Clinical Experiences
Crown Systems
Veneers

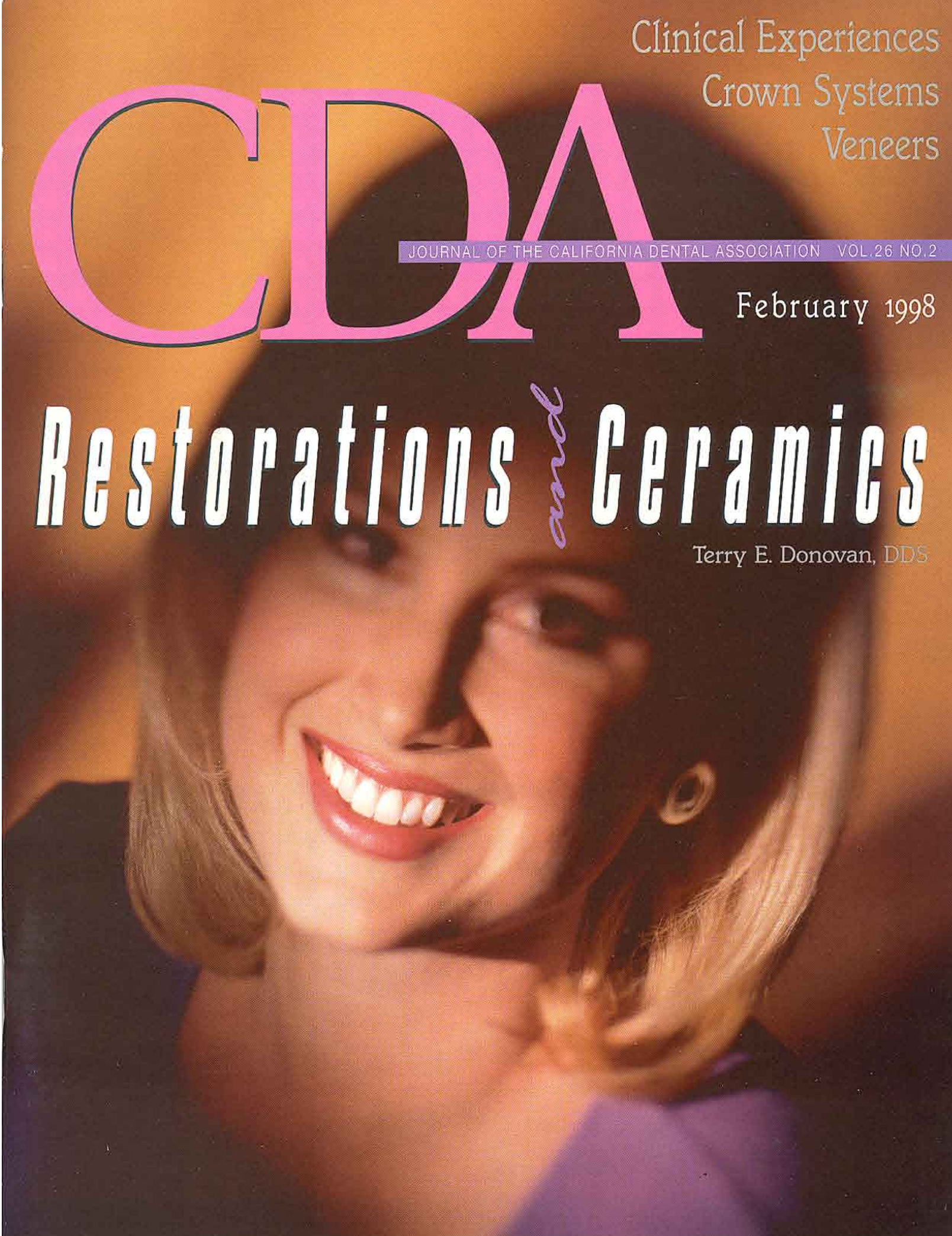
# CDA

JOURNAL OF THE CALIFORNIA DENTAL ASSOCIATION VOL.26 NO.2

February 1998

# Restorations and Ceramics

Terry E. Donovan, DDS



OF THE CALIFORNIA DENTAL ASSOCIATION
Journal
CDA Journal
Volume 26, Number 2
FEBRUARY 1998

## DEPARTMENTS



## FEATURES

CDA JOURNAL, VOL 26, Nº2

# Gatekeepers for Health

Jack F. Conley, DDS

Recent events have shown that an important responsibility that has been the province of the dentist has once more expanded in scope and significance.

We are reminded from time to time of the dentist's full role, which includes detection of oral cancer through intraoral examination; identification of patients who, without prophylactic medication, may be at risk for bacterial endocarditis; and recognition of patients with hypertension. Through review of patient medical histories and intra- and extraoral examinations, the dentist is in a unique position to uncover medical conditions that if left undiagnosed or untreated could jeopardize the well-being of the patient, particularly if dental treatment is undertaken without appropriate precautions. In some cases, the prospective dental patient has not recently undergone medical examination or tests that might identify conditions requiring treatment or preventive measures. Thus, the dentist may serve in a role as gatekeeper or guard in protecting the overall health of the dental patient.

This role -- which includes medical history review, patient interview, clinical examination and physical evaluation -- has recently taken on even greater importance and urgency in view of recent scientific reports regarding the effects or damage resulting from use of the diet drug commonly referred to as fen-phen. According to members of the ADA Council on Scientific Affairs, more than 4 million people in the United States may have used this drug, and up to 32 percent may have suffered some type of cardiac valve damage! Further, it is estimated that most dentists will see a dental patient affected by this potential problem. The specific guidelines for dental office management were published in the Nov. 14 issue of Morbidity and Mortality Weekly Report and in the mid-December issues of CDA Update and ADA News.

The important point here is that the recommendations of the Food and Drug Administration, Centers for Disease Control and Prevention, National Institutes of Health, and the Department of Health and Human Services deliver the message that we must be even more vigilant in our efforts to make complete and thorough evaluations of all patients prior to undertaking dental treatment. Referral for physician evaluation is suggested whenever a history of this drug is revealed.

Since members of the dental team frequently play a role in the interview and history review process, they are key players in this process because patients are comfortable in confiding in them. A report in the ADA News provided an excellent related example wherein a dental hygienist, familiar with the dental effects (rampant caries) of antifungal medications used to treat conditions caused by radiation therapy not only isolated this problem but aggressively sought a solution to a serious oral condition. The solution was formulation of a sucrose-free antifungal medication.

Both of these recent reports illustrate what we believe to be an expanding and necessary role for dentistry. So often we are told that with the prevention of dental diseases, caries and periodontal disease, the scope and importance of dentistry are declining. The focus on what dentistry does continues to be on the reparative or cosmetic functions, for obvious reasons. But what role is potentially of

CDA JOURNAL, VOL 26, Nº2

greatest importance to the health of the population we serve? Perhaps this role as a gatekeeper will be more appropriately acknowledged in the future.

As time passes, it is quite likely that science will uncover more oral manifestations, systemic conditions or medical-history-sensitive conditions that will increasingly be screened in the dental office rather than in a more traditional health service environment. The dental office team is uniquely positioned to take on what we believe will become a more defined health role in the future.

CDA JOURNAL, VOL 26, Nº2

## Helping a Child's Smile

By David G. Jones

Preventing dental disease in children is a nationwide year-round challenge for parents and dentists alike. But during February every year, National Children's Dental Health Month focuses on that challenge by promoting awareness of the perils of oral disease in youngsters.

A multi-headed effort is the substance underlying the theory of positively affecting the oral health of the country's children. The ADA, CDA, component societies and individual providers of dental care continue to share the challenge of creating ways to better provide dental care, access and education to young people and those who care for them.

CDA receives and distributes 15,000 special promotional posters provided by ADA to help promote National Children's Dental Health Month. The posters and corresponding promotional planning kits used by dental society volunteers use the "Dudley's Clubhouse" theme and special cartoon characters to help secure attention and interest. The promotional planning kits help promote activities and events to heighten public awareness about dental health issues, such as baby bottle tooth decay, fluoridation, sealants, access to dental care, use of mouth protectors, and other aspects of a sound dental health program.

As ongoing promotion and publicity improve public awareness, CDA's legislative agenda and the day-to-day voluntary activities of thousands of California dentists are making a difference in the quality of children's dental health. As a point of reference, a recent survey shows California's 6- to 8-year-olds to have more than twice the national average of tooth decay, while 30 percent of California kindergartners have never had a dental visit, and only 10 percent have had sealants applied.

To help improve the oral health of those children, CDA is working to expand the SB 111 program, the original goal of which was to reduce the incidence of dental disease among elementary school children through comprehensive, school-based prevention programs. Currently the program, which was signed into law in 1979, operates in 29 school-based programs in 28 of the state's 58 counties, annually serving approximately 320,000 preschool and elementary school children. CDA will be working to increase the state allocation for the program to cover more children in areas of the state not currently served. In addition, CDA has been involved in the development and implementation of another program to get dental care to more children.

"The Healthy Families Program authorizes $468 million in state funding to provide comprehensive health coverage for children whose families earn from 100 to 200 percent of the poverty level," says CDA policy analyst Bill Lewis.

A portion of the funding is for a comprehensive package of dental benefits for about 560,000 children who have no dental coverage because their families do not qualify for Denti-Cal and cannot obtain insurance by themselves or through their employer.

"California's citizens will be seeing even more attention to children's dental needs," says Ray Stewart, DMD, president of the California Society of Pediatric Dentistry, referring to CDA-sponsored legislation which would require health insurance companies to include hospital-based anesthesia benefits for children undergoing dental procedures requiring sedation.

Of course, the efforts of thousands of California dentists to provide pro bono or reduced fee services to the underserved populations makes a difference in many young lives. One example: 1,000 children are treated each year in Monterey County's Head Start program, and more than 12,000 children of indigent farm workers annually receive care at the Children's Miracle Network Dental Center in Salinas.

Another program is the award-winning San Mateo County Dental Society Brushmobile. Each year, the mobile and ongoing community preventive dentistry project, housed in a converted passenger bus, helps 20,000 kindergarten through fifth-grade students benefit from instruction provided by dental educators to reinforce home oral care techniques.

But even with the efforts of those and other dentists who voluntarily help battle children's dental disease, Stewart thinks much more needs to be done.

"I feel very strongly that we need more people taking care of these kids," he says. "The new Healthy Family legislation starting next summer will help a lot, but if we don't get more dentists into this network, there's just no way we can provide these services. CDA and the local dental societies really need to make an all-out effort to see these kids."

Stewart also said that an additional benefit of more volunteer dentistry is "a really good image enhancement, so that the pubic knows that dentistry has a lot of people doing something about the access problem."

Julie Jarrett, CDA's coordinator for the Council on Community Health, simply says, "Lots of dentists are already involved. If you're not, contact your local dental society to get involved."

## Endowed Professorship Established at UOP

Lee Atwood of San Rafael has given the University of the Pacific School of

Dentistry peace of mind by giving them a piece of land. The funds netted from the sale of property in Colma, Calif., will be used to establish an endowed professorship named in honor of her husband, Dr. T. Galt Atwood, a 1928 graduate of the San Francisco College of Physicians and Surgeons, forerunner of the UOP School of Dentistry.

