consecutive cases, the overall complication rate was 5.3%. All of the complications (n = 49) were considered to be mild (73.5%) or moderate (26.5%); there were

no reports of severe events. The complications encountered most frequently were associated with self-inflicted soft tissue injuries—to the lip (18 reports), cheek (8 reports), or tongue (2 reports). These self-inflicted injuries were followed by local anesthetic re-administration/inadequate anesthesia (11 reports), trismus (3 reports), pain at injection site (3 reports), prolonged anesthesia (1 report), undesirable nerve block (1 report), hematoma (1 report), and bleeding related to anesthetic administration (1 report). The variables found to affect the incidence of complications were the administration of PM, patient age, medical history, location of injection, and type of injection (Table 2).

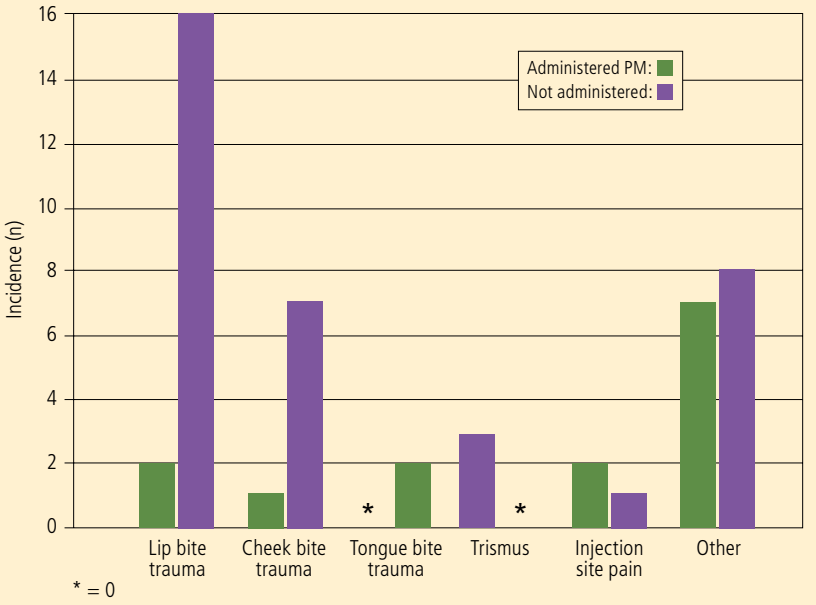
Additional analysis of the moderate complications (n = 13) revealed the majority of reports were self-inflicted soft tissue injuries—lip bite (10), cheek bite (1), tongue bite (1). The other moderate complication was a prolonged anesthesia following the administration of LIDO for an IANB. The patient reported feeling numb for approximately 10 hours after injection. PM was not administered to this patient, due to concern with the patient's apprehension/aversion during a second injection. No continued deficits were reported, and a 6-month follow-up revealed no continuing or ongoing effects. Overall, moderate complication events were most likely associated with a mean of 6.15 ± 1.78 years of age, an IANB injection, and no PM administration.

The anesthetic most often observed with complication reports was LIDO. LIDO was administered in 27 of the 49 reports (55.1%) and generated the most reports related to lip bite injury (11) and re-administration/inadequate anesthesia (10). It should be noted that LIDO was also the anesthetic used most often for IANB injections (48.5%, n = 373) during the study. Data collected from the standardized form reveals IANB injections to be a variable to complication incidence ($P < 0.05$, CI 95%), appearing in 22 of the 49 reports (44.9%). Given previous reports that IANB injections may be associated with more complications and result in lower success rates, the findings of LIDO with complication reports may relate more to injection type (IANB) than the anesthetic.[12,14-16]

Evaluation of the medical histories and complication occurrence demonstrates that patients with ADHD were more likely than other patients ($P < 0.05$, CI 95%) to have a complication occur. Additionally, 10 of the 28 (35.7%) self-inflicted soft tissue injury reports included ADHD in their medical history documentation. Besides ADHD, another significant factor in the incidence of complications was the patient's weight. Patients considered overweight or obese (according to the Centers for Disease Control and Prevention BMI-for-age growth charts for girls and boys) were associated with 23 of the 49 (46.9%) reports.[17] This included all of the cheek bite reports (8), complications involving lip bite injury (6), tongue bite injury (1), re-administration/inadequate anesthesia (5), trismus (2), and prolonged anesthesia (1).

Analysis of the complication rate difference between providers (dentists or local anesthesia-certified dental hygienists) administering the anesthetic revealed no statistically different values. In addition, no relevant or statistically different information was discovered between complication rates and sex of patient, school site, amount of anesthetic delivered, racial description, or ASA status. Due to the multitude of restorative procedures in the sample population, an evaluation comparing the type of procedure to complication reports was not completed.

Chart. Evaluation of the administration of PM and complication incidence.



Phentolamine mesylate and complication rate

Published research evaluating the use of PM in the administration of comprehensive dental care is extremely limited. As a means to acquire information on its real world use in the CSCDM clinic, additional analysis of the 381 PM administration cases was completed. The complication rate with the group administered PM was 2.6%. It should be noted that 6 additional complication reports with the PM group were associated with the re-administration of anesthetic/inadequate anesthesia prior to PM administration. These 6 reports are not included in the complication rate report with the PM administration. As shown in the Chart, the incidence of complications for the group administered PM was lower than that seen with the group not administered PM (6.1%). Self-inflicted soft tissue injury was more likely to be reported in the patients not administered PM (25/28 (89.3%) total soft tissue injury reports). It should also be noted that of the total (3) reported cases of trismus (3, 0.33%, n = 923) all involved the administration of PM. There were 3 injection site pain reports (0.22%; n = 923); of these, 2 involved the administration of PM.

Academic impact evaluation

One concern with a portable school-based dental delivery system during school hours is whether or not the student will be distracted or disruptive to class following dental treatment with local anesthetic. Questionnaires, distributed to 225 teachers located in schools that were serviced by CSCDM, yielded a response of 167 (74.2%) returned forms. The teachers' responses revealed that children administered local anesthetic for comprehensive care within the CSCDM school-based portable program were neither disruptive to class (1.34 ± 1.14 on a 10-point numerical scale), nor distracted in their ability to reorient to class work (1.48 ± 1.47 on a 10-point numerical scale). A limitation of this survey was that it offered only the teacher's perspective in general terms, without eliciting any of the subject's specific factors. Future research may be warranted to determine how the individual student was reported being distracted or disruptive in the classroom, the impact of PM use on the student's classroom behavior, and analysis of the student's ratings on tests/quizzes.

Discussion

As the environment of patient care continues to develop and progress, interest in identifying adverse events within the health care system has increased.[18-19] Reports of significant adverse occurrences are rare, and local anesthesia administration during dental treatment has a remarkable record of safety.[9,12,20] The data from this study showed a 5.3% complication rate during comprehensive, portable, school-based dental care. Most of these complications were mild in nature. A recent German study that evaluated adult local anesthetic administration complications in private dental practice demonstrated a similar complication rate (4.5%, n = 2731).[21] Overall, the 5.3% complication rate found in the procedures used in this study was considerably less than the complication rates reported in other sedation procedures used in dentistry (17%-35%).[19,22-23] The 5.3% rate was also lower than most reports of regional anesthesia administration in hospital or medical settings (0.2%-19.6%).[21,24-26]

Of all the complications examined in the present study, self-inflicted soft tissue injuries were encountered most frequently (3% overall). Self-inflicted soft tissue injuries reports range from 7% to 16%, and severe losses of labial soft tissue are documented.[16, 27,28] The occurrence of self-inflicted soft tissue trauma was previously reported to occur most often in younger patients, with the lower lip as the most frequently affected site.[16] In agreement with previous publications, this study revealed a negative correlation between the incidence of soft tissue injury and age—the lower the age of the patient, the higher the rate of soft-tissue injury. Frequent lower lip involvement was another factor in the soft-tissue injury rate. However, the complication rate of soft tissue injury occurrence (3%) was much lower than those rates proposed previously (7%-16%).[16,29] The lower complication rate in this study may be explained by following: the administration of PM; a larger sample size (n = 923) than comparative published findings, such as the study of College et al (n = 320) and of Adewumi et al (n = 264); the portable care environment in this study may have impacted the delivery of care; or the subjects involved in the analysis may have had limited previous experience with dental care.[16,29]

PM was granted Food and Drug Administration approval for dental application in May 2008, with the indication of reversing soft tissue anesthesia and associated functional deficits that are the consequences of dental care with local anesthetic administration.[8] There have been theories suggesting a possible link to the reversal of soft tissue anesthesia and a decrease in soft tissue injury.[7-8,11] However, the manufacturer does not claim the agent reduces dental-related soft tissue injuries. The results of this study suggest an improvement in complication occurrence with the administration of PM, especially as it relates to self-inflicted soft tissue trauma. Prior to a veritable conclusion of PM improving local anesthesia safety outcomes, further research should be completed evaluating multiple patient populations within different vehicles of care.

Early clinical trials of PM described injection site pain as the most frequently reported complication (3.9%-6%).[8,13] The analysis of this study found the incidence of injection site pain with PM administration to be much lower than that previously documented. It should also be noted that the administration of PM was associated with all 3 trismus reports that occurred during the evaluation period. This may relate to the fact that all 3 reports also involved an IANB injection. The most frequent cause of trismus is damage to the medial pterygoid muscle (by advancement of the needle too far medially) while administering an IANB. Given the requirement for a second injection, it may be proposed that the possibility of medial placement of the needle could increase with the physical action of PM administration. Overall, both injection site pain and trismus events rarely occurred during the course of this study and, when reported, were considered mild events.

During the course of this evaluation, LIDO was the anesthetic most often associated with inadequate anesthesia and re-administration during the dispensation of an IANB injection. Overall, success rates of anesthesia administration in dentistry has been reported to be approximately 95% with maxillary injections, and 80-85% with mandibular injections.[12,30] The lower success rates of mandibular injections are usually associated with the IANB injection, and it was previously reported that 1/5 of patients receiving an IANB injection required additional administration of anesthetic agent to improve anesthesia.[11,30] This study describes an approximate 98% overall success rate of all injections, and an approximate 97% IANB success rate. Although LIDO was associated with more inadequate anesthesia reports than other anesthetics during the period of this survey, the re-administration rate is well below the rate described in other publications.[30] It should be noted that new advances in anesthetic delivery have led some providers to view mandibular blocks in children as an older technology.[31] Alternative techniques and applications have been proposed that include new injection methodology and the use of oral laser application.[31-34] It is necessary to continue future research on alternatives to injection methodology that continues to improve the patient experience.

ADHD is characterized by insidious and impairing symptoms of carelessness, hyperactivity, and compulsion.[35] The ADHD worldwide-pooled prevalence is

5.29%, with a higher number of cases observed in North America.[36] Previous reports evaluating the occurrence of traumatic dental injuries indicate a relationship between ADHD and dental trauma.[37-40] Children with ADHD have a statistically higher prevalence of toothache, bruxism, bleeding gums, and oral trauma histories.[39] The results of this analysis demonstrated that children with ADHD were more likely than other patients to experience a complication from local anesthetic administration, usually via a self-inflicted soft tissue injury.

Besides ADHD, another possible predictor of local anesthetic complication is a patient's overweight or obese status. Of the 49 complication reports, 23 involved overweight or obese children. The majority of these reports include self-inflicted soft tissue injury, trismus, and/or the need for re-administration of local anesthetic. Obesity is often reported as a potential complicating factor in dentistry.[38-40] The quantity of adipose tissue in the oral cavity can obscure anatomical landmarks that are essential for accurate administration of local anesthetics, and decrease the field of view for dental providers administering care.[37] In addition, obesity alters the tissue distribution and elimination of drugs which can influence dosing, success, and complication.[41-43] As obesity is increasingly reported as a complicating factor in health care administration, continued research is needed in dentistry to identify, prevent, and treat possible complications associated with patients who are overweight or obese.

School-based health care programs, whether in a fixed or portable medium, are an essential part of the health care safety net. Currently, of all the school-based health care programs in the United States, only 10% are equipped to provide comprehensive dental care to students on-site.[44] These programs improve access to care and usually focus on the neediest populations. As with any school-affiliated program, the administration of care needs to be copacetic with the overall academic mission. The results of the teacher questionnaire survey presented here demonstrate that portable dental care in a school-based environment can occur with extremely limited interruption to the educational process.

Conclusion

Comprehensive care with local anesthesia delivered by a portable dental program during and after school hours has a low risk of complication. Safe administration of dental care is easily achievable with or without the intraoral administration of PM; however, the use of this agent improves safety outcomes. The administration of an IANB, ADHD, or obesity appears to significantly increase the incidence of complications, especially as it relates to soft tissue injuries. Teacher evaluations demonstrated that children receiving care by a portable dental team were able to reorient back to class work and were not disruptive to classmates.

Author information

Dr. Boynes is director, Dental Medicine, CareSouth Carolina, Society Hill, South Carolina, where Ms. Riley is manager, Dental Program; Ms. Milbee is manager, Patient Experience; Dr. Price is an associate dentist; and Ms. Ladson is lead dental hygienist. Ms. Bastin is a graduate student, University of Pittsburgh Graduate School of Public Health, Pennsylvania.

Disclaimer

Dr. Boynes has served as a consultant to Novocol of Canada Inc. (Septodont, Inc.) and Novalar Pharmaceutical Inc., regarding development of new anesthetics and/or devices for dentistry, including research and development of OraVerse. He has also served as an investigator for FDA-required Phase II-IV clinical research contracts awarded to an academic institution by Wyeth Consumer Healthcare, Novocol of Canada, Inc. (Septodont, Inc.), Hospira, Inc., Church & Dwight Co., Inc., Pfizer, Inc., and Novalar Pharmaceuticals, Inc. Henry Schein, Inc., Septodont, Inc., Ceylite Industries, Inc., and Ultra Light Optics have partially sponsored continuing education courses Dr. Boynes has presented.

References

1. Sherman P, Moslou S, Dang-Vu C. The primary care crisis and health care reform. *J Health Care Poor Underserved.* 2009;20(4):944-950.
2. Edelstein BL, Chinn CH. Update on disparities in oral health and access to dental care for America's children. *Acad Pediatr.* 2009;9(6):415-419.
3. Bailit H, Beazoglou T, Dorzdowski M. Financial feasibility of a model school-based dental program in different states. *Public Health Rep.* 2008;123(6):761-767.
4. Albert DA, McManus JM, Mitchell DA. Models for delivering school-based dental care. *J Sch Health.* 2005;75(5):157-161.
5. Speca SJ, Boynes SG, Cuddy MA. Allergic reactions to local anesthetic formulations. *Dent Clin North Am.* 2010;54(4):655-664.
6. Hersh EV, Moore PA, Papas AS, et al. Reversal of soft-tissue local anesthesia with phentolamine mesylate in adolescents and adults. *J Am Dent Assoc.* 2008;139(8):1080-1093.
7. Laviola M, McGavin SK, Freer GA, et al. Randomized study of phentolamine mesylate for reversal of local anesthesia. *J Dent Res.* 2008;87(7):635-639.
8. Hersh EV, Lindemeyer RG. Phentolamine mesylate for accelerating recovery from lip and tongue anesthesia. *Dent Clin North Am.* 2010;54(4):631-642.
9. Moore PA, Hersh EV. Local anesthetics: pharmacology and toxicity. *Dent Clin North Am.* 2010;54(4):587-599.
10. Moore PA, Hersh EV, Papas AS, et al. Pharmacokinetics of lidocaine with epinephrine following local anesthesia reversal with phentolamine mesylate. *Anesth Prog.* 2008;55(2):40-48.
11. Bassett KB, DiMarco AC, Naughton DK. *Local Anesthesia for Dental Professionals.* New Jersey: Pearson Education; 2010.
12. Malamed SF. *Handbook of Local Anesthesia.* 5th ed. Elsevier Mosby: St. Louis; 2004.
13. Novocal Pharmaceutical of Canada, Inc. OraVerse [package insert]. Available at: http://www.oraverse.com/assets/pdf/OraVersePI.pdf. Accessed May 30, 2013.
14. Pogrel MA, Bryan J, Regezi J. Nerve damage associated with inferior alveolar nerve blocks. *J Am Dent Assoc.* 1995;126(8):1150-1155.
15. Lustig JP, Zusman SP. Immediate complications of local anesthetic administration to 1,007 consecutive patients. *J Am Dent Assoc.* 1999;130(4):496-499.
16. College C, Feigal R, Wandera A, Strange M. Bilateral versus unilateral mandibular block anesthesia in a pediatric population. *Pediatr Dent.* 2000;22(6):453-457.
17. Centers for Disease Control and Prevention. *Healthy Weight: it's not a diet, it's a lifestyle!* Available at: http://www.cdc.gov/healthyweight/assessing/bmi/childrens_bmi/about_childrens_bmi.html. Accessed May 30, 2013.
18. Hines R, Barash PG, Waltrous G, O'Connor T. Complications occurring in the postanesthesia care unit: a survey. *Anesth Analg.* 1992;74(4):503-509.
19. Boynes SG, Lewis CL, Moore PA, Zovko J, Close J. Complications associated with anesthesia administered for dental treatment. *Gen Dent.* 2010;58(1):e20-e25.
20. Moore PA, Haas DA. Paresthesias in dentistry. *Dent Clin North Am.* 2010;54(4):715-730.
21. Daublander M, Muller R, Lipp MD. The incidence of complications associated with local anesthesia in dentistry. *Anesth Prog.* 1997;44(4):132-141.
22. Boynes SG, Moore PA, Lewis CL. Complications associated with anesthesia administration for dental treatment in a special needs clinic. *Spec Care Dentist.* 2010;30(1):3-7.
23. Cohen MM, Cameron CB, Duncan PG. Pediatric anesthesia morbidity and mortality in the perioperative period. *Anesth Analg.* 1990;70(2):160-167.
24. Cohen MM, Duncan PG, Pope W, Wolkenstein C. A survey of 112,000 anaesthetics at one teaching hospital (1975-83). *Can Anaesth Soc J.* 1986;33(1):22-31.

