CDA

Hypodontia

IMRT and Xerostomia

Chemo-radiation Patients

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MAXILLOFACIAL PROSTHODONTICS

ELENI D. ROUMANAS, DDS

OF THE CALIFORNIA DENTAL ASSOCIATION

Journal

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DEPARTMENTS

FEATURES

Alan L. Felsenfeld, DDS

An Ethical Imperative

The recent graduation of the first class at the University of Nevada School of Dental Medicine should have been a proud moment for the students and administration, but it was marred by a scandal involving alleged cheating in the completion of requirements for graduation. Ten students were identified as having allegedly forged instructor approval of required procedures. Surprisingly, the students were allowed to graduate but their diplomas were withheld pending an investigation of the allegations and penalization of those found guilty.

A similar event occurred at the University of Medicine and Dentistry of New Jersey, a school that has been plagued by accusations of fiscal mismanagement and faces potential loss of its accreditation. In this institution there were 18 students who were accused of trading credits for work completed either to help their classmates graduate or, in some cases, selling the credits.

As onerous as these allegations are, these are only two of the schools that face this problem today. In discussion with educators from institutions within our state, the problem of cheating within the schools is a pervasive and a significant one. One of the basic rights in this country is that anyone who is accused of misconduct should have the right to due process to hear the evidence with punishment appropriate to the action. That is not a debatable concept. Nor should cheating in professional school or any other educational environment be debatable. Those found guilty should be punished appropriately.

Arguably there could be mitigating circumstances that might engender such nefarious behavior. Ever-increasing academic requirements with multiple difficult courses challenge even the most brilliant of our students. Couple that with numerous and diverse clinical requirements and potential difficulty in completing the procedures necessary for graduation and there exists continual pressure on the student who most often lacks control of their patient care environment.

Others have suggested that cultural values bring altered ethical standards for subsets of the student population. Some have commented that generational values are changing and that contemporary students might view educational deceitfulness rational when more traditional individuals find it reprehensible. It is difficult to justify any actions that are less than honest under any circumstances.

Those found guilty should be punished appropriately.

Dentistry is a cottage industry with individuals who practice alone, unsupervised, and unchecked. Acceptable treatment rendered to patients is limited by patient desire and finances, and is not overseen at any level by peers. Unlike physicians who tend to use hospitals with extensive quality assurance review systems in place, dentists answer to no other professionals. Absent peer review claims or lawsuits, little that is done in dental offices is ever evaluated.

Ethical behavior can be defined as what you do when no one is looking. These students are unethical at this stage in their career and there is little reason to believe that their value system will change once they are out of school. What they did was blatantly wrong and inexcusable.

A licensing board that grants a license to a student who is guilty of cheating to complete school or, ethically worse, any school that grants a diploma to such a student is compromising the standards of our profession. If students cheat to get though requirements one can only assume that they might do dentistry that is not necessary, or convince patients to agree to a high-priced treatment plan when a less-expensive and equally efficacious plan would be acceptable. Similarly, they could be capable of fraud by billing for services that are over classified or never performed.

The two dental schools that have been accused in these scandals are only examples of a problem that pervades society. Recent events in corporate America have brought a wry definition to the oxymoron of business ethics. There is no circumstance under which we can even begin to allow such attitudes in a profession that is based on, and has been for so many years, a model of fidelity to the public.

Dentistry is a noble profession that inherently has been given the public trust. As a profession, we are responsible for policing ourselves and the actions of our colleagues. Any of our students or members who cannot be honest within these parameters should not be allowed to practice. **No exceptions.** ■■■■

Another Option

I feel that Dr. Peter J. Scelfo omitted a critical option in his letter to the editor June 2006 *Journal* "All Is Not So Simple" in which he charges that we can condemn many teeth to eventual fracture when we place over-large amalgams.

Many studies have been done showing that cusps capped in amalgam can be very long-lasting.

Certainly, wide MOD amalgams in which the remaining enamel is not supported by sufficient dentin can lead to fractures in subsequent years (as could wide MOD gold inlays). Certainly, amalgam does not have the edge strength of gold. Amalgam is not the material of choice for overextended restorations.

Nevertheless, we have all had large amalgams last for many years when this material must be used because of its lower cost. When cuspal areas are weak and undermined, the dentist should cap the cusp in amalgam. Many studies have been done showing that cusps capped in amalgam can be very long-lasting. My own experience verifies this.

Donna B. Hurowitz, DDS
San Francisco

Table Clinic Winners

Each year, the California Dental Association invites dental and dental hygiene students from across the state to enter the Table Clinic Competition at the Anaheim Scientific Session. The first-place finishers in each category receive certificates, cash awards, and an invitation to write an abstract of their work to appear in the Journal of the California Dental Association. Following are the winners of the 2006 table clinic competition.

Clinical Student Winners

CBCT (NewTom 3G) Bracket Plane Artifacts Generated by Four Orthodontic Bracket Materials

Matthew Sanders, Christian Hoybjerg, Curtis Chu, V. Leroy Leggitt, and Jay Kim, Loma Linda University School of Dentistry.

Objectives:

This study evaluated the artifacts generated by four types of orthodontic brackets in images produced by the NewTom 3G cone-beam CT machine.

Methods:

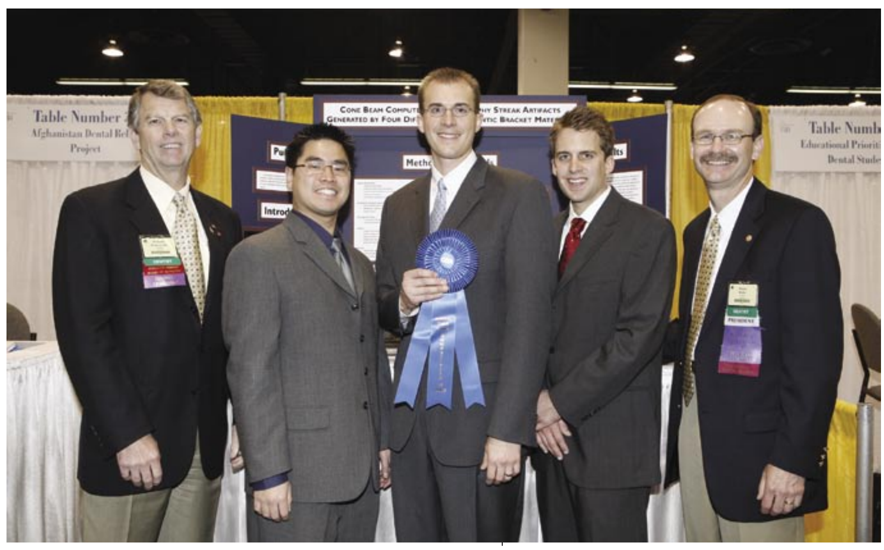
Three cadaver heads were prepared for NewTom 3G scanning by extracting all teeth containing metallic restorations and replacing them with unrestored teeth. Holes (1 mm in diameter) were drilled perpendicular to the occlusal plane in the mesial and distal occlusal pit of all four left-side premolars. Eight thermoplastic trays were constructed for each cadaver to hold a set of orthodontic brackets (stainless-steel, titanium, plastic, ceramic) in ideal positions on the cadaver dental arches (12 brackets per arch). Trays without brackets were used as controls. Twenty-five scans were performed on each cadaver head (five scans per bracket material or control). Standardized 0.5 mm-thick axial slices centered on the maxillary and mandibular bracket planes were analyzed for grayscale contrast with NIH Image analysis software (v. 1.62) along two transects: 1) an anterior tooth transect (canine to canine); and 2) a premolar transect. A Kruskal-Wallis ranks test and a Mann-Whitney U-test were performed at the $\alpha=0.05$ level of significance.

Results:

Stainless-steel brackets caused a statistically significant reduction in grayscale contrast when compared with the control ($p<0.0001$).

Conclusions:

Stainless-steel orthodontic brackets cause NewTom 3G bracket plane artifacts that reduce the contrast between normal dentin and artificial dentin defects. This type of radiologic artifact may inhibit the clinicians' ability to detect carious lesions in dental tissues along the bracket plane.



Dr. Richard Rounsavelle, far left, and CDA President Dr. Dennis Hobby, far right, congratulate Curtis B. Chu, Christian J. Hoybjerg, and Matthew A. Sanders who received first place in the clinical student table clinic competition.

To request a printed copy of this article, please contact / Matthew Sanders, 11442 Anderson St., Loma Linda, CA 92354.

Scientific Student Winners

Farnesol Inhibits C. Albicans *Biofilm Formation on Denture Acrylic*

Jane Yi, Andrew John, Loma Linda University School of Dentistry

Purpose:

The purpose of this study was to demonstrate the effectiveness of farnesol in inhibiting the formation of *Candida albicans* biofilm on denture acrylic.

Materials and Methods:

Acrylic discs were placed in four flasks, representing the following: negative control, positive control, 30µg/mL farnesol, and 300 µg/mL farnesol. CFU count and SEM viewing were performed at seven and 14 days. The data was statistically analyzed using the Mann-Whitney U-test, with $\alpha=0.05$ and a Two-Way ANOVA, with $p>0.050$.

Results:

Growth in positive control was significantly lower than in all farnesol samples. Growth in negative control was significantly higher than in all farnesol samples. Moreover, both length of incubation and concentration of farnesol had statistically significant effects.

Conclusion:

Farnesol, an FDA-approved food additive, effectively inhibits the formation of *C. albicans* biofilm on denture acrylic and has tremendous potential as a means of preventing oral candidiasis in denture patients.

To request a printed copy of this article, please contact / Jane Yi, jyi07d@llu.edu.

Andrew John and Jane Yi take a moment at their scientific table clinic with Drs. Rounsavelle and Hobby during the Spring Session in Anaheim.

Dental Hygiene Student Winners

Oral Health Care in American Sign Language

Shanan M. Carlson, Heather S. Neufeld, and Joseph D. Jordan, Loma Linda University School of Dentistry

Abstract:

Currently, there is a disparity of dental education among the deaf community. Increased access to dental care has been stressed by Healthy People 2010, the American Dental Association, and the American Dental Hygienists' Association. This study's purpose was to determine the effectiveness of an oral health care video presented in American Sign Language for the deaf.

Materials and Methods:

The dental school's support services media center was utilized to film and edit an oral health care video in American Sign Language. The actors in the video used ASL as a means of communication and explanation. Three objectives were emphasized in the video to accomplish the authors' goal to introduce and emphasize how better oral hygiene and diet is the secret to the long-term success of oral health. The first objective was to create a deaf-friendly communication environment in the dental office. The second objective was to demonstrate brushing and flossing technique on a typodont. The third objective was to discuss nutritional habits with an emphasis on minimal snacking. Following the completion of the video, the authors went to the California School for the Deaf in Riverside where a pre- and postsurvey of the video was completed with 80 children between the ages of 10 and 14.

Results:

The results of the surveys revealed overall positive behavior modifications in attitudes toward visiting a dental office and maintaining good oral hygiene. There was an increase in brushing and flossing frequency, as well as a decrease in the frequency of sugar consumption.

Conclusion:

Oral Health Care in American Sign Language is an effective means of communicating fundamental oral health care instruction to the deaf as evidenced by positive behavior modifications.

Clinical Significance:

Oral Health Care in American Sign Language is clearly a valuable tool in presenting oral health care education to the deaf, due to positive behavior modifications noted from the survey results. This study demonstrates a means for increased access to dental care and education by this special population.

To request a printed copy of this article, please contact / Heather Neufeld, hneufeld@llu.edu.

From left, dental hygiene students Heather S. Neufeld, Joseph D. Jordan, and Shanan M. Carlson receive a blue ribbon from Drs. Rounsavelle and Hobby for their table clinic Oral Health Care in American Sign Language.

Dan Hubig

Advances, Understanding Help Alleviate Fear

By Dell Richards

As a kid, Daniel Vaillancourt was so afraid of the dentist, he had to be put to sleep to have fillings. For exams and cleanings, nitrous oxide was the only way to handle his fear.

"I was kicking and screaming and trying to bite the dentist," said the Los Angeles screenwriter. "Even at the pediatric dentist, they put a 'Pinocchio nose' on me with gas in it."

As dentists know, fear causes many people to neglect their teeth. Not so for Vaillancourt, who goes regularly, despite the fact he has to be numbed for a cleaning, uses calming imagery to get through the visit, and will begin hyperventilating if a procedure takes too long.

Fear also means the practice of dentistry itself can be more stressful for the dentist.

Luckily, new technologies have come on the market that help deal with patient anxiety. Psychological remedies such as hypnotherapy also are gaining acceptance. Unlike many dentists who find the anxiety rubs off — making the experience worse for everyone — some dentists feel that bringing patients back to health through dentistry is part of their calling.

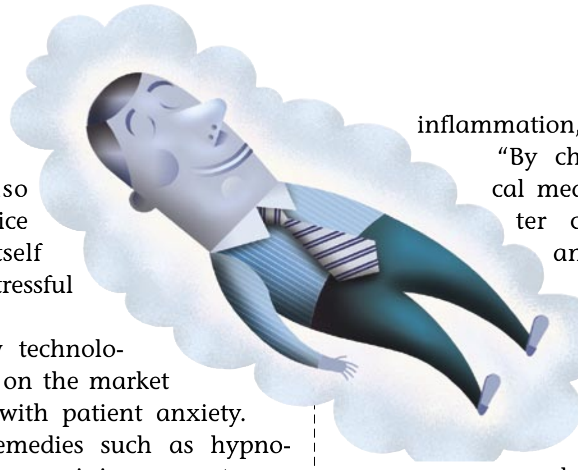
The Alpha-Stim recently became available in the United States, although dentists in the United Kingdom have used it for a number of years.

FDA-approved for anxiety, depression, and insomnia, Eric Hassid, MD, also uses it for pain management with his neurological rehabilitation patients. "We use a lot of modalities in our pain program, but to be very honest, the (cranial electro-therapy stimulator) unit is one of the most effective," said the medical director of the Davis Institute for Restorative Health.

The Alpha-Stim takes advantage of the electrical potential that crosses the cell membrane that facilitate chemical reactions. According to the manufacturer, the unit moves electrons through the brain at a variety of frequencies, collectively known as harmonic resonance, which normalizes the electrical activity of the brain.

Like a transcutaneous electrical nerve stimulation, or TENS, unit, it allows the patient to control the flow, lack of control being a key problem for many dental patients, though at a lower current.

Hassid uses the cranial electrotherapy stimulator that calms anxiety and creates a sense of well-being, and the microcurrent electro-therapy stimulator for pain, inflammation, and healing.



"By changing the chemical mediators, you see better control of anxiety and insomnia with the CES," said the Davis doctor of the CES unit. "The (microcurrent electro-therapy) is a stealth bomber for areas that need help with pain."

Anything that changes the perception of pain also increases or decreases pain. "If you look at pain, perception can alter the pain response by as much as 50 percent," Hassid said.

This understanding also allows more dentists to embrace psychological aids such as hypnotherapy and guided visualization. Both these tools can help people replay the experience in their imagination to transform it from negative to positive. Like a basketball player who visualizes making hoop after hoop, this type of internal imagery can work wonders over time.

"It gives people a way to experience going to the dentist in their mind's eye in a positive way," said Lena Kibble, MFT, "which gives them a better frame of reference."

To be effective, guided visualizations often must be done many times. "For some people, they have to do it 50 times or more to deal with particular fears."

Although most people blame prior experiences with the dentist or enculturation from society, other factors often contribute. "Although patients can learn from the parents and siblings, people can be prone to anxiety because of genetics," the Napa and Sonoma psychotherapist said. "It can also mean you have been traumatized in some other way."

Having a dentist who acknowledges the patient's struggle is essential. "Dentists need to show that they really appreciate

"By changing the chemical mediators, you see better control of anxiety and insomnia with the CES."

ERIC HASSID, MD

the effort the patient has made to get there," Kibble said. "Just giving medicine is not enough. They need to say something to acknowledge the struggle and the positive step the person has taken."

More dentists are starting to do that. Scott Snyder, DDS, is willing to put in extra time to deal with phobic patients. "Taking the time to find out what specifically the patient doesn't like gives me the opportunity to get to know the patient better," the Sacramento general dentist said. "From their past experiences, I find out where they're from and what they're about, things I always enjoy."

Snyder also has patients bring a buddy to the office. "Using the buddy system makes sure the person doesn't come up with some last-minute excuse to get out of it," Snyder said. A friend also gives them someone to talk to while waiting.

Being willing to admit the invasiveness of working in someone's mouth also helps the process of acceptance. "It all leads back to communication," said Snyder.

Sometimes dentists get so carried away by their own technical prowess, they forget what the experience is like for the vast majority of people. "They forget that going to the dentist is like having surgery," Kibble said. "Dentistry has come a long way, but it hasn't come that far."

A practicing journalist, Dell Richards runs Dell Richards Publicity, a public relations firm specializing in dentistry, health care and technological innovation.