"Galt had a love and loyalty for the College of Physicians and Surgeons," Atwood says. "I thought it was only befitting that the endowed professorship would help the school achieve its goals like Galt would do if he were alive today."

Atwood served on the board of trustees for the college in the 1960s before its amalgamation with the University of the Pacific.

The money from the property has been deposited into an interest-bearing account. Dividends from the account will be reinvested until it reaches the $500,000 goal necessary to establish the endowed professorship.

CDA JOURNAL, VOL 26, Nº2

# The Science of Communicating the Art of Dentistry

By Krikor Derbabian, DDS; Riccardo Marzola, DDS; and Alessandro Arcidiancono

**ABSTRACT** Laboratory work authorization forms are mainly developed in the form of written instructions,two-dimensional drawings or photographs. These can be supplemented with other forms ofcommunications, which will give three-dimensional information and take into account thelips, which are considered the frame of the teeth. This article will describe a systematicapproach to communication with a patient and laboratory technician using three-dimensional aids such as a smile replica, lip reproductions, provisional restoration casts and soft tissue casts.

AUTHORS

**Krikor Derbabian, DDS,** is an associate clinical professor in the Restorative Department of the University of Southern California School of Dentistry.

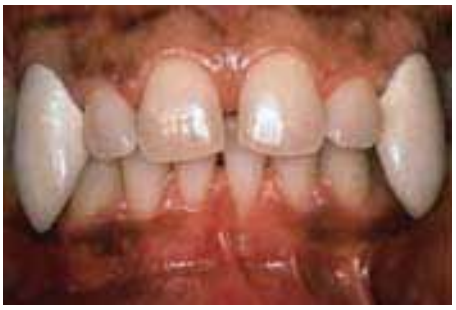
**Riccardo Marzola, DDS,** is an associate clinical professor at the USC School of Dentistry. Alessandro Arcidiacono is a dental technician and clinical instructor at the USC School of Dentistry.

One of the least emphasized but most important aspects of restorative dentistry is communication.[1] This communication must include the patient so his or her desires and expectations can be understood. The clinician must understand what a patient desires, but the patient must also understand restorative and anatomic limitations. The communication of esthetic parameters must then be made to the laboratory technician who will fabricate the restorations.

The ideal situation exists when the laboratory technician can meet the patient and the clinician personally during the diagnostic phases of the treatment.[2] Such a meeting will allow the laboratory technician to evaluate and gather information that is unavailable from mounted casts or a written work authorization form, such as the personality of the patient and the activity of his or her lips. Most clinical settings do not allow this interaction, since the dental laboratory and the dental office are often in separate locations. Thus, proper communication with the dental technician becomes a critical challenge for the success of treatment, especially in esthetically critical situations.[3-5]

## Understanding the Patient's Requirements

The most important aspect of the patient's treatment is diagnosis.[6,7] Once the diagnosis is determined, it will dictate the treatment.[8,9] In an esthetically driven treatment plan, the diagnosis includes



**Figures 1 and 2.** In Figures 1 and 2, each of the patients has his or her own cultural esthetic parameters, which can be very different from that of the restorative dentist.

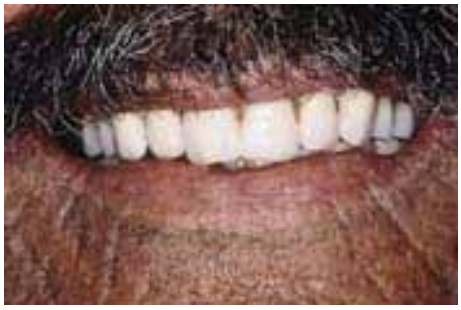


**Figure 3.** In a complete denture, the restorative dentist has maximum artistic freedom.

**Figures 4 through 7.** As shown in Figures 4 through 7, the smile replica is an easy way to give information about the existing restorations, smile line, gingival architecture and buccal corridors. An irreversible hydrocolloid impression is made of the teeth and lips, and then reproduced by pouring tooth-colored and tissue-colored acrylic resin in the appropriate areas.

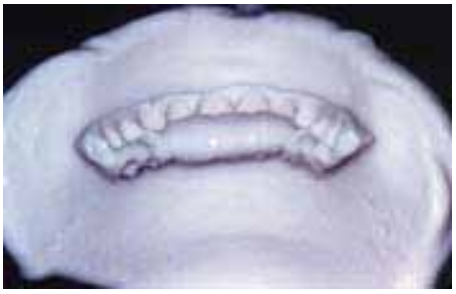


**Figure 4.**

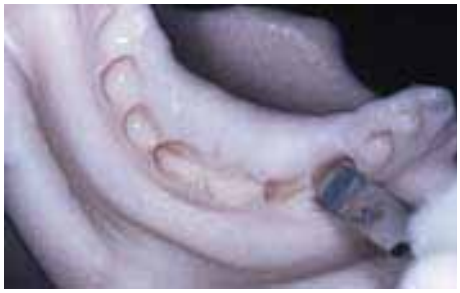


**Figure 5.**

**Figure 6.**

**Figure 7.**

**Figures 8 through 11.** As shown in Figures 8 through 11, the lip reproduction can be a very helpful three dimensional tool to aid in the placement and correction of the incisal edge and to develop the smile line.

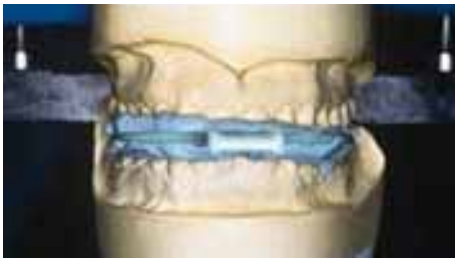


**Figure 8.**

**Figure 9.**

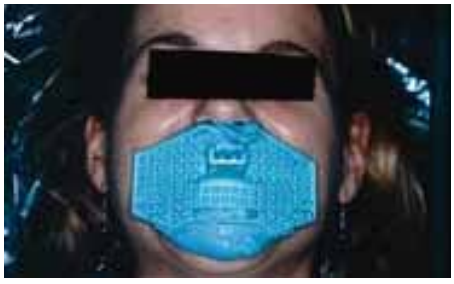


**Figure 10**

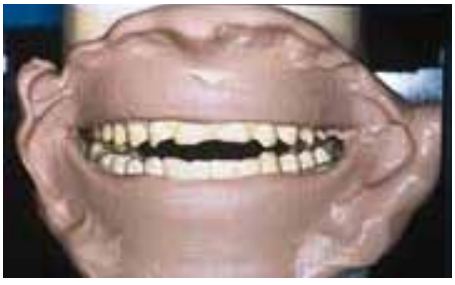


**Figure 11**

understanding the patient's desires and expectations. Will the patient accept natural-looking teeth, or does he or she want what is commonly referred to as a "Hollywood" smile, with white monochromatic teeth and artificial esthetic parameters? Does the patient understand the limitations that he or she presents with, or does he or she have unrealistic expectations? If the patient's desires are not realistic, the patient should be informed of the limitations at this time and further educated, otherwise, any future explanations will only be seen as excuses.

We should inform and educate patients about esthetics, but we should never impose our esthetic parameters on them, otherwise the consequences can be disastrous both emotionally and financially. Also, we need to keep in mind that as the patient's degree of edentulism decreases, the esthetic freedom that we enjoy as restorative dentists, decreases. When the type of restoration changes from a complete denture to a removable partial denture to a fixed partial denture and to a single unit restoration, our esthetic freedom gets more and more restricted. Restoring a single central incisor is by far more challenging than restoring several adjacent teeth. Similarly, creating an esthetic denture is far easier than a three-unit fixed partial denture, since we have a lot of freedom in selecting the shade, contour and position of the teeth, as well as in creating the gingival matrix around them to compensate for bone resorption and recession (**Figure 3**).[11]

## Visual Communication Tools

The challenge is to communicate all the gathered information to the laboratory technician who will create the final restorations. Evaluating the patient for esthetics begins with a survey of the patient's facial features. Items to note are facial symmetry, midline deviations, the parallelism between the occlusal plane and the interpupillary line, etc. [12] The smile and lips are then evaluated, noting the smile line, amount of tooth display, buccal corridors, gingival display, gingival architecture and symmetry, and gingival type which can be thin or thick and scalloped or flat. [13]

Next, focus on the teeth and evaluate their form, the presence and shape of mamelons, their texture and other internal characteristics.[14,15] The initial information that needs to be transferred to the laboratory technician includes diagnostic casts mounted in centric relation using either an average axis or transverse horizontal axis record, with the correct articulator settings. Complete face photographs, both facial and profile, as well as closeups of the smile and teeth, can also be beneficial. [16] The limitations of photographs, however, are that they are two-dimensional. Therefore, three-dimensional representations of the patient's smile and the lips can be valuable information both during the diagnostic (provisional) phase, as well as during the fabrication of the definitive restorations.

The smile replica is a simple procedure whereby an irreversible hydrocolloid impression is made of the patient's lips and teeth while the patient is smiling. This impression is then poured with autopolymerizing tooth-colored acrylic resin in the teeth areas and tissue color in the remaining areas. The result is a three-dimensional reproduction of the patient's teeth and lips (Figures 4 through 7). Another valuable communication tool is the lip reproduction. [17] This procedure has been previously described and can provide crucial information about incisal edge placement, especially if existing restorations or incisal wear have altered the teeth (Figures 8 through 12).

Transferring information about color and shade is probably one of the most difficult aspects of communicating with the laboratory technician. Many articles and textbooks have been devoted to this topic, and the readers is referred to them for further information. [18-27] An important point to make is the environment in which the shade is determined and the restorations fabricated. [28] Neutral surroundings both in the laboratory and the dental operatory are crucial, as well as a light source with a color rendering index greater than 90 and a color temperature of 5,000 degrees Kelvin. [29,30]

Research has shown the inadequacy of most shade guide systems. [31-34] Therefore, when it is not possible to find a perfect match, a shade higher in value and lower in chroma should be selected. [5] An abraded tab of the selected shade can be modified with surface colors to match the tooth (Figures 16 through 19).[29] This method is especially useful to communicate unique characterizations that some teeth exhibit. Another method of communicating the shade of the teeth is providing a detailed drawing to the laboratory technician. [35,36] This color map of the tooth can be very detailed, but it is somewhat more difficult to master (**Figure 20**).