25. Schwilk B, Muche R, Bothner U, Goertz A, Friesdorf W, Georgieff M. Prozel qualitat in der anasthesiologie. *Anasthesist.* 1995;44(4):242-249.
26. Milgrom P, Fiset L. Local anesthetic adverse effects and other emergency problems in general dental practice. *Int Dent J.* 1986;36(2):71-76.
27. Akram A, Kerr RMF, Mclennan AS. Amputation of lower left lip following dental local anesthetic. *Oral Surg.* 2008;1(2):111-113.
28. Chi D, Kanellis M Himadi E, Asselin ME. Lip biting in a pediatric dental patient after dental local anesthesia: a case report. *J Pediatr Nurs.* 2008;23(6):490-493.
29. Adewumi A, Hall M, Guelmann M, et al. The incidence of adverse reactions following 4% septocaine (articaine) in children. *Pediatr Dent.* 2008;30(5):424-428.
30. Kaufman E, Weinstein P, Milgrom P. Difficulties in achieving local anesthesia. *J Am Dent Assoc.* 1984; 108(2):205-208.
31. Malamed SF. Is the mandibular block passe? *J Am Dent Assoc.* 2011;142(Suppl 3):3S-7S.
32. Martens LC. Laser assisted pediatric dentistry: review and outlook. *J Oral Laser Applic.* 2003;3:203-209.
33. Munshi AK, Hegde A, Bashir N. Clinical evaluation of the efficacy of anesthesia and patient preference using the needle-less jet syringe in pediatric dental practice. *J Clin Pediatr Dent.* 2002;25(2):131-136.
34. Jung IY, Kim JH, Kim ES, Lee CY, Lee SJ. An evaluation of buccal infiltrations and inferior alveolar nerve blocks in pulpal anesthesia for mandibular first molars. *J Endod.* 2008;34(1):11-13.
35. American Psychiatric Association. *Diagnostic and Statistical Manual of Mental Diseases (DSM-IV).* 4th ed. Washington, DC: American Psychiatric Publishing; 1994.
36. Polanczyk G, Silva de Lima M, Horta BL, et al. The worldwide prevalence of ADHD: a systematic review and metaregression analysis. *Am J Psychiatry.* 2007; 164(6):942-948.
37. Sabuncuoglu O. Traumatic dental injuries and attention deficit/hyperactivity disorder: is there a link? *Dent Traumatol.* 2007;23(3):137-142.
38. Thikkurissy S, McTique DJ, Coury DL. Children presenting with dental trauma are more hyperactive than controls as measured by the ADHD rating scale IV. *Pediatr Dent.* 2012;34(1):28-31.
39. Bimstein E, Wilson J, Guelmann M, Primosch R. Oral characteristics of children with attention-deficit hyperactivity disorder. *Spec Care Dentist.* 2008;28(3):107-110.
40. Reilly D, Boyle CA, Craig DC. Obesity and dentistry: a growing problem. *Br Dent J.* 2009;207(4):171-175.
41. Pischon N, Heng N, Bernimoulin JP, Kleber BM, Willich SN, Pischon T. Obesity, inflammation, and periodontal disease. *J Dent Res.* 2007;86(5):400-409.
42. Cheymol G. Effects of obesity on pharmacokinetics: implications for drug therapy. *Clin Pharmocokinet.* 2000;39(3):215-231.
43. Ebbeling CB, Pawlak DB, Ludwig DS. Childhood obesity: public-health crisis, common sense cure. *Lancet.* 2002;360(9331):473-482.
44. Pekruhn C. Oral health opportunities in school based health centers [issue brief]. National Maternal and Child Oral Health Policy Center. 2010.

Manufacturer

Septodont, Inc., Lancaster, PA
800.872.8305, www.septodontusa.com

self CDE 2 HOURS CREDIT instruction

Academy of General Dentistry PACE Program Approval for Continuing Education

Approved PACE Program Provider
FAGD/MAGD Credit
Approval does not imply acceptance by a state or provincial board of dentistry or AGD endorsement
06/01/2010 to 05/31/2014

Exercise No. 336 Anesthesia and Pain Control Subject Code 132

The 15 questions for this exercise are based on the article, *Evaluating complications of local anesthesia administration and reversal with phentolamine mesylate in a portable pediatric dental clinic*, on pages 70-76. This exercise was developed by Steven E. Holbrook, DMD, MAGD, in association with the *General Dentistry* Self-Instruction committee.

Reading the article and successfully completing this exercise will enable you to:
- identify the mechanism of action of phentolamine mesylate;
- recognize that comprehensive care with local anesthesia delivered by a school-based portable dental clinic has a low risk of complications; and
- understand that the use of phentolamine mesylate can improve safety outcomes.

1. Phentolamine mesylate is a/an _____ blocker.
   A. alpha adrenergic
   B. beta adrenergic
   C. cholinergic
   D. nootropic

2. Phenotolamine mesylate decreases the duration of soft tissue anesthesia, after local anesthetic administration, by increasing
   A. the ion exchange phenomenon at the dendrite membrane.
   B. total peripheral resistance.
   C. the elimination of anesthetic.
   D. venous return to the heart.

3. A complication that resolved in an immediate manner following provider intervention was classified as a _____ complication.
   A. mild
   B. moderate
   C. severe
   D. critical

4. In this study, the percentage of complications from the administration of local anesthesia was _____.
   A. 2.7
   B. 5.3
   C. 8.6
   D. 12.2

5. The area most often injured in self inflicted soft tissue trauma is the
   A. tongue.
   B. upper lip.
   C. lower lip.
   D. cheek.

6. The most frequently reported complication of phentolamine mesylate in early clinical trials was
   A. increased heart rate.
   B. injection site pain.
   C. soft tissue trauma.
   D. decreased heart rate.

7. Phentolamine mesylate was administered _____ % of the time in this study.
   A. 24.2
   B. 41.3
   C. 67.8
   D. 87.5

8. Safe administration of dental care was achievable with or without phentolamine mesylate. The use of phentolamine mesylate did not improve safety outcomes.
   A. Both statements are true.
   B. The first statement is true; the second is false.
   C. The first statement is false; the second is true.
   D. Both statements are false.

9. The anesthetic most often associated with complication reports was
   A. articane.
   B. mepivocaine.
   C. marcaine.
   D. lidocaine.

10. Patients with _____ were more likely to have a complication.
    A. attention deficit hyperactivity disorder
    B. asthma
    C. intellectual and developmental disabilities
    D. an autism spectrum disorder

11. Patents considered overweight or obese were associated with what percentage of reported complications?
    A. 11.9
    B. 23.9
    C. 46.9
    D. 72.9

12. Children administered local anesthetics were not disruptive to class. Children administered local anesthetics were not distracted in their ability to reorient to work.
    A. Both statements are true.
    B. The first statement is true; the second is false.
    C. The first statement is false; the second is true.
    D. Both statements are false.

13. What percentage of patients administered phentolamine mesylate reported complications?
    A. 2.6
    B. 5.8
    C. 11.3
    D. 21.4

14. The most common cause of trismus, following the administration of an inferior alveolar nerve block, is damage to which of the following muscles?
    A. Masseter
    B. Lateral pterygoid
    C. Medial pterygoid
    D. Temporalis

15. The second most common complication reported to occur as the result of local anesthetic administration was
    A. pain at the injection site.
    B. self-inflicted injury to the tongue.
    C. local anesthetic readministration.
    D. hematoma.

Answer form is on page 80. Answers for this exercise must be received by July 31, 2014.

Douglas D. Damm, DDS

Bluish discoloration of alveolar ridge *(Case courtesy of Dr. Mark Cummins, Richmond, KY)*

A 30-year-old female presented with bilateral lingual mandibular enlargements (Fig. 1) exhibiting a distinctive bluish coloration (Fig. 2). Radiographic evaluation, vitality testing, and periodontal evaluation were within normal limits.

Which of the following is the most appropriate diagnosis?

A. Kaposi's sarcoma
B. Metastatic melanoma
C. Minocycline staining
D. Sturge-Weber angiomatosis

Diagnosis is on page 79.

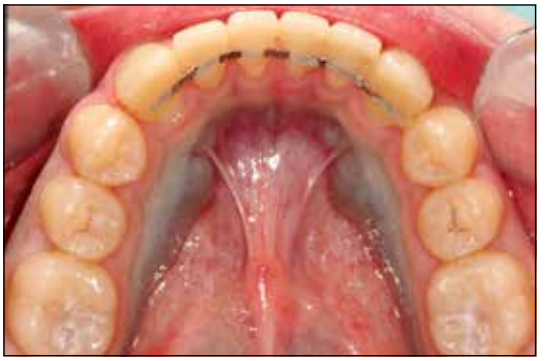


Fig. 1. Bilateral enlargements of the mandible.

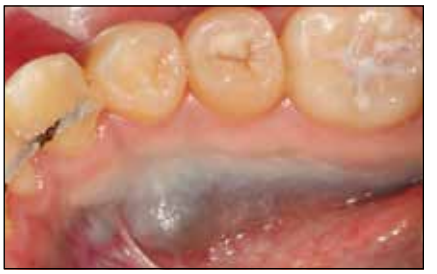


Fig. 2. Bluish alteration of the lingual surface of the mandible.

Radiolucency of anterior mandible *(Case courtesy of Dr. Oluseyi Ayangade, Michigan City, IN)*

A 29-year-old male presented with a radiolucency between the mandibular left cuspid and lateral incisor (Fig. 1). The lesion was associated with displacement and resorption of the lateral and central incisors. The adjacent teeth responded within normal limits to vitality testing. The lesion was explored surgically, with the contents curetted thoroughly and submitted for microscopic examination (Fig. 2).

Which of the following is the most appropriate diagnosis?

A. Adenomatoid odontogenic tumor
B. Ameloblastic fibro-odontoma
C. Calcifying cystic odontogenic tumor
D. Calcifying epithelial odontogenic tumor

Diagnosis is on page 79.

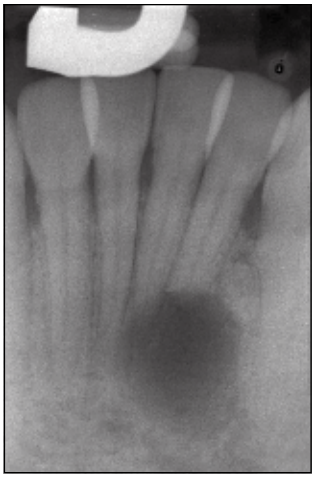


Fig. 1. Radiolucency between the mandibular left cuspid and lateral incisor.

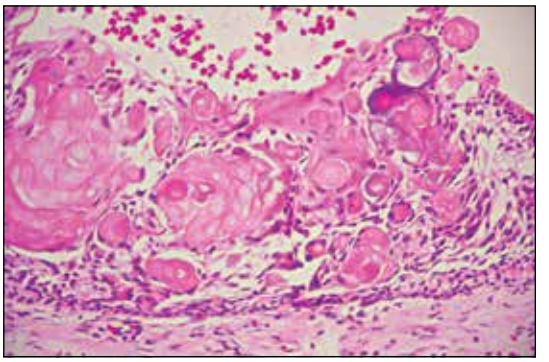


Fig. 2. Cystic structure lined by hyperchromatic epithelium, demonstrating numerous ghost cells (H&E stain, original magnification 20X).

Author information
Dr. Damm is a professor, Department of Oral Health Sciences, Division of Oral Pathology, College of Dentistry, University of Kentucky, Lexington.

Oral Diagnosis

Bluish discoloration of alveolar ridge

Diagnosis:

C. Minocycline staining

Minocycline is a semisynthetic derivative of tetracycline that appears to bind preferentially to certain types of collagenous tissues that are present in dental pulp, dentin, bone, and dermis. Once deposited in tissues, the medication can undergo oxidation and lead to a distinctive bluish discoloration. The staining is not universal, with <10% of long-term users affected.

Minocycline discoloration of erupted teeth can become evident following as little as 1 month of utilization, and typically creates a blue-gray discoloration of the incisal three-fourths of the crown. The dental changes are encountered less frequently than the discoloration of the alveolar ridges. The most common presentation is a linear band of bluish bone noted above the facial attached gingiva of both alveolar ridges. Other frequent findings are diffuse discoloration of the hard palate, and involvement of tori. Some investigators have suggested that the antioxidant, ascorbic acid, can block the formation of the discoloration.

Bibliography

Neville BW, Damm DD, Allen CM, Bouquot JE. *Oral and Maxillofacial Pathology.* 3rd ed., St. Louis: Saunders/Elsevier; 2009:73, 317-318.

Radiolucency of anterior mandible

Diagnosis:

C. Calcifying cystic odontogenic tumor

The histopathologic specimen revealed a cystic structure lined by hyperchromatic epithelium demonstrating numerous ghost cells (Fig. 2). The name of this pathosis was altered in the most recent World Health Organization classification, and also is known as a *calcifying odontogenic cyst*, or *Gorlin cyst*.

This odontogenic cyst may be seen with and without odontoma. Although the majority of these tumors are cystic, a solid variant is seen and termed *dentinogenic ghost tumor.* The cystic variants respond well to simple enucleation, and demonstrate a low recurrence rate.

Bibliography

Neville BW, Damm DD, Allen CM, Bouquot JE. *Oral and Maxillofacial Pathology.* 3rd ed., St. Louis: Saunders/Elsevier; 2009:695-697.

self CDE 2 HOURS CREDIT instruction

Answer Sheet

Academy of General Dentistry™
PACE Program Approval for Continuing Education

Approved PACE Program Provider
FAGD/MAGD Credit
Approval does not imply acceptance by a state or provincial board of dentistry or AGD endorsement
06/01/2010 to 05/31/2014

AGD/ADA ID: _____

First name: _____ Middle initial: _____ Last name: _____

Address 1: _____

Address 2: _____

City: _____ State/Province: _____ ZIP/Postal code: _____

PAYMENT ☐ Currently enrolled in Self-Instruction ☐ Enrolling today

I am paying by: ☐ Check (Payable to AGD) ☐ Credit Card (Complete payment information)

Credit Card Number: _____ Expiration Date: _____

Signature: _____

Select the number of exercises you wish to purchase:

	AGD Member	Non-member
1 Exercise	☐ $30	☐ $50
2 Exercises	☐ $50	☐ $75
3 Exercises	☐ $60	☐ $90
6 Exercises	☐ $100	☐ $150
Best Value!		
12 Exercises	☐ $150	☐ $225

Each exercise is worth 2 CE credits.

ANSWERS Select the best answer by completely filling in **one** box for each response.

Correct ■ **Incorrect** ☑ **Incorrect** ☒

Exercise No. 334	Exercise No. 335	Exercise No. 336
1 A B C D	1 A B C D	1 A B C D
2 A B C D	2 A B C D	2 A B C D
3 A B C D	3 A B C D	3 A B C D
4 A B C D	4 A B C D	4 A B C D
5 A B C D	5 A B C D	5 A B C D
6 A B C D	6 A B C D	6 A B C D
7 A B C D	7 A B C D	7 A B C D
8 A B C D	8 A B C D	8 A B C D
9 A B C D	9 A B C D	9 A B C D
10 A B C D	10 A B C D	10 A B C D
11 A B C D	11 A B C D	11 A B C D
12 A B C D	12 A B C D	12 A B C D
13 A B C D	13 A B C D	13 A B C D
14 A B C D	14 A B C D	14 A B C D
15 A B C D	15 A B C D	15 A B C D

This form can be submitted via mail or fax.

Self-Instruction
Academy of General Dentistry
211 E. Chicago Ave., Suite 900
Chicago, IL 60611-1999

312.440.4261

Answers can also be submitted online.

www.agd.org

For more information, contact Cassandra Bannon at 888.AGD.DENT (888.243.3368), ext. 4353, or at self-instruction@agd.org.

Please allow 2 weeks for credit to be awarded.

EVALUATION Please respond to the statements below, using the following scale: **1** Poor; **2** Below average; **3** Average; **4** Above average; **5** Excellent

	Exercise No. 334	Exercise No. 335	Exercise No. 336
Practicality of the content	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Benefit to your clinical practice	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Quality of illustrations	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Clarity of objectives	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Clarity of exercise questions	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Relevance of exercise questions	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Did this exercise achieve its objectives?	Yes ☐ No ☐	Yes ☐ No ☐	Yes ☐ No ☐
Did this article present new information?	Yes ☐ No ☐	Yes ☐ No ☐	Yes ☐ No ☐
How much time did it take you to complete this exercise?	_____mins	_____mins	_____ mins

Deadline for submission of answers to Exercises 334-336 is July 31, 2014.

A conservative treatment approach using direct composite resins for anterior teeth eroded by lemon sucking

Vanara Florencio Passos, DDS, MSc, PhD ▪ Andre Mattos Brito de Souza, DDS, MSc ▪ Lidiany Karla Azevedo Rodrigues, DDS, MSc, PhD
Juliana de Campos Fraga Soares Bombonatti, DDS, MSc, PhD ▪ Sergio Lima Santiago, DDS, MSc, PhD

An excessively acidic diet results in the progressive deterioration of dental health, with functional, esthetic, and biological consequences. Previously, rehabilitation required placing numerous full crowns and root canal treatments; however, with improved adhesive techniques, a more conservative approach may be utilized to preserve tooth structure. This article describes 2 cases that utilized conservative dental treatments (involving direct composite resins with minimal preparation of the tooth structure) to treat eroded dentition induced by lemon sucking.

Received: January 31, 2012
Accepted: April 30, 2012

Key words: erosion, composite resin, citric acid

Tooth wear is produced by noncarious destructive events and often is a multifactorial phenomenon. In fact, it is a cumulative lifetime process that can lead to tooth surface loss and may encompass erosion, abrasion, and/or attrition.[1] Intrinsic and extrinsic acids are thought to be the main etiologic factors for dental erosion. Erosion among younger patients is caused mainly by foods and beverages; fruits (including juices and candies), carbonated beverages, and sports drinks are common extrinsic dietary instigators of dental erosion.[2-5] The most prominent of these acids, citric acid, with a reported pH value of 2.5, is present in fruit juices (such as lemon juice).[6] Citric acid can demineralize tooth structure in the same manner as stomach acid and other acids present in food and beverages. Acid exposure from sucking lemons is greatest for both those teeth that have penetrated the lemon and the adjacent teeth exposed to the juice that is sucked out of the fruit.[7] Although the prevalence of erosion in individuals who have a habit of sucking lemons is considered high, there are few reports in the literature regarding tooth erosion caused by lemon juice.[8,9]

Early signs of enamel erosion appear as a smooth, silky/shiny glazed surface with the absence of perikymata.[4] Tooth loss caused by acidic fruits, beverages, and chemical irritants can be aggravated if an abrasive process (such as parafunctional habits) are involved as well.[4-7,10]

Tooth surface loss may expose dentinal tubules and cause dentin hypersensitivity.[11] As a result, the exact cause of tooth structure loss must be determined before it can be eliminated. The treatment selected to regain function and esthetics must relate directly to the severity of dental tissue loss.[12,13]

According to Lambrechts et al, restorative treatment may be necessary if the structural integrity of the tooth is threatened, the tooth is hypersensitive, the defect is esthetically unacceptable to the patient, or pulpal exposure is likely.[14]

Standard guidelines for conventional rehabilitation involve root canal treatments and the placing of numerous full crowns, which is expensive. The recent development of direct restorative techniques now allows dentists to restore teeth with minimal dental preparation. Some authors have reported using composite resins as part of a conservative dental treatment for eroded dental tissues, with positive results.[12,15-21]

This article presents 2 case reports that used a conservative approach to restore anterior teeth with excessive wear due to lemon sucking.

Case report No. 1

A 19-year-old woman visited the Federal University of Ceara, Brazil, to complain of dental sensitivity and dissatisfaction with the esthetic appearance of her maxillary incisors (Fig. 1). A clinical examination revealed notable tooth wear in the maxillary anterior region and some effects related to lemon sucking. The maxillary anterior teeth usually are used to crush and squeeze the pulp of the lemon before sucking, which could explain the marked wear on the labial surfaces and incisal edges of the maxillary teeth.

The patient's medical history indicated she was in excellent health; she had no caries lesions or periodontal disease, and her mucosa displayed normal moisture. To determine the cause of the erosive process, the patient was questioned about her dietary habits, emotional and physical disturbances, and possible diseases. An analysis of her history and feeding regimen revealed that for the last 7 years, she had engaged in the habit of sucking on lemons and that she drank cola every day in excessive quantities. Evidence of dental wear due to parafunctional habits (onychophagy) was also observed.