"Dentistry has come a long way, but it hasn't come that far."

SCOTT SNYDER, DDS

Periodontitis May Increase C-reactive Protein Levels in Pregnancy

Researchers have found that pregnant women with periodontitis had 65 percent higher C-reactive protein levels compared to their periodontally healthy counterparts, according to a recent issue of the *Journal of Periodontology*.

"Elevated CRP may indeed be caused by periodontal infection and inflammation," said Dr. Waranuch Pitiphat, DDS, Department of Community Dentistry, Faculty of Dentistry, Khon Kaen University, Thailand. "If this is the case, CRP could amplify the inflammatory response and ultimately cause adverse pregnancy outcomes. Alternatively, periodontal disease and CRP may share a common risk factor for predisposing individuals to a hyperinflammatory response. More research is clearly needed to further our understanding about the association between periodontal disease and adverse pregnancy outcomes."

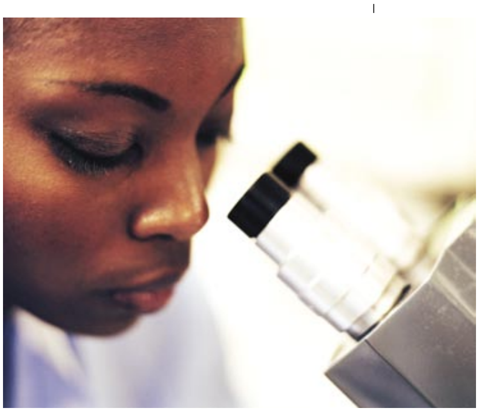
CRP levels, a marker of systemic inflammation, are associated with periodontal disease. CRP also has been associated with adverse pregnancy outcomes, including preterm delivery and pre-eclampsia. Previous studies examining the relationship between CRP and periodontal disease found that often after standard nonsurgical periodontal therapy, CRP levels decreased.

"This is one more study that really drives home the importance of taking care of the entire body including oral health," said Kenneth A. Krebs, DMD, and AAP president. "In addition to this study about the relationship between CRP and pregnant women with periodontal disease, previous studies reported that inflammatory effects from periodontal disease could cause the liver to make proteins such as CRP that inflame arteries causing blood clots that contribute to heart attacks or strokes."

Data supporting the association between CRP and periodontitis is only based on studies in men and nonpregnant women. This is the first study that looked at the association between CRP and periodontitis in pregnant women. These findings are consistent with previous studies conducted among men and nonpregnant women. CRP was higher in people with periodontal disease compared to those without disease.

For additional information about periodontal disease and treatment, go to the academy's website www.perio.org. A brochure, "Women and Periodontal Diseases" is available by calling (800) FLOSS-EM.

Natural Tumor Suppressor Discovered



Researchers at the University of California at Los Angeles School of Dentistry, studying a basic human protein vital in processing and metabolizing RNA, have found it works as a natural tumor suppressor effective against neck and head cancer.

The findings were reported in the May 15 issue of *Clinical Cancer Research*.

The protein, heterogeneous nuclear ribonucleoprotein G (hnRNP G), was, until now, possibly the least investigated of a class of 30 ribonucleic acid-binding proteins with diverse biological functions.

While researchers readily detected hnRNP G in healthy skin tissue, they reported they did not find the protein in the vast majority of precancerous and cancerous tissues. Furthermore, the UCLA scientists presented evidence that hnRNP G injected into human oral squamous cell carcinoma, HOSCC, cells is effective in inhibiting the proliferation and tumor-forming capacity of HOSCC in test tubes and in an animal model.

These findings suggest the protein has value in the development of new ways to diagnose and treat HOSCC.

According to the National Cancer Institute, most neck and head cancers can be attributed to this type of cancer, which begins in the squamous cells lining the mucosal surfaces in the head and neck. It is estimated that about 40,000 individuals will develop a form of head and neck cancer this year.

"If we know that hnRNP G is present in healthy cells but absent in precancerous and cancerous cells, then we should be able to design a test to diagnose HOSCC by measuring the level of this protein present in a tissue sample," said No-Hee Park, PhD, DDS, MS, professor of diagnostic and surgical sciences, dean of the UCLA School of Dentistry, and a member of UCLA's Jonsson Cancer Center. "Our examination of the unique biological properties and functions of hnRNP G represents one small step toward a better understanding of carcinogenesis as well as improved methods of early diagnosis and treatment."

Track a Practice's Progress Using Profit-and-Loss Statements

Utilizing a profit-and-loss statement may assist practice owners to calculate the amount of money they bring in compared to the total spent to provide services.

In the June 2006 issue of *Colorado Dentistry*, Debra Lane, a certified public accountant, commented on how a profit-and-loss statement helps a business owner figure out net profits as well as see how efficiently the business is being run.

For example, when using a profit-and-loss expense account, it is beneficial to divide them into subgroups. Lane suggested using the following: production, staff, facility, administration, depreciation and amortization, and doctor's compensation. She further recommended using a profit-and-loss statement to make sure expenses as a percentage of income are shown, which is helpful in tracking a practice's progress from year to year. Typically, she wrote, expenses of a dental practice look like this:

- Overhead: Less than 62 percent, calculated before depreciations, amortization, and doctor's compensation,
- Lab fees: 8 percent to 12 percent,
- Dental supplies: 4 percent to 6 percent,
- Staff expenses: 24 percent to 28 percent,
- Facility expenses: Less than 8 percent, and
- Administrative expenses: 8 percent to 12 percent.

The article also suggested that a dentist with expenses (overhead, for example) higher than the industry norm should take the time to find out why.

Latest Guidelines for Handling Disaster Victims

First responders have a new field manual that offers step-by-step directions on how to recover and identify disaster victims while respecting the needs and rights of their survivors.

Chapters in the book provide guidance and useful data on additional subjects, including the health risks posed by corpses, the proper methods of storing them, communications and the media, as well as providing support to families and relatives. The book also provides practical annexes, including Dead Body Identification and Missing Persons forms, and a chart of sequential numbers for unique referencing of bodies.

Management of Dead Bodies After Disasters: A Field Manual for First Responders was published recently by the Pan American Health Organization, the World Health Organization, the International Committee of the Red Cross, and the International Federation of Red Cross and Red Crescent Societies.

The manual's goal is facilitating proper identification of victims and preventing mass cremations and burials. The book also dispels the widely held inaccuracy that cadavers pose a serious health threat following disasters.

"After most natural disasters, there is a fear that dead bodies will cause epidemics," said Oliver Morgan, an honorary research fellow at the London School of Hygiene and Tropical Medicine and one of the book's three co-editors. "This belief is wrong — most infectious organisms do not survive beyond 48 hours in a dead body, and it is the surviving population that is more likely to spread disease."

"Most infectious organisms do not survive beyond 48 hours in a dead body, and it is the surviving population that is more likely to spread disease."

OLIVER MORGAN

Four Dental Schools Share Funding in Support of Evidenced-based Dentistry

Four dental schools are sharing $100,000 in competitive grants from the American Dental Association Foundation to conduct oral health research.

Entries from the winning schools were in response to a request for proposals in support of evidenced-based dental research. The request for proposals, issued last fall, was for systematic literature reviews, seeking answers to four questions in three oral health areas: root canal therapy, teeth alignment, and professional dental cleanings.

In a joint submission, applicants from Loma Linda University School of Dentistry and the University of California at Los Angeles School of Dentistry received funds to compare the clinical, biological, and psychosocial outcomes of treating a single tooth with the following: root canal, tooth extraction, tooth extraction with implant placement, or placement of a fixed-partial denture. The proposal also called for the investigation of the long-term effects of root canal therapy compared with tooth extraction and implant placement.

Recipients at Boston University's Goldman School of Dental Medicine will use their grant to address how often professional dental cleanings are required to prevent periodontal disease in patients at risk and not at risk for developing the disease.

Researchers at the University of Washington, School of Dentistry, in Seattle, will use their award to determine if correcting malocclusion in children and adults reduces the risk for developing periodontal disease.

The dental research awards are part of the ADA Foundation's annual request for proposals program that rotates among key program areas: research, education, and access to care. Next year's request for proposals will focus on access-to-care programs.

Honors

William Lundergan, DDS, MA, of Novato, and **Lisa Harpenau, DDS, MS, MBA**, of San Francisco, faculty members with the department of periodontics at University of the Pacific, Arthur A. Dugoni School of Dentistry, received the Thomas P. Nowlin Best Performance by a Section Award from the American Dental Education Association.

Dr. Torabinejad accepts his Vanguard Award.

During the final gala of the Loma Linda University Adventist Health Sciences Center Centennial Celebration, six faculty members and pioneers from the School of Dentistry were recognized with a Vanguard Award.

They were honored for their contributions to research and outreach to LLUAHSC Mission of Healing. Awardees included **Lloyd Baum, DMD**, one of the original four members of the school faculty; **James Crawford, DDS**, immediate past executive associate dean and director, health ministry department, General Conference; **Robert James, DDS**, a faculty member and pioneer in implant dentistry; **Niels Jorgensen, DDS**, who in 1953, when the school opened, joined as professor and chair, department of oral surgery as well as developing early techniques in dental anesthesia and painless dentistry; **Mahmoud Torabinejad, DMD**, program director, advanced education program in endodontics and a leader in endodontic research; and **Melvin Lund, DDS**, who was named a charter member of the school's Society of Scholars and who chaired the department of restorative dentistry in 1959.

Drs. James and Jorgensen were given the award posthumously.

Dennis Shinbori, DDS, was elected chair of the American Dental Association Council on ADA Sessions recently. He will lead the council as they plan for the 2008 Annual Session in San Antonio.

Upcoming Meetings

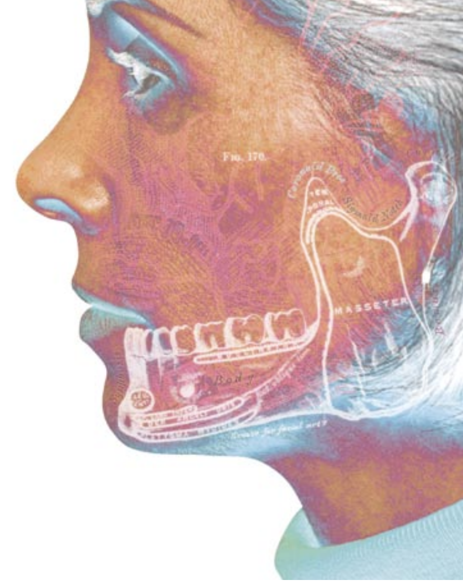
2006

Sept. 15-17	CDA Fall Session, San Francisco, (866) CDA-MEMBER (232-6362).
Sept. 28-30	17th International Congress of Head and Neck Radiology, Budapest, Hungary, Eva Schiff at Redhill Travel, (415) 924-3229.
Oct. 7-11	Pacific Coast Society of Orthodontists 70th Annual Session, Honolulu; Oct. 11-13 post-meeting program, Poipu Beach, Kauai; www.pcsortho.org, (415) 674-4500.
Oct. 16-19	ADA Annual Session, Las Vegas, (312) 440-2500.
Nov. 2-4	Hispanic Dental Association 14th Annual Meeting, Universal City, www.hdassoc.org or (217) 793-0035.
Nov. 5-11	United States Dental Tennis Association, Palm Desert, www.dentaltennis.org.
Nov. 12-18	57th American Academy of Oral and Maxillofacial Radiology 57th Annual Session, Kansas City, MO., www.aaomr.org.
Dec. 3-6	International Workshop of the International Cleft Lip and Palate Foundation, Chennai, India, (91) 44-24331696.

2007

April 15-21	United States Dental Tennis Association, Sarasota, FL, www.dentaltennis.org.
May 3-6	CDA Spring Session, Anaheim, (866) CDA-MEMBER (232-6362).
Nov. 27-Dec. 1	American Academy of Oral and Maxillofacial Radiology 58th Annual Session, Chicago, www.aaomr.org.

To have an event included on this list of nonprofit association meetings, please send the information to Upcoming Meetings, *CDA Journal,* 1201 K St., 16th Floor, Sacramento, CA 95814 or fax the information to (916) 554-5962.



Use of Osseointegrated Implants in the Restoration of Head and Neck Defects

Eleni D. Roumanas, DDS; Ting-Ling Chang, DDS; and John Beumer, III, DDS, MSc

ABSTRACT

Osseointegrated implants can be applied to facilitate retention, stability, and support for facial and intraoral prostheses used to restore head and neck defects. At the University of California, Los Angeles, Maxillofacial Prosthetics Clinic, retrospective studies have indicated that in nonirradiated maxillectomy patients, implant survival rates are 82.6 percent. In mandibles reconstructed with fibula free flaps, survival rates are 94.6 percent. Similarly, high implant survival rates have been observed for most sites used to support facial prostheses. Cumulative six-year survival rates for auricular sites exceed 95 percent and for floor of nose sites, success rates exceed 87 percent. However, survival rates are low (53 percent) for implants placed in the frontal bone for retention of orbital prostheses and even lower for irradiated bone sites ranging from 63 percent in the maxilla to 27 percent in the orbit.

Surgical resection of head and neck tumors often create large defects accompanied by dysfunction and disfigurement, and radiation therapy produces significant morbidity and unique tissue management problems. Speech, swallowing, control of saliva, and mastication can be adversely affected. Prosthetic restorations may be necessary in the rehabilitation of these defects. However, appropriate retention, stability, and support must be provided for the prosthesis if successful results are to be achieved. Osseointegrated implants have been shown to be useful in the restoration of these patients. The purpose of this paper is to review the experience gained at University of California, Los Angeles, and compare these experiences with others.

Guest editor / Eleni D. Roumanas, DDS, is a professor and director, Graduate Prosthodontics, Division of Advanced Prosthodontics, Biomaterials and Hospital Dentistry, University of California, Los Angeles, School of Dentistry, and The Weintraub Center for Reconstructive Biotechnology.

Authors / Ting-Ling Chang, DDS, is a clinical associate professor and chair, Section of Removable Prosthodontics, Division of Advanced Prosthodontics, Biomaterials and Hospital Dentistry, UCLA School of Dentistry, and The Weintraub Center for Reconstructive Biotechnology. John Beumer, III, DDS, MSc, *(not pictured)* is a professor and chair, Division of Advanced Prosthodontics, Biomaterials and Hospital Dentistry, UCLA School of Dentistry, and The Weintraub Center for Reconstructive Biotechnology.

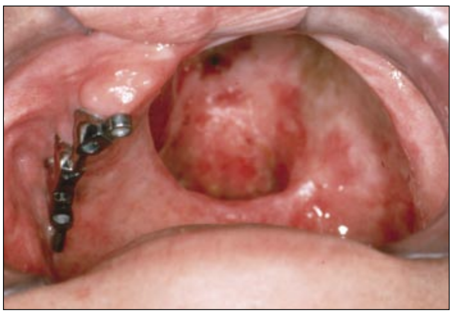


Figure 1. Total maxillectomy defect in edentulous patient with implants placed in the remaining premaxilla.

Figure 2. Tissue surface of a maxillary obturator.

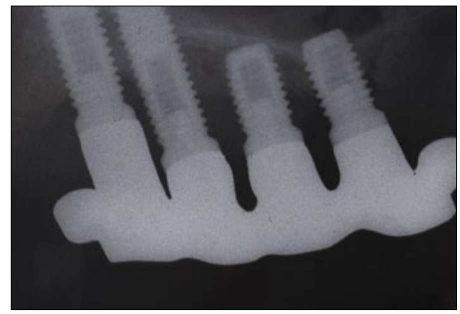


Figure 3. Implants demonstrating excessive bone loss.

Maxillary Defects

Maxillectomy defects produce a variety of functional problems and cosmetic deformities. The loss of dental structures and/or denture-bearing tissue surfaces may make mastication difficult, particularly for edentulous patients. Swallowing is awkward since food and liquids may be forced up into the nasal cavity and out the nose. Hypernasality affects speech intelligibility, and facial disfigurement can result from lack of midface bony support. In some cases, tumor invasion superiorly requires exenteration of the orbital contents.

Maxillary obturators provide an effective means of rehabilitation of maxillary defect patients.[1,2] Although surgical reconstruction is an option, it is rather complex with a less predictable outcome.[3] Compromised retention, stability, and support are the main problems encountered when designing and fabricating an effective obturator prosthesis. The difficulty is dramatically accentuated when the residual maxillary segment is edentulous. Remaining teeth or properly positioned osseointegrated implants, or a combination of these two, therefore become important assets if a desirable outcome is to be achieved. In edentulous patients, implants provide retention, enhance support, and improve the stability of the obturator prosthesis. Mastication is significantly improved, and speech and swallowing are made more efficient. However, the maxillectomy defect must be properly designed and prepared during tumor ablation so that the forces generated during oral function can be shared between the implants, the tissues of the defect, and residual denture bearing surfaces. Implants alone are not capable of providing total support for the obturator and excessive nonaxial loads result in severe bone loss.