These tools, in addition to a thorough laboratory work authorization form, are necessary for the laboratory technician to develop the diagnostic wax patterns. Once the patterns are completed, they need to be evaluated by the patient. Several methods are available to evaluate diagnostic wax patterns, including evaluating on the articulator and making tooth-colored acrylic resin overlays, which can be trial placed and modified intraorally (Figures 12 through 14). But by far the best method and the method that is recommended for any extensive restorative treatment is the provisional restoration (**Figure 15**). [37-40]

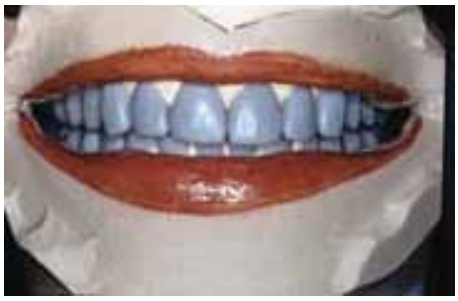


**Figure 12.** A completed diagnostic wax pattern.

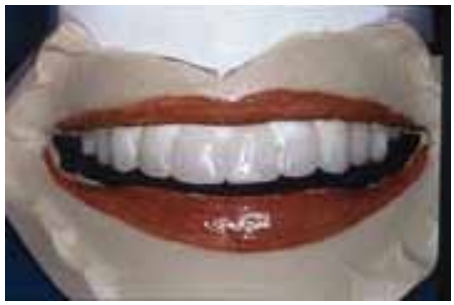


**Figure 13.** Acrylic overlay fabricated on existing casts.

## The Provisional Restoration as a Matrix

As shown in Figures 21 through 24, the provisional restoration is the best method to evaluate patient acceptance. Once the provisional restorations are accepted by the patient, they can be used in duplicating and creating the definitive restorations. This figure shows provisional restorations evaluated intraorally.

The soft tissue cast reproduces the gingival tissues that are lost on the working cast. It will help the laboratory technician in visualizing the sot tissues when contouring the gingival embrasures and is made by making a pick-up impression of the frameworks. Care must be used in selecting compatible materials for the impression and soft tissue materials.

Provisional restorations can be used to develop and modify the diagnostic wax patterns according to the patient's desires and wishes, as well as functional requirements. Once the patient is satisfied with the esthetic, phonetic and functional aspects of the provisional restorations, they will be used in communicating the patient's esthetic demands to the laboratory technician (Figures 21 through 23). [41]

Complete arch impressions are made of the provisional restorations intraorally. A silicone putty impression is made of these casts to be used to create full-contour wax patterns. This same index is also used as a guide to cut back the wax to provide a uniform layer of porcelain. Complete arch impressions of the prepared teeth are made and cross-mounted with casts of the provisional restorations. Depending on the extent of the treatment and circumstances, a new lip replica may be made at this time. Most often this is not necessary since the provisional restorations will be duplicated to create the final prosthesis.

**Figure 14.** Intraoral evaluation of the acrylic resin overlay.

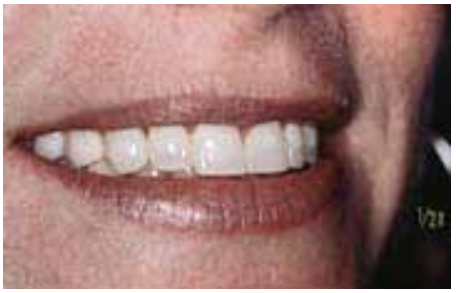


**Figure 15.** Intraoral evaluation of provisional restorations that will serve as a matrix for the definitive restorations.

**Figures 16 through 19.** As shown in Figures 16 through 19, an abraded shade tab can be characterized using surface colors to match the tooth.

**Figure 16.**


**Figure 17.**

**Figure 18.**

**Figure 19.**

**Figure 20.** A detailed drawing can be used to communicate shade and texture with the laboratory technician.

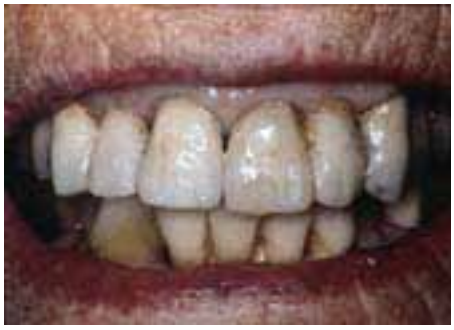


**Figure 21.** As shown in Figures 21 though 24, the provisional restoration is the best method to evaluate patient acceptance. Once the provisional restorations are accepted by the patient, they can be used in duplicating and creating the definitive restorations. This figure shows provisional restorations evaluated intraorally.

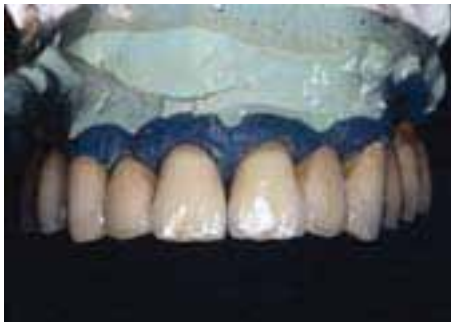
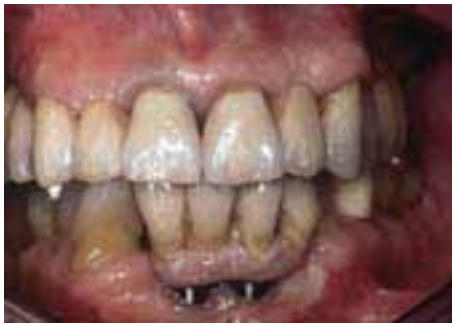


**Figure 22.** The soft tissue cast reproduces the gingival tissues that are lost on the working cast. It will help the laboratory technician in visualizing the soft tissues when contouring the gingival embrasures and is made by making a pick-up impression of the frameworks. Care must be used in selecting compatible materials for the impression and soft tissue materials.



**Figures 23 and 24.** Figures 23 and 24 show the definitive restorations.

The laboratory technician now has enough information to fabricate the metal frameworks. When these are ready, they will be trial placed intraorally and their fit checked and adjusted. Since most of the information about the soft tissue is lost when trimming the dies for the framework wax patterns, a pick-up impression is made at this time to create a soft-tissue cast. It is important to select the impression material as well as the soft tissue material carefully so that they are compatible. [42] With this cast, the laboratory technician has enough information about the gingival architecture and margin location to create the gingival embrasure forms to maximize esthetics. The final restorations are returned in the bisque bake stage for another esthetic evaluation. Since these are very close duplications of the provisional restorations, patient acceptance is almost certain. When the patient and dentist are satisfied, the restorations are returned to the laboratory for glazing and polishing.

## Summary

Written laboratory work authorization forms are not adequate to communicate both the science and art of dentistry. Several techniques and three-dimensional visual tools (smile replica, lip reproduction, provisional restoration casts and soft tissue casts) are available to better communicate these artistic and esthetic parameters with the patient and laboratory technician. Using a systematic approach, it is possible to evaluate and communicate the patient's esthetic and functional needs to the laboratory technician in a precise fashion.

References
1. Kessler JC, Dentist and laboratory: communication for success. Esthetic Dentistry, *J Am Dent Assoc* (special issue) December, 97-E, 1987.
2. Rieder CE, The role of operatory and laboratory personnel in patient esthetic consultations. *Dent Clin North Am* 32(2):275, 1998.
3. Rivers JA and Schmidt GA, Improving laboratory performances through effective dentist/technician communication. Quintessence Dent Technol 7(1):51, 1983.
4. Preston JD, Current status of shade selection and color matching. Quintessence International 1:47, 1985.
5. Clark EB, The color problem in dentistry. Dent Dig 37:499, 1931.
6. McCollum BB, Considering the mouth as a functioning unit as the basis of a dental diagnosis, in A Research Report, Scientific Press, 1955, p 9.
7. Mann AW, Examination, diagnosis and treatment planning in occlusal in rehabilitation. J Prosthet Dent 17(1):73, 1967.

8. Dawson PE, Solving occlusal problems through programmed treatment planning, in Evaluation, Diagnosis and Treatment of Occlusal Problems, CV Mosby, Chap 28, 1989, p 477.
9. Lindhe J, Textbook of Clinical Periodontology. Munksgaard, Copenhagen 1989, Chap 13.
10. Preston JD, Color and esthetics. In, Yamada NH, ed, Dental Porcelain: the State of the Art 1977. University of Southern California, Los Angeles, 1977, p 309.
11. Chee WW and Donovan TE, Treatment planning and soft tissue management for optimal implant esthetics. Ann Acad Med Singapore 24:113, 1995.
12. Rufenacht CR, Fundamentals of Esthetics. Quintessence Publishing Co, Inc, Chicago, Ill, 1990.
13. Ochsenbein C and Ross S, A re-evaluation of osseous surgery. In, *Dent Clin North Am*. WB Saunders, Philadelphia, 1969, p 87.
14. McLean JW, The Science and Art of Dental Ceramics. Vol I: the nature of dental ceramics and their clinical use. Quintessence Publishing Co, Inc, Chicago, 1979.
15. McLean JW, The Science and Art of Dental Ceramics. Vol II, Bridge design and laboratory procedures in dental ceramics. Quintessence Publishing Co, Inc, Chicago, 1980.
16. Miller L, Organizing color in dentistry. Esthetic Dentistry, *J Am Dent Assoc* (special issue) December, 26-E, 1987.
17. Rifkin L and Materdomini D, Facial/lip reproduction system for anterior restorations. J Esthet Dent 5(3):126, 1993.
18. Nevins M, The periodontist, prosthodontist and laboratory technician: a clinical team. In, Perspective in Dental Ceramics (Proceedings of the Fourth International Symposium on Ceramics). Quintessence Publishing Co, Inc, Chicago, 1988, p 407.
19. Martin D, The dental technologist's role in the clinical team. In, Perspectives in Dental Ceramics (Proceedings of the Fourth International Symposium on Ceramics). Quintessence Publishing Co, Inc, Chicago, 1988, p 421.
20. Preston J, The metal ceramic restoration: the problem remains. Int J Periodont Rest Dent 4(5):9, 1984.
21. Shavell HM, Dentist-laboratory, relationship in fixed prosthodontics. In, Perspective in Dental Ceramics (Proceedings of the Fourth International Symposium on Ceramics. Quintessence Publishing Co, Inc, Chicago, 1988, p 439.
22. Tanaka A, Successful technologist-dentist teamwork. In, Perspective in Dental Ceramics (Proceedings of the Fourth International Symposium on Ceramics). Quintessence Publishing Co, Inc, Chicago, 1988, p 439.
23. Wolf M, Teamwork and communication in implantology: dentist-technician-implant surgeon. Int *J Dent* Symp 2(1):12, 1994.
24. Shannon JL and Rogers WA, Communicating patients' esthetic needs to the dental laboratory. J Prosthet Den 65(4):526, 1991.
25. Drago CJ, Clinical and laboratory parameters in fixed prosthodontic treatment. J Prosthet Dent 76(3):233, 1996.
26. Rivers JA and Schmidt GA, Improving laboratory performance through effective dentist/technician communications. Quintessence Dent Technol 7(1):51, 1983.
27. Karlsrud GM, Technician-dentist communication: the key to superior restorations. Trends Techniques Contemp Dent Lab 10(3):49, 1993.
28. Jinoian V, The importance of proper light sources in metal ceramics. In, Perspectives in Dental Ceramics (Proceedings of the Fourth International Symposium on Ceramics. Quintessence Publishing Co, Inc, Chicago, 1988, p 229.
29. Preston JD, Color and esthetics. In, Yamada NH, ed, Dental Porcelain: the State of the Art 1977. University of Southern California, Los Angeles, 1977, p 309.
30. Preston JD, Ward LC and Bobrick M, Light and lighting in the dental office. *Dent Clin North Am* 22:432, 1978.
31. Lemire PA and Burk B, Color in Dentistry. JM Ney Co, Bloomfield, Conn, 1975.
32. Culpepper WP, A comparative study of shade matching procedures. J Prosthet Dent 24(2):166, 1970.
33. Sproull RC, Color matching in dentistry: the three-dimensional nature of color. J Prosthet Dent 29(4):416, 1973.
34. Sproull RC, Color matching in dentistry: practical applications of the organization of color. J Prosthet Dent 29(5):556, 1973.
35. McLean JW. The Science and Art of Dental Ceramics. Vol I: The nature of dental ceramics and their clinical use. Quintessence Publishing Co, Inc, Chicago, 1979.
36. McLean JW, The Science and Art of Dental Ceramics. Vol II: Bridge design and laboratory procedures in dental ceramics. Quintessence Publishing Co, Inc, Chicago, 1980.
37. Preston JD, A systematic approach to the control of esthetic form. J Prosthet Dent 35(4):393, 1976.
38. Youdelis RA and Faucher R, Provisional restorations: An integrated approach to periodontics and restorative dentistry. Dent Clin N Am April:285, 1980.
39. Fisher D, Shillingburg HT and Dewhirst RB, Indirect temporary restorations. *J Am Dent Assoc* 82:160, 1971.
40. Dawson PE, Solving occlusal wear problems. In, Evaluation, Diagnosis and Treatment of Occlusal Problems. CV Mosby, Chap 30, 1989, p 500.
41. Rieder CD, The use of provisional restorations to develop and achieve esthetic expectations. Int J Periodont Rest Dent 9(2):123, 1989.
42. Beyak BL and Chee WW, Compatibility of elastomeric impression materials for use as soft tissue casts. J Prosthet Dent 76(5):510, 1996.