Case report No. 2

A 35-year-old woman was referred to the Federal University of Ceara, Brazil, complaining of tooth sensitivity and excessive wear on her maxillary incisors (Fig. 2). In the anterior region, the clinical crown lengths of her teeth were diminished at the incisal edges due to erosion. The sharp edges of the eroded areas caused irritation to the patient's tongue. A comprehensive periodontal examination revealed no signs of periodontal disease. The remainder of the soft tissue examination was normal as well. The patient did not complain of muscular or temporomandibular articulation pain. Medical anamnestic data showed no evidence of systemic disorders; however, the patient admitted that she had a habit of sucking on lemons over the past 12 years.

Fig. 1. Anterior views of the 19-year-old patient with tooth wear in the maxilla (Case report No. 1). *Left.* Full mouth view. *Right.* Close-up anterior maxilla view.

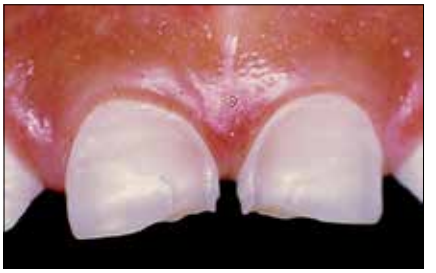


Fig. 2. Anterior view of the 35-year-old patient with excessive wear on the maxillary incisors (Case report No. 2).

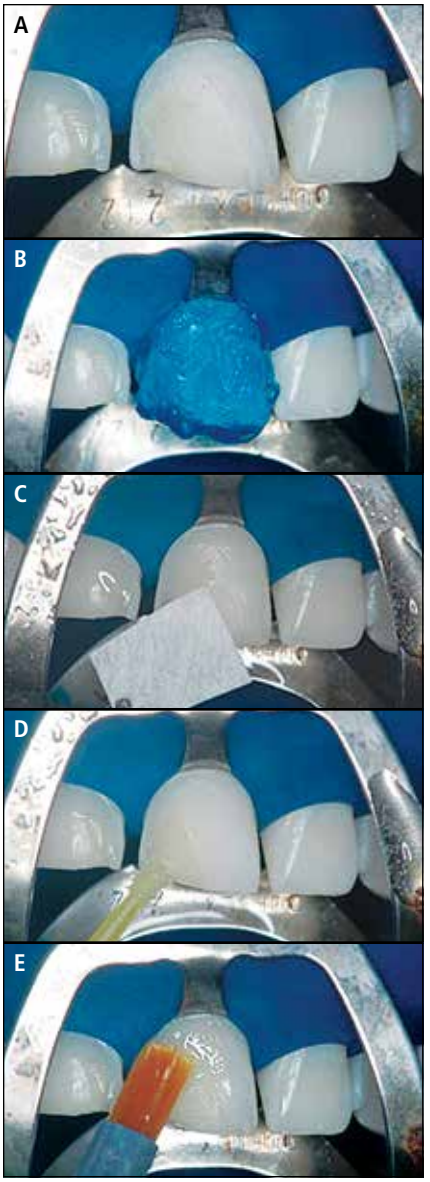


Fig. 3. Application of the resin composite on the surfaces of the incisive teeth of the 19-year-old patient.

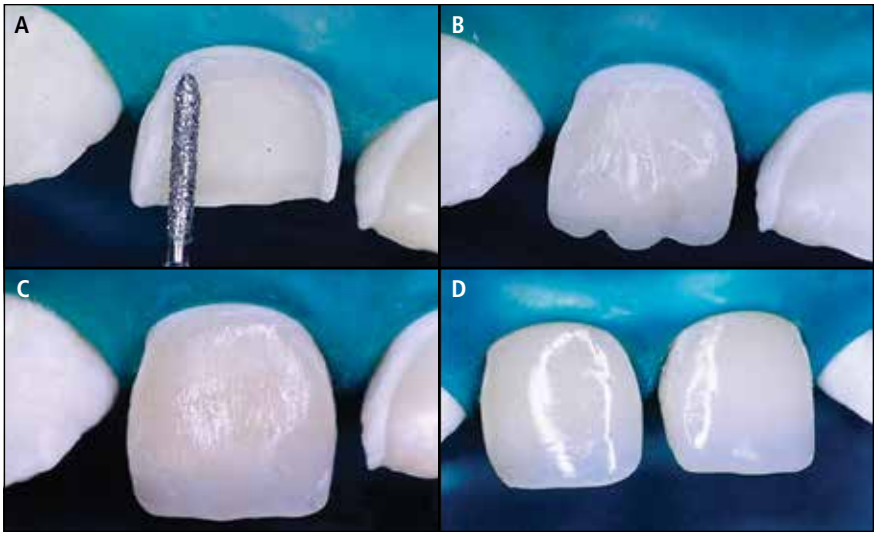


Fig. 4. Application of the resin composite on the surfaces of the incisive teeth of the 35-year-old patient.

Restorative treatment

Initially, the treatment involved removing the etiologic factors. To that end, the patients were advised to reduce the ingestion of acidic substances, and were counseled on the necessity of habit control.

After controlling the extrinsic acids, the goal of treatment was to restore health, function, and esthetics with a less-invasive procedure than the standard full crowns and root canals treatment. Based on the patients' ages and the desire for conservative treatment, composite resin was chosen as the restorative material. Both patients were informed of and consented to their respective treatment plans.

Prior to restorative treatment, the shade of the central incisors was tested with the composite resin. Specifically, a small quantity of resin was placed on the incisal third of the tooth and polymerized. Local anesthesia was performed, along with complete isolation of the operating field. No cavity preparations were performed. The adjacent dental structures (where adhesive material was applied later) were prepared using diamond-coated burs to cause a reactive process with the adhesive system (Fig. 3A, Case report No. 1 and Figure 4A, Case report No. 2).

The teeth were etched with 37% phosphoric acid (Scotchbond Etchant, 3M ESPE) for 15 seconds, rinsed for 30 seconds, and dried with absorbent paper, resulting in a moist dentinal surface (Fig. 3B and 3C).

The adhesive system (Single Bond, 3M ESPE) was applied and photocured according to the manufacturer's instructions (Fig. 3D). Following hybridization, small stratified increments of resin

Fig. 5. Postoperative facial view of the 19-year-old patient.

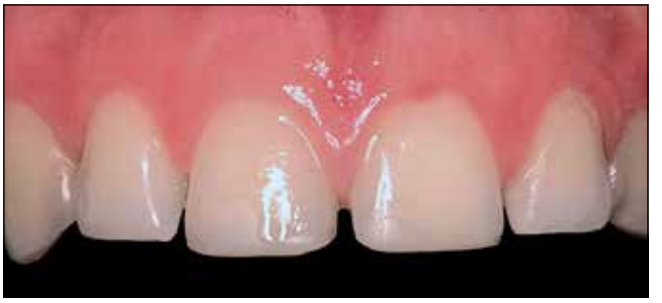


Fig. 6. Facial view of the 19-year-old patient 2 years after treatment.

Fig. 7. Facial view of the 35-year-old patient 1 year after treatment.

composite were applied in 2 mm layers (Fig. 3E and 4B), using thin brushes and a No. 1 spatula for insertion (Hu-Friedy Mfg. Co., LLC). Each layer was photocured for 40 seconds and resin composite was applied until the tooth was restored fully (Fig. 4C).

Finishing and polishing were performed using multi-bladed burs (SS White Burs, Inc.) and abrasive and feltrum disks (Fig. 4D). Final polishing was performed 1 week later. The results of these esthetic and functional restorations can be seen in Figures 4D and 5.

Upon completing treatment, the dentists warned the patients to avoid soft drinks and sucking on lemons. The patients were scheduled for annual recall dental visits. The restored teeth demonstrated a positive outcome (Fig. 6 and 7).

Discussion

Severe wear is a dental condition that may result from a number of different etiologies. The prevalence of erosion is linked to the consumption of fresh fruits (such as lemon sucking) and soft drinks (such as cola drinks), as in the case reports presented here.[2] Treatment may involve multiple approaches. Initially, causal factors must be eliminated, and deleterious habits must be prevented. If the causative factor is not eliminated, then tooth wearing will progress over time.

Normally, esthetics and dentin hypersensitivity are the main complaints related to excessive anterior wear; the patients in the 2 case reports had similar complaints.[11] In advanced cases, the dentin becomes exposed, and the patient feels hypersensitivity; in such cases, restorations are necessary not only for esthetic needs, but also to reduce hypersensitivity and prevent further progression. According to Jaeggi et al, direct composite coatings or porcelain veneers (in more advanced cases) should be considered the treatment of choice.[13] Treatment options also may involve no-preparation techniques that can maintain maximum levels of healthy tooth structure.

The treatment of tooth wear due to erosion and abrasive processes presents challenges in contemporary dentistry. Normally, the therapy restores lost structures while obtaining good long-term stability, function and aesthetics. According to Vailati & Belser, the guidelines for conventional oral rehabilitation dictate full-crown coverage for a compromised tooth; however, this approach is both highly invasive and expensive.[15] As adhesive materials improve, more alternative treatment options become possible. The conservation of tooth structure is the major goal of restorative dental treatment; however, composite resin restorations may fail over time if patients do not stop consuming acidic products. Another important factor for effective results with direct composite resin techniques is the clinical skill of the professional utilizing the adhesive technique, including the use of rubber dams and enhanced attention during the application of adhesive systems. Regular follow-up visits are necessary to monitor possible tooth wear due to abrasion and attrition. If necessary, repairs or new restorations may be warranted. Effective treatment can improve patient self-esteem, while eliminating dentin hypersensitivity and promoting good dental hygiene and dietary habits.

Javaheri determined certain advantages in the conservation of tooth structure, including the lack of need for anesthesia, absence of postoperative sensitivity, minimal flexing stress, longer-lasting restorations, potential for reversal, and higher levels of treatment acceptance among patients.[22] Reis et al agreed that the chosen material should require minimal preparation.[18]

Composite resin has been used successfully for tooth wear due to erosive and abrasive challenges.[6,12,15-18,20,21,23,24] However, Jaeggi et al reported that composite resin use may be more problematic when the loss of vertical dimension is >2 mm; in such cases, reconstruction with full ceramic overlays is appropriate.[13] This practice was not practical in the present cases, due to the pattern of wear.

The key to prevention is modifying dietary habits related to acidic intake.[9] Fluoridated toothpastes, mouthwash agents, and topical applications should also be encouraged, and instructions regarding proper tooth brushing methods (such as using soft-bristled toothbrushes) should be provided.[9]

Conclusion

Even after adequate treatment and patient instruction are accomplished, restorative treatment will only be successful if the

patient complies with the prescribed treatment and recommendations for behavioral modifications. Composite resin represents a viable and economical method for restoring esthetics, function, and overall health of teeth. The conservative approach employed in these cases was satisfactory and acceptable to both patients.

Author information

Dr. Passos is an auxiliary professor, School of Dentistry, University of Fortaleza, CE, Brazil. Dr. de Souza is in private practice in Fortaleza, Brazil. Dr. Bombonatti is a postdoctoral researcher, Bauru School of Dentistry, University of Sao Paulo, Brazil. Drs. Rodrigues and Santiago are associate professors, Department of Restorative Dentistry, Faculty of Pharmacy, Dentistry, and Nursing, Federal University of Ceara, Brazil.

Disclaimer

The authors have no financial interest in any of the manufacturers whose products are discussed in this article.

References

1. Bartlett D, Smith BG. *Tooth wear and sensitivity.* London: Martin Dunitz; 2000:83-92.
2. Larsen MJ. *Dental Caries: The disease and its clinical management.*1st ed. Oxford: Blackwell Munksgaard; 2008:234-237.
3. Gandara BK, Truelove EL. Diagnosis and management of dental erosion. *J Contemp Dent Pract.* 1999;1(1): 16-23.
4. Lussi A, Jaeggi T, Zero D. The role of diet in the aetiology of dental erosion. *Caries Res.* 2001;38(Suppl 1): S34-S44.
5. Mandel L. Dental erosion due to wine consumption. *J Am Dent Assoc.* 2005;136(1):71-75.
6. Guldag MU, Buyukkaplan US, Ay ZY, Katirci G. A multidisciplinary approach to dental erosion: a case report. *Eur J Dent.* 2008;2(2):110-114.
7. Spear F. A patient with severe wear on the anterior teeth and minimal wear on the posterior teeth. *J Am Dent Assoc.* 2008;139(10):1399-1403.
8. Correr GM, Alonso RC, Correa MA, Campos EA, Baratto-Filho F, Puppin-Rontani RM. Influence of diet and salivary characteristics on the prevalence of dental erosion among 12-year-old schoolchildren. *J Dent Child.* 2009;76(3):181-187.
9. Bamise CT, Dinyain VE, Kolawole KA. Dental erosion due to lime consumption; review of literature and case report. *East Afr J Public Health.* 2009;6(2):141-143.
10. Barbour ME, Rees GD. The role of erosion, abrasion and attrition in tooth. *J Clin Dent.* 2006;17(4):88-93.
11. Vieira AH, Santiago SL. Management of dentinal hypersensitivity. *Gen Dent.* 2009;57(2):120-126.
12. Bernardo JK, Maia EA, Cardoso AC, de Araujo Junior EM, Monteiro Junior S. Diagnosis and management of maxillary incisors affected by incisal wear: an interdisciplinary case report. *J Esthet Restor Dent.* 2002;14(6): 331-339.
13. Jaeggi T, Gruninger A, Lussi A. Restorative therapy of erosion. *Monogr Oral Sci.* 2006:200-214.
14. Lambrechts P, Van Meerbeek B, Perdigao J, Gladys S, Braem M, Vanherle G. Restorative therapy for erosive lesions. *Eur J Oral Sci.* 1996;104(2 Pt 2):229-240.
15. Vailati F, Belser UC. Full-mouth adhesive rehabilitation of a severely eroded dentition: the three-step technique. Part 3. *Eur J Esthet Dent.* 2008;3(3):236-257.
16. Spreafico RC. Composite resin rehabilitation of eroded dentition in a bulimic patient: a case report. *Eur J Esthet Dent.* 2010;5(1):28-48.
17. Reston EG, Closs LQ, Busato AL, Broliato GA, Tessarollo FR. Restoration of occlusal vertical dimension in dental erosion caused by gastroesophageal reflux: case report. *Oper Dent.* 2010;35(1):125-129.
18. Reis A, Higashi C, Loguercio AD. Re-anatomization of anterior eroded teeth by stratification with direct composite resin. *J Esthet Restor Dent.* 2009;21(5):304-316.
19. Broliato GA, Volcato DB, Reston EG, et al. Esthetic and functional dental rehabilitation in a patient with gastroesophageal reflux. *Quintessence Int.* 2008;39(2): 131-137.
20. Vailati F, Vaglio G, Belser UC. Full-mouth minimally invasive adhesive rehabilitation to treat severe dental erosion: a case report. *J Adhes Dent.* 2012;14(1):83-92.
21. de Melo MA, Passos VF, Apolonio FM, Rego RO, Rodrigues LK, Santiago SL. Restoring esthetic in eroded anterior teeth: a conservative multidisciplinary approach. *Gen Dent.* 2011;59(1):48-52.
22. Javaheri D. Considerations for planning esthetic treatment with veneers involving no or minimal preparation. *J Am Dent Assoc.* 2007;138(3):331-337.
23. Aziz K, Ziebert AJ, Cobb D. Restoring erosion associated with gastroesophageal reflux using direct resins: case report. *Oper Dent.* 2005;30(3):395-401.
24. Franco EB, Benetti AR, Ishikiriama SK, et al. 5-year clinical performance of resin composite versus resin modified glass ionomer restorative system in non-carious cervical lesions. *Oper Dent.* 2006;31(4):403-408.

Manufacturers

Hu-Friedy Mfg. Co., LLC, Chicago, IL
800.483.7433, www.hu-friedy.com

SS White Burs, Inc., Lakewood, NJ
732.905.1100, www.sswhiteburs.com

3M ESPE, St. Paul, MN
888.364.3577, solutions.3m.com

The effect of baking soda when applied to bleached enamel prior to restorative treatment

Bhenya Ottoni Tostes, MSc ▪ Rafael Francisco Lia Mondelli, DDS, PhD, MSc ▪ Ynara Bosco de Oliveira Lima-Arsati, DDS, PhD, MSc
Jose Augusto Rodrigues, DDS, PhD, MSc ▪ Leonardo Cesar Costa, DDS, PhD, MSc

This in vitro study evaluated the effect of 10% baking soda solution and sodium bicarbonate powder (applied with jets) when applied to bleached enamel prior to restorative treatment. The surfaces of 40 bovine incisors were flattened and divided into 5 groups (n = 8): Group B (bleached and restored, negative control), Group W (bleached, stored in distilled water for 7 days, and restored), Group BSJ (bleached, abraded with baking soda jet for 1 min, and restored), Group BSS (bleached, application of 10% baking soda solution for 5 min, and restored), and Group R (restored, without bleaching, positive control). The samples were bleached in 1 session with 3 applications of 35% HP-based gel and activated with a LED appliance for 9 min each. Resin composite cylinders (2 mm height and 0.8 mm diameter) were made on the enamel surface after the acid etching and a conventional 1-step single vial adhesive application was performed. After storage in distilled water (37 ± 1°C, 24 hr), the microshear bond test was performed (1 mm/min). ANOVA and Tukey tests were applied to compare the results. The mean results of these tests showed that Groups W, BBS, and R were not statistically different. These groups also indicated a higher bond strength when compared with Groups B and BSJ. The application of 10% baking soda solution for 5 min may be an alternative pre-restorative treatment for bleached enamel, but further studies are needed to consider whether or not this treatment may be effectively used in clinical practice.