The most desirable site for implants for most edentulous maxillectomy patients is the residual premaxillary segment[4,5] (**Figure 1**). This site is preferred because the anterior maxillary segment is diagonally opposite the most retentive portion of the defect, the skin-lined posterior lateral wall. In addition, satisfactory volume and density of bone can be found in the residual premaxilla in most patients. The maxillary tuberosity, posterior alveolar ridge, and the zygoma are considered secondary sites. In the maxillary tuberosity, the trabecular bone is not very dense, initial implant anchorage is difficult to achieve, and the bone-implant interface formed may not ensure a predictable long-term result. The edentulous posterior alveolar process may serve as an alternative site if there is at least 10 mm of bone available between the crest of the alveolus and the maxillary sinus. In nonirradiated patients, if insufficient bone is present, the site may be augmented by elevating the sinus membrane and grafting the sinus with bone. This technique has become a popular option when treating conventional patients, but its predictability in maxillary defect patients has yet to be determined. Residual elements of the zygoma within the maxillectomy defect have also been used as implant sites. However, there are important disadvantages to be considered. First, the implants will be located high in the defect making oral hygiene very difficult for the patient. Second, because of angulation problems, the implants can only be used to facilitate retention. In defects lined with a skin graft with good posterior lateral wall undercuts, implants placed in the zygoma make only a limited contribution to retention on the defect side of the prosthesis. Zygomaticus implants (Nobel Biocare USA, Yorba Linda, CA) placed into the unresected side of the maxilla have also been attempted in this group of patients, with some reported success.[6]

The authors' experience indicates that implants can be used successfully in total or partial maxillectomy patients in order to help retain obturator prostheses[5] (**Figure 2**). Initial results, however, were disappointing. Implant failures can be grouped into two categories: 1) early, when implants are removed because they fail to achieve a state of osseointegration, and 2) late, when implants fail after being subjected to clinical function for a year or more. In the anterior maxilla most failures occurred "late" or after loading, secondary to progressive bone loss (**Figure 3**). In contrast, in the maxillary tuberosity where the bone quality is generally poorer, virtually all of the implant failures were "early" or prior to functional loading. In the tuberosities, once osseointegration was achieved and the implants were placed into function, bone levels did not appear to deteriorate over time.

In recent years, it has become increasingly clear that implant overload precipitates a resorptive remodeling response of bone around the implants.[7] Brunski has proposed the following mechanisms.[8] Application of excessive occlusal loads result in microdamage of the surrounding bone (fractures, cracks, delaminations). This microdamage elicits a response from osteocytes imbedded within bone precipitating a resorption remodeling response resulting in increased porosity of bone adjacent to the implant.[9] This vicious cycle proceeds — continued loading, causing more microdamage and more porosity — until implant failure.

In maxillectomy patients, the authors were frequently unable to place sufficient numbers of implants of sufficient length, with adequate anterior posterior spread to withstand the forces generated by large obturator prostheses. In retrospect, the early tissue bar designs were "implant-supported" i.e., most, if not all, of the forces generated during function were borne by the implants, particularly the implants adjacent to the defect. Designs used in association with implants placed in the maxillary tuberosity tended to be implant assisted, i.e., forces generated during function were shared between the implants, the residual denture bearing surfaces and the maxillectomy defect. When the tissue bars were replaced with implant-assisted designs specifically tailored for maxillectory defects based on a series of photoelastic analysis studies conducted in the lab, late implant failures were dramatically reduced.[4]

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Mandibular Defects

Disabilities associated with tongue-mandible defects include impaired speech articulation, difficulty swallowing, deviation of the mandible during functional movements, malocclusion, poor control of salivary secretions and severe cosmetic disfigurement. In the past, these patients presented a far more difficult rehabilitation problem than did patients with maxillary surgical defects, particularly if significant portions of the tongue were involved in the resection. A number of factors affect the patient's functional status after resection.[10]

- The impairment of motor and/or sensory control, in particular the integrated neuromuscular balance between the tongue, lips, and cheeks, limits the ability of the patient to control saliva, the food bolus, and dentures during function.
- Loss of tongue bulk and immobility of the residual tongue element caused by surgical closure further inhibit the patient's ability to intelligibly articulate speech sounds, swallow, and manipulate saliva, the food bolus, and dentures.
- Deviation of the mandible and the angular pathway of mandibular closure induces lateral forces upon removable prostheses that tend to dislodge them.
- The deviation of the mandible at closure creates abnormal maxillomandibular relationships that may prevent proper occlusion of the residual dentition or ideal placement of the denture teeth over their supporting structures.
- Frontal plane rotation and unilateral forces of occlusion tend to tip and dislodge both maxillary and mandibular dentures during function.

Two developments have reduced the severity of the disabilities associated with composite resection of tongue, floor of mouth, mandible and tonsillar neoplasms — microvascular free flaps and osseointegrated implants.[11-16] In the 1980s, pedicled myocutaneous flaps were used to replace the resected soft tissues and these flaps eliminated the need to approximate the tongue margin to the cheek margin for primary closure of the defect. The residual or reconstructed tongue had improved mobility and was better situated to control the air stream during articulation and manipulate the bolus during mastication. Free flaps (iliac crest, fibula, radial forearm, scapula, lateral thigh, etc.), introduced in the early 1990s improved the patient's post-resection function even more dramatically.[13-16] These flaps are particularly useful in replacing the bulk of the anterior two-thirds of the tongue because they demonstrate improved flexibility, resulting in less inhibition of tongue mobility. If the patient has dentition

Figure 4. Hypertrophic tissue around implant bar which emerges through skin in a fibula reconstructed mandible.

Figure 5a. Lateral mandibular defect with implants and milled tissue bar.

Figure 5b. Removable implant overdenture was used to restore lost dentition and alveolar ridge contour.

remaining in the unresected portion of the mandible or implants to retain a prosthesis, these patients may be able to masticate at a reasonable level dependent upon the amount of remaining tongue and innervation.[17,18]

The bone associated with free flaps, particularly the fibula, present with prominent cortical plates, which when properly engaged, provide excellent stabilization for the implants. The reported success rates of implants in fibula flaps are generally more than 95 percent.[19-21] Two major challenges are encountered when placing implants into these patients. The first is for the surgeon to properly position the implants. This is best accomplished with the use of a surgical template. Placement of implants at the time of tumor ablation is not recommended.[22] The second is to create thin, attached, keratinized peri-implant tissues around the implant. Bulky soft tissues overlying the bone of free flaps must be carefully thinned and attached to periosteum. Ideally, the thickness of the tissues adjacent to the implants should not exceed 4 mm. If the tissues are not thinned sufficiently, deep peri-implant pockets will result that predispose to infection. Peri-implant soft tissue hypertrophy is a common problem when implants emerge through skin in the oral cavity (**Figure 4**). This may be the skin's reaction to environmental changes. The oral cavity presents a moist, warm environment with a variety of new microbial challenges. Use of highly polished metal bars or porcelain restorations, strict hygiene maintenance and daily use of chlorhexidine oral rinse appear to ameliorate the problems with hypertrophy. In severe cases, palatal mucosal grafts may be necessary.

The question is whether the placement of implants into bone grafts or flaps used to restore mandible defects of dentate or edentulous patients improves masticatory performance, the data is limited.[18,23] Masticatory performance may theoretically be improved with implants in these patients when motor and sensory innervation of the tongue is retained. However, the lingual nerve and hypoglossal nerves are frequently sacrificed during composite resection, particularly of lateral tongue and/or lateral floor of mouth tumors. These neurologic deficits prevent patients from detecting or manipulating the bolus on the defect side regardless of how effectively the bone, dentition, and soft tissue defects have been restored. So-called "sensate flaps" have not proven to be beneficial because the nature of the sensory feedback is not sufficient for the patient to detect, manipulate, or control the food bolus.

The objective of the prosthesis extension into the side of the defect is for lip support, esthetics, prevention of eruption of opposing dentition and speech. These objectives can be met with a conventional removable partial denture, providing the residual dentition on the nonresected side is in reasonable condition. If motor and sensory innervation on the reconstructed side is intact, the use of implants is justified and may enable efficient mastication on the reconstructed side.[23]

Removable overlay prostheses with tissue bars are preferred for restoring these defects (**Figures 5a and b**). Support for mastication is provided by the implants and by the denture bearing surfaces or dentition available posteriorly. Denture flanges can be contoured to correctly position and support the lower lip. In addition, access for oral hygiene is made easier for the patient.

Free bone grafts, such as iliac crest, are still used for mandibular reconstruction in patients with nonmalignant tumors or patients who are unlikely to undergo postoperative radiation therapy. Implants are placed into the bone six to nine months later to allow consolidation of the graft. Free bone grafts demonstrate a homogeneous calcification pattern, which also results in an excellent bone implant interface.

Figure 6. Craniofacial implants with flange design.

Figure 7a. Nasal implants with tissue bar designed for hygiene access. Vertical and horizontal Hader clips securely retain nasal prosthesis.

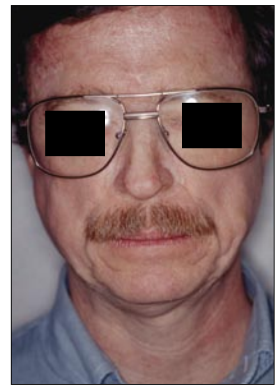

Figure 7b. Eyeglass frames effectively hide margins of nasal prosthesis.

Implants placed in free bone grafts used to reconstruct this region have a high success rate.[24]

Facial Defects

Restoration of facial defects is a difficult challenge for both surgeons and prosthodontists. In the past, prosthodontic restorations had distinct limitations due to movable tissue beds, lack of retention of large prostheses, and the patient's acceptance of the prosthesis. The use of osseointegrated implants has eliminated some of these problems.[25-27] The retention provided by the implants makes it possible to use large prostheses resting on movable tissues. Patient acceptance is significantly enhanced because of the quality of the retention, and this enables the prosthodontist to fabricate thin margins in silicone which blend more effectively with peripheral tissues.[28]

Craniofacial implant fixtures were specifically designed to retain facial prostheses. They are available in 3 mm to 5 mm lengths, with or without a flange (**Figure 6**). The short lengths allow placement in areas with limited available bone. The flange, when present, facilitates initial stabilization of the implant and prevents accidental penetration into interior compartments of the cranium. In some locations (nasal floor, supraorbital rim, glabella) these implants may be used in combination with longer dental-type implants consistent with CT scan data of the amount of available bone. The position and angulation of the implants must be compatible with the proposed facial prosthesis. In most patients it is desirable to sculpt a wax replica of the prosthesis, and to use this replica to fabricate a surgical template. This template is sterilized and used at surgery as a guide to ensure the proper positioning and angulation of implants.

Once the facial prosthesis has been designed, the number and arrangement of the implants necessary to retain and stabilize the prosthesis are determined and the possible bone sites evaluated. In routine surgical defects sophisticated radiographic studies usually are not necessary. In extensive acquired defects or in some congenital defects, a CT scan and 3-D model of the cranium are valuable aids in evaluating potential implant sites and key adjacent structures.[29]

The skin and soft tissues overlying the proposed implant sites require careful evaluation. The health of the soft tissues surrounding osseointegrated implants is easier to maintain if these tissues are thin (less than 4 mm in thickness) and attached to the underlying periosteum. If the skin and soft tissues overlying the implant sites contain hair follicles or tissue remnants of past reconstructive procedures, these tissues should be considered for removal and replaced with a skin graft.

Success rates of osseointegrated implants used to restore craniofacial defects have been quite good, particularly for auricular sites. Success for the auricular sites have exceeded 95 percent in most studies and few complications have been encountered.[25,30,31] Minimizing the thickness of the peri-implant tissues will keep soft tissue complications to a minimum. Success rates for floor of nose sites are about the same as implants placed in the premaxillary segment. The authors' series indicates an 87 percent cumulative six-year survival rate.[31] All patients in the authors' series had undergone total or partial rhinectomy secondary to resection of malignant neoplasms. There have been few soft tissue complications associated with implants placed in the floor of nose site regardless of whether they penetrate mucosa or skin. However, the implants should not exit the mobile tissue of the lip and/or nasal labial-fold region. Design of the retention bar should allow sufficient space for hygiene maintenance (**Figures 7a and b**). Implants placed too far posteriorly into the nasal passage will compromise hygiene access and also lead to soft tissue problems.

The survival rates of implants placed in the frontal bone and around the orbit have been disappointing (**Figures 8a and b**). The authors' failure rates are three to four times greater than that seen with the auricular or floor of nose sites. The survival rate in nonirradiated orbital defects was 55 percent. The survival rates are particularly diminished if the implant sites have previously been irradiated. In the authors' series, the survival rate for implants placed in the irradiated frontal bone was 27 percent. The dosages delivered to the implant sites ranged from 45 to 60 Gy. Of particular interest is the fact that many of the remaining implants demonstrated signs of impending implant failure such as flange exposure, soft tissues reactions, and obvious bone loss.

There appears to be a direct correlation between the level of hygiene compliance and soft tissue reactions at all sites. In the authors' experience, the orbital implants are the most difficult for the patients to clean and have the highest rates of peri-implant tissue reactions. The floor of nose implants are the easiest to clean and have the lowest rate of soft tissue reactions. For all sites, when hygiene improved the inflammatory soft tissue, reactions subsided or were eliminated.[32-34]

Figure 8a. Craniofacial implants in irradiated frontal bone demonstrating bone loss, flange exposure, and soft tissue inflammation.

Figure 8b. Loss of integration of irradiated orbital implants.

Implants in Irradiated Tissues

Irradiation of head and neck tumors predispose to vascular changes in bone, skin, and mucosa, which affect the predictability of osseointegrated implants. Long-term function of osseointegrated implants is dependent on the presence of viable bone that is capable of remodeling as the implant is subjected to stresses associated with supporting, retaining, and stabilizing prosthetic restorations. The viability of irradiated bone may not be sufficient to ensure a predictable result, particularly in anatomical sites such as the supraorbital rim and the body of the mandible. Even in the maxilla remodeling and turnover of bone subjected to high-dose radiotherapy (above 50 Gy) may be adversely affected to the point where an implant subject to functional stresses cannot be sustained.

Reported results indicate that the success rates of osseointegrated implants in irradiated bone appear to be dependent upon the anatomical site selected, the dose to the site, and the use of hyperbaric oxygen. Animal experiments have shown that the quantity of the bone at the bone-implant interface (bone implant appositional index) is reduced in irradiated bone.[35] Other investigators have shown that the quality of bone in the implant appositional zone is compromised, particularly at high-radiation dose levels.[36] These studies reveal a steady decrease in cellular activity in bone, especially when the equivalent dosage exceeds 58 Gy.

Clinical reports appear to substantiate the concerns raised in the animal studies; namely, a high percentage of implants in irradiated tissues demonstrated advanced bone loss upon loading and appear to have significantly lower success rates than implants in nonirradiated tissues.[5,31,37-40] Because of these results, some clinicians have attempted to improve the viability of bone with hyperbaric oxygen, HBO, treatments prior to implant placement. Granstron et al. treated 13 patients with hyperbaric oxygen who had previously been irradiated.[41] Each patient received 20 HBO treatments, implant surgery was performed, followed by 10 more HBO treatments. The follow-up period was short but only one implant fixture has been lost (2.0 percent of the total).

In summary, it is clear from the current data that osseointegration is impaired in bone that has received doses in excess of 50 Gy. Success rates, based on retrospective clinical reports, are reduced as compared to nonirradiated sites, particularly the orbit.[31,40] The success rates are lower even in the maxilla with its excellent blood supply. In addition, preliminary animal studies referred to previously appear to indicate that the bone — implant interface may be significantly compromised making the implant less able to tolerate functional loads. Hyperbaric oxygen appears to help revitalize the bone, leading to improved success rates, but long-term clinical follow-up data are still lacking. In addition, its high cost precludes its use in most patients.

Table 1

Implants in the Irradiated Mandible

Doses 55 Gy and below

- Implants can be inserted with little or no risk of osteoradionecrosis.
- Success rates will be approximately 10-15 percent lower than normal.

Doses between 55 and 65 Gy

- Individual patient factors such as fractionation, tissue response, clinical findings, dental and medical history etc. impact the decision.
- Hyperbaric oxygen before implant placement should be considered.

Doses above 6500 cGy

- The risk of osteoradionecrosis becomes significant.