To request a printed copy of this article, please contact Krikor Derbabian, DDS, USC School of Dentistry, 925 W. 34th St., Room 4366, Los Angeles, CA 90089-0641.

CDA JOURNAL, VOL 26, Nº2

# Soft Tissue Management With Metal-Ceramic and All-Ceramic Restorations

TERRY E. DONOVAN, DDS, AND GEORGE C. CHO, DDS

**ABSTRACT** Many advances have been made in recent years to the science and the art of metal-ceramic and all-ceramic restorations. However, no matter how natural and lifelike such restorations may be, the final esthetic result is most dependent upon the health and level of the surrounding gingival tissues. The key to success is effective soft tissue management, and the goal of this soft tissue management has been to provide healthy gingival tissues covering sound, smooth restorative margins.

AUTHORS

**Terry E. Donovan, DDS,** is an associate professor and executive associate dean at the University of Southern California School of Dentistry. He is also chairman of the Department of Restorative Dentistry and co-director for advanced education in prosthodontics.

**George C. Cho, DDS,** is an assistant professor and the director of clinical education for Advanced Education in Prosthodontics at the USC School of Dentistry.

The past three decades have witnessed numerous improvements in metal-ceramic and all-ceramic crowns. In spite of these technological improvements, the majority of esthetic failures with such restorations are biologic. The two primary types of esthetic failure have been recession of the gingival tissues resulting in exposure of the restorative margins and the presence of chronic marginal gingival inflammation (Figures 1 and 2).

When metal-ceramic crowns were introduced to the profession in the late 1950s, shoulder-bevel margins with metal collars were advocated to provide optimal fit (**FIGURE 3**).[1] To obtain acceptable esthetics, the metal margins were intended to be hidden within the confines of the gingival sulcus. This concept proved to be rather unpredictable and lead to the development of numerous techniques for fabrication of all-porcelain labial margins with metal-ceramic crowns.[2-7] The evolution of such simplified techniques, along with the introduction of several innovative all-ceramic crown modalities, has eliminated the necessity of hiding metal margins deep in the gingival sulcus. However, it is clear that it is impossible to precisely match the shade of the restoration with the color of the gingival portion of the tooth with these restorations, and in most clinical situations it is still desirable to hide the restorative margins underneath the healthy gingival tissues. The exception to this statement is bonded porcelain veneers, where tooth reduction is minimal

and the restoration is bonded to sound enamel. In these situations, the contact lens effect allows margins to be placed in a supragingival location (**Figure 4**).

## Gingival Recession

Gingival recession in adults is not a natural effect of aging but rather is a result of pathology. If excellent gingival health is attained prior to definitive margin placement and proper clinical techniques are utilized, the relationship between the prepared restorative margin and the gingival tissues can be very stable, as long as the patient practices proper oral hygiene. There are a number of ways to prevent gingival recession related to anterior crown fabrication, but most of these are under control of the clinician.

One of the most important factors in the predictability of the final result is ensuring that the gingival tissues are very healthy at the time of definitive margin placement and making of the impression. Most often patients requiring extensive restoration of anterior teeth do not present with healthy gingival tissues.[8] Preparing these teeth for esthetic crown restorations and making the impressions at the same appointment in the presence of gingival inflammation or periodontal disease is a prescription for disaster.

FWith placement of the definitive restorations a few weeks later, it is reasonable to assume an improved effort on behalf of the patient to comply with oral hygiene procedures, and often in these situations the inflammation in the gingival tissues will resolve or at least be reduced. In these situations, the gingival tissues will move in an apical direction, often exposing the restorative margins. This can occur during the provisional phase or shortly after the definitive restorations are placed. In either situation, the clinician is faced with an esthetic failure.

The optimum approach is to wait to determine the final margin location when the gingival tissues have attained a state of optimal health. With most anterior restorations, the approach recommended is to prepare the teeth, leaving the margins in a slightly supragingival location (**Figure 5**). Excellent provisional restorations are fabricated, which restore optimum crown and gingival tissue contours, provide access for proper oral hygiene, and serve as predictors for the definitive restorations (**Figures 6 and 7 a through c**).[9] Whatever periodontal procedures are necessary to return the tissues to a state of optimal health are performed. After the tissues are deemed healthy with accepted clinical parameters, the patient is placed on Peridex (Colgate/ Palmolive, Cincinnati, Ohio) for two weeks. 10 The optimal location for the gingival margin is determined, and the margin is prepared. Impressions are made and the patient continues rinsing with Peridex until the definitive restorations are placed.

It is essential that tooth preparation does not result in damage to the gingival tissues. Pre-packing the gingival sulcus with retraction cord prior to placing the margin in the confines of the sulcus will prevent iatrogenic damage. On removal of the cord, a defined space permits dropping of the margin with minimal chance for trauma. Use of rotary instruments especially designed to minimize trauma is recommended (Tissue Protection Diamonds, Premier Dental Products, Norristown, Pa. ) (**Figure 8**).

It is also critical not to damage the attachment apparatus during gingival displacement procedures. The philosophy of attaining optimum gingival health prior to definitive margin location, coupled with placement of the gingival margin a short distance into the gingival sulcus, permits relatively atraumatic retraction procedures. A suitable diameter retraction cord (Ultrapack Retraction Cord, Ultradent Products, Salt Lake City, Utah) soaked in a hemostatic agent (Hemodent, Premier Dental Products, Norristown, Pa.) is placed in the gingival sulcus for eight to 10 minutes.[11] Prior to removal of the cord, it is soaked with water to prevent damage to the inner epithelial lining of the sulcus.[12]

The importance of fabricating quality provisional restorations cannot be overemphasized. These restorations may be made early in the restorative sequence as part of the healing phase or after the preparations are finalized. In either event, such provisionals must demonstrate physiologic crown contours and excellent marginal integrity and provide adequate esthetics. The authors prefer an indirect/direct technique for provisional fabrication, but whatever technique is utilized, the aforementioned parameters must be met.[13-15]

When final cementation is with a conventional dental luting agent, such as zinc phosphate or glass ionomer cement, a zinc oxide-eugenol temporary cement (Temp-Bond, Kerr Dental Mfg., Romulus, Mich.) is preferred. While it is now known that zinc oxide-eugenol cements are not obtundent to pulpal tissues, they do provide an excellent initial seal of the prepared tooth. This tends to eliminate sensitivity during the provisional stage. However, zinc oxide-eugenol is a potent soft tissue irritant, and care must be taken that all excess temporary luting agent is removed from the sulcus prior to dismissing the patient. Any residual cement left in the sulcus will result in significant inflammation. This inflammation is transitory and will resolve with cementation of the definitive

CDA JOURNAL, VOL 26, Nº2

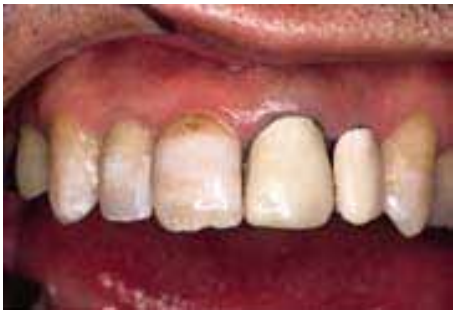


**Figure 1.** Tooth Nos. 7, 9 and 10 have been restored with metal-ceramic crowns, with the exception of a porcelain labial margin on No. 7. The crowns on teeth Nos. 9 and 10 have many esthetic deficiencies, and recession of the gingival tissues has exposed the unsightly metal gingival margins.

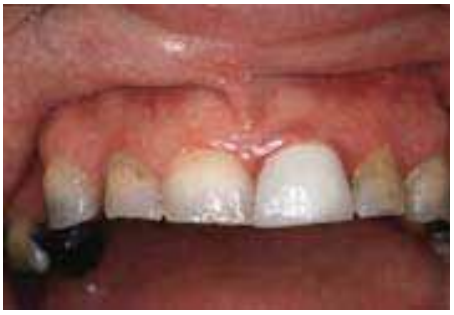


**Figure 2.** The obvious chronic marginal inflammation displayed around the crown on tooth No. 9 is typical of biologic width violation.

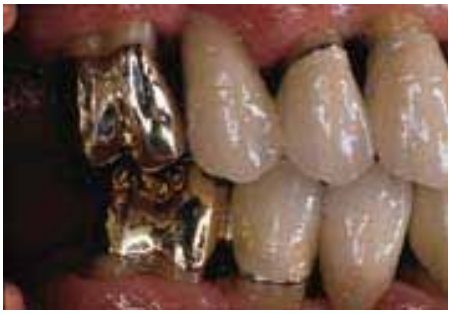


**Figure 3.** Teeth Nos. 5 and 29 have metal-ceramic restorations with supragingival margins and a metal collar. Such margins provide excellent marginal integrity and can be used where esthetics is not critical.

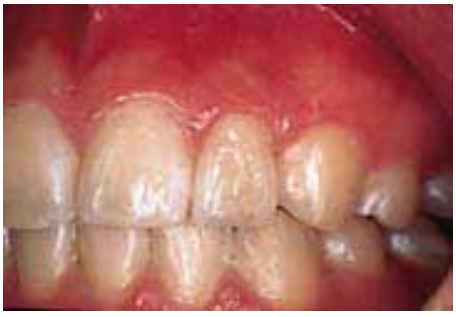


**Figure 4.** The porcelain laminate veneer on tooth No. 10 has a supragingival margin that is almost invisible because of the contact lens effect that occurs with these restorations.