Received: March 19, 2012
Revised: July 2, 2012
Accepted: October 31, 2012

Key words: dental bleaching, shear bond strength, baking soda, bovine dental enamel

Many dental patients' greatest esthetic concern pertains to the color of their teeth, which inevitably changes over the course of their lives. Therefore, tooth bleaching is a significant option for esthetic treatments. Due to the inherent porosity and permeability of the enamel and dentin, it is possible to bleach teeth by applying chemical substances to the enamel. One of the most frequently used bleaching agents is hydrogen peroxide (HP), which forms unstable molecules with unpaired electrons known as *free radicals*. Free radicals are highly oxidizing agents that break down organic pigmented molecules, such as chromosphere molecules. This results in tooth staining.[1]

In a comprehensive esthetic treatment, the replacement of adhesive composite resin restorations is commonly done after tooth bleaching, when the desired tooth color has been achieved. There is a consensus in the literature that bleaching treatments may reduce the bond strength of adhesive systems and composite resins to the tooth structure, due to the deleterious effects of the bleaching agents.[2-8]

There are 2 hypotheses concerning why the bond strength of adhesive systems and composite resins to the tooth structure are reduced by bleaching treatments. The first hypothesis proposes that peroxides produce enamel and dentin demineralization, and thus impair the adhesion process.[9] The second, and most widely accepted hypothesis, is that the presence of HP byproducts, such as free oxygen radicals, can interfere with the infiltration of the adhesive into the substrate and thus prevent the correct curing of the material.[10-15]

The free radicals that are generated during the bleaching process may impair the adhesion after polymerization.[10-15] While there are a few studies that have found no reduction on the enamel bond strength after bleaching, it must be considered that bleaching, depending on the severity of the tooth discoloration, may involve the application of HP for long and frequent periods.[16-18] Dentin and dentinal fluids may even store residual HP and free radicals. If these byproducts are not completely eliminated, they may prevent the complete polymerization of the adhesive.[4,19] Consequently, the side effects of bleaching are time/concentration dependent, possibly resulting in an accumulation of residual HP and free radicals in the tooth structures. Furthermore, when treatment doses increase, severe alterations are expected.[5-9,16-18]

According to the literature, the most appropriate and efficient method to perform restorative procedures after bleaching is to wait 7-14 days before performing a restoration, since over a period of time, the residual HP and the free radicals are naturally released from the teeth, and enamel remineralization occurs.[2,3,15,20-22] In order to reduce the prolonged waiting time before the restoration of the bleached tooth, the use of antioxidants (such as catalase, sodium ascorbate, and α-tocopherol) were proposed to reduce the concentration of free radicals on the hard dental surfaces, and thus minimize their deleterious effects on the composite resin bond.[18,23-26]

This study sought to find a practical, immediate, and easily accessible alternative to the traditional waiting period required after HP bleaching before the restoration can begin. The bicarbonate ion found in sodium bicarbonate (commonly known as *baking soda*) is a widely-used activator for HP in the oxidation of organic compounds. Also, the bicarbonate-activated peroxide (BAP) oxidation system is a simple, inexpensive, and relatively nontoxic alternative to other oxidants and peroxyacids. It can be used in a variety of oxidations where a mild, neutral pH oxidant is required. The chemical reaction of HP and bicarbonate rapidly forms peroxymonocarbonate ions (HCO_4^-) at 25°C near a neutral pH level. In the absence of added catalysts and the subsequent

Table 1. Composition of products used in study.

Product	Composition	Manufacturer
37% phosphoric acid gel	Water, 35% phosphoric acid	DENTSPLY International
One-Step, adhesive	Biphenyl dimethacrylate, hydroxyethyl methacrylate, acetone	Bisco, Inc.
Opallis, flow composite resin	Microhybrid composite (monomeric matrix Bis (GMA), Bis (EMA), UDMA and TEGDMA. Barium glass, silanized silicate and aluminum nanoparticles of silicon dioxide, camphorquinone as photo-initiator, accelerators, stabilizers, and pigments. Particles in the range of 40 nm to 3.0 microns with an average particle size of 0.5 microns, and the total load of 78.5 to 79.8 weight % and 57 to 58 volume % of inorganic filler, radiopaque, medium viscosity	FGM Produtos Odontologicos
LED/Laser Three Light Plus, hybrid light	1 laser beam + 2 LED beams	Clean Line

oxidization of the organic substrate, water is the only byproduct that is produced. The buffering capacity of baking soda in neutralized HP remains on the tooth surfaces, permitting the acids to be neutralized, and the HP to release oxygen, which accelerates its degradation. This reaction can permit an adhesive restoration immediately after bleaching.

This study utilized baking soda as an antioxidant agent, and sought to assess its feasibility for use as a pre-restorative treatment immediately after a tooth whitening procedure. The authors assessed the effect on the enamel bond strength when a 10% baking soda solution and sodium bicarbonate powder (applied with jets) was employed as a pre-restorative method after a 35% HP bleaching treatment. Baking soda was chosen over other antioxidant agents due to advantages such as longer storing time, lower costs, increased stability, and facility of use.

Materials and methods

This in vitro study was comprised of 5 experimental groups, based on each pre-restorative treatment. The experimental units consisted of bovine enamel tooth blocks (n = 8). The response variable was the microshear bond strength, which was measured in MPa.

Preparation of the enamel tooth blocks

This study protocol (No. 2007/0200) was approved by the Animal Research Ethics Committee of the Sao Leopoldo Mandic School, Brazil. Forty bovine incisors were utilized. The teeth were brushed with soap and water using a toothbrush, and then stored in distilled water under refrigeration until use.

A perpendicular cut along the axis of the tooth, which separated the crown from the root, was performed with a double-faced diamond disk in a metallographic cutting machine (Extec Corporation). The crowns were cut with carborundum disks (Dedeco International, Inc.) that were mounted on a straight handpiece (KaVo Dental) and cooled in water. The first cut was made parallel to the long axis of the crown, from the cervical to incisal, as the disk penetrated into the center of the coronary pulp chamber in the mesiodistal direction to divide the crown into the lingual and vestibular faces. The lingual face was ignored. The second cut was made by wearing down all sides of the blocks, thus reducing the size of the vestibular faces to fit into a plastic tube that measured 1.8 cm in diameter and 1.5 cm in height. The tooth blocks (1 cm x 1 cm) were then inserted into the plastic tubes by using a type-IV stone plaster (Vigodent S/A Industria e Comercio). Next, the vestibular enamel surfaces were flattened in a polishing machine (Metalprisma PL02, Teclago Industria Comercio). To achieve a sequential abrasion, 120, 400, and 600 grit silicon carbide abrasive papers (3M ESPE) were used respectively, at a speed of 100 rpm, and then cooled with water. A magnifying glass (2.5X and 5X, Magnifiers, Waltex) was used to verify whether or not any areas of the dentin were exposed after polishing.

Bleaching treatment

The bleaching procedures were the same for all groups except for the control group (Group R), which was not submitted to the bleaching treatment. Before receiving the application of the bleaching gel (35% Lase Peroxide Sensy, DMC USA), the teeth were cleaned with a Robinson brush (KG Sorensen) and pumice stone paste (SS White) at a low speed, then washed and air-dried. The bleaching gel preparation was performed by mixing 3 drops from Bottle A (containing 35% Lase Peroxide Sensy) plus 1 drop from Bottle B (containing thickener and coloring substances, vegetable extracts, tertiary amine, sequestering agent, glycol, and water).

The bleaching gel was applied to the surfaces of the 4 experimental groups; after 1 minute, the gel was activated with a hybrid light from an LED/laser curing device (780-787 nm/100 mW laser and 470 nm /500 mW) (Three Light Plus, Clean Line) for 3 minutes. The light activation procedure was repeated 3 times (each 3 minutes in duration), with an interval of 1 minute between each application. Next, the teeth blocks were washed with copious water for 1 minute and dried with air jets. This entire process—the gel application followed by the light activations—was performed 3 times, and then the teeth were immersed in distilled water. The bleaching treatment lasted a total of 36 minutes. The bleaching gel was applied according to the manufacturer's instructions, which included a light (LED) application.

Table 2. Mean, standard deviation (SD), minimum, and maximum results of microshear bond strength tests of the experimental groups.

	B (Negative control)	W	BSJ	BSS	R (Positive control)
Mean	7.99[b]	13.76[a]	7.23[b]	12.36[a]	12.74[a]
SD	0.88	1.99	1.13	1.05	1.50
Min	6.98	11.63	6.24	11.08	10.94
Max	9.78	17.65	9.59	14.20	15.05

B: only bleaching treatment, W: immersion in distilled water for 7 days after bleaching treatment, BSJ: application of baking soda jet after bleaching treatment, BSS: application of 10% baking soda solution after bleaching treatment, R: non-bleached group.

[a,b] Different letters indicate statistically significant differences (ANOVA + Tukey Tests, $P < 0.05$).

Restorative treatment

The teeth blocks were conditioned with 37% phosphoric acid gel (DENTSPLY International) for 30 seconds, washed with water for 1 minute, and dried with light jets of air until an opaque whitening surface was obtained. The adhesive was applied on the entire enamel surface with the disposable brush (KG Sorensen) and left to rest for 10 seconds. A light jet of air was applied for 5 seconds at a distance of 5 cm from the tooth. The matrices (2 mm height x 0.8 mm diameter) were obtained from a surgical cannula (Descarpack) and placed with the aid of clinical tweezers. The adhesive (One-Step, Bisco, Inc.) was then light cured for 10 seconds. The cylinders were filled with flow composite resin (Opallis, FGM Produtos Odontologicos) and light cured for 60 seconds (Table 1). Six cylinders were made in each tooth block (n = 8), totaling 48 cylinders per group. The specimens were immersed in distilled water and placed into an oven (Fanem, Ltda.) at 37 ± 1°C for 24 hours. The aforementioned restorative treatment was performed on all groups. The light-curing unit was tested with a radiometer (Demetron, Kerr Corporation). The desirable power level was achieved at all times (450 mW/cm^2).

Pre-restorative treatment groups

Group B (negative control): These teeth slabs (n = 8) were bleached and immediately restored, as described above.

Group W: After bleaching, these slabs (n = 8) remained immersed in distilled water, at 37 °C ± 1°C, for 7 days. The slabs were restored as described above.

Group BSJ: After bleaching, these slabs (n = 8) were submitted to a baking soda jet (Jet Sonic, Gnatus) for 1 minute at a distance of approximately 5 cm (jet tip/test specimen) in a scanning movement from the cervical to the incisal, then washed with water for 1 minute and restored as described above.

Group BSS: After bleaching, these slabs (n = 8) received the application of a cotton ball embedded in 50 µl of 10% baking soda solution (pH = 10.37), for 5 minutes, and then washed with water for 1 minute and restored as described above.

Group R (positive control group): These nonbleached slabs (n = 8) were restored as described above.

Microshear bond test

The microshear bond test was conducted in a universal testing machine (Model 4442, EMIC Equipamentos e Sistemas de Ensaio, LTDA.), using a wire-loop method in order to separately test the adhesion of each of the 6 cylinders. The samples were fractured at a crosshead speed of 1 mm/minute. The rupture strength was expressed in newtons (N) and converted into MPa (MPa = N/area [mm^2]). The average value of the 6 cylinders was considered for each dental block.

Statistical analysis

The data was compiled in Excel (Microsoft). The values obtained in the microshear bond tests were submitted to the adherence test for the normal curve and Cochran's test for homogeneity. Due to the fact that the distribution of errors around the mean was normal, and the variances involved were homogeneous, the parametric statistical tests, ANOVA, and post hoc Tukey, were applied to compare the results that were obtained among the experimental groups. The level of significance was established at 5%.

Results

Statistically significant differences were found among the groups. Group BSJ was similar to Group C. Groups W and SB were similar to Group R. The results are shown in Table 2.

Discussion

In an adhesive restoration, resin monomers are introduced and polymerized in the microporosities that are created by phosphoric acid etching in the enamel structure. The restoration's effectiveness depends on the conditioning patterns and the infiltration ability of the adhesive monomers. Scanning electron microscopy studies of bleached enamel have revealed areas with erosion and fissures, and lack adequate monomer infiltration. Also, bond strength studies have confirmed that the adhesive failure on bleached enamel occurs predominantly in the tooth/restoration interface.[15,21]

With respect to the reduced bond strength of the composite to the enamel soon after bleaching, the most-accepted hypothesis is that the presence of HP residual products competes with the free radicals that are generated in the photoactivation process.[15] Therefore, the free oxygen inhibits the polymerization of the adhesive and reduces the bond strength.[11,12,21] As a result, the interval time between the bleaching treatment and the restoration has been investigated. Although various studies

recommend waiting times that range from 24 hours to 3 weeks, most authors recommend waiting approximately 1 week to perform the bonding procedures on the enamel.[2,15,19-22] In the present study, no significant difference was found between the positive control group (non-bleached group) and the group that was immersed in distilled water for 7 days. The negative control group, which was immediately restored after the bleaching treatment, showed a statistically significant lower bond strength than the positive control group, thus proving the impairing effect of the bleaching protocol that was used in the study.

In an endeavor to reduce this waiting time, researchers search for techniques and products to reduce the deleterious effects of bleaching agents on the enamel bond strength. One of the techniques recommends the removal of residual HP by Erbium laser irradiation. The laser irradiation delivers energy on the target adhesive surface in the form of heat to catalyze the residual HP and release free radicals.[17] Other techniques attempt to remove or neutralize the residual HP and free radicals by using a reducing agent. These agents, also called antioxidants, are molecules that are able to react with the free oxygen radicals and neutralize the HP effects. These antioxidants include ascorbic acid (vitamin C), α-tocopherol (vitamin E), catalase, and baking soda.[25]

Baking soda releases bicarbonate ions in an aqueous solution. The bicarbonate ion is a widely effective activator for HP in the oxidation of organic compounds. Furthermore, the BAP oxidation system is a simple, inexpensive, and relatively nontoxic alternative to other oxidants and peroxyacids, and it can be used in a variety of oxidations where a mild, neutral pH oxidant is required. When studying the recovery of HP in the oral cavity after the use of a 3% HP dentifrice, Marshall et al reported that the use of a dentifrice that also contained 5% baking soda provided a significantly lower recovery of the HP. [23] They suggest that baking soda increases the pH level of HP, which destabilizes the peroxide molecule and accelerates its decomposition.[11] Despite the suggestion that baking soda accelerates HP degradation, Torres et al reported that a 7% baking soda solution was not an efficient way to reduce the deleterious effect of bleaching treatments on the enamel bond strength.[25,27] The 10% baking soda solution is commercialized with some in-office bleaching kits as a neutralizing agent for the residual HP in the soft tissues. This product is available for dentists in the office, which makes it easy to use.

When considering vitamin C in the form of sodium ascorbate (SA) as an antioxidant to destabilize the peroxide molecule, there is a disagreement regarding the minimum time to achieve the expected result.[18,28] While there are studies that state that SA should be applied for 3 hours after dental bleaching, 1 study concluded that the 10% SA gel becomes effective after at least 60 minutes in contact with the treated surface.[29-31] Other authors have proposed the use of 10% SA for 10 minutes, successfully reversing the adverse effects of the bleaching agent.[26,32,33] A 2009 study by Freire et al indicated a direct correlation between the mass of HP and that of the antioxidant agent.[28] The reaction kinetics between the oxidant and antioxidant showed that a longer application time for the SA does not influence the effectiveness of the reaction. This study used a 25% SA solution, and concluded that it sufficiently exerts an antioxidant effect in 5 minutes. A study by Turkun & Kaya affirmed that the use of SA in a concentration <10% is not an effective way to reduce the deleterious effects of bleaching.[31] Also, 10% SA gel has a short durability and needs special storage. It must be kept in a cool place and protected from light. The amount needed for each patient (approximately 5 ml) must be prepared, which is another disadvantage of this antioxidant.[33] Torres et al compared 10% SA gel, catalase, and 7% bicarbonate solution, among others, and the result was more favorable for the catalase.[27] Another antioxidant agent cited in the study is vitamin E (α-tocopherol). Another study compared vitamin E with 10% SA gel, and the vitamin E produced positive results, minimizing the accumulation of O_2 on the enamel surface after bleaching.[14] Nevertheless, these authors recommend additional studies in order to observe the stability of the action of vitamin E, the different concentrations, and its applications to define a clinical protocol.[14,27]

The use of baking soda jets on the surface, which is a commonly used mechanical tooth cleaning procedure in dental offices, was also tested in this study.[34] It was thought that the possible impregnation of the enamel bleached surface by baking soda powder particles could prevent the penetration of phosphoric acid. However, the use of jets was not effective in reducing the deleterious effect of the bleaching agent on the bond strength, and the effects on the group using the jets were similar to the negative control group, which was bleached and immediately restored. In addition, the prophylaxis protocol in several clinical procedures used baking soda jets, due to the mechanical surface treatment they provide.[34] This may influence the bond strength of restorative procedures in unbleached teeth.

Conclusion

The decomposition of residual HP may be enhanced approximately 6-fold by the presence of baking soda in dentifrices.[35] It is suggested that the action of baking soda on the residual HP is due to its high pH level, which destabilizes the HP molecules, accelerating its decomposition, and thus reducing its residual effect.[27] The present study presented promising results with respect to the use of the 10% baking soda solution as a pre-restorative procedure for bleached teeth with 35% HP, since it did not show a statistical difference from the positive control group and distilled water group.

As of yet, there is no evidence that these products are effective in clinical situations. Thus, few professionals use these techniques. On the other hand, 10% baking soda solution is commercialized in some in-office bleaching kits as a neutralizing agent for the residual HP in soft tissues, so this solution is available for dentists in the office, which makes it more accessible.

The results of this in vitro study indicated that the application of 10% baking soda solution for 5 minutes, or immersion in distilled water for 1 week, seems to reduce the deleterious effects of bleaching with HP on the enamel bond strength. It can be concluded that the 10% baking soda solution may be an easy alternative for the pre-restorative treatment for bleached enamel, but further studies are needed to determine whether or not this treatment may be effectively used in clinical practice.

Author information

Mrs. Tostes is a postdoctoral candidate at Bauru Dental School-USP, Brazil,

where Dr. Mondelli is an assistant professor and coordinator, Department of Restorative Dentistry, Endodontics, and Dental Materials, Bauru Dental School, University of Sao Paulo, Brazil. Dr. Costa is an assistant professor, Department of Restorative Dentistry, Endodontics, and Dental Materials, Federal University of Juiz de Fora, Brazil. Dr. Lima-Arsati is an assistant professor, Department of Biological Sciences, State University of Feira de Santana, Brazil. Dr. Rodrigues is an assistant professor, Department of Restorative Dentistry, Dental Research, University of Guarulhos, Brazil.