Risk of Osteoradionecrosis Secondary to Implants

The risk of osteoradionecrosis in the mandible is probably best determined by an analysis of the bone necrosis rate seen secondary to postradiation extractions.[42] Based on these data it should be relatively safe to place implants in irradiated mandibular sites if the dose is less than 55 Gy (**Table 1**). In patients with doses to bone sites between 55 to 65 Gy, individual patient factors such as the dose per fraction, a previous radical neck dissection, the quality of the overlying soft tissues and the presence of telangiectasia, are some of the important cofactors to consider when assessing the risk. In such patients, if implants are essential, the authors recommend a course of hyperbaric oxygen.[39,41] The risk could be quite high for doses above 65 Gy. In these patients, implants are not recommended, even in conjunction with HBO. It should be noted that when most oral cavity tumors are treated, most patients do not receive radiation to the symphyseal region. Therefore, implants can be placed with a high degree of predictability in these patients. In the maxilla, the risk of bone necrosis is probably negligible. The use of hyperbaric oxygen can be justified only on the basis of improving implant success rates.

Irradiation of Existing Implants

Irradiation of titanium implants already in place results in backscatter and, therefore, the tissues on the radiation source side of the implants receive a higher dose than the other tissues in the field. The dose is increased about 10-15 percent within 1 mm of the surface of the implant.[43,44] Because of backscatter and the increased numbers of elderly patients receiving implants, clinicians often ask if osseointegrated implants should be removed in patients about to be irradiated for head and neck tumors. In a report by Granstrom, 11 patients with 32 existing titanium implants were irradiated. Dosages ranged from 50 to 80 Gy delivered four to 60 months after the implants were placed. Based on their findings, the authors recommended that all abutments and superstructures be removed prior to radiation and skin and/or mucosa should be closed over the implant fixtures.[39] When healing is complete, radiation therapy can begin. Following the completion of radiation, abutments and the superstructure are reattached and the prosthesis is remade or readapted.

Conclusions

The application of osseointegrated implants in this patient population significantly improves the retention and function of the various prostheses and hence the quality of life of the patient. Implants, however, are not uniformly successful. Implant failures appear to be site specific and radiation dependent. ■■■■

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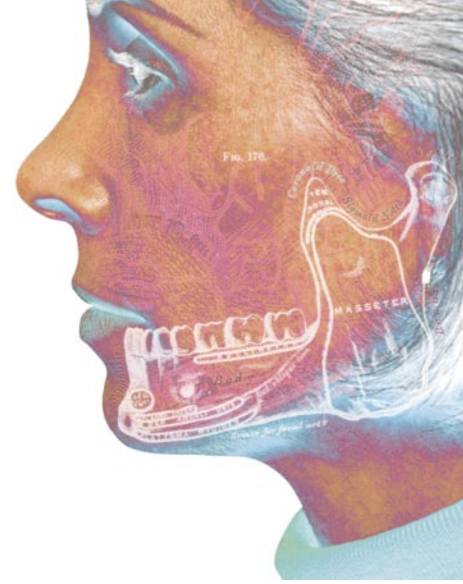

Using Implants for the Growing Child

Arun B. Sharma, BDS, MSc, and Karin Vargervik, DDS

ABSTRACT

The use of implants for the growing child is not routinely recommended. The concerns about placing implants for patients in this age group are related to jaw growth. However, not all children with missing teeth need to wait for growth to be completed prior to implant placement. In this paper, the authors will discuss the indications for implant placement in the growing child. The decision for implant placement is based not only on growth, but also the number and location of the missing teeth.

In treatment planning the restoration of any edentulous space, the available options today almost always include implants. Implant-supported prostheses have had a high rate of success, as reported by Adell et al., Zarb and Symington, and as confirmed in a multicenter study by Albrektsson.[1-4] In edentulous patients, the 10-year survival rates of such implants were 82 percent for the maxilla and 94 percent for the mandible. Jemt et al. reported similar results for the partially edentulous patients.[5] In a meta-analysis of 66 papers over 10 years, Lindh et al. showed implant survival under load after six years was 93.6 percent for fixed-partial dentures and 97.5 percent for single crowns.[6] Implant-supported prostheses provide a number of advantages. In the partially dentate patient they eliminate the need for tooth preparation, and for the edentulous patient provide increased retention and stability for the prosthesis.

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The use of implants to restore edentulous and partially edentulous patients has enabled the dentist to rehabilitate patients to a more normal masticatory function and an improved lifestyle.

There is no reason to doubt that implants will integrate when placed in the maxilla or mandible of the growing child. It is known that an integrated implant behaves like an ankylosed tooth.[7] The authors' concerns about placing implants in the growing child are related to jaw growth. If an implant is placed before growth is completed, will the implant still be in a position to support a restoration when growth is complete? Will the normal growth pattern of the maxilla and mandible be interfered with if an implant is placed before growth is complete? These unanswered questions have been responsible for the limited use of implants in the growing child. The purpose of this paper is to outline the indications and timing for the use of implants in the adolescent.

The basal bone of the maxilla occupies the space between the zygomatic bones laterally, the nasal structures medially, and the orbits superiorly. It forms the floor of the nose and the palate. These parts are evident in the adult edentulous patient with resorbed alveolar ridges. The maxilla in the newborn also lacks pronounced alveolar ridges. Maxillary vertical development comes with developing tooth buds and with the formation and eruption of teeth. As growth and development continue, the maxilla comes down and forward with sutural apposition and with downward and forward growth of the alveolar process with the eruption of primary and permanent teeth. The eruption path of the maxillary molars is approximately 55 degrees to the line between the anterior nasal spine and the mandibular condyle.

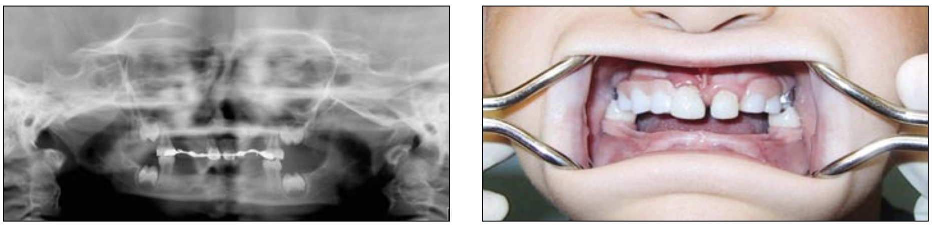
Figure 1a. Radiograph at completion of orthodontic treatment at age 15 years and 3 months.

Figure 1b. Same patient with a retainer maintaining space until growth is complete.

In the absence of maxillary teeth, the alveolar ridges will not develop, and the maxilla will be underdeveloped both sagittally and vertically. In contrast, mandibular growth is not dependent on the presence of teeth. Therefore, in the presence of hypodontia or anodontia, the relationship between the two jaws will tend to be disproportionate with class III development as growth continues throughout the normal growth period.[8]

At the University of California, San Francisco, researchers have been conducting clinical trials using implants in children ranging in age from 6 to 18. One of the studies included an evaluation of implants placed in grafted alveolar clefts of patients with unilateral or bilateral cleft lip and palate.[9] A second study involved the use of implants in patients with ectodermal dysplasia.[7] The authors have also placed implants in children who have had maxillary or mandibular resections for tumors and subsequent reconstruction. Long-term follow up of these patients has allowed for development of a protocol for implant placement in the growing child. The authors' objective is to discuss this protocol and provide guidelines for implant placement in the growing child.

In this paper, two studies that evaluated the effects of jaw growth on implants in the dentoalveolar region in growing pigs are cited. Odman et al. used six pigs to determine vertical dentoalveolar development in the presence of implants.[10] The clinical and radiographic findings demonstrated that the osseointegrated fixtures and surrounding alveolus failed to move occlusally with the adjacent dentition and bone. They concluded that implants placed in growing jaws do not change position with growth and do not improve vertical alveolar development. Thilander et al. evaluated the effect of implants on 3-D growth of the maxilla and mandible. They found that transverse growth of the mandible in the molar-premolar region of the growing pig occurred by buccal bone apposition and lingual remodeling and resorption. Therefore, they theorized that implants placed in the posterior growing mandible would be at risk for failure by progressive displacement in the alveolus. Similar bony remodeling and apposition of the



2a.

2b.

Figures 2a and 2b. Panoramic radiograph and clinical photograph of a patient with partial anodontia. Molars are present in both maxilla and mandible.

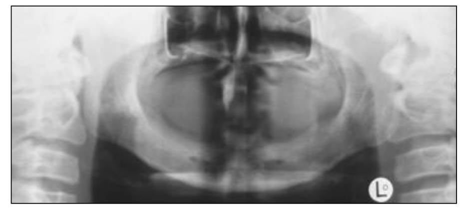


Figure 3. Panoramic radiograph of a patient with ectodermal dysplasia — only one tooth present in the anterior maxilla.

mandible anterior to the canines did not occur. Increases in maxillary width developed as a result of intermaxillary sutural growth. As in the mandible there was no evidence of buccal bone apposition or remodeling in the maxilla anterior to the canine.

Based on published data and the authors' clinical experience, they found it practical to divide the treatment of the partial or complete anodontia adolescent into three distinct groups that follow specific anatomic criteria.

- **Group I:** Children who are congenitally missing a single tooth and have adjacent permanent teeth. (**Figure 1**).
- **Group II:** Children who are missing more than a few teeth but have permanent teeth present adjacent to the edentulous sites (**Figure 2**). This group of patients includes those that are not included in Group I or Group III. There are many different combinations, but general guidelines will be discussed.
- **Group III:** Children who are completely edentulous in one arch or have one or two teeth in poor positions in the arch (**Figure 3**).

These three groups need to be treated very differently with respect to the timing of implant placement.

Group I

Children Missing a Single Permanent Tooth With Adjacent Permanent Teeth

For patients in this group, the skeletal development is a more important consideration than chronological age. The concern here is the dentoalveolar development adjacent to the edentulous space. With growth there is downward and forward development of the alveolus in the maxilla and height increase of the alveolus in the mandible. If an implant is placed before dentoalveolar growth is complete, the implant will become submerged relative to the adjacent teeth. The implant and tooth would therefore appear apical to the adjacent teeth with a discrepancy in the free gingival margin. Not only would this be an esthetic complication, but could also result in a poor implant to crown ratio if the restoration was remade to its appropriate length. To avoid the complication of implant and dentition height discrepancies in the growing child, at UCSF, the authors recommend not placing implants until two annual cephalograms show no change in the position of the adjacent teeth and alveolus.[7] Completion of dentoalveolar development/growth can be seen as early as age 16 in girls and as late as age 22 in boys (**Figure 4**).

Group II

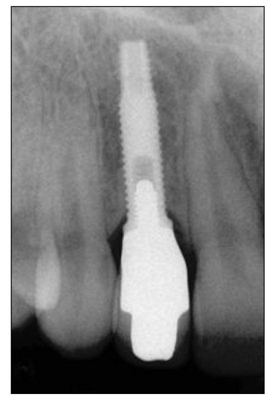
Children Missing More Than a Few Teeth But Have Permanent Teeth Present Adjacent to the Edentulous Sites

Patients in this group are the most complex with regard to location and timing of implant placement. In terms of overall diagnosis they may have some form of ectodermal dysplasia or nonsyndromic partial anodontia. There are many variations in the number of missing teeth and the extent and location of the edentulous spans. In planning implant placement, future dentoalveolar development and the psychological development of the patient need to be considered.

The initial objective is to orthodontically optimize the position the teeth present and to consolidate edentulous spaces. Removable prostheses are used until the entire team (including patient and family) has no objections to implant placement. The safest approach is to wait until dentoalveolar development is complete as assessed by no change in lateral cephalograms taken one year apart. However, for some patients implants may be placed before growth is completed, in order to provide the psychological benefit of having a more functional, stable, and esthetic solution. For this group of patients, it is critical the entire team understands that when growth is completed, there will be the need for either surgical repositioning of the implant segment to a more favorable position and/or a replacement of the prosthesis.

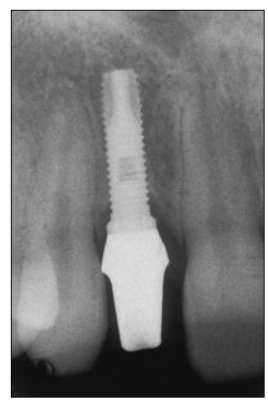
The patient shown in **Figure 5** is a good example of what can happen when implants are placed before dentoalveolar development is complete. As posterior teeth continued to erupt, an anterior open bite developed. Once growth is complete, choices are limited. The entire anterior segment with the implants and prosthesis can be surgically repositioned with a segmental osteotomy or distraction osteogenesis. The alternative would be to remake the prosthesis utilizing pink porcelain. The pink porcelain would provide replacement for the submerged alveolus and improve the esthetic symmetry of tooth proportion and gingival position. If this child had not had implants placed before growth was completed and had a removable prosthesis, the authors believe that the treatment alternatives at this stage would be similar. The edentulous alveolus in the anterior area would be deficient and would require a large bone graft, distraction or a segmental osteotomy, followed by implant placement. If surgery was not an option and implants had to be placed, then pink porcelain or acrylic would have to be utilized for a fixed or removable implant-supported prosthesis.

4a.



4b.

4c.



4d.

Figure 4. A sister and brother with congenitally missing lateral incisor. Figures 4a and 4b. The sister had implant placed at age 16 years and 2 months. Figures 4c and 4d. Her brother had implant placed at age 18 years and 6 months.

5a.

5b.

Figures 5a and 5b. A patient with partial anodontia who had implants placed and restored before growth was complete. These photographs demonstrate submerged implants and an anterior open bite that has developed as the posterior natural teeth have continued to erupt. *(Photographs courtesy of Dr. Raymond Carpenter)*

Group III

The Edentulous Arch

Patients in this group usually have a diagnosis of ectodermal dysplasia. Because teeth are not present, one does not need to be concerned about dentoalveolar growth. The only concern is the down and forward growth of the entire mandible. This can result in a jaw size discrepancy, but the implant position will not be adversely affected.[9]

Careful consideration must be given to the physical and psychological development of the patient when an implant placement is planned. Patients must understand the oral hygiene requirements and must be able to perform them adequately. In the authors' experience, oral hygiene is rarely satisfactory in patients younger than 7 years old. For these reasons, the authors believe that placement of implants in patients younger than the age of 7 is not indicated.

On the basis of the studies of jaw growth, the authors avoid placement of implants posterior to the mandibular canines.[10,11] In the authors' study on patients with ectodermal dysplasia, implants have been successfully placed in the maxillary arch and in the mandible anterior to the mental foramen.[9]

The patient shown in **Figure 6** had four implants placed in the anterior maxilla and five implants placed in the anterior mandible when he was 11 years old. A maxillary implant and tissue-supported overdenture and a mandibular fixed implant-supported prosthesis was fabricated when he was 13 years old. As seen in the serial lateral cephalograms (**Figure 7**), as the boy grew, the mandible moved forward. When growth was completed, orthognathic surgery was performed to improve the relationship of the maxilla and mandible and the prosthesis was remade (**Figure 8**). The authors believe that if he had not had the implants placed at age 11, he still would have required the orthognathic procedure. The implant position would have been the same if similar prosthesis was planned. The patient had the advantage of having the benefit of an implant-supported prosthesis during his growing years, which was significant in his social and psychological development. Having implant-supported prostheses also made the orthognathic surgery similar to a dentate patient, and the surgeon did not have the additional difficulties of working with edentulous arches.

6a.

6b.

Figures 6a and 6b. Completed treatment for a patient with ectodermal dysplasia — implants were placed when he was 11 years old.

7a.

7b.

7c.

Figure 7. Serial lateral cephalograms demonstrating mandibular growth. Figure 7a. Age 14 years. Figure 7b. 16 years. Figure 7c. Age 17.

Conclusion

For the growing child who is missing a single tooth with adjacent natural teeth, implants should not be placed until dentoalveolar development is complete (two lateral cephalograms one year apart with no change).

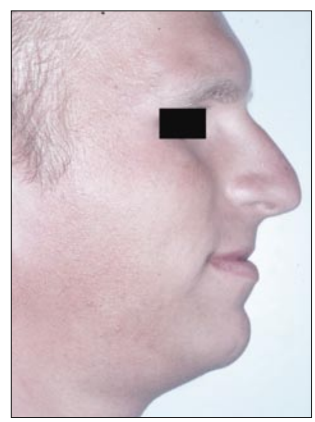
For the completely edentulous growing child, implants can be planned as early as age 7. Surgery may be necessary when growth is complete to correct the jaw size discrepancy. The prosthesis may have to be remade.

For the partially edentulous growing child, the decision as to when to place implants is more complex and is dictated by the extent of the edentulous space and its proximity to natural permanent teeth. The authors' treatment approach is to first make a conventional removable prosthesis after orthodontic treatment is complete. If this provides a satisfactory result, the authors wait for growth to be completed before implant placement. If the conventional treatment is unsatisfactory, implants can be placed, but the need for surgery and/or remake of the prosthesis must be anticipated at the end of growth. ■■■■

8a.

8b.

8c.



8d.

Figure 8. After orthognathic surgery at age 19 and remake of prosthesis at age 20.