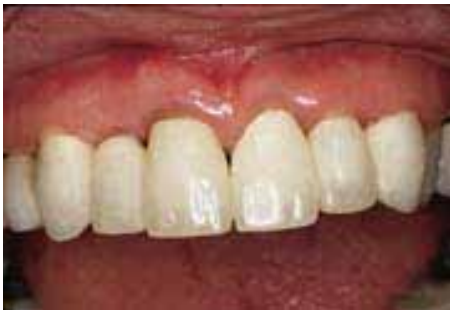


**Figure 5.** The anterior teeth have been prepared with supragingival margins and provisional restorations fabricated prior to and during definitive periodontal therapy

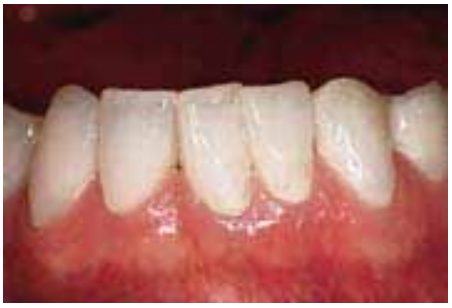


**Figure 6.** The provisional restorations on teeth Nos. 22 through 27 demonstrate excellentesthetics, marginal integrity and physiologic crown contour.

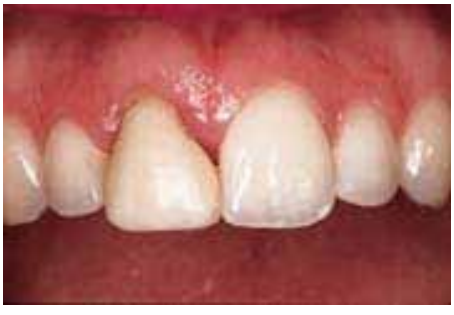


**Figure 7A.** The patient presented with a poorly contoured provisional restoration on tooth No. 8.

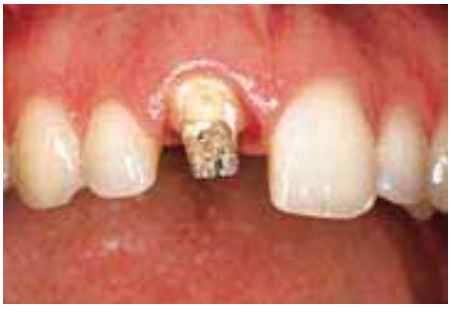


**Figure 7B.** The tooth preparation was completed.

**Figure 7C.** A new provisional restoration was fabricated and designed to contour the gingival tissues.

**Figure 8.** Tissue protection diamonds, such as these illustrated here (Premier Dental Products, Norristown, Pa.) are excellent for atraumatically dropping cervical margins to a subgingival location.

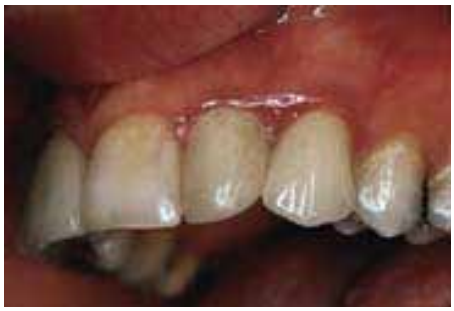


**Figure 9.** The inflammation around the crowns on teeth Nos. 10 and 11 is typical of biologic width violation and is not likely simply a result of poor oral hygiene.

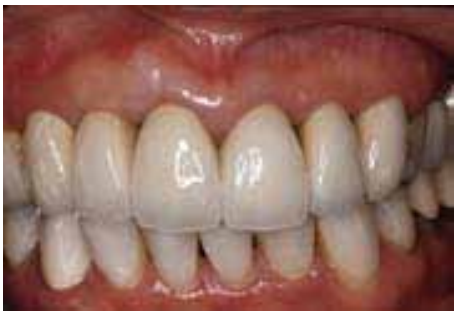


**Figure 10.** The metal-ceramic splinted fixed partial denture on these anterior teeth have all-porcelain labial margins (except tooth No. 7, ovate pontic) that are smooth and esthetic, and provide adequate marginal integrity.

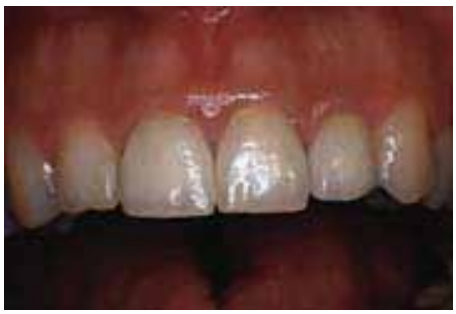


**Figure 11.** Metal-ceramic crowns (teeth Nos. 8, 9 and 10) with a properly placed porcelain labial margin can provide excellent esthetics and periodontal health.

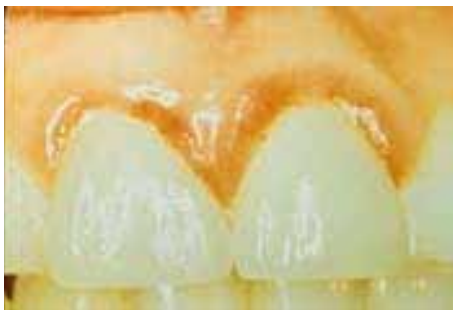


**Figure 12.** These restorations have been placed deep in the sulcus, and the resultant violation of biologic width has caused the chronic gingival inflammation.

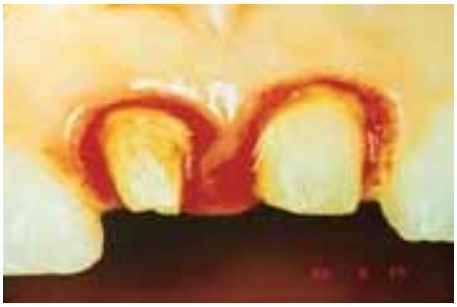


**Figure 13.** After the crowns in Figure 12 have been removed, it is obvious how deep into the sulcus the margins were placed. Crown lengthening is necessary to move the gingival attachment to a more apical position.

restorations; but when the tissue heals, it will be at a more apical level and the resultant recession may expose the restorative margins.

When patients require periodontal surgical procedures such as crown lengthening, sufficient time must be allowed after the surgery to permit stabilization of the gingival crest. It is often stated that a waiting period of six to eight weeks is required to attain adequate stability. However, for many patients, this time frame is far too short.[16] In a majority of patients, a waiting period of five to six months is recommended. This will mean that many patients will be wearing provisional restorations for protracted lengths of time. It is recommended that such provisional restorations be removed and recemented approximately every six weeks to prevent leakage and subsequent recurrent caries.

In summary, recession in association with the placement of anterior restorations is preventable. Attaining optimum soft tissue health prior to final determination of margin location is essential. Atraumatic tooth preparation and gingival displacement procedures are required, along with the fabrication of excellent provisional restorations. A meticulous technique for provisional cementation is critical, and provision must be made for tissue shrinkage after periodontal surgical procedures.

## Gingival Inflammation

While recession exposing the gingival margins has been a primary cause of esthetic failure with metal-ceramic and all-ceramic restorations, an equally compelling problem is the chronic marginal inflammation in the gingival tissues associated with such restorations (**Figure 9**). For many years, such marginal inflammation was attributed to poor oral hygiene, and the patient was admonished to improve oral physiotherapy, usually to no avail. Certain cervical marginal configurations have been demonstrated to be inherently rough and thus to increase the potential for plaque accumulation and retention. Therefore, they may contribute significantly to such marginal inflammation.[17] It is clear that smooth margins of highly polished metal or glazed porcelain are the optimum materials to be placed in the gingival sulcus (Figures 10 and 11).

However, possibly a majority of

chronic inflammatory gingival responses are likely caused by a violation of biologic width. [18,19] It is tempting for the clinician, especially when having experienced recession in previous patients, to decide to place crown margins deep into the gingival sulcus to prevent marginal exposure in the event of recession. Clinical studies have demonstrated that the closer the restorative margin is to the attachment, the poorer is the periodontal response, or expressed another way, the further the margin is from the attachment, the better is the periodontal response. [20] Specific recommendations have been made to place the restorative margins 0.5 mm from the healthy free gingival margin, or more precisely, a minimum of 3.0 mm from the alveolar crest. [21,22]

It is the opinion of the authors that the etiology of the gingival inflammation seen in the majority of anterior crown restorations is biologic width violation because margins are routinely placed too deep into the sulcus (Figures 12 and 13). Often, this results from the clinician not following the anatomical sculpting of the gingival tissues, and the interproximal margins are place too close to the attachment.

While almost all authorities recommend supragingival crown margin placement wherever possible, most anterior crowns are automatically prepared with subgingival margins for esthetic reasons. One excellent study demonstrated that as many as 25 percent of patients do not display the anterior gingival tissues with a normal or even and exaggerated smile. [23] This finding has significant clinical implications in that if patient consent is obtained, many anterior restorations can be placed with supragingival margins, which results in an improved periodontal response, better evaluation of marginal integrity, and substantially simplified operative procedures. [24]

In summary, chronic marginal inflammation associated with anterior crowns can be prevented by using restorative margins that are inherently smooth and by placement of such margins a relatively short distance (0.5 mm) into the sulcus as measured from the crest of healthy gingival tissues. Margins must be a minimum of 3 mm from the alveolar crest, and patients must be instructed in and encouraged to perform optimum oral hygiene procedures.

## Summary and Conclusions

Many advances have been made in recent years to the science and the art of metal-ceramic and all-ceramic restorations. However, no matter how natural and lifelike such restorations may be, the final esthetic result is most dependent upon the health and level of the surrounding gingival tissues. The key to success is effective soft tissue management, and the goal of this soft tissue management has been to provide healthy gingival tissues covering sound, smooth restorative margins. The essential details for effective soft tissue management have been delineated and expanded upon, and are the same whether all-ceramic or metal-ceramic restorations are utilized. Successful, meticulous attention to detail will result in clinical success regardless of the type of restoration chosen.