References

1. Leonetti Edos D, Rodrigues JA, Reis AF, Navarro RS, Aranha AC, Cassoni A. Microtensile bond strength of resin composite to dentin treated with Er:YAG laser of bleached teeth. *Lasers Med Sci.* 2012;27(1):31-38.
2. Barbosa CM, Sasaki RT, Florio FM, Basting RT. Influence of time on bond strength after bleaching with 35% hydrogen peroxide. *J Contemp Dent Pract.* 2008;9(2):81-88.
3. McEvoy SA. Chemical agents for removing intrinsic stains from vital teeth. I. Technique development. *Quintessence Int.* 1989;20(5):323-328.
4. Muraguchi K, Shigenobu S, Suzuki S, Tanaka T. Improvement of bonding to bleached bovine tooth surfaces by ascorbic acid treatment. *Dent Mater J.* 2007;26(6):875-881.
5. De Munck J, Van Landuyt K, Peumans M, et al. A critical review of the durability of adhesion to tooth tissue: methods and results. *J Dent Res.* 2005;84(2):118-132.
6. Perdigao J, Francci C, Swift EJ Jr, Ambrose WW, Lopes M. Ultra-morphological study of the interaction of dental adhesives with carbamide peroxide-bleached enamel. *Am J Dent.* 1998;6(11): 291-301.
7. Richardson DE, Regino CA, Yao H, Johnson JV. Methionine oxidation by peroxymonocarbonate, a reactive oxygen species formed from CO_2/bicarbonate and hydrogen peroxide. *Free Radic Biol Med.* 2003;15;35 (12): 1538-1550.
8. Rodrigues JA, Basting RT, Serra MC, Rodrigues Junior AL. Effects of 10% carbamide peroxide bleaching materials on enamel microhardness. *Am J Dent.* 2001; 14(2):67-71.
9. Shinohara MS, Rodrigues JA, Pimenta LA. In vitro microleakage of composite restorations after nonvital bleaching. *Quintessence Int.* 2001;32(5):413-417.
10. Basting RT, Rodrigues JA, Serra MC, Pimenta LA. Shear bond strength of enamel treated with seven carbamide peroxide bleaching agents. *J Esthet Restor Dent.* 2004;16(4):250-259; discussion 259-260.
11. Cadenaro M, Breschi L, Antoniolli F, Mazzoni A, Di Lenarda R. Influence of whitening on the degree of conversion of dental adhesives on dentin. *Eur J Oral Sci.* 2006;114(3):257-262.
12. Rodrigues JA, Marchi GM, Ambrosano GM, Heymann HO, Pimenta LA. Microhardness evaluation of *in situ* vital bleaching on human dental enamel using a novel study design. *Dent Mater.* 2005;21(11):1059-1067.
13. Rueggeberg FA, Margeson DH. The effect of oxygen inhibition on an unfilled/filled composite system. *J Dent Res.* 1990;69(10):1652-1658.
14. Sasaki RT, Florio FM, Basting RT. Effect of 10% sodium ascorbate and 10% alfa-tocopherol in different formulations on the shear bond strength of enamel and dentin submitted to a home-use bleaching treatment. *Oper Dent.* 2009;34(6):746-752.
15. Titley KC, Torneck CD, Ruse ND. The effect of carbamide peroxide gel on the shear bond strength of a microfill resin to bovine enamel. *J Dent Res.* 1992; 71(1):20-24.
16. Amaral C, Jorge A, Veloso K, Erthardt M, Arias V, Rodrigues JA. The effect of in-office in combination with intracoronal bleaching on enamel and dentin bond strength and dentin morphology. *J Contemp Dent Pract.* 2008;9(5):17-24.
17. Lai SC, Tay FR, Cheung GS, et al. Reversal of compromised bonding in bleached enamel. *J Dent Res.* 2002; 81(7):477-481.
18. Lai SC, Mak YF, Cheung GS, Osorio R, Toledano M, Carvalho RM, et al. Reversal of compromised bonding to oxidized etched dentin. *J Dent Res.* 2001; 80(10):1919-1924.
19. Soldani P, Amaral CM, Rodrigues JA. Microhardness evaluation of *in situ* vital bleaching and thickening agents on human dental enamel. *Int J Periodontics Restorative Dent.* 2010;30(2):203-211.
20. Bittencourt ME, Trentin MS, Linden MS, et al. Influence of *in situ* post bleaching times on shear bond strength of resin-based composite restorations. *J Am Dent Assoc.* 2010;141(3):300-306.
21. de Oliveira R, Basting RT, Rodrigues JA, Rodrigues AL Jr, Serra MC. Effects of a carbamide peroxide agent and desensitizing dentifrices on enamel microhardness. *Am J Dent.* 2003;16(1);42-46.
22. Shinohara MS, Peris AR, Rodrigues JA, Pimenta LA, Ambrosano GM. The effect of nonvital bleaching on the shear bond strength of composite resin using three adhesive systems. *J Adhes Dent.* 2004;6(3):205-209.
23. Marshall MV, Gragg PP, Packmann EW, Wright PB, Cancro LP. Hydrogen peroxide decomposition in the oral cavity. *Am J Dent.* 2001;14(1):39-45.
24. Rodrigues JA, Oliveira GP, Amaral CM. Effect of thickener agents on dental enamel microhardness submitted to at-home bleaching. *Bras Oral Res.* 2007;21(2): 170-175.
25. Titley KC, Torneck CD, Smith DC, Chernechy R, Adibfar A. Scanning electron microscopy observations on the penetration and structure of resin tags in bleached and unbleached enamel. *J Endod.* 1991;17(2):72-75.
26. Torneck CD, Titley KC, Smith DC, Adibfar A. The influence of time of hydrogen peroxide exposure on the adhesion of composite resin to bleached bovine enamel. *J Endod.* 1990;16(3):123-128.
27. Torres CGR, Koga AF, Borges AB. The effects of antioxidants agents as neutralizers of bleaching agents on enamel bond strength. *Braz J Oral Sci.* 2006;5(16): 971-976.
28. Freire A, Souza EM, de Menezes Caldas DB, et al. Reaction kinetics of sodium ascorbate and dental bleaching gel. *J Dent.* 2009;37(12):932-936.
29. Honorio HM, Rios D, Abdo RCC, Machado MA. Effect of different prophylaxis methods on sound and demineralized enamel. *J Appl Oral Sci.* 2006;14(2):117-123.
30. Kimyai S, Valizadeh H. The effect of hydrogel and solution of sodium ascorbate on bond strength in bleached enamel. *Oper Dent.* 2006;31(4):496-499.
31. Turkun M, Kaya AD. Effect of 10% sodium ascorbate on the shear bond strength of composite resin to bleached bovine enamel. *J Oral Rehabil.* 2004; 31(12):1184-1191.
32. Bulut H, Turkun M, Kaya AD. Effect of an antioxidizing agent on the shear bond strength of brackets bonded to bleached human enamel. *Am J Orthod Dentofacial Orthop.* 2006;129(2):266-272.
33. Garcia EJ, Mena-Serrano AP, Andrade AM. Alternativas para realizacao de restauracoes esteticas imediatas ao clareamento dental: relato de caso. *Clinica: Int J Brazil Dent.* 2010;6(2):192-201.
34. Gokce B, Comlekoglu ME, Ozpinar B, Turkun M, Kaya AD. Effect of antioxidant treatment on bond strength of a luting resin to bleached enamel. *J Dent.* 2008; 36(10):780-785.
35. Leonetti Edos S, Rodrigues JA, Reis AF, Navarro RS, Aranha AC, Cassoni A. Effects of Er:YAG laser irradiation on the microtensile bond strength to bleached enamel. *Photomed Laser Surg.* 2011;29(8):551-558.

Manufacturers

Bisco, Inc., Schaumburg, IL
800.247.3368, www.bisco.com

Clean Line, Lexington, KY
859.275.5015, www.cleanline.com.br

Dedeco International, Inc., Long Eddy, NY
845.887.4840, www.dedeco.com

DENTSPLY International, York, PA
800.877.0020, www.denstply.com

Descarpack, Sao Paulo, Brazil
11.3649.5555, www.descarpack.com.br

DMC USA, Plantation, FL
954.916.2605, www.dmcgroup.com.br

EMIC Equipamentos e Sistemas de Ensaio, LTDA., San Jose dos Pinhais, Brazil
55.42.3035.9400, www.emic.com.br

Extec Corporation, Enfield, CT
800.543.9832, www.extec.com

Fanem, Ltda., Sao Paulo, SP, Brazil
55.11.2972.5700, www.fanem.com.br

FGM Produtos Odontologicos, Joinville, SC, Brazil
55.47.3441.6100, www.fgm.ind.br

Gnatus, Ribeirao, Brazil
55.16.2102.5000, gnatus.com.br

KaVo Dental, Charlotte, NC
800.452.1472, www.kavousa.com

Kerr Corporation, Orange CA, USA
800.452.1472, www.kerrdental.com

KG Sorensen, Cotia, SP, Brazil
55.11.4777.1061, www.kgsorensen.com.br

Microsoft, Redmond, WA
425.882.8080, www.microsoft.com

SS White, Rio de Janeiro, RJ, Brazil
21.2122.9323, www.sswhite.com.br

Teclago Industria Comercio, Sao Paulo, SP, Brazil
55.11.4158.9225, www.teclago.com.br

Vigodent S/A Industria e Comercio, Rio de Janeiro, RJ, Brazil
55.21.3866.5600, www.vigodent.com.br

Waltex (via Unitrade Associates), Toronto, Canada
416.242.5900, www.unitradeassoc.com

3M ESPE, St. Paul, MN, USA
888.364.3577, solutions.3m.com

Non-drug induced gingival enlargement

Michelle L. Moffitt, RDH ▪ Robert E. Cohen, DDS, PhD

Gingival enlargement refers to an increase in the size of the gingival tissue. The etiology varies, and often is multifactorial; however, local and systemic conditions, disease, and idiopathic factors may contribute to gingival enlargement. Tissue consistency can vary from soft and spongy to dense, typically appearing darker in shade compared to the drug-induced gingival enlargement. Treatment modalities usually involve surgical removal of excess tissue, non-surgical debridement, use of chemotherapeutic agents, and/or elimination or mitigation of contributing factors and conditions.

Received: July 6, 2012
Accepted: January 2, 2013

Gingival enlargement is the term used to describe an increase in gingival tissue size. The etiology varies and often is multifactorial or idiopathic. Etiological agents that are thought to be involved in non-drug induced gingival overgrowth can be local, such as plaque or an acute infection; or systemic, due to disease, such as leukemia or hereditary gingival fibromatosis.[1,2]

Local acute inflammatory conditions

Local acute inflammatory conditions of the periodontium may be associated with gingival enlargement. Abscesses of the periodontium typically are classified by their location within the periodontal tissues. The gingival abscess usually is confined to the marginal gingiva or interdental papilla, while pericoronal abscesses are localized around the crown of an unerupted tooth.[3] Combined periodontal/endodontic abscesses can originate from the dental pulp or from the surrounding tissues, and typically manifest with severe bone loss affecting the furcation or apex.[3] Periodontal abscesses are located within the periodontal pocket and may cause deterioration of the periodontal ligament and alveolar bone.[4] Foreign bodies, such as seeds or toothbrush bristles, may become trapped within the periodontal pocket and carry bacteria deep into the tissues, causing an abscess and inducing an inflammatory response.[3] Typical features of a periodontal abscess include a shiny and smooth surface appearance, with erythematous swelling that increases rapidly. The consistency may vary from firm and stiff to soft and edematous; purulent exudate often can be observed following gentle pressure. The lesion may be associated with such symptoms as regional lymphoadenopathy, throbbing or radiating pain, or gingival tenderness to palpation.[3]

Radiographic examination may reveal a normal appearance of the interdental bone or aberrations ranging from a widening of the periodontal ligament space to various levels of bone loss. When the lesion is confined to the marginal gingiva, radiographic examinations frequently are negative, due to the lack of involvement with the underlying alveolar bone. A periodontal abscess may become evident radiographically when viewed with the lateral aspect of a root and surrounding alveolar bone.[5]

Local chronic inflammatory conditions

Plaque is the most common etiologic factor in non-drug induced gingival enlargement.[6] Etiologic factors that favor the accumulation of plaque include overhanging restorations, food impaction, orthodontic therapy, irritation from prosthetic clasps, and personal habits, such as mouth breathing. Chronic exposure to such iatrogenic factors can lead to inflammatory changes that may manifest as gingival enlargement.[7]

Clinically, hyperplastic changes may become evident with a slight swelling of the interdental papilla or (less frequently) of the gingival margin.[3] The enlargement varies in size, depending on the severity of the etiologic agent and time of exposure. The gingival tissues can enlarge beyond the level of the occlusal plane of adjacent teeth; at this stage, ulcerations and infections secondary to occlusal trauma become common.[1] The consistency of the hyperplastic gingiva ranges from soft and spongy to dense, and typically is a darker shade compared to drug-induced gingival enlargement.[3,4] Compared to an acute abscess, the onset of hyperplastic gingival is slow and generally painless. Over time, the tissues may become more fibrotic and bulky and the gingival margin rolled and blunted. Histological analysis typically reveals an abundance of collagen along with an increased number of fibroblasts. Prominent capillaries and various degrees of epithelial hyperplasia are observed frequently, as well.[6]

Peripheral giant cell and pyogenic granulomas are associated with local inflammatory changes resulting from chronic noxious stimuli, such as mechanical trauma or plaque. Both are often observed at interdental or marginal sites, and may appear pedunculated or sessile, with surfaces ranging from smooth to irregular (with multilobulated protuberances). The size of the granulomas may vary significantly, with some lesions spanning several teeth.[6]

Peripheral giant cell granulomas generally are exclusive to the gingiva and seem to arise from the periodontal ligament or periosteum.[8] Since their clinical appearance is similar to the pyogenic granuloma, the differentiation of these clinical entities is based upon histological analysis. Pyogenic granulomas are composed of lobular masses of granulation tissue with abundant capillaries, which usually are seen in association with neutrophils. Peripheral giant cell granulomas exhibit a stroma rich in multinucleated giant cells, that appear nonfunctional in terms of phagocytosis and bone resorption.[9] Peripheral ossifying gingival fibromas originate in the gingival connective tissue or periodontal ligament. They manifest as slow-growing, painless, often lobulated, spherical lesions. Early lesions are quite irregular and red. Histologically, they are

characterized by dense bundles of collagen fibers with interspersed fibroblasts. Bone formation (in the form of irregularly arranged trabeculae) is frequently found within the stroma.[8]

Gingival cysts originate in dental lamina rests. These cysts appear as localized, round enlargements that involve either the gingival margin, or the attached gingiva. They usually are painless; however, expansion may erode the subjacent cortical plates, involve the periosteum, and produce varying degrees of discomfort. The gingival cyst appears histologically as a cystic cavity lined by thin flattened epithelium, with focal budding and numerous cells within a clear cytoplasm.[8]

The role of plaque

Treatment modalities for both acute and chronic gingival enlargement usually involve removing the etiologic factors. Gingival and periodontal abscesses typically are treated through curettage (via the sulcus), flap surgery, or incision and drainage. Nonsurgical debridement may be performed to treat a chronic inflammatory enlargement; however, surgical access might be required to correct anatomical factors (such as development grooves) that favor plaque retention. A surgical approach to reduce hyperplastic gingival tissue is another option.[6]

When managing acute conditions, chemotherapeutic agents may be used to support local therapy. When systemic signs such as fever, lymphoadenopathy, or general malaise follow the appearance of an acute lesion, antibiotic therapy often is appropriate.[10] Antimicrobial agents can also be very useful for managing acute inflammation with immunocompromised and elderly patients, as well as for the management of patients with other systemic conditions, such as diabetes.[6]

Metabolic conditions

Numerous systemic conditions have been associated with the development of gingival enlargement.[8] The influence of systemic diseases may or may not depend upon the presence of local factors such as plaque. For example, an endocrine condition in the presence of plaque may be able to induce an exaggerated response; however, once the plaque is removed, the condition is unable to induce the same overgrowth. By contrast, systemic conditions, such as neoplastic lesions, can induce gingival overgrowth independent of plaque or other local irritants.[11,12]

Nutritional deficiencies can cause gingival enlargement by altering the gingival response to plaque. Scurvy, a disease resulting from vitamin C deficiency, has a clinical appearance of a bluish-red enlarged gingiva with spontaneous hemorrhaging. Connective tissue edema is induced due to increased vascularity in the gingival tissues. Histological studies have revealed a generalized collagen deficiency due to increased degradation, marked by diffused edema of the lamina propria, and engorged capillaries with focal areas of hemorrhage.[12]

Pregnancy is one of the most common systemic conditions associated with gingival hyperplasia, with an incidence as high as 70%.[13,14] The condition can be either generalized or localized and involves the interproximal papillae more frequently than the facial aspect of the gingiva. Clinical manifestations range from enlarged gingiva with edematous, brittle, or soft margins to a mushroom-like pedunculated lesion protruding from either the gingival margin or the interproximal papilla.[13] Enlargement often occurs after the third month of pregnancy, although earlier lesion onset has been reported. The altered tissue metabolism resulting from pregnancy is thought to be responsible for the abnormal response to local irritants.[15]

Puberty also can induce hormonal changes that may exhibit the same gingival enlargements as pregnancy. Typically characterized by bulbous interdental papillae with a spongy consistency, the overgrowth is triggered and maintained by local irritants.[3,4] Although it can regress spontaneously after puberty, it may not resolve completely until the irritation is removed.[16]

Chronic systemic inflammatory conditions

Rare conditions (such as Wegener's granulomatosis and sarcoidosis) have the potential to affect the oral cavity due to mucosal ulcerations, gingival enlargement, abnormal tooth mobility, and delayed healing.[17] The initial manifestation of Wegener's granulomatosis has been described as a strawberry-like appearance.[18] Histology reveals Wegener's is characterized by non-caseating granulomas, lymphocytes, neutrophils, and the occasional multinucleated giant cells. Some histopathological studies have described micro-abscess formation without significant vascular changes.[19] Gingival enlargement has been reported in association with rare systemic conditions such as acromegaly, microscopic polyangitis, and rare pediatric congenital syndromes, in addition to rare metabolic conditions, such as mucolipidosis.[20-23]

Neoplastic lesions

Neoplastic gingival enlargements can be either malignant or benign, and may result from local neoplastic changes or as the expression of a neoplastic condition originating outside the oral cavity.[24] A gingival papilloma typically manifests as a hard, exophytic mass; it may be sessile or pedunculated, and usually is painless and slow-growing. The surface is pale pink in color with an irregular texture. Histological studies have shown that these irregularities are related to localized hyperproliferation and hyperkeratosis of the gingival epithelium.[8] Malignant neoplastic enlargements of the gingiva are relatively uncommon. Oral cancer accounts for approximately 2% of all malignancies in the human body; of those, only 10% occur in the gingiva.[8] Squamous cell carcinoma is the most frequently found oral cancer.[25]

Squamous cell carcinoma manifests clinically, either as exophytic masses or as non-healing ulcerated flat lesions. They usually are invasive, eroding the adjacent mucosa and bone. Symptoms typically follow local invasion and involve the periosteum or sensory fibers of the adjacent oral mucosa. In advanced stages, moderate-to-severe dull pain is usually present. Metastasis generally is limited to the supraclavicular region; however, lung and liver involvement have been reported in advanced cases.[26] Most oral squamous cell carcinomas (such as those involving the gingival tissue) are well-differentiated lesions at the microscopic level.[25] Keratin pearls with individual cell keratinization are common, as are small nests of hyperchromatic cells invading surrounding tissues.[26]

Malignant melanoma is a rare tumor, usually observed in the gingiva of the anterior maxilla or the palate. Generally,

the behavior of a melanoma is aggressive, characterized by rapid growth and early metastasis.[27] Melanomas originate from melanocytes that reside in the basal stratum of the gingival epithelium and tend to infiltrate surrounding structures, such as bone or lymph nodes.[28] They appear clinically (in either flat or nodular form) as an asymmetric, darkly pigmented lesion with irregular margins; however, amelanotic gingival melanoma also has been documented.[29]

Sarcomas of the gingiva are rare. They appear as slow-growing, often painless masses of round shape, with color mimicking the surrounding tissues; they also may appear ulcerated.[30] Kaposi's sarcoma is frequently observed as a nodular or exophytic mass in the oral cavity of AIDS patients. The lesion can be single or multifocal, and usually is located in the gingiva or the palate.[31] Histological studies show slit blood vessels and extravasated red blood cells with hypercellular foci rich in spindle mesenchymal cells.[30]