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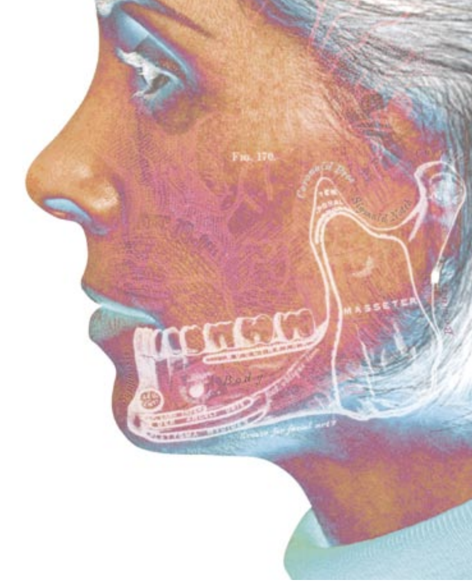

Prosthodontic Treatment of Patients with Hypodontia

Ting-Ling Chang, DDS

ABSTRACT

Hypodontia is a relatively rare occurrence that can have a significant impact on treatment planning for those patients with the condition. This paper will describe the forms of hypodontia, as well as associated dental issues. Treatment planning considerations for children, adolescents, and adults will be presented.

Hypodontia is defined as the developmental absence of one or more teeth in the primary or permanent dentition, excluding the third molars. It is the most common developmental dental anomaly and is classified according to the severity of the condition:[1-3]

- Mild to moderate hypodontia: Absence of usually two teeth or more but fewer than six teeth, excluding third molars.
- Severe hypodontia: Absence of six teeth or more, excluding third molars. It may be associated with microdontia.
- Oligodontia: Absence of multiple teeth usually associated with systemic manifestations.

In the primary dentition the prevalence of hypodontia is 0.1 percent to 0.9 percent. Hypodontia in the permanent dentition occurs in about 3.5 percent to 6.5 percent of the normal population. The teeth most commonly affected are the maxillary lateral incisors, the man-

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dibular and maxillary second premolars, and the mandibular incisors.

Hypodontia can occur in isolated fashion caused by local factors such as early irradiation of the tooth germ, hormonal and metabolic influences, trauma, and osteomyelitis, which can disrupt the normal development of the permanent dentition. Hypodontia may also be a part of more generalized systemic conditions such as ectodermal dysplasia, cleft lip and palate, Down syndrome, etc. It is important for dentists to take a detailed history in order to differentiate nonsyndromic versus syndrome-related hypodontia, and to consider referring children with congenitally missing teeth for screening for other ectodermal anomalies or to rule out the possibility of a syndrome.

Figure 1a. A child with hypodontia whose chief complaint is related to the esthetics of the conical shape of Nos. 8 and 9, a common clinical feature associated with hypodontia.

Figure 1b. Restorative treatment included composite build-ups to reshape conical teeth Nos. 8 and 9 to normal central incisor tooth form and a removable treatment partial denture to address the patient's esthetic and functional needs.

Clinical Presentation

Hypodontia patients are not uncommon to all dental practices. They have complex clinical presentation with wide variation in degrees of severity. A number of features have been reported to be associated with hypodontia:

■ Microdontia: The teeth are often microdontic, conical, or tapered, presenting esthetic and functional problems. Preparation of such teeth for fixed restoration may be difficult, and lack of undercuts presents retention problems for removable prostheses.[4]

■ Eruption of permanent teeth may be delayed or abnormal.[5]

■ Impaction of the permanent canine: If the maxillary lateral incisors are microdontic or absent, the maxillary canine may follow an ectopic path.[6]

■ Disruption of the plane of occlusion: The retained deciduous teeth may become ankylosed and infraoccluded. A deep overbite may also be noted as result of a compromised vertical dimension of occlusion.

■ Poor alveolar ridge development: The lack of teeth is often associated with a developmental failure of alveolar bone, resulting atrophy of the ridge.

■ Anterior-posterior skeletal relationship: Some studies suggest that patients with hypodontia have smaller, more retrognathic maxillae and tend to have a class III skeletal relationship.[7-9] This tendency becomes more significant as the severity of the hypodontia problem worsens.[9]

■ Vertical skeletal pattern: Cephalometric studies report that hypodontia patients have a tendency toward a reduced lower facial height.[10,11]

These clinical features complicate treatment planning and patient management. Treatment typically requires several phases and the involvement of practitioners in various dental specialties including pediatric dentistry, orthodontics, oral surgery, and prosthodontics to achieve optimal esthetics and function. The greater the extent of hypodontia, the greater the need for specialist referral and interdisciplinary care.

Treatment Considerations for Children and Adolescent Patients With Hypodontia

Prosthodontic treatment can play an important role in the dental management of children whose dentition fails to develop normally. Early intervention in growing young patients provides numerous functional and esthetic benefits including development of normal patterns of chewing, swallowing, and speech; normal facial support; and improved temporomandibular joint function.

In addition, studies show that the psychosocial benefits of early intervention are as important as the dental benefits.[12-14] This presents a challenge to the clinician. As Nowak stated, treating young patients requires the clinician to be knowledgeable in growth and development, behavioral management, techniques in fabrication of a prosthesis, the modification of existing teeth utilizing

Figure 2a. A young patient with severe hypodontia with only anterior teeth present. Her chief complaints were "unaesthetic short teeth with spaces," and "unable to chew."

Figure 2b. After diagnostic wax-up, full coverage composite crowns were bonded to all anterior teeth to improve tooth size and form and eliminate the diastemas.

Figure 2c. Maxillary and mandibular removable treatment partial dentures used to restore posterior occlusion.

Figure 2d. Frontal view of smile at completion of treatment. This young patient was very pleased with the treatment result.

composite resin, the ability to motivate the patient and parent in the use of the prosthesis, and the long-term follow up for the modification and/or replacement of the prosthesis.[15] Ultimately, the decision to begin treatment should be made by the treating dentist along with the parents and patient. When indicated, dental treatment can begin as early as age 2. A patient's and parents' motivation, compliance, and understanding of the proposed treatment and its limitations need to be carefully evaluated before any treatment is rendered for this young patient group.

Age-specific Treatment Modalities

Phase I- Treatment for Children and Adolescent Patients

The treatments generally used at this phase include operative and removable prosthodontic treatment. Anteriorly, the appearance of diastemas and malformed teeth can be reshaped and esthetically improved by bonded composite veneers and build-ups (**Figures 1a and b, Figures 2a-d**). Removable prostheses, including treatment partial dentures (**Figures 1b and 2c**) and overlay dentures (**Figures 3a-e**), are often the treatment of choice to replace missing teeth and/or restore vertical dimension of occlusion prior to definitive treatment. Removable prostheses are easily modified or remade during the growth period, offering an easy, affordable, and reversible method of dental rehabilitation.[16] However, patient cooperation and full support of the parents is essential if removable prostheses are to be successful in preteen patients. The restorative dentists should follow the patients regularly to monitor the fit and the occlusion of the prostheses.

A six- to 12-month recall schedule is advised, until skeletal growth is completed. The removable prosthesis needs to be adjusted or replaced when a decreased vertical dimension of occlusion or an abnormal mandibular posture is detected due to growth. Although the use of removable prostheses is beneficial to esthetics and function, increased incidence of caries and periodontal disease can become evident over time. Prevention of caries is important in young patients, especially in xerostomic ectodermal dysplasia patients. Oral hygiene instruction should be emphasized, and in patients with overdentures, the application of daily topical fluoride therapy is recommended.[17]

In patients who present with complete anodontia, implants can be planned in the maxilla and anterior mandible as early as age 7. However, clinicians need to be aware that surgery may be necessary once growth is complete to correct the jaw size discrepancy and the implant prosthesis may have to be remade.[18]

Definitive Treatment for Adult Patients

Depending on the severity of hypodontia there are a range of treat-

Figure 3a. Frontal view of a young patient's smile with severe hypodontia. Esthetics and function were the patient's primary complaints.

Figure 3b. Intraoral exam reveals malposition of deciduous canine (#R) and tooth No. 23. Both teeth demonstrated very short roots radiographically.

Figure 3c. Following the diagnostic work up, deciduous canine (#R) and malpositioned No. 23 were planned for extraction due to short roots and interference with the planned occlusion.

Figure 3d. Maxillary and mandibular immediate overlay dentures delivered following extraction of No. 23 and deciduous canine (#R).

Figure 3e. Frontal view of smile with removable prostheses in place.

ment options including implants, resin-bonded bridges, conventional fixed prostheses, and removable prostheses which can be considered for definitive treatment for adult patients. The use of resin-bonded bridges, like the Maryland Bridge, requires careful case selection and is only suitable for a few patients. Conventional fixed prostheses are limited to the replacement of short edentulous spans and disadvantaged by the required 1 mm to 2 mm tooth reduction. In young adults, the pulp chambers are large due to lack of secondary dentine formation, resulting in an increased risk of pulpal damage during tooth preparation. Removable prostheses are an economic and conservative alternative for patients who cannot afford other treatment options or prefer to avoid invasive surgical procedures associated with bone grafting and implant placement.

Clinical reports and research in the application of implant prosthodontics on cases of hypodontia have shown excellent long-term results achieved after appropriate case selection, good occlusal harmony and oral hygiene, and careful handling of the soft and hard tissues.[19-23] A common problem in the management of hypodontia patients is lack of sufficient bone for implant placement that results from local to general decrease of growth stimuli of the jaw bone because of the absence of large numbers of teeth.[19] Such bone deficiencies can be rectified by an augmentation procedure. There are few reports on the survival rate of dental implants in hypodontia patients in various age groups, particularly ectodermal dysplasia patients.

Durstberger et al. reported a 96 percent implant survival rate (13 patients and 69 implants).[19] Kearns et al. reported a survival rate of 94.7 percent for the maxilla and 100 percent for the mandible (six patients and 41 implants).[20] Guckes et al. reported 76 percent for the maxilla and 91 percent for the mandible (51 patients and 242 implants).[21] Recently, Finnema et al. reported an implant survival rate of 86 percent and 96 percent for the maxilla and mandible respectively (13 patients and 87 implants).[22] In addition, Finnema suggested that oral

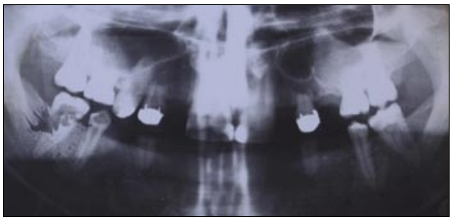

Figure 4a. Pretreatment panoramic radiograph of an adult patient with severe hypodontia. The patient is congenitally missing Nos. 5-7, 10-13, 18, 21-28, and 31 and has retained deciduous teeth #B, K, L, and S.

Figure 4b. Panoramic radiograph after placement of three implants at Nos. 6, 10, and 12 positions for the maxillary arch and five implants at Nos. 21, 22, 25, 27, and 29 positions for the mandibular arch.

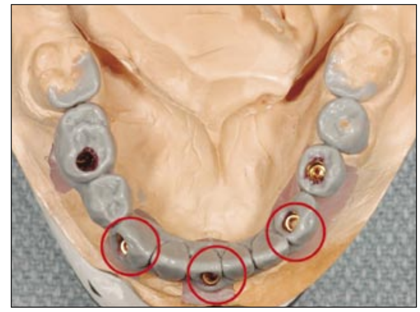

Figure 4c. Full contoured wax-up demonstrates the labial angulation of implants at Nos. 25 and 27 positions. The implant screw access holes located on the labial surface of the wax-up created an esthetic problem. A custom substructure with UCLA abutments was used to resolve this angulation problem.

Figure 4d. Wax cutback for the porcelain at Nos. 21, 28, and 29 positions and for the space required for the metal suprastructure and porcelain at Nos. 22-27 positions.

Figure 4e. Completed substructure metal casting prior to porcelain addition.

Figure 4f. Substructure after addition of porcelain for Nos. 21, 28, and 29 and gingiva-colored porcelain.

Figure 4g. Insertion of suprastructure for Nos. 22-27 onto the substructure. Gingiva-colored porcelain was used on both the substructure and suprastructure for optimal esthetic tooth length and harmonized gingival outline.

Figure 4h. Suprastructure of Nos. 22-27 retained with lingual set screws.

Figure 4i. Post-treatment intraoral frontal view of implant prostheses. Noted gingiva-colored porcelain used to create esthetic tooth length with harmonized gingival outline that blends in with his remaining natural teeth.

Figure 4j. Frontal view of post-treatment smile. Teeth Nos. 6-7 and 10-12 are implant-supported fixed bridges.

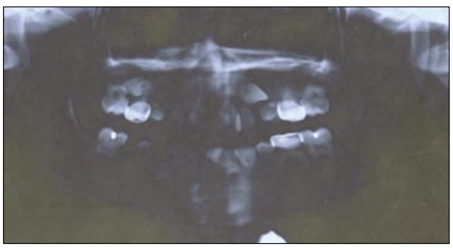

Figure 5a. Pretreatment panoramic radiograph of a young female adult patient with hypodontia secondary to radiation therapy which she received as a child. Early radiation exposure of the tooth germ causes tooth agenesis, arrested root development, and reduced growth of the craniofacial skeleton as seen on this panoramic radiograph.

Figure 5b. Mandibular master cast with UCLA implant abutment sleeves in position demonstrating implant angulation problems. This prosthodontic challenge was resolved using UCLA custom abutments to correct the angulation problems.

Figure 5c. Post-treatment panoramic radiograph. In this case, eight implants were placed in the maxilla and five implants were placed in the mandible for fixed implant prosthodontic rehabilitation.

Figure 5d. Frontal view of smile after the implant rehabilitation was completed.

rehabilitation with dental implants was efficacious for oligodontia patients based on subjective outcome evaluation.[22] Patients reported considerable improvement in function and good overall treatment satisfaction and experience with implant-based dental rehabilitation. The previously mentioned studies strongly support the use of dental implants to restore the missing teeth for hypodontia patients.

Although various surgical augmentation techniques facilitate successful implant placement and integration, the dental and skeletal nature of hypodontia patients often presents prosthodontic challenges such as esthetics, implant angulation, compromises in implant position, limited interocclusal space, and biomechanical considerations. Screw-retained splinted implant prosthesis with UCLA abutments and the use of gingiva-colored porcelain have worked well in the author's experience to overcome these prosthodontic challenges as demonstrated in the following two case presentations[23] (**Figures 4a-j and 5a-d**).

Coordination of Multidisciplinary Treatments

The range of problems that can present in patients with hypodontia is enormous and each case should be discussed fully within a multidisciplinary team. Patients' concerns, needs, and attitude to various treatment options should be taken into full consideration when formulating a treatment plan. For the prosthodontist or restorative dentist, the primary areas of concern are the provision of an interim prosthetic solution that will meet the esthetic and functional needs of the patient during the individual's growth, early determination of the type of definitive therapy, and the ideal orthodontic placement or positioning of abutment teeth based on a prosthodontic diagnostic workup.[24] Working closely with a committed team where each member contributes their expertise is the key to achieving an optimum outcome for hypodontia patients. ■■■■

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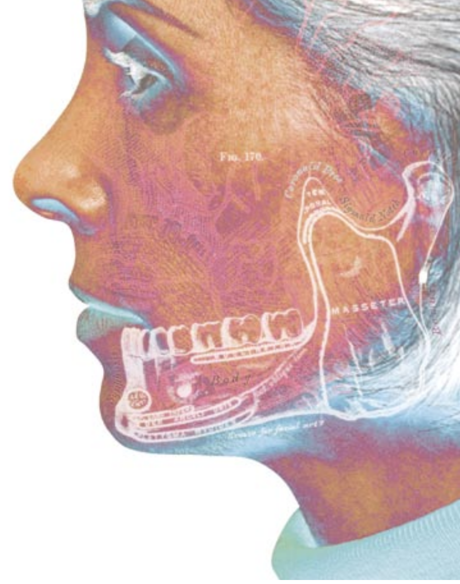

Dental Management of Chemoradiation Patients

Evelyn M. Chung, DDS, and Eric C. Sung, DDS

ABSTRACT

The utilization of combined chemoradiation therapy has recently increased in the treatment of head and neck cancers. This patient population is significantly more prone to various oral complications during and after medical therapy. Oral complications and long-term effects include mucositis, xerostomia, alterations in taste, vascular compromise, mucosal thinning and increased risk of rampant caries and periodontal disease. The most serious oral complication that can arise is osteoradionecrosis. Managing patients properly prior to medical treatment can help decrease these potential complications during and after treatment.

This purpose of this article is to review the different radiation and chemotherapy regimens used to treat patients with head and neck cancers, as well as protocols in the dental management of these patients before, during, and after medical treatment.

Surgery and/or radiotherapy, RT, are used routinely in the management of neoplasms of the head and neck region and treatment can be curative if tumors are diagnosed early (stage I and II).[1] RT is defined as the therapeutic use of ionizing radiation. Ionizing radiation disrupts and ultimately causes cellular death in replicating cells. RT can be delivered by an external source (external beam), or as a sealed radioactive material delivered close to the tumor site (brachytherapy). Either approach is effective in destroying most tumors, but the amount of radiation is limited by the tolerance of the normal surrounding tissues.