References
1. Donovan TE and Prince J, An analysis of margin configurations for metal-ceramic crowns. J Prosthet Dent 53:153-7, 1985.
2. Toogood GD and Archibald JF, Technique for establishing porcelain margins. J Prosthet Dent 40:464-6, 1985.
3. Vryonis P, A simplified approach to the complete porcelain margin. J Prosthet Dent 42:592-3, 1979.
4. Prince J, Donovan TE and Presswood RG, The all-porcelain labial margin for metal-ceramic restorations: A new concept. J Prosthet Dent 50:793-6, 1983.
5. Prince J and Donovan TE, The esthetic metal-ceramic margin: A comparison of techniques. J Prosthet Dent 51:273-5, 1984.
6. Cooney JP, Richter WA and MacIntee MI, Evaluation of ceramic margins for metal-ceramic restorations. J Prosthet Dent 54:1-5, 1985.
7. Kessler JC, Brooks TD and Keenan MP, The direct lift-off technique for constructing porcelain margins. Quint Dent Tech 10:145-150, 1986.
8. Nemetz H, Tissue management in fixed prosthodontics. J Prosthet Dent 31: 628-36, 1974.
9. Preston JD, Rational approach to tooth preparation for ceramo-metal restorations. Dent Clin N Amer 21:683-9, 1974.
10. Sorensen JA, Doherty FA, Newman MG and Flemming TF, Gingival enhancement in fixed prosthodontics. Part I: Clinical findings. J Prosthet Dent 65:100-7, 1991.
11. Nemetz H, Donovan TE and Landesman HM, Exposing the gingival margin. A systematic approach to the control of hemorrhage. J Prosthet Dent 51:647-51, 1984.
12. Anneroth G and Nordenram A, Reaction of the gingiva to the application of threads in the gingival pocket for taking impressions with elastic materials. Odontol Rev 20:301-10, 1969.
13. Fisher DW, Shillingburg HT and Dewhirst RB, Indirect temporary restorations. J Prosthet Dent 32:160-5, 1971.
14. Donovan TE and Chee WWL, Tissue management in fixed prosthodontics. Part II: Provisional restorations. Cal Inst Cont Ed March 1990:9-18.
15. Cho GC and Chee WWL, Custom characterization of the provisional restoration. J Prosthet Dent 69:529-32, 1993.
16. Wise MD, Stability of gingival crest after surgery and before anterior crown placement. J Prosthet Dent 53:20-3, 1985.
17. Keenan MP, Shillingburg HT et al, Effects of cast gold surface finishing on plaque retention. J Prosthet Dent 43:168-73, 1980.
18. Gargiulo AW, Wentz FM and Orban B, Dimensions and relations of the dentogingival junction in man. *J Periodontol* 32:261-7, 1961.
19. Ingber JS, Rose LF and Coslet JG, The biologic width: A concept in periodontics and restorative dentistry. Alpha Omegan 70:62-5, 1977.
20. Newcomb GM, The relationship between the location of subgingival crown margins and gingival inflammation. *J Periodontol* 45:151-4, 1974.
21. Block PL, Restorative margins and periodontal health: A new look at an old problem. J Prosthet Dent 57:683-9, 1987.
22. Kois JC, Altering gingival levels: The restorative connection. Part I: Biologic variables. J Esthet Dent 6:3-9, 1994.
23. Crispin BJ and Watson JF, Margin placement of esthetic veneer crowns. Part I: Anterior tooth visibility. J Prosthet Dent 45:278-80, 1981.
24. Christensen GJ, Marginal fit of gold inlay castings. J Prosthet Dent 16:297-301, 1966.
To request a printed copy of this article, please contact Terry E. Donovan, DDS, USC School of Dentistry, DEN 4368, MC 0641, Los Angeles, CA 90089-0641.

CDA JOURNAL, VOL 26, Nº2

# Rational Use of Contemporary All-Ceramic Crown Systems

By George C. Cho, DDS; Terry E. Donovan, DDS; and Winston W.L. Chee, BDS

**ABSTRACT** There are a host of contemporary all-ceramic systems available today, as well as improved techniques for metal-ceramic restorations. Perhaps the most important factor in achieving predictable success with these restorations is excellent soft tissue management. Metal-ceramic restorations provide the most predictable service in terms of clinical longevity, versatility and prevention of wear to the opposing dentition.

AUTHORS

**George C. Cho, DDS**, is an assistant professor and director of clinical education for advanced education in prosthodontics at the University of Southern California School of Dentistry.

**Terry E. Donovan, DDS,** is an associate professor and executive associate dean at the USC School of Dentistry. He is also chairman of the Department of Restorative Dentistry and co-director of advanced education in prosthodontics.

**Winston W.L. Chee, BDS,** is an associate professor and the Ralph W. and Jean L. Bleak Professor of Restorative Dentistry at the USC School of Dentistry. He is also director of implant dentistry and co-director of advanced education in prosthodontics at USC.

During the past 20 years, several all-ceramic crown systems have been developed and introduced to the profession. Some of these systems have represented significant technological innovations, and some have been evolutionary generations of earlier ceramic systems. All have been developed in an attempt to compensate for some of the inherent deficiencies in metal-ceramic restorations.[1-4]

However, what has not been primarily understood is that most esthetic failures with anterior restorations are a result of inappropriate soft tissue management rather than deficiencies that can directly be attributed to the restorations themselves.[5] Such deficiencies in tissue management will result in esthetic failure regardless of the type of restoration utilized (**Figures 1 and 2**).

The metal-ceramic crown has been the predominant restoration of the past two decades. Any discussion on indications and contraindications for all-ceramic crowns must first consider the advantages and disadvantages of metal-ceramic restorations.

There have been two significant developments with metal-ceramic restorations in the past several years that have dramatically improved their inherent esthetic potential. The first is the development of techniques to build color internally within the ceramic veneer and the concomitant development of lateral segmental build-up techniques. The ability to place the color internally and veneer it with more translucent incisal and

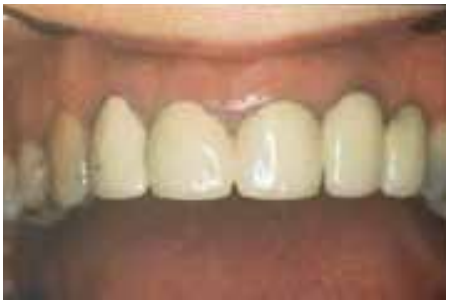


**Figure 1.** Recession is perhaps the most common esthetic failure with anterior crowns.

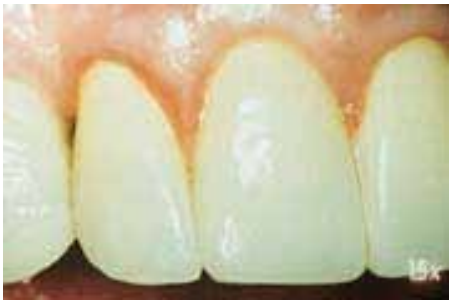


**Figure 2.** Inflammation frequently occurs with anterior crowns as a result of placing the margins too deep in the gingival sulcus.

**Figure 3.** By placing color internally on a textured opaque surface, the refraction of light can create a natural appearance.

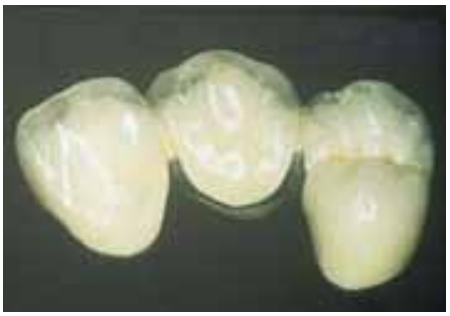
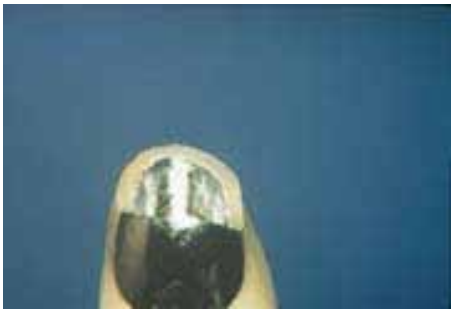


**Figure 4.** Translucent incisal and body porcelains allow the internal color to predominate.



**Figures 5 and 6,** Porcelain margins on metal ceramic crowns can provide excellent fit and esthetics.

**Figure 7.** The incidence of fracture with all-ceramic crowns has been quite high.

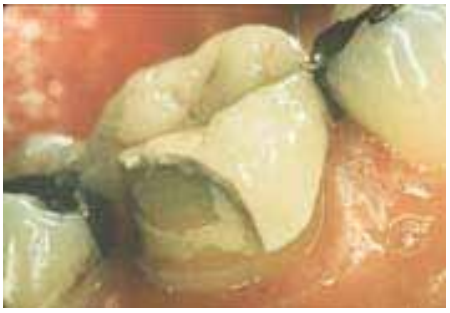


**Figure 8.** Many systems demonstrate excellent marginal integrity when used on a cylindrical test die.

**Figure 9.** All-ceramic preparations (B) generally require more tooth reduction on the lingual and interproximal surfaces than preparations for metal-ceramic crowns. (C)

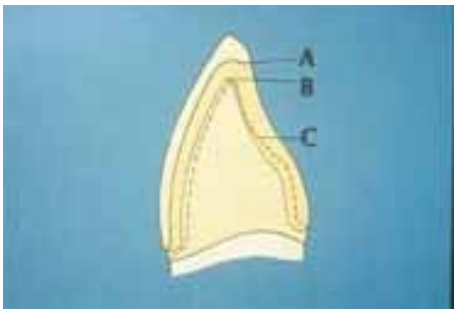



**Figure 10.** All-ceramic crowns are not indicated with non-ideal tooth preparation because of lack of support for the restorative material.

**Figure 11.** Metal copings can provide optimum support for the ceramic veneer.

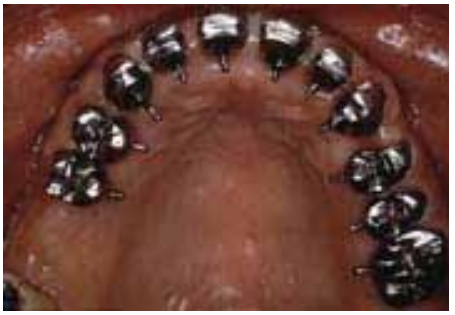


**Figure 12.** Porcelain in gliding contact with natural dentition will cause attrition.

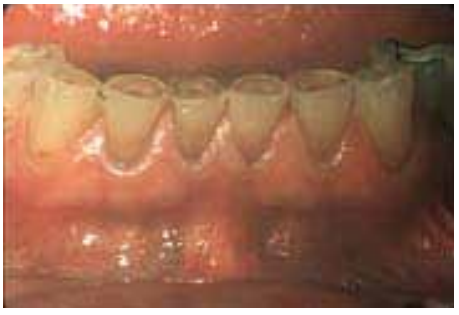


**Figure 13.** Design of the cutback and resultant metal framework on anterior crowns can provide optimum compression bonding and reduce wear.

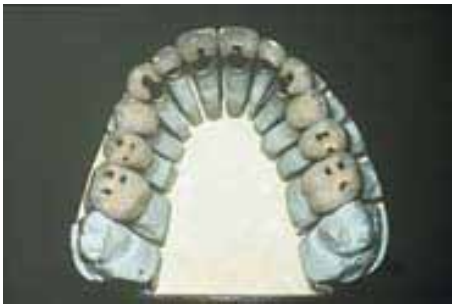


**Figure 14.** Metal occlusal surfaces on posterior restorations require less tooth reduction, permit more precise occlusal contacts, and will prevent wear of the opposing dentition.