Leukemia may manifest as generalized or localized gingival enlargement.[32] It can be either acute or chronic, depending on clinical onset and the maturation of the neoplastic cell.[33] Gingival manifestations can range from gingival erosions or ulcerations to hemorrhaging and hyperplasia.[34] Oral manifestations are very rare in the acute forms of leukemia, but they are more common in the chronic subtypes.[33] Gingival hyperplasia has an incidence of approximately 3.5% in individuals with chronic leukemia; profuse bleeding is more common in acute leukemic patients (17%) compared to chronic patients (4.4%).[34] Gingival bleeding may occur secondary to thrombocytopenia; as a result, periodontal surgery often is avoided or is performed only after consultation with the patient's physician.[32] Histological analysis shows diffuse infiltration of the bone marrow by neoplastic cells and displacement of the normal cell population. Leukemic infiltrates also may be observed in the liver, spleen, and other tissues (such as those lining the oral cavity).[33] Gingival histology of leukemic enlargements shows a mixture of mature and immature lymphocytes in the connective tissue. Engorged capillaries with connective tissue edema and degeneration are common findings also.[32]

The American Academy of Periodontology recommends that periodontal management of a leukemic patient includes using appropriate periodontal therapy, prior to the start of leukemia treatment or bone marrow transplantation, to minimize sites containing periodontal infection. Elective periodontal therapy in the acute leukemic patient during exacerbations and chemotherapy should be avoided.[35] Due to an enhanced susceptibility to infection, antibiotic coverage for a stable leukemic patient should be considered during any periodontal procedure.[36]

Neoplastic enlargement of the gingival tissue also may be associated with less common conditions, including Hodgkin's lymphoma, oral focal mucinosis, salivary gland type tumors, eosinophilic granulomas, and plasmocytoma of the gingival.[37-41] Gingival tumor metastases have been associated with adenocarcinoma of the colon, lung carcinoma, primary hepatocellular carcinoma, renal cell carcinoma, chondrosarcoma, and testicular tumors.[37,42] Metastatic tumors usually resemble the primary tumor of origin in histological sections. Their clinical appearance may vary greatly, from non-healing ulcerated lesions to exophytic round masses of gingival tissue.[36]

Idiopathic enlargement

The origin of idiopathic gingival enlargement is unknown, although it is unrelated to any systemic disease or acquired condition, or to any medication; nutritional and hormonal factors have been investigated but not substantiated.[1] Some cases seem to show familial clustering, suggesting a hereditary basis; however, the genetic mechanisms are not yet known.[2] Idiopathic gingival fibromatosis, hereditary gingival hyperplasia, and gingival elephantiasis may manifest orally as an asymptomatic rounded submucosal mass, usually beginning with the eruption of the primary or secondary dentition and involving both the attached and free gingiva.[43] By contrast, the more common drug-induced hyperplasia is confined to marginal gingiva and interdental papillae rather than the attached gingiva. Idiopathic gingival fibromatosis produces a pink gingiva, with a leathery consistency and a characteristic minutely pebbled surface.[44] Histological analysis reveals the presence of dense, poorly vascular connective tissue, with closely packed collagen bundles and numerous fibroblasts.[43]

Summary

The etiology of gingival enlargement is multifactorial; contributing factors include local inflammatory conditions, plaque, systemic factors, neoplastic lesions, and idiopathic enlargement. Treatment modalities can vary according to etiology, and typically include the removal of the factor; medications, such as antibiotics or antiplaque agents; local debridement; and/or surgical therapy.

Author information

Ms. Moffitt is an adjunct instructor and registered dental hygienist, Department of Periodontics and Endodontics, School of Dental Medicine, University at Buffalo, The State University of New York, where Dr. Cohen is a professor and director of Postgraduate Periodontics.

Acknowledgments

This study was supported in part by the Department of Periodontics and Endodontics, School of Dental Medicine, University at Buffalo, The State University of New York.

References

1. Shetty AK, Shah HJ, Patil MA, Jhota KN. Idiopathic gingival enlargement and its management. *J Indian Soc Periodontol.* 2010;14(4):263-265.
2. Hakkinen L, Csiszar A. Hereditary gingival fibromatosis: characteristics and novel putative pathogenic mechanisms. *J Dent Res.* 2007;86(1):25-30.
3. Patel PV, Kumar SG, Patel A. Periodontal abscess: a review. *J Clin Diag Res.* 2011;5(2):404-409.
4. Newman MG, Sims TN. The predominant cultivable microbiota of the periodontal abscess. *J Periodontol.* 1979;50(7):350-354.
5. Rotstein I, Simon JH. Diagnosis, prognosis, and decision-making in the treatment of combined periodontal-endodontic lesions. *Periodontol 2000.* 2004;34: 165-203.
6. Research, Science and Therapy Committee of the American Academy of Periodontology. Treatment of plaque-induced gingivitis, chronic periodontitis, and other clinical conditions. *J Periodontol.* 2001;72(12): 1790-1800.
7. Matthews DC, Tabesh M. Detection of localized tooth-related factors that predispose to periodontal infections. *Periodontol 2000.* 2004;34:136-150.
8. Regezi J. Odontogenic cysts, odontogenic tumors, fibroosseous and giant cell lesions of the jaws. *Mod Pathol.* 2001;15(3):331-341.
9. Schneider LC, Weisinger E. The true gingival fibroma. An analysis of 129 fibrous gingival lesions. *J Periodontol.* 1978;49(8):423-424.
10. Herrera D, Roldan S, Gonzalez I, Sanz M. The periodontal abscess (I). Clinical and microbiological findings. *J Clin Periodontol.* 2000;27(6):387-394.

11. Fontana M. Vitamin C (ascorbic acid): clinical implications for oral health—a literature review. *Compend Contin Educ Dent.* 1994;15(7):916-920.
12. Carrillo-de-Albornoz A, Figuero E, Herrera D, Bascones-Martinez A. Gingival changes during pregnancy: II. Influence of hormonal variations on the subgingival biofilm. *J Clin Periodontol.* 2010;37(3):230-240.
13. de Lange J, Rosenberg AJ, van den Akker HP, Koole R, Wirds JJ, van den Berg H. The treatment of central giant cell granuloma of the jaw with calcitonin. *Int J Oral Maxillofac Surg.* 1999;28(5):372-376.
14. Silness J, Loe H. Periodontal disease in pregnancy. 3. Response to local treatment. *Acta Odontol Scand.* 1966;24(6):747-759.
15. Oh TJ, Eber R, Wang HL. Effect of pregnancy on periodontal diseases in the child and adolescent. *J Clin Periodontol.* 2002;29(5):400-410.
16. Setia AP. Severe bleeding from a pregnancy tumor. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.* 1973;36(2):192-194.
17. Buckley DJ, Barrett AP, Bilous AM, Despas PJ. Wegener's granulomatosis - are gingival changes pathognomonic? *J Oral Med.* 1987;42:169-172.
18. Cohen RE, Cardoza TT, Drinnan AJ, Aguirre AA, Neiders ME. Gingival manifestations of Wegener's granulomatosis. *J Periodontol.* 1990;61(11):705-709.
19. Israelson H, Binnie WH, Hurt WC. The hyperplastic gingivitis of Wegener's granulomatosis. *J Periodontol.* 1981;52(2):81-87.
20. Capoglu I, Yilmaz AB, Unuvar N, Orbak R, Aksoy H, Yesilyurt H. Gingival enlargement in acromegaly. *Endocrine.* 2002;18(3):207-210.
21. Shiboski CH, Regezi JA, Sanchez HC, Silverman S Jr. Oral lesions as the first clinical sign of microscopic polyangiitis: a case report. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.* 2002;94(6):707-711.
22. Kondoh T, Kamimura N, Tsuru A, Matsumoto T, Matsuzaka T, Moriuchi H. A case of Schnizel-Giedion syndrome complicated with progressive severe gingival hyperplasia and progressive brain atrophy. *Pediatr Int.* 2001;43(2):181-184.
23. Lee W, O'Donnell D. Severe gingival hyperplasia in a child with I-cell disease. *Int J Paediatr Dent.* 2003; 13(1):41-45.
24. Savage NW, Daly CG. Gingival enlargements and localized gingival overgrowths. *Aust Dent J.* 2010; 55(Suppl1):55-60.
25. Krolls SO, Hoffman S. Squamous cell carcinomas of the oral soft tissues: a statistical analysis of 14,253 cases by age, sex, and race of patients. *J Am Dent Assoc.* 1976;92(3):571-574.
26. Sugerman PB, Joseph BK, Savage NW. The role of oncogenes, tumour suppressor genes and growth factors in oral squamous cell carcinoma: a case of apoptosis versus proliferation. *Oral Dis.* 1995;1(3):172-188.
27. Manganaro AM, Hammond HL, Dalton MJ, Williams TP. Oral melanoma: case reports and review of the literature. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.* 1995;80(6):670-676.
28. Hicks MJ, Flaitz CM. Oral mucosa melanoma: epidemiology and pathobiology. *Oral Oncol.* 2000;36(2):152-169.
29. Tanaka N, Mimura M, Kimijima Y, Amagasa T. Clinical investigation of amelanotic malignant melanoma in the oral region. *J Maxillofac Oral Surg.* 2004;62(8): 933-937.
30. Grimer R, Athanasou N, Gerrand C, et al. UK Guidelines for the Management of Bone Sarcomas. *Sarcoma.* 2010;317462. Epub 2010 Dec 29.
31. Feller L, Masipa JN, Wood NH, Raubenheimer EJ, Lemmer J. The prognostic significance of facial lymphoedema in HIV-seropositive subjects with Kaposi sarcoma. *AIDS Res Ther.* 2008;5:2.
32. Cooper CL, Loewen R, Shore T. Gingival hyperplasia complicating acute myelomonocytic leukemia. *J Can Dent Assoc.* 2000;66(2):78-79.
33. Weckx LL, Hidal LB, Marcucci G. Oral manifestations of leukemia. *Ear Nose Throat J.* 1990;69(5):341-342, 345-346.
34. Barrett AP. Gingival lesions in leukemia. A classification. *J Periodontol.* 1984;55(10):585-588.
35. Parameter on periodontitis associated with systemic conditions. American Academy of Periodontology. *J Periodontol.* 2000;(5 Suppl):876-879.
36. Peterson DE, Gerald H, Williams LT. An unusual instance of leukemic infiltrate. Diagnosis and management of periapical tooth involvement. *Cancer.* 1983; 51(9):1716-1719.
37. Nicolatou-Galitis O, Papadaki T, Moschovi, et al. Gingival overgrowth as the initial paraneoplastic manifestation of Hodgkin's lymphoma in a child. A case report. *J Periodontol.* 2001;72(1):107-112.
38. Iezzi G, Rubini C, Fioroni M, Piattelli A. Oral focal mucinosis of the gingiva: case report. *J Periodontol.* 2001; 72(8):1100-1102.
39. Lai PH, Chang JM, Hou YY, Chu ST, Lin SL ,Yang CF. Carcinosarcoma of the Salivary Gland on CT. *AJNR Am J Neuroradiol.* 1995;16(8):1733-1735.
40. Goodman RH, Post KD, Molitch ME, Adelman LS, Altemus LR, Johnston H. Eosinophilic granuloma mimicking a pituitary tumor. *Neurosurgery.* 1979;5(6): 723-725.
41. Peison B, Benisch B, Coopersmith EG. Primary plasmacytoma of the gingiva. *J Oral Maxillofac Surg.* 1982; 40(9):588-589.
42. Epstein JB, Raber-Drulacher JE, Wilkins A, Chavarria MG, Myint H. Advances in hematologic stem cell transplant: an update for oral health care providers. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.* 2009;107(3):301-312.
43. Mody RN, Samdani D. Idiopathic gingival enlargement: report of two cases. *J Pierre Fauchard Acad.* 1994;8(2): 67-69.
44. Moreau JL, Ndiaye R, Dupoit M, Diallo PD. [Congenital idiopathic gingival hyperplasia observed in a 6-year-old child] [article in French]. *Rev Stomatol Chir Maxillofac.* 1985;86(3):192-194.

Optimal depth of cure for nanohybrid resin composite using quartz tungsten halogen and new high intensity light-emitting diode curing units

Saijai Tanthanuch, DDS, MSc ▪ Prapansri Ruengsri, DDS ▪ Boonlert Kukiattrakoon, DDS, MSc

This study sought to evaluate the effects of quartz tungsten halogen (QTH) and light-emitting diode (LED) photocuring units on the degree of conversion (DC) and surface microhardness of a resin composite that had been cured for optimal depth of cure (DoC) assessment. Two hundred and forty cylindrical specimens (4.0 mm in diameter, 2.0-4.0 mm thick) of shade A2 resin composite were prepared and cured with either a QTH or an LED. The DC and top and bottom surface hardness were recorded, and data were analyzed using 2-way ANOVA, Tukey's test, t-test ($\alpha = 0.05$), and linear regression analysis. The results showed that surface microhardness values and DC were affected by light intensity ($P < 0.01$), and resin composite thickness (2, 3, and 4 mm) ($P < 0.01$). Resin composite polymerized by the QTH had an optimal DoC of 3 mm, compared to 4 mm for the LED.

Received: May 25, 2012
Accepted: November 26, 2012

Resin-based composites (RBCs) were first introduced in the 1960s, and are used routinely for restoring anterior and posterior teeth.[1] A newer class of RBCs (known as *nanohybrid resin composites*) have been reported to combine the good mechanical strength of the hybrids and the superior polish of the microfills.[2-4] Other positive features reported in the literature include high wear resistance, improved optical characteristics, and reduced polymerization shrinkage.[2,5,6]

The modes for curing RBCs have evolved as well. At present, 4 types of light-curing units are available for clinical use: quartz tungsten halogen lamps (QTH), light-emitting diode (LED) units, plasma-arc lamps, and argon-ion lasers. Many of these curing units are programmed with different curing protocols (such as soft-start, step-curing, and pulsed or oscillating irradiation) to improve photopolymerization and restoration quality.[7] Commercially available curing units differ in terms of high light intensity (with energy levels ranging from 300 mW/cm² to >2000 mW/cm²), and source (wavelengths ranging from 430-480 nm).[8,9]

Depending on the material and curing conditions, monomer to polymer conversion (an important factor in determining an RBC's mechanical properties and resistance to biodegradation) varies between 40%-75%.[10,11] Light curing units are used to initiate polymerization by activating the photoinitiators in the restorative materials. By absorbing photons, these photoinitiators change the molecular structure of the restorative material, converting monomers to a polymer network. The amount of activated photoinitiator depends on the photoinitiator concentration, the quantity of photons to which the material is exposed, and the energy of the photons (wavelength), the latter which depends on the curing light used.[8]

The ISO standard for polymer-based filling materials requires RBCs to have an optimal depth of cure (DoC) of 1.5 mm when irradiated per the manufacturer's recommended time.[12] A variety of methods have been used to measure the DoC of RBC materials, including hardness tests and double-bond conversions (DCs).[13-16] Molecular spectroscopy, such as Fourier transform infrared (FTIR) and micro-Raman spectroscopy, have proven useful in determining the DC of an RBC.[11,17-19] The DC is conventionally calculated as the ratio of carbon-carbon (C=C) double bonds in cured and uncured materials related to an internal standard. The DC is never 100%; however, low conversion (<55%) affects many properties and compromises wear resistance.[7] Factors that affect polymerization include curing and exposure times, wavelength, intensity of the light source, filler type, thickness, shade of restoration material, size and loading, effectiveness of light transmission (such as light guide tips that are free from debris and scratches), and the distance between the light source and the restorative material.[7,20,21] Previous studies have shown that high light intensity results in higher DC; however, LEDs may produce greater contraction strains during polymerization.[22-24] Several studies have addressed the effect of LED curing units on hybrid resin composites; however, few studies have examined the high light intensity of LED units on the DCs of nanohybrid resin composites.[25,26] Additional information concerning the mechanical properties of nanohybrid resin composites (such as microhardness and DoC) following polymerization with the newer LED units is necessary to judge their clinical potential.

This study sought to evaluate the DC of resin composite using QTH and LED curing units, as determined by Knoop hardness measurement and a FTIR spectrometer for optimal DoC assessment. The null hypothesis was that the QTH and LED units would have no effect on the DC of a resin composite, based on the Knoop hardness measurement of the resin composite and the results of an FTIR spectrometer.

Materials and methods

For this study, 240 cylindrical specimens (n = 20) of nanohybrid resin composite (Premise shade A2, Kerr Corporation) were prepared in polytetramethylfluoroethylene ring molds, each with an internal diameter of 4.0 mm, and ranging in thickness (in 1 mm increments) from 2-4 mm. The A2 shade of resin composite

Table. Mean microhardness, hardness ratio, and degree of conversion (DC) of nanohybrid resin composite at 2, 3, and 4 mm thickness.

Light curing unit	Thickness (mm)	Mean microhardness (in kg/mm²) (SD)		Microhardness ratio (SD)	DC% (SD)
		Top	Bottom		
Demetron LC	2	63.70 (3.76)	60.97 (4.89)	0.96 (0.11)	68.01 (0.98)
	3	64.10 (2.99)	54.56 (2.30)	0.85 (0.06)	57.10 (0.93)
	4	64.21 (2.29)	45.40 (3.07)	0.71 (0.05)*,a	43.43 (0.66)*,b
Elipar S10	2	84.91 (3.07)	80.53 (2.16)	0.95 (0.13)	69.04 (0.83)
	3	83.48 (2.55)	73.45 (2.84)	0.88 (0.04)	58.32 (0.76)
	4	83.69 (4.45)	67.12 (2.06)	0.80 (0.04)*,a	50.08 (0.51)*,b

* Indicates significant difference for hardness ratio and DC among the 2, 3, and 4 mm thickness levels, for each type of light curing unit ($P < 0.05$).

Same superscript letters indicate significant differences between curing units in terms of hardness ratio and DC ($P < 0.05$).

was selected to minimize the effects of colorants on light penetration.[21] The cavity mold was filled with a single increment of resin composite on a glass plate. The plate was covered with a mylar matrix strip, and a second glass plate was placed over the mylar strip. A static load of approximately 500 g was applied to this plate for 30 seconds to extrude excess resin composite and to obtain a flat surface that would facilitate hardness testing; at that point, the glass plate was removed from the top of the mold, and the tip of either a QTH curing light (Demetron LC, Kerr Corporation) or an LED light (Elipar S10, 3M ESPE) was placed in contact with the top surface of the specimens for 40 seconds. The Elipar S10 was used in continuous mode. To ensure consistency in intensity output from the light source, the light intensity of both curing units was checked with a radiometer prior to use. After polymerization, the mylar strip and the glass plate on the bottom of the mold were removed, and the specimen was removed from the ring mold.