External beam RT is delivered in a series of treatments called fractions over a period of approximately five to seven weeks. Total dose is ultimately determined by the type and staging of the tumor. Modifications of conventional fractionation consist of hyperfractionation, accelerated fractionation and, more recently, the use of inten-

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sity-modulated radiotherapy, IMRT. Hyperfractionation consists of increasing the total dose by increasing the total number of fractions and the number of fractions per day, but decreasing the dose per fraction. Although this method may improve tolerance to the late effects of radiation, it may increase the severity of the acute effects of radiation (oral mucositis). Accelerated fractionation decreases the total treatment time without changing the total dose by decreasing the dose per fraction and increasing the number of fractions per day. This method is employed to decrease treatment time and to increase tumor growth control by maintaining a lethal dose rate equivalent to the accelerated repopulation of tumor cells. However, like hyperfractionation, acute reactions can be severe and are usually dose-limiting. Intensity-modulated radiation therapy is an advanced mode of high-precision radiotherapy that utilizes computer-controlled X-ray accelerators to deliver precise radiation doses to a malignant tumor or specific areas within the tumor.

Brachytherapy consists of interstitial (direct insertion into tissue), intracavitary (placement within a cavity) or surface applications (molds). The advantage to this procedure is that it allows a high dose of radiation to be delivered directly or very close to the tumor site while sparing normal surrounding tissues. The disadvantage to this approach is underdosing portions of the tumor volume.

Table 1

Effects of Radiation Therapy

Acute effects of RT	Long-term effects of RT
1. Erythema, swelling, pain	1. Epithelial atrophy
2. Desquamation and ultimately ulcerations (radiation-induced mucositis)	2. Loss of keratinization
3. Inability to wear dental prostheses	3. Telangiectasis of mucosa
4. Increased risk for fungal infections	4. Xerostomia
5. Loss or alteration of taste	5. Increased risk for fungal infections
6. Trismus	6. Delayed healing
7. Reduction in salivary output as well as changes in viscosity, pH and constituents	7. Decreased bone remodeling ability
	8. Possible increased risk for ORN
	9. Decreased pulpal response
	10. Possible inability to wear dental prostheses

Side Effects of Radiation Therapy

During RT, acute effects (**Table 1**) on the oral mucosa include erythema, edema, ulceration and ultimately, desquamation (mucositis). The edema can often lead to cheek biting and the inability to wear a dental prosthesis. Mucositis is usually most severe in the soft palate (**Figure 1**) followed by, in descending order, the mucosa of the hypopharynx, floor of the mouth, buccal mucosa, base of the tongue, and the dorsum of the tongue. Tissue areas that have rapidly dividing cells are usually affected the most. Severity and location of the mucositis are dependent on the field and dose of radiation, but can vary from patient to patient. If the pain is severe, RT may need to be stopped until the patient is sufficiently recovered to continue with treatment. Treatment for the side effects during this time is supportive and symptomatic. Once the radiation treatment has been completed, the mucositis resolves in about two to four weeks.

Late effects (**Table 1**) include reduction in salivary flow, compromised buffering capacity of the saliva, temporary or permanent partial or complete loss of taste (hypoguesia or ageusia), and a decrease in keratinization of the mucosa. Decreased vascularity and increased fibrosis at the submucosal level may result in trismus, dysphagia, and at high doses may result in osteoradionecrosis, particularly in the mandible. Pulpal tissues also become hypocellular, atrophied and sometimes fibrotic.[2] Decreased salivary volume, buffering capacity and immunologic functions of saliva, predispose to changes in the oral flora and result in increased risk of dental caries. The changes in saliva quantity and quality are usually permanent, especially in the range of radiation dose used for treatment of most head and neck cancers. Loss or changes in taste is usually most severe during and immediately following RT, and may return to normal gradually over a period of several years. Loss of keratinization in the oral mucosa leads to thin, friable tissue with prominent telangiectasias prone to ulcerations from minimal trauma (**Figure 2**). The most severe complication of head and neck RT is osteoradionecrosis, ORN, in which irradiated bone is exposed due to trauma or infection and fails to heal over a period of three months or longer in duration. ORN is seen most commonly in the mandible because the bone is dense thus absorbing more radiation and its unique blood supply as compared to the maxilla. If the total dose of radiation to the mandible exceeds 6500 cGy and the field consists of more than 75 percent of the mandible, there is an increased chance of ORN.[3] Changes in the bone that predispose to ORN include: obliteration of fine vasculature, progressive fibrosis, loss of normal marrow cellular elements, and fatty degeneration of the bone marrow. As a result, bone is less able

Figure 1. Erythema and mucositis of the soft palate resulting from radiation therapy.

Figure 2. Thin tissues and telangiectasis present in areas of high-dose irradiation.

Figure 3a. Clinical view of osteoradionecrosis (ORN) arising in the furcation of a mandibular first molar.

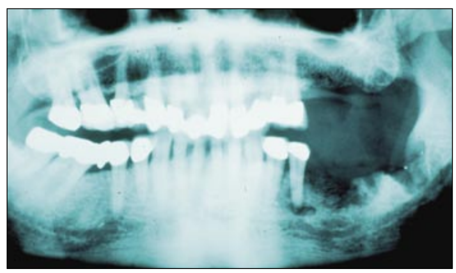

Figure 3b. Panoramic view of ORN in the left mandible.

to remodel and heal following trauma or infection. Clinical presentation of ORN may include pain, suppuration, exposed necrotic bone and pathologic fracture (**Figures 3a and b**).

Chemoradiation Therapy

Chemo RT is being used with increasing frequency, particularly for treatment of carcinomas of the nasopharynx, base of tongue, and tonsillar region. It is commonly employed and most effective when used concurrently with radiation therapy for advanced lesions (Stage III and IV), recurrent and/or metastatic squamous cell carcinomas, especially those with lymph node involvement when surgery and RT may not be sufficient to control the cancer.[4] Expectations of CT include increasing the cure rate by either improved locoregional tumor control, elimination of micrometastases or tissue preservation during surgery.

Chemotherapeutic agents such as 5-fluorouracil (5-FU) and the platinum compounds (cisplatin) enhance radiosensitization by disrupting DNA synthesis. 5-fluorouracil prevents angiogenesis thus inhibiting the formation and further growth of neoplasms. Cisplatin prevents DNA replication thus disrupting tumor cell growth. It is one of the most actively used chemotherapeutic regimens for the treatment of head and neck squamous cell carcinomas and has been recognized in some studies to possibly prolong the survival in patients with recurrent and/or metastatic head and neck cancer.[5-7]

In a study published by the Department of Veterans Affairs Laryngeal Cancer Study Group, induction chemotherapy, CT, plus RT compared with just surgery and RT in patients with advanced laryngeal cancer provided the same two-year survival rate for both treatment groups.[1] Based on this study, chemo RT is used more in the overall management of oral neoplasms. Other studies performed evaluating the efficacy of chemo RT following surgical resection of head and neck cancers suggest that this modality of treatment may have a beneficial effect on locoregional control of tumors in patients that have multinodal involvement, rupture of the tumor through the lymph node capsule and/or microscopic involvement of the resected margins.[8,9]

Side Effects of Chemoradiation Therapy

When a patient undergoes concomitant chemo RT, the acute oral complications are significantly more severe than those associated with radiation alone.[10] Oral mucositis is considerably more severe and results in premature termination or disruption of treatment in 25 percent of the patients. Most patients require gastric tubes in order to make it through treatment, and the oral mucositis may last up to six months following therapy compared to two to four weeks with radiation alone. The main systemic side effects of CT consist of myelosuppression, hemorrhaging, nausea and vomiting, peripheral neuropathy, tinnitus, nephrotoxicity, hepatotoxicity and in some cases, cardiotoxicity.[11]

With emerging trends of chemo RT as a prime multimodal approach in the management of oral cancer, increased attention should be given to the oral complications and their appropriate management. As mentioned previously, acute and late adverse effects are more severe in this treatment population than in patients treated by RT alone.[7,12] Adverse effects are heightened with concomitant chemo RT, since chemotherapy potentiates the effects of RT. These effects include oral mucositis, severe trismus, dysgeusia, dysphagia, salivary dysfunction, impaired lymphatic drainage, infection, detrimental changes in the mucosa and periodontium, increased risk of dental caries, increased risk of osteoradionecrosis, even in the maxilla, and nutritional complications.[7,12] The role of dental professionals at all points of treatment is essential in the management of this patient population since the immediate and long-term effects of treatment such as ORN, rampant caries, and periodontal disease fall within the realm of dentistry.

Table 2

Summary of Dental Management of Chemo RT Patients

Pretreatment considerations

1. Comprehensive medical history and exam, full-mouth radiographs
2. Consultation with oncology team to delineate fields of RT and the use of concomitant CT
3. Full-mouth prophylaxis or scaling and root planing
4. Extractions of teeth with questionable and poor prognosis due to caries, periodontal disease, failing endodontic therapies, or patient compliance
5. Restoration of dental caries
6. Evaluation of any removable prostheses for proper fit and any needed adjustments
7. Fabrication of custom-fitted fluoride trays
8. Emphasis on meticulous oral hygiene to the patient

Perioperative management

1. Palliative treatment as needed
2. Use of mouthrinses for hygiene, lubrication, and/or pain management
3. Prescribe anti-fungal medication, antibiotics, and/or oral analgesics if necessary
4. Emphasis on meticulous oral hygiene to the patient

Postoperative management

1. Frequent dental recall examinations (every three months)
2. Restorations of dental decay
3. Consultation with radiation oncologist prior to oral surgical procedures
   - Low risk of ORN <5500 cGy
   - Moderate risk of ORN 5500-6500 cGy
   - High risk of ORN >6500 cGy
4. Use of oral lubricants to treat xerostomia
5. Prescribe anti-fungal medication and/or antibiotics, if necessary
6. Emphasis on meticulous oral hygiene to the patient as well as daily application of fluoride gel in custom carriers

Pretreatment Evaluation and Management

These patients should be seen by a dental professional with training or experience in treating these type of patients prior to undergoing any chemoradiation or radiation therapy (**Table 2**). A thorough medical and dental history and detailed clinical and radiographic examination should be obtained. The dose, type and fields of RT and the long-term prognosis of the patient are essential factors to help determine whether or not carious and/or periodontally involved teeth should be treated conservatively or be extracted. Knowing the fields of radiation is necessary since the larger the area radiated, the greater the morbidity. For example, if the major salivary glands are within the fields, mean salivary output can be significantly reduced 86 percent to 93 percent.[13] If severe xerostomia following RT is anticipated, custom-fitted fluoride trays should be fabricated. The fluoride trays should be soft, well-fitting, and comfortable without any sharp edges. Patients apply a topical fluoride gel daily with these custom trays, and in compliant patients postirradiation dental caries can be prevented.[14] Casein calcium phosphate may also be used for remineralization of enamel.[15] Patients suffering from xerostomia should also be encouraged to keep the oral mucosa moist either by water, noncariogenic liquids or saliva substitutes. Pilocarpine has been proposed by some as a means of increasing salivary output, but the results have been mixed.[16,17]

At radiation doses below 5500 cGy, compromised teeth in the fields of radiation may not need to be extracted prior to RT. Generally, at doses below this level, postradiation extractions may be performed without any unfavorable complications, even in the mandible. However, at doses higher than 5500 cGy, the mandible may be predisposed to ORN and extractions of teeth in the field should be considered prior to RT. Questionable teeth include those with class II or III furcation involvements, periodontal disease, gross caries or periapical pathology (**Table 3**).

Preradiation extractions should be performed in conjunction with radical alveolectomy and primary closure of the surgical site with minimum tension of the tissue flaps. Postextraction healing time usually requires seven to 10 days. A follow-up visit should be scheduled to ensure the wound sites have healed suf-

Table 3

Criteria for Preradiation Extractions

DENTAL DISEASE FACTORS

Condition of the residual dentition

- Advanced caries
- Periapical infection
- Periodontal bone loss
- Furcation involvement

Dental compliance of the patient

An aggressive policy of extraction is recommended in patients with poor dental compliance.

Maxillary teeth vs. mandibular teeth

Mandibular teeth are scrutinized more closely than maxillary teeth, since maxillary teeth in the field can be extracted postradiation with minimal risk of osteoradionecrosis.

ficiently without dehiscence of the flaps prior to initiation of RT or chemo RT. There are times that treatment needs to be initiated urgently. In such cases, it may not be possible to properly treat compromised teeth. Risks and possible complications of leaving these teeth untreated should be addressed by the oncology team.

Information about the type of CT regimen, such as the agents being used and the number of cycles of CT should also be obtained. The dose and type of CT is useful because it may reflect the amount of myelosuppression and severity of stomatitis to be anticipated. The schedule of the CT is also important because it may affect the timing and the type of dental treatment that should be rendered for the patient. Following each cycle, a patient's ability to recover from the effects of CT may become weaker due to the cumulative toxicities to the bone marrow, kidney, and nervous system.[18] In a chemo RT patient, if the dose to the tumor area exceeds 5500 cGy, the patient may become susceptible to ORN. Currently, no studies have been reported that have definitively linked CRT with an increased incidence of ORN. However, emerging clinical trends point to such an increase.[19]

Regardless whether the patient is having RT alone or chemo RT, priority should be to rule out all potential sources of dental infection prior to the start of cancer treatment (**Table 2**). Urgent treatment should be rendered first with less urgent dental needs addressed after the therapy is completed. Most importantly, during the patient's nadir, or when the patient is the most myelosuppressed and pancytopenic, all dental treatment should be avoided. Treatment prior to chemo RT should include dental prophylaxis, scaling and root planning, definitive restorations, endodontic therapy and/or extractions in order to ensure that the patient is at a low risk for an oral source of sepsis. Subacute odontogenic infections should be treated more aggressively in this patient population since myelosuppression will occur and dormant disease or infection could subsequently become active, resulting in sepsis. Teeth that have only fair or guarded long-term prognosis following chemo RT may need to be extracted. Some clinicians recommend that all mandibular teeth in the field be extracted in patients treated with chemo RT, since these teeth will be even more difficult to maintain, and it is likely that patient compliance with routine dental care will further decrease following treatment.[20]

If the patient wears a dental prosthesis, the prosthesis should be assessed. Adjustments should be made at this time to ensure proper fit and function since denture irritation may lead to ORN, sepsis or uncontrolled bleeding. If the prosthesis is so ill-fitting that adjustments cannot be made, it should be left out of patient's mouth, especially during periods of myelosuppression and/or in the presence of mucositis or stomatitis.

Patients should be instructed on the importance of maintaining proper and meticulous oral hygiene during and after medical treatment. Maintaining good oral hygiene during chemo RT helps to decrease the severity of mucositis as well as reduce the probability for sepsis due to oral infections.[21]

Perioperative Management

During this period, most dental treatment consists of palliative care. Typical symptoms are oral discomfort and pain secondary to mucositis. Topical anesthetics such as viscous lidocaine, or dyclonine hydrochloride may help to soothe the oral cavity and permit swallowing. In more severe cases, patients may require systemic analgesics. Many chemo RT patients require gastric tubes due to the severity of mucositis.

Patients who have metal restorations in their teeth that are in the fields of radiation may suffer from radiation backscatter. The soft tissue areas immediately adjacent to these teeth will have increased radiation exposure resulting in a more severe mucosal reaction. This phenomenon can be alleviated by fabricating a plastic mouthguard that physically displaces the soft tissue away from the metal restoration. The mouthguard should be at least 1 millimeter in thickness and should have smooth edges to prevent further mucosal irritation.

Xerostomia becomes apparent midway through treatment. Water, noncariogenic liquids or salivary substitutes should be used to keep the oral mucosa moist at all times. Oral lubricants can also be used at this stage.

Whether the patient is undergoing RT or chemo RT, preventive oral care and meticulous hygiene must be strongly encouraged during and after treatment. Mouthwashes such as chlorhexidine gluconate can be used to help reduce the oral flora populations which may decrease severity of the oral mucositis. Patients should also brush carefully after every meal with a soft or extra soft toothbrush to prevent bleeding and trauma to delicate soft tissues.

With chemo RT, patients will present with varying amounts of myelosuppression and decreased platelet counts. If platelet counts are low, the patient may be at moderate (platelet count 20,000 to 60,000) or high risk (platelet count <20,000) for prolonged or spontaneous bleeding after minimal trauma. In such cases, the patient should use gauze or soft sponges to clean the teeth in lieu of a toothbrush to reduce the risk of trauma to the gingiva. If the patient is at high risk of spontaneous bleeding, flossing should not be done until the patient's platelet counts have recovered sufficiently.