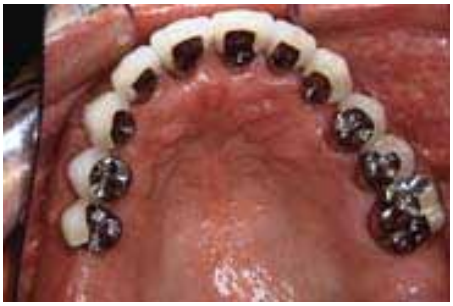
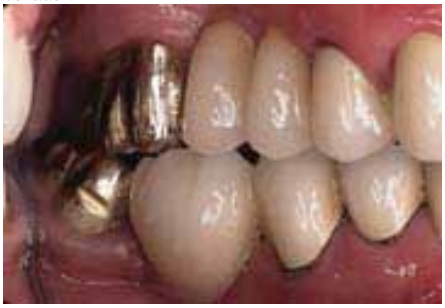


**Figure 13.** Design of the cutback and resultant metal framework on anterior crowns can provide optimum compression bonding and reduce wear.



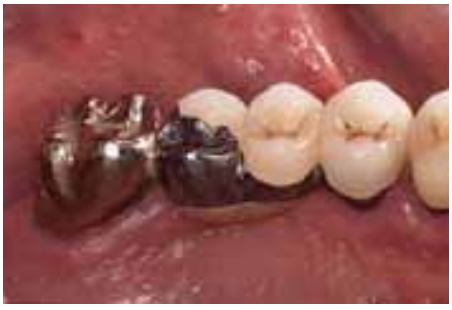


**Figure 15 and 16** As seen in Figures 15 and 16, Metal-ceramic restorations can be used in simple and complex restorative situations. Figure 17. If an all-ceramic crown has an internal opaque core, the esthetic potential will be no better than that of a metal-ceramic crow

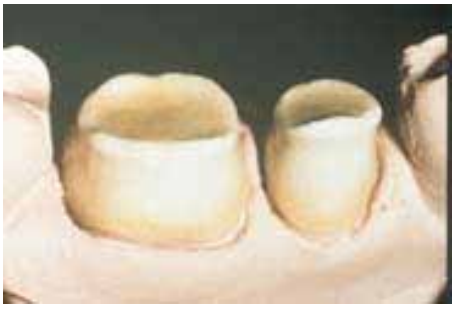


**Figure 17.** If an all-ceramic crown has an internal opaque core, the esthetic potential will be no better than that of a metal-ceramic crown.

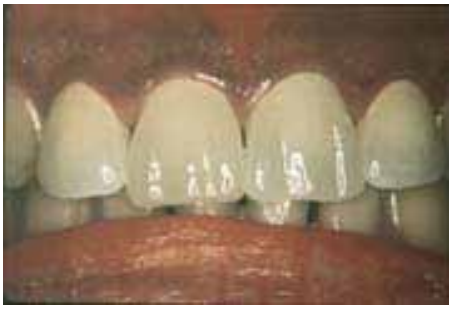


**Figure 18.** Dicor restorations are shaded with extrinsic coloration. This can result in high surface reflectivity.

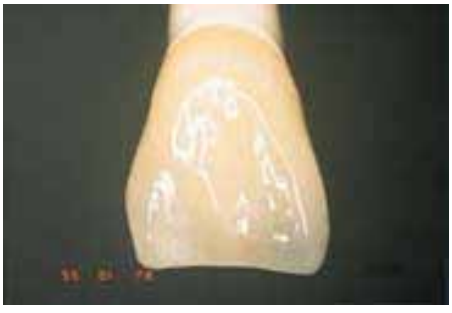


**Figure 19.** Willi's Glass restorations are highly esthetic but have a poor clinical track record.

body porcelains through these layering techniques has added the dimension of depth to metal-ceramic crowns and significantly improved the appearance of these crowns (**Figures 3 and 4**). Any restoration today that cannot provide such depth of appearance will run the risk of failure due to specular reflection and a high incidence of metameric mismatches.

As seen in **Figures 5 and 6**, Porcelain margins on metal ceramic crowns can provide excellent fit and esthetics.

The second improvement in metal-ceramic technology has been the development of numerous techniques for simplifying fabrication of all porcelain labial margins (**Figures 5 and 6**).[6-12] Some authorities even recommend 360 degree all-ceramic margins to improve light transmission in the cervical third. While a comparison of techniques for fabricating porcelain margins is beyond the scope of this article, it is safe to state that several effective techniques are available to the ceramist today, and all can result in esthetic margins with acceptable marginal integrity. Routine use of such margins for anterior restorations can result in esthetic restorations and eliminate the necessity of placing margins deep into the sulcus to hide them.

Given that metal-ceramic restorations can be fabricated to provide both excellent esthetics and good longevity, this article will compare results with these restorations with a number of contemporary all-ceramic systems.

Such an analysis may provide the reader with important guidelines when making a choice between metal-supported and all-ceramic systems, and also differentiate the all-ceramic systems. In this process, several important principles regarding metal-ceramic and all-ceramic crowns will be delineated and highlighted as a guide to the practicing clinician.

The parameters that will be compared include strength, fit, conservation of tooth structure, wear potential, ease of fabrication, use in multiple unit situations, economic factors, biocompatibility, and esthetic potential.

## Strength and Clinical Life Span

While the need for extremely esthetic and natural restorations has become predominant in recent years, in most situations the requirement that such restorations also provide a reasonably

predictable long-term clinical Life Span is also paramount. One of the deficiencies of early all-ceramic crowns such as the feldspathic porcelain jacket crown was its lack of such predictability. Many of the newer systems have been marketed heavily on the basis that these crowns are stronger or are reinforced with a core material that will prevent clinical fracture.

The underlying assumption that strengthened porcelains will result in improved clinical performance simply lacks validity. Ceramic restorations do not fail because they lack strength. Flaw-free glass has been shown to be stronger than stainless steel.[13] The real problem with dental ceramics is that with our current techniques it is impossible to produce restorations that are free of microscopic defects, or what are known as Griffith's flaws.[14] Such flaws will propagate under even minor occlusal loads and will undergo static fatigue.[15,16] The result is often sudden, catastrophic failure of the restoration under low-stress situations (**Figure 7**).

Clinicians should be guided in their choice of an all-ceramic system on the basis of controlled clinical trials. Unfortunately, these are only infrequently conducted, and often the data is not available on a system until long after the system has been introduced, been a commercial failure, and has disappeared from the scene. It is apparent that increases in strength, documented by laboratory studies using static loads, are useless in predicting clinical performance.

In general, the clinical trials that have been conducted indicate that most available systems have high failure rates when used on posterior teeth. As a simplistic guide, most studies report a failure rate of 33 percent or higher within three to five years on posterior teeth. Given that the primary indication for an all-ceramic restoration is high esthetic demand, and that this is rarely a problem with posterior restorations, it would seem prudent to avoid placing all-ceramic crowns on posterior teeth.

Many clinical trials were conducted with all-ceramic crowns luted with conventional cements. It is generally accepted today that most all-ceramic crowns should be internally etched and bonded into place with a resin cement. Bonding these restorations results in somewhat greater strength, which should translate into improved clinical service; however, this has not been well-documented. Clinicians should avoid using resin-modified glass ionomer cements with all-ceramic crowns. There have been numerous anecdotal reports of post-cement expansion of such cements, which has reportedly resulted in fracture of the restoration. More research in this area is indicated.

With regards to strength of all-ceramic restorations, three important principles emerge:

- Principle No. 1. Gains in strength of all-ceramic restorations, as documented by laboratory studies, are of no value in determining clinical performance.
- Principle No. 2. Controlled clinical trials are essential to indicate criteria for clinical success with all-ceramic systems.
- Principle No. 3. All-ceramic crowns should not be used indiscriminately to restore posterior teeth.

## Marginal Integrity

Almost all new ceramic systems come to market with exaggerated claims that this new system will automatically provide superior marginal integrity over all other systems. Research into such claims has generally demonstrated that decent marginal integrity can be achieved with most systems. Marginal integrity is usually more dependent upon the ability of the clinician to provide a margin of optimum design and upon the skill of the laboratory technician than the inherent accuracies of each system.[17]

With most systems, manufacturers supply slides illustrating the superior seating of their crowns (**Figure 8**). However, most of these restorations are fabricated on circular test dies that do not have the usual clinical margin configuration with the labial margin significantly apical in position compared to the interproximal margins. Usually, the lingual margin is positioned in between the labial and interproximal margins. Research has demonstrated that when such clinically relevant margins are used, the accuracy of the fit is significantly reduced.

Crown systems utilizing refractory dies may well provide unpredictable results related to marginal integrity. This is because each batch of refractory material must be carefully calibrated by the laboratory technician to provide maximum accuracy. This is rarely done in most commercial laboratories.

- Principle No. 4. No all-ceramic system provides inherently superior marginal integrity. Overall, all-ceramic crowns have slightly poorer marginal integrity than metal-ceramic crowns.
- Principle No. 5. Any all-ceramic crown system that utilizes refractory dies will be technique-sensitive unless each batch of refractory material is carefully calibrated in the laboratory.

## Conservation of Tooth Structure

A basic tenet of almost all restorative procedures is that it is important to conserve tooth structure. Tooth preparations for metal-ceramic crowns are inherently radical, and teeth are weakened considerably with such preparations.

CDA JOURNAL, VOL 26, Nº2

It is important to understand that preparations for current generations of all-ceramic crowns are even more radical.18 With the advent of porcelain laminate veneers that can be successfully bonded to etched enamel, such radical preparations would seem to be headed in the wrong direction.

To provide sufficient thickness of ceramic material for strength and esthetics, a uniform circumferential 1.5 mm of reduction is recommended with most all-ceramic systems (**Figure 9**). It is important that an all-ceramic crown is fabricated with a relatively uniform cross-sectional bulk of porcelain so that minimal stress is built up internally in the restoration as it is heated and cooled during the firing procedures. This means more tooth structure is reduced axially from the interproximal and lingual surfaces with all-ceramic preparations than with metal-ceramic preparations.

- Principle No. 6. All-ceramic crowns, as they are presently conceived, require more tooth reduction and are therefore less conservative than metal-ceramic crowns.

## Non-Ideal Tooth Preparations

Most tooth preparations in a clinical setting are done because of the presence of significant caries or fractured cusps and because the tooth cannot be restored by more conservative means. This means that many tooth preparations for both metal-ceramic and all-ceramic crowns are considerably less than ideal (**Figure 10**).

With metal-ceramic crowns, the loss of tooth structure and less than ideal tooth preparations can be compensated for with metal copings (**Figure 11**).

Thus, a uniform amount of ceramic veneer can be applied to the coping and minimal stress will accumulate at the bond. This also will ensure that the porcelain is adequately supported by the metal sub-structure.

With all-ceramic crowns, there is no adequate way to compensate for lack of an ideal tooth preparation. This often means there will be considerable variability in thickness that corresponds to unsupported porcelain in the final restoration that may well result in early clinical fracture of the crown.

- Principle No. 7. With all-ceramic crowns it is difficult, if not impossible, to compensate for lack of an ideal tooth preparation.

## Wear of Opposing Dentition

When porcelain is in gliding contact with opposing dentition, it will cause accelerated attrition of the opposing teeth (**Figure 12**).[19]

This is a major problem when restoring anterior teeth since the occlusal scheme usually advocated is anterior group function with disclusion of the posterior teeth in protrusive and lateral excursions. There is no clinical documentation for the claim that certain porcelain systems do not wear the opposing dentition. There is also no adequate laboratory test that can predict the clinical effect of any system in this regard.