Twenty specimens from each group were tested using a Knoop hardness testing device (Micromet II, Buehler). Hardness measurements were taken for 10 seconds under a 100 g load. Five hardness indentations were made on both the top surface (near the light source) and the bottom surface (away from the light source) of each specimen of 2, 3, and 4 mm in thickness. For each specimen, the mean of the 5 hardness measurements was recorded as the hardness value of that surface of the specimen. The hardness ratio also was calculated by dividing the hardness values of the top surface by hardness values of the bottom surface for each thickness and curing time. The hardness value should be >0.8.[21] Twenty specimens of each group were tested using a FTIR spectrometer (Equinox 55, Bruker Corporation). Uncured resin composite paste was smeared onto a potassium bromide disc and the FTIR spectrometer (in transmission mode) was used to determine the absorbance peaks prior to curing. Immediately after curing, a hard tissue-grinding machine pulverized the polymerized specimen into fine powder, and the FTIR spectrometer (in diffuse-reflection mode) was used to record the absorbance peaks. The percentage of unreacted C=C (C=C%) was examined from the ratio of absorbance intensities of aliphatic C=C (peak at 1635 cm^{-1}) against an internal standard before and after curing of the specimen and the aromatic C-C (peak at 1614 cm^{-1}). The DC was calculated by subtracting the C=C% from 100%, according to the following formula: DC% = 1 – (1635 cm^{-1}/1614 cm^{-1}) cured/(1635 cm^{-1}/1614 cm^{-1}) uncured x 100.[15]

Statistical analysis

Two-way ANOVA and Tukey's test were applied to test the effect of curing unit intensity and thickness on the DC, and the hardness ratio of the resin composite. Two sample t-tests were used to gauge the effect on the DC and hardness ratio between the Demetron LC and Elipar S10 ($\alpha = 0.05$). Linear regression analysis was performed, using the DC recorded by the FTIR and hardness values taken at the bottom surfaces.

Results

The intensities of QTH and LED light-curing units were 402.00 ± 7.21 (Demetron LC) and 1,417.00 ± 14.93 mW/cm² (Elipar S10), respectively.

Hardness values and DC (by FTIR), as a function of specimen depth for both units, can be found in the Table. In terms of hardness ratio, no significant difference between the QTH and LED curing lights was detected up to 3.0 mm; however, the Demetron LC showed significantly lower ratio values at a depth of 4 mm. RBC behavior in terms of DC by FTIR was similar in hardness, regardless of which light curing unit was used. The RBC behavior also presented slightly gradual reductions.

Chart 1 displays the linear regression of hardness as a function of DC for the Demetron LC QTH curing unit; Chart 2 displays the linear regression of hardness for the Elipar S10 LED curing unit. There is a high correlation between the DC and hardness values for both curing units (r^2 = 0.999 for QTH, r^2 = 0.998 for LED).

Discussion

The results of this study indicate that the thickness of resin composite affected both the resin's hardness and its DC. The light's intensity decreases as it passes through the resin composite, due to the filler particles and the resin matrix absorbing and scattering light. Darker shades and more heavily filled composites present a more severe gradient.[10] This decrease in light intensity resulted in a gradation of cure, decreasing from the top surface inward. Both of the LCUs in this study had higher top surface values, which could be attributed to the distance of the irradiation and the effectiveness of polymerization.

A 1992 study by Pilo & Cardash suggested that the top-to-bottom ratio should be >0.8 for adequate in-depth polymerization.[27] The QTH curing unit hardness ratio values recorded in this present study were >0.8 up to 3 mm depth, but were <0.8 at 4 mm depth. The LED curing unit hardness ratio was >0.8 at 4 mm depth. This result suggests that QTH curing units reduce light transmittance throughout the bulk material, thus these units may be inadequate for efficient light diffusion at a depth of ≥4 mm.

The results of the present study contradict previous studies that reported higher hardness values when a QTH light was used.[28-30] It should be noted that the LED units used in those studies produce low-intensity light, which could explain this difference; in addition, 2 of the studies had a waiting time of 24 hours between photocuring and hardness measurement.[29,30] This waiting period could have affected the results, since hardness increases significantly with the passing of time.[31]

A 2004 study by Uhl et al produced results similar to the current study by using an LED prototype with an intensity of 901 mW/cm^2, and found that it provided greater resin composite hardness 24 hours after photocuring.[32] The Elipar S10 used in the present study had an intensity of 1417 mW/cm^2. The results of this present study are in agreement with previous studies that reported greater light intensity results in higher degrees of conversion; however, LEDs also may produce greater contraction during polymerization.[22-24]

Various methods can be used to determine a resin composite's DoC; 2 of the most common are DC and hardness evaluation. Although measurement of the DC is considered to be the most reliable technique, the authors also suggest a hardness evaluation, due to the high correlation found between the 2 methods in the present study.

It must be noted that there are some limitations to the present study. For example, the role of saliva was not taken into consideration. The oral cavity may affect these results, as it presents a different testing environment due to the presence of water, temperature changes, and pH levels. Additional in vivo studies are needed to assess the effects of different light intensities, period of time the light was used, and thickness of the filler material on the microhardness and DC values.

Chart 1. Linear regression analysis of Knoop hardness number (KHN) as a function of the degree of conversion (DC) (%) for the Demetron LC curing unit.

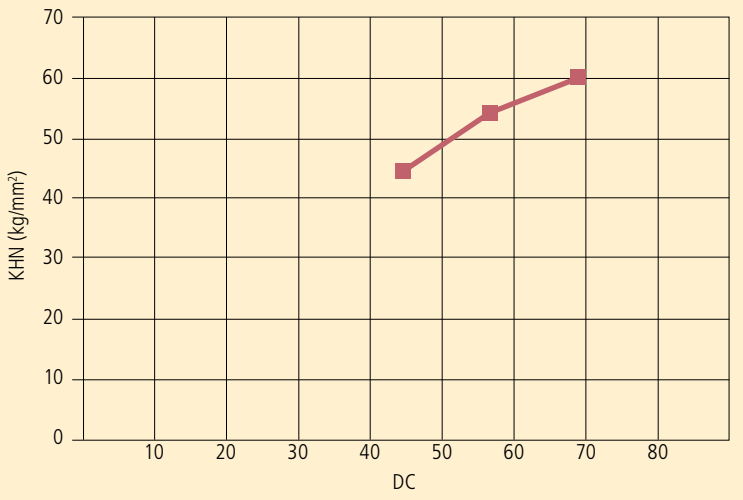
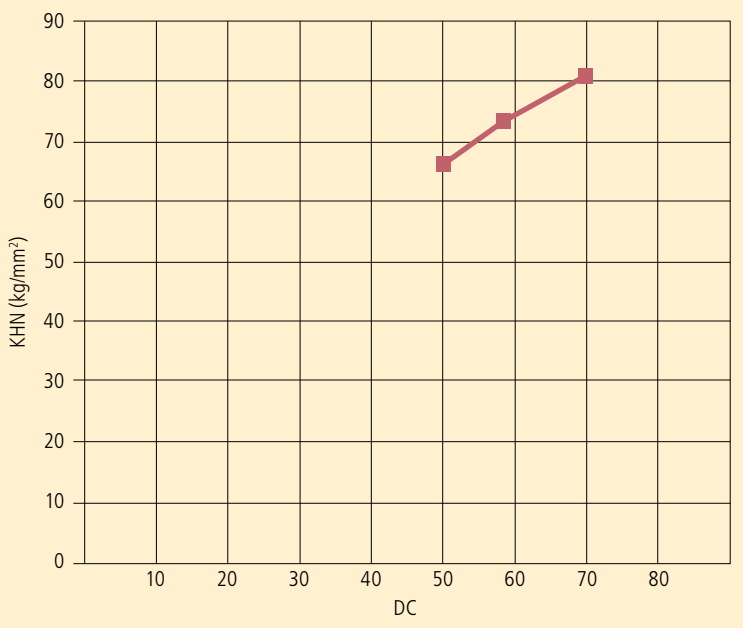


Chart 2. Linear regression analysis of Knoop hardness number (KHN) as a function of the degree of conversion (DC) (%) for the Elipar S10 curing unit.



Summary

Within the limitations of this study, the results indicate that the intensities of light from curing units, and the thickness of nanohybrid resin composite, affected the

DC of resin composite, as determined by hardness measurement and an FTIR spectrometer. Optimal DoC for the polymerized resin composite was 3 mm for a QTH light, compared to 4 mm for an LED light.

Author information

Dr. Tanthanuch is an assistant professor, Department of Conservative Dentistry, Faculty of Dentistry, Prince of Songkla University, Hat Yai, Songkhla, Thailand, where Dr. Ruengsri is a lecturer, Dr. Kukiattrakoon is an associate professor, Department of Conservative Dentistry, and the Dental Material and Maxillofacial Prosthodontics Rehabilitation Research Unit.

Acknowledgments

This project was supported by the Faculty of Dentistry, Prince of Songkla University research fund.

References

1. Bowen RL, Rodriguez MS. Tensile strength and modulus of elasticity of tooth structure and several restorative materials. *J Am Dent Assoc.* 1962;64(2):378-387.
2. Mitra SB, Wu D, Holmes BN. An application of nanotechnology in advanced dental materials. *J Am Dent Assoc.* 2003;134(10):1382-1390.
3. Moszner N, Klapdohr S. Nanotechnology for dental composites. *Int J Nanotechnol.* 2004;1(1/2):130-156.
4. Turssi CP, Saad JR, Duarte SL Jr, Rodrigues AL. Composite surfaces after finishing and polishing techniques. *Am J Dent.* 2000;13(3):136-138.
5. Yap AU, Tan CH, Chung SM. Wear behavior of new composite restoratives. *Oper Dent.* 2004;29(3):269-274.
6. Turssi CP, Ferracane JL, Serra MC. Abrasive wear of resin composites as related to finishing and polishing procedures. *Dent Mater.* 2005;21(7):641-648.
7. Santini A. Current status of visible light activation units and the curing of light-activated resin-based composite materials. *Dent Update.* 2010;37(4):214-227.
8. Abate PF, Zahra VN, Macchi RL. Effect of photopolymerization variables on composite hardness. *J Prosthet Dent.* 2001;86(6):632-635.
9. Aguiar FH, Lazzari CR, Lima DA, Ambrosano GM, Lovadino JR. Effect of light curing tip distance and resin shade on microhardness of a hybrid resin composite. *Braz Oral Res.* 2005;19(4):302-306.
10. Santos GB, Medeiros IS, Fellows CE, Muench A, Braga RR. Composite depth of cure obtained with QTH and LED units assessed by microhardness and micro-Raman spectroscopy. *Oper Dent.* 2007;32(1):79-83.
11. Miletic VJ, Santini A. Remaining unreacted methacrylate groups in resin-based composite with respect to sample preparation and storing conditions using micro-Raman spectroscopy. *J Biomed Mater Res B Appl Biomater.* 2008;87(2):468-474.
12. International Organization for Standardization. ISO 10650-1. Dentistry – Powered polymerization activators – Part 1: quartz tungsten halogen lamps. Geneva, Switzerland; 2004.
13. DeWald JP, Ferracane JL. A comparison of four modes of evaluating depth of cure of light-activated composites. *J Dent Res.* 1987;66(3):727-730.
14. Hansen EK, Asmussen E. Correlation between depth of cure and surface hardness of a light-activated resin. *Scand J Dent Res.* 1993;101(1):62-64.
15. Peutzfeldt A. Quantity of remaining double bonds of propanal-containing resins. *J Dent Res.* 1994;73(10):1657-1662.
16. Santini A, Miletic V. Quantitative micro-Raman assessment of dentine demineralization, adhesive penetration, and degree of conversion of three dentine bonding systems. *Eur J Oral Sci.* 2008;116(2):177-183.
17. Feng L, Carvalho R, Suh BI. Insufficient cure under the condition of high irradiance and short irradiation time. *Dent Mater.* 2009;25(3):283-289.
18. Tarle Z, Meniga A, Knezevic A, Sutalo J, Ristic M, Pichler G. Composite conversion and temperature rise using a conventional, plasma arc, and an experimental blue LED curing unit. *J Oral Rehabil.* 2002;29(7):662-667.
19. Miletic V, Santini A, Trkulja I. Quantification of monomer elution and carbon-carbon double bonds in dental adhesive systems using HPLC and micro-Raman spectroscopy. *J Dent.* 2009;37(3):177-184.
20. Halvorson RH, Erickson RL, Davidson CL. Energy dependent polymerization of resin-based composite. *Dent Mater.* 2002;18(6):463-469.
21. Tarle Z, Meniga A, Ristic M, Sutalo J, Pichler G, Davidson CL. The effect of the photopolymerization method on the quality of composite resin samples. *J Oral Rehabil.* 1998;25(6):436-442.
22. Sakaguchi RL, Berge HX. Reduced light energy density decreases post-gel contraction while maintaining degree of conversion in composites. *J Dent.* 1998;26(8): 695-700.
23. Nomura Y, Teshima W, Tanaka N, Yoshida Y, Nahara Y, Okazaki M. Thermal analysis of dental resins cured with blue light-emitting diodes (LEDs). *J Biomed Mater Res.* 2002;63(2):209-213.
24. Jandt KD, Mills RW, Blackwell GB, Ashworth SH. Depth of cure and compressive strength of dental composites cured with blue light emitting diodes (LEDs). *Dent Mater.* 2000;16(1):41-47.
25. Sideridou ID, Karabela MM, Vouvoudi ECh. Physical properties of current dental nanohybrid and nanofill light-cured resin composites. *Dent Mater.* 2011;27(6):598-607.
26. Pick B, Pelka M, Belli R, Braga RR, Lohbauer U. Tailoring of physical properties in highly filled experimental nanohybrid resin composites. *Dent Mater.* 2011;27(7):664-669.
27. Pilo R, Cardash HS. Post-irradiation polymerization of different anterior and posterior visible light-activated resin composite. *Dent Mater.* 1992;8(5):299-304.
28. Kurachi C, Tuboy AM, Magalhaes DV, Bagnato VS. Hardness evaluation of a dental composite polymerized with experimental LED-based devices. *Dent Mater.* 2001;17(4):309-315.
29. Leonard DL, Charlton DG, Roberts HW, Cohen ME. Polymerization efficiency of LED curing lights. *J Esthet Restor Dent.* 2002;14(5):286-295.
30. Rahiotis C, Kakaboura A, Loukidis M, Vougiouklakis G. Curing efficiency of various types of light-curing units. *Eur J Oral Sci.* 2004;112(1):89-94.
31. Dannheimer MF, Marais JT, Borman J, Germishuys PJ, Nel JC. Surface hardness of light-cured composite resins cured directly or through a transparent matrix using three different light guides. *J Dent Assoc South Afr.* 1996;51(6):193-195.
32. Uhl A, Sigushi BW, Jandt KD. Second generation LEDs for the polymerization of oral biomaterials. *Dent Mater.* 2004;20(1):80-87.

Manufacturers

Bruker Corporation, Billerica, MA
978.439.9989, www.bruker.com

Buehler, Lake Bluff, IL
800.283.4537, www.buehler.com

Kerr Corporation, Orange, CA
800.537.7123, www.kerrdental.com

3M ESPE, St. Paul, MN
888.364.3577, solutions.3m.com

Microleakage of 3 single-bottle self-etch adhesives having different solvents

Cigdem Elbek Cubukcu, PhD ▪ Ece Eden, PhD ▪ Tijen Pamir, PhD

This study compared the microleakage from 3 single-bottle self-etch adhesives (SEAs) with a conventional etch and rinse (ER) system. Class V cavities were prepared on buccal and lingual surfaces at the cemento-enamel junction of 40 extracted human third molars. The cavities were allocated into 4 groups (n = 20). The groups were treated with either a combination of composite resin and 1 of 3 SEAs, or with a conventional ER system. Dye penetration of the samples was performed by placing them in a fresh solution of India ink for 48 hours. After rinsing and sectioning, the samples were placed under a light microscope and evaluated for microleakage along occlusal (enamel) and gingival (dentin) margins. The data were analyzed statistically.

Microleakage scores of the adhesives exhibited significant differences ($P < 0.05$). All 3 single-bottle SEAs tested exhibited more microleakage than the ER system. There was no difference in terms of microleakage between the enamel and dentin margins in the SEA-bonded specimens ($P > 0.05$). The ER system was more successful in sealing enamel than dentin.

Received: February 19, 2012
Accepted: June 27, 2012

Key words: self-etch adhesives, microleakage, G-Bond, Tetric N-Bond, Optibond All-in-One

The classic concept of etch and rinse (ER) bonding to dental tissues has become more user-friendly with simplified adhesive systems that comprise the 2-step ER, 2-step self-etch, and single-bottle self-etch adhesives (SEAs). The clinical efficiency of combining conditioner and primer offers a significant advantage in terms of time (especially in pediatric dentistry) compared to the multiple-step adhesive systems currently available.

The adhesion mechanism of an SEA is based on smear layer penetration, demineralization of superficial underlying substrate, and monomer diffusion enhancement into the dematerialized dentin, thus facilitating hybrid layer formation.[1,2] Acidic monomers in the SEAs are responsible for the etching action. Water is an essential component that enables ionization of the acidic monomers, and the demineralization of dental hard tissues.[3] The acidity level of contemporary SEAs may be classified as mild (pH ≈ 2.0), moderate (pH ≈ 1.5), and aggressive (pH ≤ 1), based on their ability to penetrate the dentin smear layer, and their depth of demineralization into the subsurface dentin.[3] Hydrophilic resin monomers in adhesives often are dissolved in volatile solvents, such as ethanol and acetone. These solvents aid in displacing water from the dentine surface and facilitating penetration of the resin monomers into the microporosities of the exposed, acid-dematerialized, collagen network.

There have been contradictory results in studies comparing SEAs' sealing abilities against the sealing abilities of multiple-bottle ER systems. Some studies reported the SEAs had lower sealing abilities whereas Duarte et al found that SEAs and ER systems had similar effects in reducing microleakage in margins.[4-6]

This study sought to compare the microleakage patterns of a conventional ER system (Adper Scotchbond Multipurpose, 3M ESPE) with those of 3 new generation SEAs: G-Bond (GC America, Inc.), Tetric N-Bond (Ivoclar Vivadent, Inc.), and Optibond All-in-One (Kerr Corporation), with different solvents. Although all the SEAs were single-bottle self-etch systems, it was possible that their different solvents might produce different results when sealing enamel and dentin. Therefore, the null hypothesis tested in this study is twofold: that the difference between the microleakage scores of enamel and dentin for each of the SEA systems is insignificant; and the sealing ability of the ER system is not significantly superior to the SEA systems tested in this study.

Materials and methods

Forty recently extracted human third molars (without decay) were used. Two rectangular cavities (2 mm x 1.5 mm x 3mm, ± 0.3 mm) were prepared on the lingual and buccal surfaces of each tooth, using a cylindrical diamond bur (0.9 mm in diameter) under water coolant. The margins of the cavities were butt-joined, half in the enamel and half in the root dentin. Teeth were allocated randomly to 4 groups (n = 10) of tested adhesive systems. Procedures for pretreating the dental tissues are summarized in Table 1. Following the application of adhesive, samples were photocured with the same calibrated LED device (Elipar FreeLight, 3M ESPE). A single increment of resin composite (Tetric N-Ceram, Ivoclar Vivadent, Inc.) was placed and photocured for 40 seconds. The restorations were finished with polishing discs (Sof-Lex, 3M ESPE) under water spray. After finishing and polishing, the teeth were stored in saline solution (at 37°C) for 24 hours and thermocycled for 1000 cycles in a water bath (5-55°C) with a 20-second dwell time. Following thermocycling, all samples were air-dried and nail polish was applied to the teeth, except for the restorations and a 1 mm rim of the tooth structure around each restoration. Next, all teeth were immersed in separate vials of India ink (at 37°C) for 48 hours. The teeth were rinsed under running tap water and sectioned in two—mesiodistally along the long axis and longitudinally across the center of the restoration—using a low speed diamond saw (Isomet, Buehler Ltd.). Final sample sizes were <20 in 3 of the enamel groups and in all 4 of the dentin groups, due to problems encountered when sectioning.