If an odontogenic or periodontal infection should arise, consultation with the oncologist is advisable and options for treatment discussed. Should definitive treatment be necessary, it should be done as atraumatically as possible and patients should be placed on antibiotics following treatment for at least a week due to the patient's myelosuppression. In part due to myelosuppression and decreased salivary output, these patients can also be at an increased risk for local and systemic fungal infections.[22]

With all these changes occurring in the patient's mouth as well as other side effects from their medical treatment, patients often experience loss of appetite, dehydration, and subsequent weight loss. Enriched dietary supplements are useful in these situations, but can also contain high levels of sugar leading to increased caries activity. Therefore, it should again be stressed that patients brush or clean their teeth after every meal.

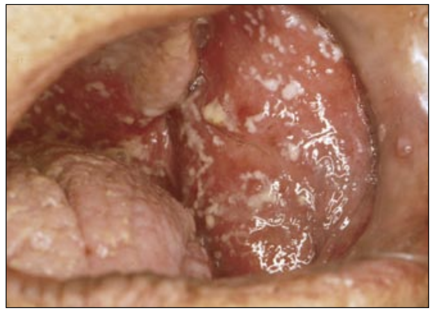

Figure 4. Generalized oral candidiasis.

Figure 5. Rampant radiation caries.

Post-treatment Management

Immediately following RT or chemo RT, palliative treatment may still be required since mucositis can take several weeks to heal. Once sufficient healing has occurred, the patient should be placed on a very strict and regular regimen of oral care and maintenance. A more frequent dental maintenance interval, approximately every three months, but ultimately dependent on patient compliance, is recommended. During visits, all areas of dentinal and cervical exposure, incisal tips, and any furcation-involved teeth for incipient carious lesions since these are the most vulnerable areas must be examined.[23] The most practical and effective method of keeping oral tissues moist is the intermittent use of water and other noncariogenic liquids throughout the day in a portable spray bottle. Because of xerostomia, these patients are also at increased risk for fungal infections (**Figure 4**). The most common locations are the corners of the mouth (angular chelitis), and mucosal areas covered with removable prostheses. Patients may experience a burning or painful sensation, or be completely asymptomatic. Treatment is with anti-fungal powders or ointments. Clotrimazole troches, nystatin pastilles and suspensions are not recommended due to the high sugar content of these formulations which could increase the risk of dental caries of this already susceptible patient population.

These patients require daily fluoride treatments for the rest of their lives. Use of 0.4 percent stannous or 1.1 percent neutral sodium fluoride gels is recommended. Because of the high risk of caries, incipient lesions may rapidly progress to larger decayed areas and may need to be treated either with more aggressive fluoride applications (increasing the frequency to twice a day and/or increasing the time of application from four to 15 minutes per treatment) or remineralization solutions.

Cervical caries in the early stages are best treated conservatively with either amalgam or composites. Fluoride releasing restorations probably do not have a significant impact on anti-caries activity since the greatest release of fluoride is usually in the first 24 hours and then drops off considerably.[24] Full coverage or partial coverage crowns should be provided only when the patient can demonstrate good oral hygiene, since caries can quickly progress around the

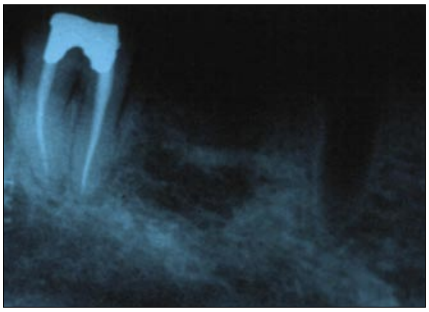

Figure 6a. Radiograph of endodontically treated molar adjacent to ORN.

Figure 6b. Clinical view of endodontically treated molar with crown amputation.

margins of these types of restorations eventually leading to carious amputation of the crown. Should full coverage be warranted, the margins should be placed subgingivally.

Patients with poor compliance may present with rampant caries (**Figure 5**). For these patients, there are few options. Aggressive caries control along with increased daily fluoride usage should be immediately implemented. Mandibular teeth that are deemed nonrestorable either due to severe caries, periodontal disease, or infection should only be extracted after consultation with the radiotherapist to determine whether or not these teeth were within the field of RT and if the total dose to bone was less than 5500 cGy. For maxillary or mandibular teeth out of the field or maxillary teeth in the field, extractions may be done with relatively low risk of developing ORN. If mandibular teeth in the field of radiation received 6500 cGy or greater, the risk of developing ORN following surgical procedures is substantial and does not consistently respond well to conservative treatment measures such as endodontic therapy (**Figure 6a**) and crown amputation (**Figure 6b**) and hyperbaric oxygen may be required.[25] Endodontic therapy and root contouring can be employed to reduce the depth of the periodontal pockets and/or expose furcation areas to maintain better hygiene. Should the furcation area need to be opened using a bur, care should be taken to avoid exposing the interradicular bone. The remaining root tips in either scenario will eventually exfoliate over time while hopefully maintaining mucosal coverage of the underlying bone.

If soft tissue ulcerations occur in the areas of high dose radiation (>6500 cGy), the area should be monitored closely for healing and to rule out recurrence of tumor. Immediate biopsy is not advisable since any surgical procedure can subsequently lead to further bone exposure. In cases where a patient develops ORN, there are many approaches to treatment ranging from periodic conservative debridement and irrigation, to hyperbaric oxygen treatments, combined with surgical resection, sequestrectomy and reconstruction. Beumer reported that in patients who received greater than 6500 cGy or when 75 percent of the mandible was in the fields of RT, ORN did not respond favorably to conservative measures.[3] Conservative measures include local debridement, irrigation with saline or chlorhexidine, analgesics and/or antibiotics for acute infections. In more severe cases of ORN, patients can develop fistulas and subsequently pathologic fractures of the mandible. These unfortunate patients may eventually require surgical resection of the involved bone leading to discontinuity defects. Vascularized bone grafts provide an effective means of restoring the mandible.[26,27] Because of the severity of ORN, prevention of oral infections through meticulous oral care and hygiene, and daily fluoride treatments is an absolute priority.

Conclusion

Head and neck cancers have traditionally been treated with surgery and/or radiation therapy, but concomitant use of chemotherapy is becoming quite common. However, these patients are faced with difficult dental maintenance issues following their cancer treatments. The dental team needs to actively participate in the delivery and maintenance of proper dental care to control oral complications that may arise due to medical treatments. This will ultimately help to improve a patient's quality of life. ■■■■

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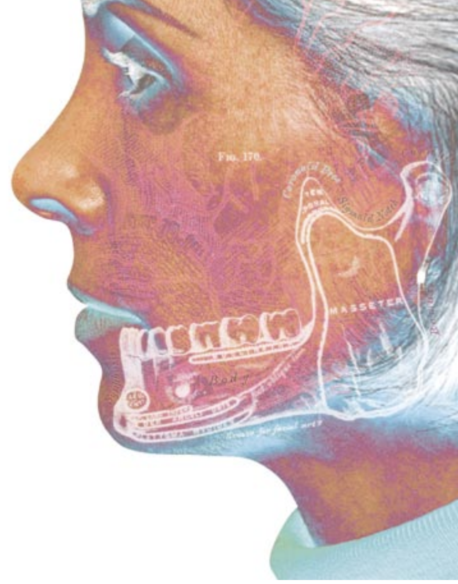

Intensity-modulated Radiation Therapy and Xerostomia

Mark S. Chambers, DMD, MS; Randal S. Weber, MD; and Adam S. Garden, MD

ABSTRACT

Conformal radiation with intensity-modulated radiation therapy, IMRT, is a radiation technique that potentially can minimize the dose to salivary glands and thereby decrease the incidence of xerostomia. Precise target determination and delineation is most important when using salivary gland-sparing techniques of IMRT. The reduction of xerostomia may be achieved by sparing the salivary glands on the noninvolved oral cavity and keeping the mean parotid gland dose of <26-30 Gy if the treatment of disease is not compromised and parotid function preservation is desired.

Intensity-modulated radiation therapy, IMRT, is commonly used in the treatment of head and neck cancers because of its effectiveness in reducing radiation exposure to major salivary glands, which can result in xerostomia.[1] With IMRT, dose distributions can be designed to conform specifically to a 3-D target, the advantages of which are improved radiation dose uniformity, creation of concave dose patterns exacting to the shape of the tumor, treatment of multiple targets simultaneously, and lowering complication rates.[2] Studies have shown that

  

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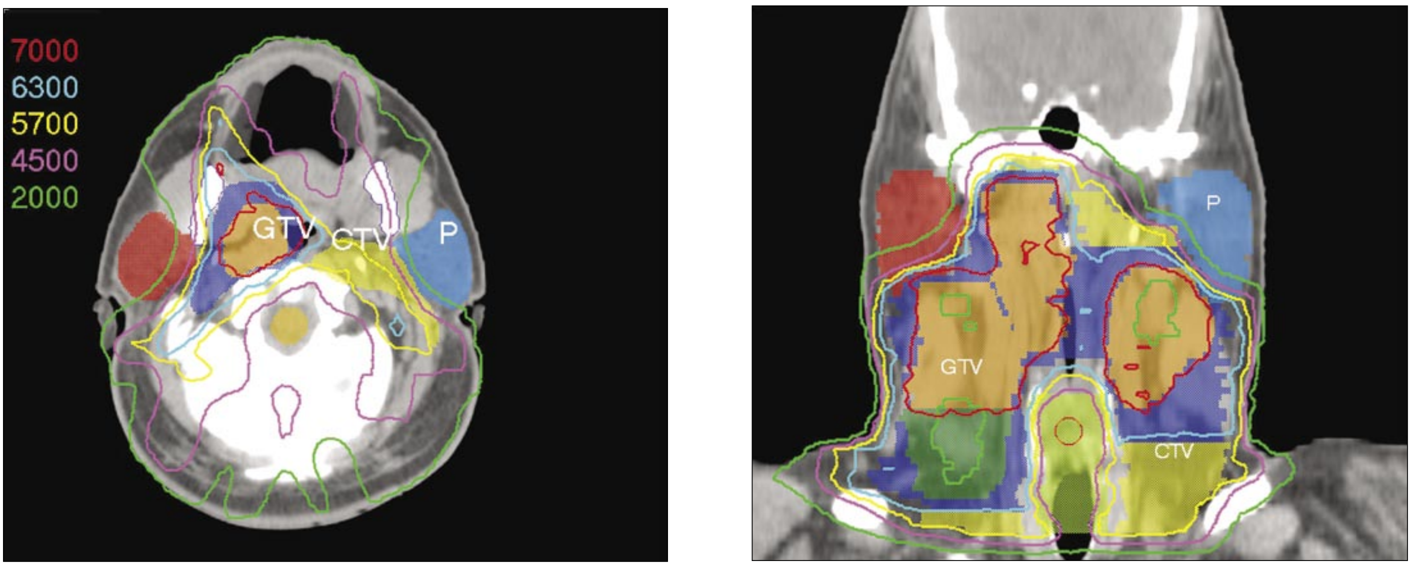

1a. **1b.**

Figures 1a and 1b. Example of parotid-sparing IMRT in a patient with advanced oropharyngeal cancer. In these axial (Figure 1a) and coronal (Figure 1b) sections (treatment planning CT scan) illustrating planned doses, the gross tumor volume (GTV) is 70 Gy and the clinical target volume (CTV) is 57-63 Gy, and the bulk of the superficial parotid (P) region is <20 Gy.

the tight, conformal radiation doses produced by IMRT and the absence of internal organ motion in the head and neck, substantially improve organ sparing and tumor control.[3,4] As well, other studies have shown that IMRT is dosimetrically (prescribed dose of radiation to the tumor volume) superior to conventional treatment approaches.[3-5] More recently, IMRT has been associated with improvements in tumor coverage, local-regional tumor control, and short-term toxicity in patients with head and neck cancers.[6] However, there is limited data about the long-term therapeutic benefit and late radiation toxicity associated with IMRT.[6] Several authors have reported a reduction of radiation-induced xerostomia following IMRT compared with conventional therapies.[1-7] In this article, the authors review current reports of salivary gland injury following IMRT for head and neck cancer.

Parotid Sparing

An effective way to diminish xerostomia is to spare one major gland from exposure to moderate- to high-dose radiation (**Figures 1a and 1b**). Traditionally, tonsillar carcinoma, even at an early stage, has been treated with bilateral therapy, which resulted in irradiation of all major glands. It was believed that early-stage carcinomas could be treated only to the involved side. Several large retrospective studies have subsequently demonstrated that ipsilateral radiation was safe. A study reported by O'Sullivan and colleagues described an ipsilateral radiation technique to restrict treatment to only the primary tumor and draining lymphatics of the neck on the same side as the tumor in patients with carcinoma of the tonsillar region.[8] From 1970 to 1991, these researchers treated 228 of 642 patients with carcinoma of the tonsillar region (mainly T1 and T2, N0, and N1) with this technique. After a mean follow-up of seven years, the three-year actuarial local control rate was 77 percent and the cause-specific survival rate was 76 percent, with failure in the opposite side of the neck occurring in only eight patients.[8] Difficulties with primary coverage early in the study resulted in higher rates of local failure. The researchers concluded that in appropriately selected patients with tonsillar carcinoma, the risk of failure in the opposite side of the neck is minimal with ipsilateral therapy, but computed tomography planning is necessary to ensure adequate target coverage.[8] However, the authors did not assess for xerostomia, but rather assumed that its incidence would be reduced in this population with the more volume limited technique.

Reddy and colleagues compared the outcomes of patients with cancer of the oral cavity who were treated with a 2-D technique, sparing at least one parotid gland (n=31) and a bilateral, opposed photon beam technique that included both parotid glands (n=83).[9] Patients for whom the parotid-sparing technique was used were able to maintain nutritional intake and retained their baseline body weight during and after irradiation. However, those treated with the bilateral technique had poor nutritional intake and lost more than 10 percent of their baseline body weights, and these patients did not regain their body weights within the two years post-treatment.[9] The primary tumor-control rates, with respect to tumor stage, for patients undergoing the parotid-sparing and bilateral techniques were similar (93 percent and 87 percent, respectively, for early-stage tumors; 42 percent and 36 percent, respectively, for advanced-stage tumors).

The authors noted that it was essential for the physician to consider the risk of contralateral cervical lymph node metastases when selecting patients for whom parotid sparing might provide benefit.[9]

While highly conformal techniques are being developed and used for patients requiring bilateral therapy of the head and neck, with very low doses delivered to the parotid glands, unilateral therapy appears to remain advantageous. Eisbruch and colleagues, comparing the outcomes of unilateral techniques and bilateral conformal techniques (including IMRT), demonstrated that unilateral therapy produced higher rates of salivary flow from the major contralateral glands.[2] In some cases of unilateral therapy, flow rates in the untreated gland were often higher than the pretreatment rates, suggesting a compensatory mechanism. Additionally, the mean radiation dose in the oral cavity correlated significantly with xerostomia scores, indicating that sparing the noninvolved oral cavity might facilitate further reduction of xerostomia.[2]

Parotid Doses and Xerostomia

One of the great challenges for radiation oncologists, who must treat all of the major glands, is understanding what dose limits exist to minimize xerostomia. Dreizen et al. in the 1970s, quantified saliva production in patients with head and neck cancer who were treated with radiation therapy.[10] In this study, it was noted that after 10 Gy, patients already developed a 50 percent reduction in salivary flow.[10] Furthermore, after receiving 50 Gy, patients had less than 10 percent salivary flow remaining and few patients regained salivary function.[10]

> The authors noted that it was essential for the physician to consider the risk of contralateral cervical lymph node metastases when selecting patients for whom parotid sparing might provide benefit.

In the 1980s, Marks et al. described decreased flow rates seen in the contralateral glands of patients treated with ipsilateral appositional electron beam fields due to the lower doses from the exit of the beam.[11] In these patients, the "untreated" gland was receiving <15 Gy. Emami et al. defined the tolerance dose (TD) of the saliva glands to radiation, stating the minimum TD 5/5 (tumor dose causing 5 percent complication rate at five years) as 30 Gy, and the TD 50/5 as 50 Gy.[12] Leslie and Dische described high rates of xerostomia in patients whose parotid glands received 40 Gy, but neglible rates in patients who received <14 Gy.[13] Thus, the tolerance doses of the glands lies somewhere within this wide range.[13] Investigators subsequently have tried to determine more precisely what this tolerance dose is through multicenter clinical research.

Part of the complexity of this task is to determine precisely where this dose lies, and to appropriately model this dose. The works of Dreizen and subsequently Leslie and Dische were relatively straightforward, as they made assumptions that the entire gland received the dose in question.[10,13] However, the parotid gland is often thought to be a parallel organ. It consists of multiple functional subunits, with xerostomia (if using a strict categorical definition) occurring only when a sufficient number of units are destroyed. Not only is dose determination and its definition complex, but the definition of xerostomia is also not uniformly accepted. Thus studies may either use subjective scores, or attempt objective measures of salivary flow when assessing xerostomia. Even the latter is fraught with challenges, as many investigators rely on whole saliva, while others will cannulate the specific ducts to obtain clearer measures. Blanco et al. addressed these challenges by studying numerous complex dose-volume models.[14] They concluded that a mean-dose model, which others had used for defining a tolerance dose, was predictive of xerostomia.[14]

Eisbruch and colleagues were the first to investigate the dose, volume, and functional relationships in parotid salivary glands following conformal and IMRT treatments for head and neck cancer.[15] They examined 88 patients with head and neck cancer who were irradiated with parotid-sparing conformal and multisegmental IMRT.[15] Unstimulated and stimulated saliva were measured from each parotid gland before radiation therapy (RT) and at 1, 3, 6, and 12 months post-RT. In glands receiving a mean dose below or equal to a threshold less than 25 percent of pretreatment level (24 Gy for unstimulated and 26 Gy for stimulated saliva) demonstrated preservation of the flow rates post-RT and continued to improve over time.[15] The glands that received doses below the threshold had functional recovery over time; whereas, glands receiving higher doses did not recover.[7,15] Partial volume thresholds were found as well: 67 percent, 45 percent, and 24 percent gland volumes receiving more than 15 Gy, 30 Gy, and 45 Gy of radiation, respectively.[15] Notably, salivary flow rates were not found to be affected by the patient's age, gender, pre-RT surgery, chemotherapy, and certain intercurrent illnesses. The conclusion of Eisbruch et al. was that a parotid gland mean dose of <26 Gy should be planned to substantially spare gland function and reduce overall xerostomia.[5,15,16] By subjective assessment in Eisbruch's series it was demonstrated that xerostomia has been significantly reduced in patients treated with bilateral neck, parotid-sparing RT as compared to patients with similar disease treated with conventional RT.[16,17] Twelve months following administration of post-parotid sparing IMRT, statistical significance (positive association) was found between patient-reported xerostomia and four domains of quality of life: eating, communication, pain, and emotion.[17]

Chao and colleagues, using mathematical modeling, concluded that the functional outcome of salivary flow using inverse-planning IMRT could be modeled as a function of dose; therefore, making the mean dose to each parotid gland a reasonable indicator for the functional outcome of each gland.[18] The entire parotid volume was used to compute dose-volume histograms in this trial evaluating 41 patients with head and neck cancer. At six months, the stimulated salivary flow rate reduced exponentially for each gland, independently, at a rate of approximately 4 percent per Gy of mean parotid dose.[18] This work was further developed and reported by Blanco et al.[14] After studying 65 patients, and evaluating six separate models, the mean-dose model remained predictive, thus, the researchers advocated its continued use. They also recommended keeping at least one parotid gland below 25.8 Gy; however, with the exponential improvement in flow rates (5 percent per 1 Gy), they suggested that even lower mean doses imply increased late salivary function.[14]

An additional finding made by both groups of investigators challenged the conventional wisdom that xerostomia was a permanent irreversible sequela of radiation.

An additional finding made by both groups of investigators challenged the conventional wisdom that xerostomia was a permanent irreversible sequela of radiation. Eisbruch and colleagues assessed long-term xerostomia in 84 patients with head and neck cancer who had undergone comprehensive bilateral neck RT using conformal and multisegmental IMRT to spare major salivary glands.[2] Xerostomia was assessed using a validated eight-item xerostomia-specific questionnaire. The researchers observed that, with these parotid-sparing techniques, xerostomia improved over time (second-year post-RT), with rising salivary production from the spared major salivary glands; thus, a long-term clinical benefit was achieved. This University of Michigan research group also studied the parotid salivary function up to 12 months post-RT in 20 patients receiving bilateral neck parotid-sparing RT to determine whether parotid preservation improved xerostomia-related quality of life.[19] Salivary sampling and a 15-item xerostomia-related quality of life scale were completed by each patient. The salivary flow rate from spared and treated glands decreased significantly at the completion of RT. Post-RT unstimulated and stimulated function increased and did not differ significantly from baseline; therefore, the researchers concluded that with the use of parotid-sparing RT, contralateral glands are preserved at 12-months post-RT with parallel improvement in xerostomia-related quality of life.[19] Similarly, Blanco et al. were able to measure stimulated whole saliva rates at six months (61 patients) and 12 months (31 patients), and demonstrated improvements in rates from six to 12 months after radiation.[14]

In a longitudinal trial, Munter and colleagues, using quantitative pertechnetate scintigraphy, evaluated salivary gland function following IMRT for head and neck cancer.[20] The mean dose to the primary planning target volume was 61.5 Gy and median follow-up was 23 months. In their study, it was concluded that it was possible to protect the parotid glands and reduce the incidence of xerostomia in head and neck cancer patients if mean parotid doses were <30 Gy.[20]

Bussels et al. used salivary gland scintigraphy and single photon emission computed tomography in 16 patients treated with a conformal parotid-sparing technique.[21] These researchers concluded that 22.5 Gy of RT resulted in a 50 percent loss of the excretion fraction of the functional subunit.[21]

Clinical Results of IMRT and Xerostomia

Further study by Chao and colleagues, compared the outcomes of conventional-beam RT and IMRT in patients treated for oropharyngeal cancer (n=430).[22] Specifically, the acute toxicity, late toxicity, and tumor control associated with these treatments were retrospectively reviewed. The dosimetric advantage of IMRT resulted in a significant reduction of late salivary toxicity, with no adverse impact on tumor control or disease-free survival.[22,23] After IMRT, only 17 percent to 30 percent of patients had late-grade 2 xerostomia (Common Terminology Criteria for Adverse Events v3.0: Symptomatic and significant oral intake alteration (e.g., copious water, other lubricants, diet limited to purees and/or soft, moist foods); unstimulated saliva 0.1 to 0.2 ml/min).

Although the majority had moderate to severe dry mouth during therapy, the spared salivary glands showed recovery over time. Chao et al. also evaluated the dosimetric conformity of IMRT for normal tissue-sparing in patients with oropharyngeal cancer by assessing the therapeutic outcomes of IMRT treatment as it relates to the impact on gross tumor volume (GTV) and nodal gross tumor volume (nGTV).[24] The results of a multivariate analysis showed that GTV and nGTV were important independent risk factors predictive of therapeutic outcome for definitive therapy for patients undergoing IMRT for oropharyngeal cancer.[24]

Recently, Eisbruch and colleagues conducted a longitudinal clinical trial in delineating the RT target volume in a parotid gland-sparing technique.[25] The researchers assessed patients treated with parotid-sparing IMRT for non-nasopharyngeal head and neck squamous cell carcinomas. Patients were assessed for the occurrence of local-regional failure near the base of skull and their relationships to the target delineation in the high neck.[25] The results reported in this study confirmed defining level II delineation in the contralateral node-negative neck so that the targets would include the subdigastric nodes, and not defining them as cranial as in conventional RT, allowing for substantial sparing of the contralateral parotid glands; hence, reduced salivary dysfunction.[25]

Although the majority had moderate to severe dry mouth during therapy, the spared salivary glands showed recovery over time.

Another study evaluating the RT target volume and organs at risk in oropharyngeal carcinoma defined the lowering of the cranial border of the level II lymph nodes from C1 to C2 in bilateral cervical RT in order to reduce the toxic effects on major salivary gland tissue as proposed by Astreinidou et al.[26] Lowering the cranial border to C2 with IMRT could be considered on the contralateral side if the risk of metastasis on that side is significantly low, thus reducing the average mean dose to the contralateral parotid gland.[26] Astreinidou reported a reduction of up to 68 percent in the normal tissue complication probability for xerostomia one year following RT (lowering the cranial border to C2) compared to conventional RT when treating C1.

Lee and colleagues analyzed the results of IMRT in the treatment of 67 patients with nasopharynx cancer.[27] Although the goal of the technique was improved tumor coverage with delivery of high dosing to the target, it is notable that lower doses to the parotid glands were demonstrated, and a low incidence of RTOG grade 2 or greater xerostomia. At three months post-IMRT, 64 percent of the patients had RTOG grade 2; 28 percent had grade 1; and 8 percent had grade 0 xerostomia.[27] In agreement with previous studies, Lee showed that the incidence of xerostomia decreased over time.[27] Wolden et al. recently updated previously reported findings from a study in which patients with nasopharyngeal cancer (n=74) treated with IMRT at Memorial Sloan-Kettering Cancer Center were found to have low rates of xerostomia in 59 patients with >one-year follow-up.[28] The rates of xerostomia were as follows: 26 percent none; 42 percent grade 1; and 32 percent grade 2.[28] The Radiation Therapy Oncology Group, RTOG, is now testing IMRT for treatment of nasopharyngeal cancer in a multi-institutional setting (RTOG 0225).[1]

Conclusions

IMRT and parotid-sparing techniques, in appropriately selected patients, hold promise for the treatment of head and neck cancer, potentially offering reduced severity of xerostomia without compromised tumor control.[6,29] Target determination and delineation is most important when planning salivary gland-sparing techniques of IMRT.[7] The extent to which the clinical benefits of parotid gland sparing are detectable depends on the volume of salivary tissues receiving subthreshold doses. Phase III clinical trials using RTOG guidelines and assessing IMRT in multicenter approaches or in cooperative groups will further validate the acute and longitudinal effects on salivary gland toxicity and oral sequelae. ■■■■

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Robert E. Horseman, DDS

The Her-story of Toothpaste

This was a boon for mothers who could discourage the further use of bad language and clean their kid's teeth at the same time.

In the eyes of the average citizen, the subject of toothpaste holds an interest rivaling that of coleslaw to anyone but dentists. This is a misconception. Dentists see toothpaste as a useful adjunct to oral hygiene surrounded by mountains of hype and concede that Colgate, Crest, et al. came, as the missionaries did to Hawaii, to do good and did very, very well. It helps to appreciate how far we've come by lifting the curtain on a bit of history.

The scene: Downtown Akhetaten, Egypt, in the year 3001 B.C.

Amenhotep, a local stringer for the *Cairo Daily Bhlat* has chanced upon beautiful Meht-urt, a recent graduate of the Lower Nile Cosmetology and Embalming Academy.

Amenhotep: Meht-urt, baby! You look like a million piasters! What have you done to yourself?

Meht-urt: I assume you are referring to my scintillating smile. It's the direct result of something called "toothpaste" what me and the girls at school have developed to brighten our otherwise dull teeth.

Amenhotep: What's in it? I must have some forthwith!

Meht-urt: Not so fast, Buster. Listen carefully; I shall say this only once. There's some black soot and gum arabic, a pinch of powdered ox hooves, and burnt egg shells and the secret ingredient, pumice.

You dip your chew stick in it; rub it on your teeth and Holy Hatshepsut! Teeth whiter than snow!

Amenhotep: What is snow?

Meht-urt: (ignoring him) Well, I'm off to the Dark Continent to have my toothpaste patented and declared a national treasure.

Amenhotep: Abyssinia?

Meht-urt: Not if I see you first.

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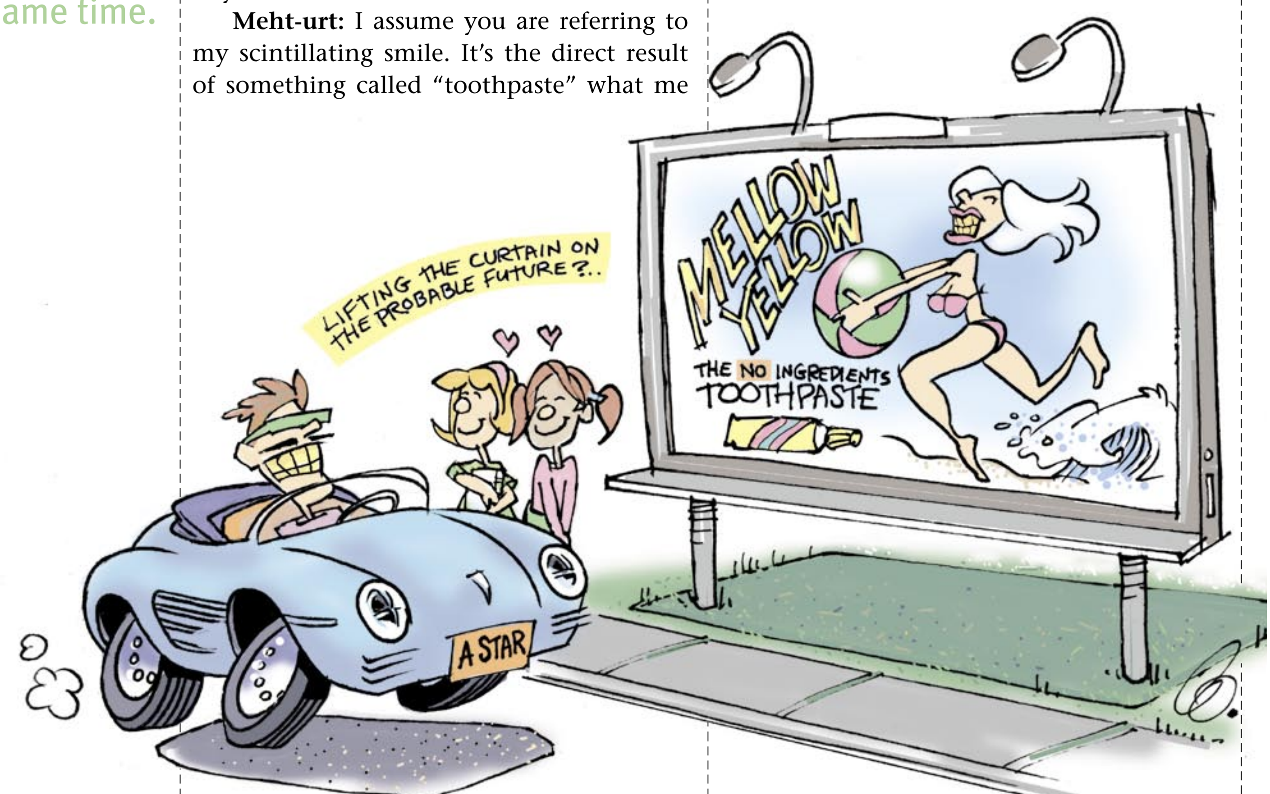

In 1937, Wallace H. Carothers in the DuPont Laboratories invented nylon, and bingo: Dr. West's miracle toothbrush with nylon bristles!

Continued from Page 770

Despite this auspicious beginning, toothpaste received little notice from the media what with the Huns, the Visigoths, the Romans and first and second Thessalonians all busily engaged in making the world safe for themselves at the expense of the others.

In 1824, a dentist called Peabody whose full name has been lost, or perhaps he, like Cher and Madonna, and Sting, rather fancied the cachet a single name endowed, added soap to toothpaste. This was a boon for mothers who could discourage the further use of bad language and clean their kid's teeth at the same time. Six years later, John Harris added chalk. On a roll now, improvements came fast and furious. Toothpaste first became mass-produced. A little glycerin to keep it moist, some calcium carbonate for bulk, maybe a bit of charcoal and some detergent for foam so it didn't dribble on your blouse or tie. It came in a jar, and according to Fortunata Stallwort, who died in Hartford at the age of 104 with two of her original teeth, "It smelled good."

The big break, though, came in 1850 when Dr. Washington Sheffield of Connecticut was the first to put toothpaste into a collapsible tube and his wife was the first to squeeze it from the top. He formed a company to market Dr. Sheffield's Crème Dentifrice, a company that was to become Colgate. Today, promptly at 10 a.m., employees at Colgate genuflect before Dr. Sheffield's portrait before taking their brush break.

Previously, around 1780, William Addis of Clerkenald, England, made his first toothbrush. Until that time, application of toothpaste was sharply divided between the haves and have-nots. The rich used aromatic twigs and the poor used their index finger, or in the case of the upwardly mobile, their pinky. In 1937, Wallace H. Carothers in the DuPont Laboratories invented nylon, and bingo: Dr. West's miracle toothbrush with nylon bristles!

Today we face an embarrassment of riches in toothpastes. When it became obvious, even to the most beef-witted, that flavor was the driving incentive to the use of toothpaste; the marketing mavens took over the development of dentifrice. Their early forays into selling toothpaste resulted in such pallid copy as Ipana's Ipana for the Smile of Beauty and Pepsodent's "You'll wonder where the yellow went when you brush with Pepsodent."

Now, of course, your local supermarket devotes entire aisles from floor to ceiling touting upward of 89 different brands of toothpaste. In addition, each company offers a half-dozen purportedly different formulas of their basic product. All of this backed by more media money than the combined GNP of a dozen nations.

The American public, many of whom have progressed to the 12th grade and beyond, will continue to be mesmerized by the chimera of tooth whitening, tartar reduction, and the chance of acquiring a better classmate.

Now that Meht-urt's patent on her Egyptian formulary has expired, look for the addition of powdered ox hooves and the attar of potrezebie to take their place alongside sodium lauryl sulfate and fluoride to cure a yet-to-be-determined oral ailment. ■■■■