Table 1. Pretreatment and bonding procedures for the 4 adhesive materials (n = 20) used in the study.

Material	Procedure
Adper Scotchbond Multipurpose	Enamel and dentin were etched for 15 seconds with 35% phosphoric acid gel, rinsed and dried; primer was applied to enamel and dentin and dried gently with an airstream; following adhesive application, material was photocured for 10 seconds.
G-Bond	One-step SEA was applied to enamel and dentin surfaces and left undisturbed for 5-10 seconds; adhesive was dried thoroughly for 5 seconds with oil-free air (under maximum air pressure); photocuring was performed for 10 seconds.
Tetric N-Bond	A thick layer of material was applied to the prepared enamel and dentin surfaces and brushed for at least 30 seconds; adhesive was dried thoroughly with oil-free air (under maximum air pressure) until a glossy, immobile liquid film resulted; photocuring was performed for 10 seconds.
Optibond All-in-One	The adhesive was applied to the prepared enamel and dentin surfaces with brushing motion for 20 seconds; procedure was repeated for the same duration; adhesive was dried thoroughly for at least 5 seconds and photocured for 10 seconds.

Dye penetration was examined using a light microscope (Leica S8APO, Leica Microsystems), and integrated with a digital camera (Leica DFC 280, Leica Microsystems) and a computer by 2 independent precalibrated examiners. The examiners used a leakage scoring method presented in 2004 by Cenci et al, with 0 = no penetration, 1 = dye penetration up to one-third of cavity depth, 2 = dye penetration up to two-thirds of cavity depth, 3 = dye penetration to full cavity depth, and 4 = dye penetration onto the axial wall of the cavity.[7] In case of any disagreement, new readings were performed until a consensus was reached. Differences among the groups were analyzed statistically by Kruskal-Wallis test ($P = 0.05$). Pairwise comparisons were made using Mann-Whitney U test; in addition, Wilcoxon signed ranks test was used to analyze differences between microleakage at enamel and dentin margins. The level of significance was 0.05.

Table 2. Number of samples (%) that demonstrated microleakage at enamel margins. Different superscript letters indicate statistically significant differences.

Enamel	G-Bond[a]	Tetric N-Bond[b]	Optibond All-in-One[a]	Adper Scotchbond Multipurpose[c]
N	20	18	19	19
No penetration	11 (55)	9 (50)	15 (79)	19 (100)
Dye penetration up to one-third of cavity depth	6 (30)	7 (39)	2 (11)	0
Dye penetration up to two-thirds of cavity depth	0	0	1 (5)	0
Dye penetration to full cavity depth	2 (10)	2 (11)	1 (5)	0
Dye penetration onto the axial wall of the cavity	1(5)	0	0	0
Median	0	0.5	0.0	0
Minimum-maximum	0-4	0-3	0-3	0-0

Note: Final sample sizes were <20 in 3 of the enamel groups due to problems encountered when sectioning.

Results

Kruskal-Wallis exhibited significant differences among the study groups ($P < 0.05$). Tables 2 and 3 show the distribution of microleakage scores for all groups at the enamel and dentin margins, respectively. According to pairwise comparisons, all single-bottle SEAs exhibited more microleakage with enamel than the ER system ($P < 0.05$), with Tetric N-Bond exhibiting the most microleakage ($P < 0.05$). At dentin margins, the SEA Optibond All-in-One offered similar sealing to the ER system ($P > 0.05$) and superior sealing compared to the other two SEAs tested ($P < 0.05$). No difference was found between the microleakage of enamel and dentin margins when the SEAs were used ($P > 0.05$). However, the ER system demonstrated a statistically significant difference between enamel and dentin margins ($P < 0.01$).

Discussion

This study confirmed the null hypothesis that the difference between the microleakage scores from enamel and dentin for each SEA was insignificant, as the results did not support the second part of the hypothesis. The sealing ability of the ER system was significantly superior compared to the SEAs tested.

An ER system (Adper Scotchbond Multipurpose) was chosen as the control in this study because it has demonstrated bonding efficiency, and has been used as a control material in previous studies involving single-bottle SEAs.[8-10] According to the literature, enamel demonstrates less microleakage than dentin.[11,12] In this study, none of the control group samples showed enamel microleakage; in addition, there was a significant difference between the microleakage of enamel and that of dentin. By contrast, no such difference was

Table 3. Number of samples (%) that demonstrated microleakage at dentin margins. Different superscript letters indicate statistically significant differences.

Dentin	G-Bond[a]	Tetric N-Bond[b]	Optibond All-in-One[c]	Adper Scotchbond Multipurpose[c]
N	19	15	18	19
No penetration	12 (63)	6 (40)	12 (67)	15 (79)
Dye penetration up to one-third of cavity depth	4 (22)	3 (21)	2 (11)	2 (11)
Dye penetration up to two-thirds of cavity depth	1 (5)	2 (13)	2 (11)	1 (5)
Dye penetration to full cavity depth	1 (5)	2 (13)	2 (11)	1 (5)
Dye penetration onto the axial wall of the cavity	1 (5)	2 (13)	0	0
Median	0	1.00	0	0
Minimum-maximum	0-4	0-4	0-3	0-3

Note: Final sample sizes were <20 in all of the dentin groups, due to problems encountered when sectioning.

observed when the SEAs were used. Based on these results, it was concluded that the etching capabilities of SEAs in enamel and dentin did not differ from each other. The sealing capability of the ER adhesive on enamel margins was superior to all the tested SEAs. The difference between the ER adhesive and the SEAs may be explained by the latter's additional etching step, which yields the characteristic demineralization patterns in enamel, and improves the bonding quality of ERs. Gregoire & Ahmed reported lower microleakage values when enamel was etched initially with phosphoric acid.[13]

Tetric N-Bond is a water-based SEA that was only recently made available commercially. To the authors' knowledge, the microleakage scores reported in this study were the first published data concerning this material's sealing ability. Tetric N-Bond showed significantly more microleakage at the enamel margins compared to the other SEAs tested in this study. Dematerialized and ground enamel etching capacity of another water-based single-bottle SEA (Adper Prompt L-Pop) has been found to be an inferior etching agent compared to phosphoric acid; this finding was in agreement with the results of our study. However, according to Gregoire & Ahmed, this material showed superior etching capacity when compared to a water- and acetone-based adhesive (iBond).[13] These results contradict the results of the present study, where the sealing ability of Tetric N-Bond was inferior to the water- and acetone-based G-Bond.

It has been proposed that acetone is an appropriate solvent for adhesives that combine hydrophobic and hydrophilic components, and it has a very good water-chasing and removing capacity. According to Zhao et al, water-based solvent systems created a thinner hybrid layer with some incompletely sealed dentinal tubules.[14] In a recent study, however, another water-based single-bottle SEA (Futura Bond) showed marginal permeability, similar to that of other SEAs with different solvent content.[15] It has been reported that there is no consensus in the literature concerning enamel and dentin microleakage of water-based SEAs, a controversy that can be attributed to the different materials' compositions.[6,16,17]

SEAs could be arranged in the order of their ability to etch dentin smear layers and penetrate into intact dentin. The different etching pattern of SEAs has been attributed to their aggressiveness and pH.[18] The present study could not confirm that—with the exception of the control ER adhesive—increased aggressiveness with low pH level led to better sealing ability; conversely, the SEAs with reduced acidity in this study demonstrated better sealing ability.

Tetric N-Bond, with a pH of 1.7, demonstrated the greatest amount of enamel and dentin mircoleakage, while Optibond All-in-One, with the highest pH of the 3 materials (2.5-3.0), demonstrated the least microleakage (G-Bond had a pH of 2.0). The 34%-37% phosphoric acid gel used in the ER system had a lower pH level (0.5-1.0) than any of the SEAs used in this study.

The results of this study suggest that the aggressiveness of SEAs should be assessed differently than ER systems. The pH level of the SEAs may not be a major contributing factor in terms of adhesion to dental substrates; conversely, solvent contents may be important factors in terms of proper tooth adhesion and the prevention of microleakage. Optibond All-in-One uses a ternary solvent (water, alcohol, and acetone); its unique composition might result in spontaneous evaporation of the water and other cosolvents following adhesive application.[19] Furthermore, applying this material in 2 layers may improve its sealing ability. Brackett et al reported that the bond strength of Optibond All-in-One was similar to ER controls for dentin, despite less surface topography; however, its efficient bonding ability to dentin was due to its solvents and hydroxyethyl methacrylate monomer-free composition.[20]

Although the surface of the dentin was decalcified slightly by G-Bond and there was almost no exposure of the collagen fibers, the material created a better seal for dentin compared to Tetric N-Bond. According to Radovic et al, the 4-MET monomer whilst phosphoric acid ester monomer in G-Bond ensures a tight bond to enamel and dentin.[21] Additionally, the 5% filler content of G-Bond further seals the tubules, which minimize microleakage.[21]

Conclusion

Within the limitations of this study, all single-bottle SEAs tested exhibited more microleakage than the ER system; however, the ER system was more successful in sealing enamel than dentin. Optibond

All-in-One demonstrated similar microleakage to Adper Scotchbond Multipurpose, and demonstrated superior results compared to the other SEAs in dentin. No significant differences were found between the microleakage of enamel and dentin margins when SEAs were used.

Author information

Dr. Cubukcu is head of the Consultation Unit of Oral Diseases, Uludag University, Bursa, Turkey, where Dr. Eden is a professor, Department of Pedodontics, and Dr. Pamir is a professor, Department of Restorative Dentistry and Endodontics.

Acknowledgments

The authors wish to acknowledge the contributions of Dr. F. Ertugrul in evaluating the microleakage of the study samples.

References

1. Vanajasan PP, Dhakshinamoorthy M, Rao CS. Factors affecting the bond strength of self-etch adhesives: a meta-analysis of literature. *J Conserv Dent.* 2011;14(1):62-67.
2. Nagpal R, Manuja N, Tyagi SP, Singh UP. In vitro bonding effectiveness of self-etch adhesives with different application techniques: a microleakage and scanning electron microscopic study. *J Conserv Dent.* 2011; 14(3):258-263.
3. Moszner N, Salz U, Zimmermann J. Chemical aspects of self-etching enamel-dentin adhesives: a systematic review. *Dent Mater.* 2005;21(10):895-910.
4. Atoui JA, Chinelatti MA, Palma-Dibb RG, Corona SA. Microleakage in conservative cavities varying the preparation method and surface treatment. *J Appl Oral Sci.* 2010;18(4):421-425.
5. Kirk PC, Fitchie JG, Philips SM, Puckett AD. Microleakage evaluation of four self-etching adhesive systems. *Gen Dent.* 2010;58(3):e104-e109.
6. Duarte S Jr, de Freitas CR, Saad JR, Sadan A. The effect of immediate dentin sealing on the marginal adaptation and bond strengths of total-etch and self-etch adhesives. *J Prosthet Dent.* 2009;102(1):1-9.
7. Cenci MS, Piva E, Potrich F, Formolo E, Demarco FF, Powers JM. Microleakage in bonded amalgam restorations using different adhesive materials. *Braz Dent J.* 2004;15(1):13-18.
8. Khosravi K, Ataei E, Mousavi M, Khodaeian N. Effect of phosphoric acid etching of enamel margins on the microleakage of a simplified all-in-one and a self-etch adhesive system. *Oper Dent.* 2009;34(5):531-536.
9. Gueders AM, Charpentier JF, Albert AI, Geerts SO. Microleakage after thermocycling of 4 etch and rinse and 3 self-etch adhesives with and without a flowable composite lining. *Oper Dent.* 2006;31(4):450-455.
10. Carvalho AP, Turbino ML. Can previous acid etching increase the bond strength of a self-etching primer adhesive to enamel? *Braz Oral Res.* 2009;23(2):169-174.
11. Vinay S, Shivanna V. Comparative evaluation of microleakage of fifth, sixth, and seventh generation dentin bonding agents: an in vitro study. *J Conserv Dent.* 2010;13(3):136-140.
12. Mousavinasab SM, Atai M, Alavi B. To compare the microleakage among experimental adhesives containing nanoclay fillers after the storages of 24 hours and 6 months. *Open Dent J.* 2011;5:52-57.
13. Gregoire G, Ahmed Y. Evaluation of the enamel etching capacity of six contemporary self-etching adhesives. *J Dent.* 2007;35(5):388-397.
14. Zhao SJ, Zhang L, Tang LH, Chen JH. Effect of acid etching time on nanoleakage and microtensile bond strength of the adhesive-dentin bond interface. *Int Chin J Dent.* 2006;23(6):29-37.
15. Pushpa R, Suresh BS. Marginal permeability of one step self-etch adhesives: effects of double application or the application of hydrophobic layer. *J Conserv Dent.* 2010;13(3):141-144.
16. Van Landuyt KL, Kanumilli P, de Munck J, Peumans M, Lambrechts P, Van Meerbeek B. Bond strength of a mild self-etch adhesive with and without prior acid etching. *J Dent.* 2006;34(1):77-85.
17. Van Landuyt KL, Peumans M, de Munck J, Lambrechts P, Van Meerbeek B. Extension of a one-step self-etch adhesive into a multi-step adhesive. *Dent Mater.* 2006;22(6):533-544.
18. Van Landuyt KL, Kanumilli P, de Munck J, Peumans M, Lambrechts P, Van Meerbeek B. Bond strength of a mild self-etch adhesive with and without prior acid-etching. *J Dent.* 2006;34(1):77-85.
19. Gregoire G, Dabsie F, Dieng-Sarr F, Akon B. Solvent composition of one-step self-etch adhesives and dentine wettability. *J Dent.* 2011;39(1):30-39.
20. Brackett WW, Tay FR, Looney SW, Ito S, Haisch LD, Pashley DH. Microtensile dentin and enamel bond strengths of recent self-etching resins. *Oper Dent.* 2008;33(1):89-95.
21. Radovic I, Vulicevic ZR, García-Godoy F. Morphological evaluation of 2- and 1-step self-etching system interfaces with dentin. *Oper Dent.* 2006;31(6):710-718.

Manufacturers

Buehler Ltd., Lake Bluff, IL
800.283.4537, www.buehler.com

GC America, Inc., Alsip, IL
800.323.7063, www.gcamerica.com

Ivoclar Vivadent, Inc., Amherst, NY
800.533.6825, www.ivoclarvivadent.us

Kerr Corporation, Orange, CA
800.537.7123, www.kerrdental.com

Leica Microsystems, Buffalo Grove, IL
800.248.0123, www.leica-microsystems.com

3M ESPE, St. Paul, MN
888.364.3577, solutions.3m.com

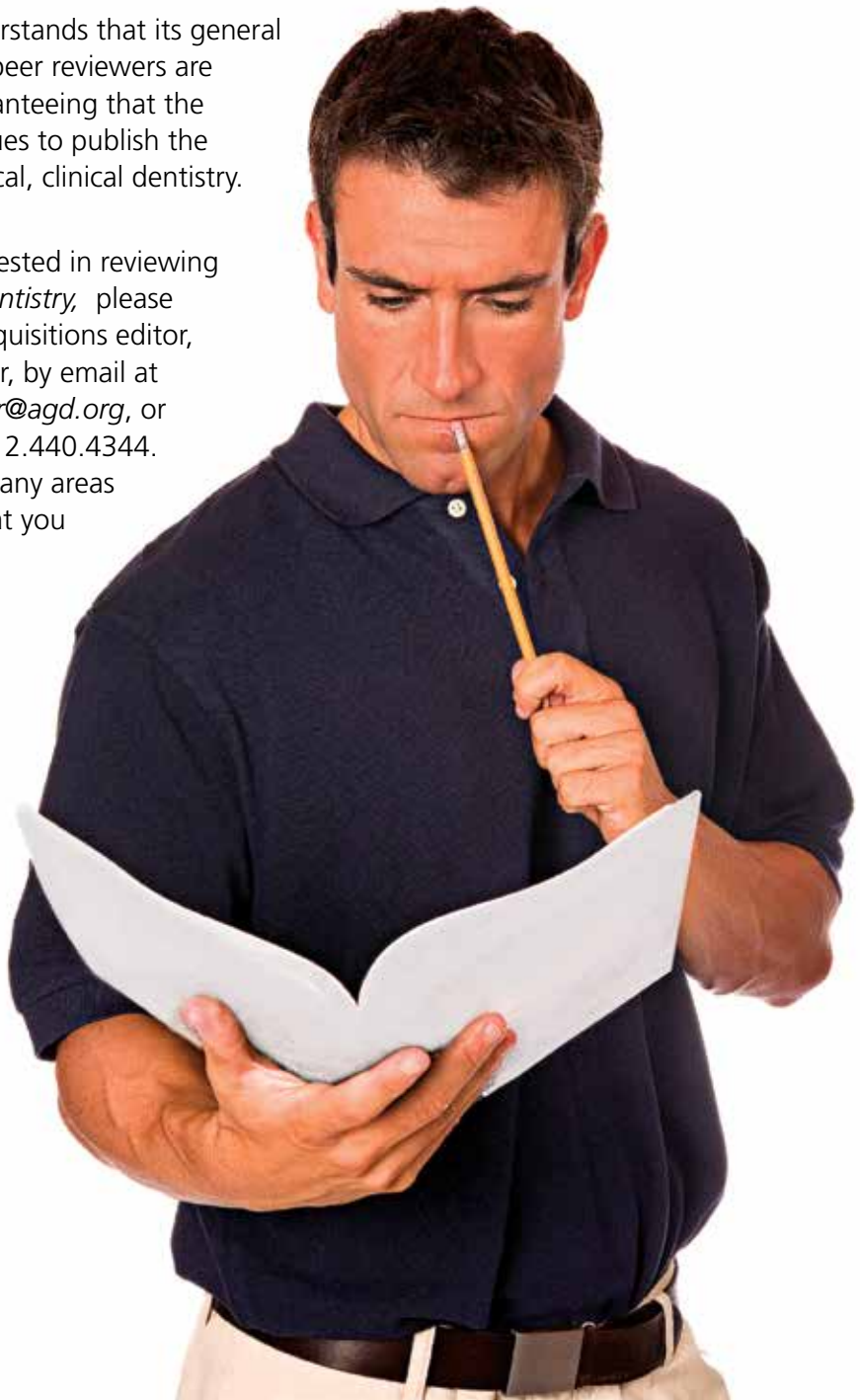
3 CE CREDITS

CE Credit for Peer Reviewers is Now Available!

Peer reviewers for the Academy of General Dentistry's (AGD) scientific journal, *General Dentistry*, can now earn continuing education (CE) credits for their reviews! Each review that a peer reviewer completes will be approved for 3 CE credits, with a limit of 9 CE credits earned per year.

The AGD understands that its general and specialist peer reviewers are crucial in guaranteeing that the journal continues to publish the finest in practical, clinical dentistry.

If you are interested in reviewing for *General Dentistry,* please contact the acquisitions editor, Rebecca Palmer, by email at *rebecca.palmer@agd.org*, or by phone at 312.440.4344. Please provide any areas of specialty that you are interested in reviewing.



Academy of General Dentistry™