With anterior metal-ceramic crowns, this problem of wear can be addressed with proper design of the metal framework. Generally, centric occlusion contact can be established in metal as well as most of the lateral and protrusive excursions (**Figure 13**). Metal occlusals are preferred for posterior crowns because less tooth reduction is required, a more precise occlusal pattern can be obtained, and wear of the opposing dentition is prevented (**Figure 14**).

- Principle No. 8. All types of porcelains will cause attrition of the opposing dentition when in gliding contact with natural teeth.

## Use as Fixed Partial Dentures or Multiple Splinted Units

All-ceramic restorations as currently conceived should only be used as single units. There are techniques for fabricating fixed partial dentures with many of the available systems, but clinical results have been very poor and usually limited to three units.

Metal-ceramic restorations can be used as single units, fixed partial dentures, multi-unit fixed splints, or as bonded (Maryland) prostheses. They can be cast in one piece, or either pre- or postsoldered (Figures 15 and 16).

- Principle No. 9. All-ceramic restorations are primarily single-unit crowns.

As seen in Figures 15 and 16, Metal-ceramic restorations can be used in simple and complex restorative situations.

## Ease of Fabrication

One of the most important factors in success with any restorative modality is lack of technique sensitivity. The success of silver amalgam as a restorative material is a prime example. Most all-ceramic systems are technique-sensitive. They often require use of alternative die materials or refractories.[20] Special equipment such as casting machines, investing units, computer-controlled ovens, CAD-CAM, etc. are required; and the laboratory technician is required to learn new procedures and techniques, each of which may have its own learning curve.

In addition, the clinician must provide a very specific tooth preparation for all-ceramic crowns that requires rounded internals without any sharp angles. This may often be subtly different from what the clinician normally prepares for metal-ceramic preparations. Initially, many all-ceramic crown systems experienced unduly high failure rates because the tooth preparations received from clinicians were

CDA JOURNAL, VOL 26, Nº2

often inadequate. This commonly occurred because the clinicians had not been properly educated regarding the critical nature of the all-ceramic preparations.

In a global sense, all dentists will continue to place many metal-ceramic restorations, since fixed partial dentures and splinted restorations will continue to be a necessity in patient treatment plans. The clinical and laboratory procedures required for fabrication of esthetic and durable metal-ceramic restorations have been well-researched and utilized for more than 30 years. It would seem a reasonable philosophy to attempt to educate dentists on optimal tooth preparations for metal-ceramic restorations and at the same time ensure that technicians understand how to achieve optimal esthetics with metal-ceramic restorations. In the long run, such an approach may be preferable and may yield improved results, rather than requiring both dentists and technicians to learn and re-learn the subtleties involved with each new ceramic system.

- Principle 10. Optimum results are obtained with standardized procedures and techniques. Any system that is classified as technique-sensitive will have a lack of predictability in the clinical setting.

## Economic Considerations

When evaluating laboratory costs for the practitioner, it is difficult to generalize on the differences between metal-ceramic and all-ceramic crowns. However, it is relatively safe to state that the fees for all-ceramic crowns are usually not less than those charged by the average laboratory for metal-ceramic units.

Often dental laboratories incur significant expenses when installing a new all-ceramic system. In an effort to recoup these expenses, a laboratory will usually undertake an aggressive marketing campaign to gain new clients and to maximize the utilization of the new system. This frequently results in both the dentist and laboratory providing less than an optimum service, as both are in the early stages of the learning curve specific for that system. The costs associated with remakes and loss of patient confidence should be considered when analyzing the overall impact of utilizing a new all-ceramic system in the practice.

- Principle No. 11. There are no economic advantages associated with all-ceramic crowns for either the patient or dentist.

## Biocompatibility

It has often been stated that certain all-ceramic crowns are more biocompatible than their metal-ceramic counterparts. While this statement has scant documentation, it is true that ceramic materials tend to be less biologically active than metal alloys. Whether this is of any real benefit is questionable, except in the case of documented allergy to a component of a metal alloy.

There are some patients who have real or imagined sensitivity to certain materials. These patients often request certain all-ceramic restorative materials to prevent systemic reactions. The reader is warned that these patients should be treated with great caution. Often, emotional and systemic problems will be attributed to reactions to dental materials that are totally out of the control of the operator.

Patients with sensitivity to metal alloys can be treated with all-ceramic restorations, but they should be informed prior to treatment that fracture incidence is significantly higher with all-ceramic crowns and they will be financially responsible for any necessary remakes.

- Principle No. 12. All-ceramic crowns systems are less biologically active than those using metal alloys. These ceramic crowns may be of use in treating select patients with documented metal allergy. These patients should be informed of the likelihood of an increased fracture rate.

## Esthetic Potential

The primary indication for all-ceramic crowns is the need for optimum esthetics. However, it is important to understand that not every all-ceramic system automatically provides an esthetic result that is superior to metal-ceramic crowns.

Given the assumption that porcelain labial margins with metal-ceramic crowns eliminate the problem of metal show through or excess opacity in the cervical third, the major advantage possessed by all-ceramic crowns is the potential for improved light transmission in the cervical third. The strengthening mechanism for many all-ceramic systems is the use of a high-strength internal core. Most of these internal cores are quite opaque, and the transmission of light with these systems is no better than that achieved with a metal core (**Figure 17**). Given that the primary indication for all-ceramic crowns is improved esthetics, it would seem prudent to avoid those systems that do not provide this.

- Principle No. 13. If an all-ceramic crown system uses an internal opaque core, the esthetic results achieved with that system will be no better than what could achieved with a metal-ceramic crown.

Many other all-ceramic systems consist of cast or pressed ceramics with no potential for internal characterization or layering effect. With these systems, all the color is on the external surface; and with these restorations it is difficult to control the desired texture of the labial surface, and the surface tends to be highly reflective resulting in metameric mismatches.

These restorations do not look natural because of the lack of depth in color and specular reflectance (**Figure 18**). Restorative systems that do not allow internal color characterization should be avoided.

- Principle No. 14. If internal characterization is impossible with an all-ceramic crown system, the restorations will likely lack color depth and exhibit an unnatural appearance.

Attempts have been made with some all-ceramic systems to use the cast component as a coping that is then veneered with conventional porcelain (**Figure 19**).[21] While these systems exhibit exceptional esthetics, the clinical track record has been extremely poor. The high early clinical fracture rate may be due to loss of strength from the thinning of the coping material, or due to stress created because of not properly matching the coefficients of thermal expansion and contraction between the core and the veneering material. Crown systems that provide excellent esthetics but limited clinical service should be used with great caution, and the patient should be informed of the assumed risks.

One system that appears to have great promise is IPS Empress (Ivoclar North America, Inc. Amherst, N.Y.) when used as a veneered crown. The core material with this system has excellent translucency, and the esthetic results obtained with the system are excellent and predictable. One study of 75 IPS Empress restorations placed on first molars, bicuspids and anterior teeth reported only 1 fracture with the length of service ranging from 15 to 43 months.[22]

While many practitioners believe that all-ceramic restorations are inherently more esthetic than their metal-ceramic counterparts, this may be primarily because typically more tooth structure is removed with all-ceramic preparations. Most laboratory technicians could produce metal-ceramic restorations with equivalent esthetic results if this increased tooth reduction is provided.

- Principle No. 15. Excellent esthetic results can be achieved by talented technicians with both all-ceramic and metal-ceramic systems if adequate tooth reduction is accomplished by the dentist.

## Summary and Conclusions

There are a host of contemporary all-ceramic systems available today, as well as improved techniques for metal-ceramic restorations. Perhaps the most important factor in achieving predictable success with these restorations is excellent soft tissue management. Metal-ceramic restorations provide the most predictable service in terms of clinical longevity, versatility and prevention of wear to the opposing dentition.

Many all-ceramic systems are strengthened with an internal opaque core and seem to have few advantages over metal-ceramics and have numerous disadvantages. The same statement is true for all-ceramic restorations that have no provision for intrinsic coloration.

A few all-ceramic systems have the potential for intrinsic coloration and do not utilize an internal opaque core. With uniform tooth reduction of 1.5 mm. these systems can provide excellent esthetics. With less tooth reduction, the esthetic result may be somewhat compromised.

It is suggested that metal-ceramic crowns will continue to be the standard and will be used extensively in the future. Certain all-ceramic systems should be used with discrimination in situations where they are indicated.

References
1. Donovan TE and Daftary F, Alternatives to metal-ceramics. J Cal Dent Assoc 16(2):10-17, 1988.
2. Chee WWL and Daftary F, Alternatives to metal-ceramic restorations. J Cal Dent Assoc 15(11):28-32.
3. Donovan TE, Contemporary ceramic restorations: A comparative analysis. Alpha Omegan 81:57-64, 1988.
4. Cho GC and Donovan TE, The versatile and esthetic metal-ceramic crown. J Cal Dent Assoc 24:39-43, 1996.
5. Donovan TE and Cho GC, Soft tissue management with metal-ceramic and all-ceramic restorations. J Cal Dent Assoc 26(2)TK-TK.
6. Toogood GD and Archibald JF, Technique for establishing porcelain margins. J Prosthet Dent 40:464-6, 1978.
7. Prince J, Donovan TE and Presswood RG, The all-porcelain labial margin for metal-ceramic restorations: A new concept. J Prosthet Dent 50:793-6, 1983.
8. Prince J and Donovan TE, The esthetic metal-ceramic margin: A comparison of techniques. J Prosthet Dent 51:273-5, 1984.
9. Vryonis P, A simplified approach to the complete porcelain margin. J Prosthet Dent 42:592-3, 1979.
10. Cooney JP, Richter WA and MacIntee MI, Evaluation of ceramic margins for metal-ceramic restorations. J Prosthet Dent 54:1-5, 1985.
11. Kessler JC, Brooks TD and Keenan MP, The direct lift-off technique for constructing porcelain margins. Quintessence Dent Technolog 10:145-50, 1986.
12. Donovan TE and Prince J, An analysis of margin configurations for metal-ceramic crowns. J Prosthet Dent 53:153-7, 1985.
13. Michalske TA and Banker BC, The fracture of glass. Scientific American 257:122, 1987.
14. McLean JW, High strength ceramics. Quintessence Int 18:97-106, 1987.
15. White SN, Zhao XY et al, Cyclic mechanical fatigue of a feldspathic dental porcelain. Int J Prosthodont 8:413-20, 1995.
16. Kelly JR, Campbell SD and Bowen HK, Fracture surface analysis of dental ceramics. J Prosthet Dent 62:536-41, 1989.
17. Holmes JR, Sulik WD et al, Marginal fit of castable ceramic crowns. J Prosthet Dent 67:594-9, 1992.
18. Scoble HO and Donovan TE, Tooth preparation for indirect esthetic restorations. J Cal Dent Assoc 18(1)31-7, 1992.
19. Monasky GE and Taylor DF, Studies on the wear of porcelain, enamel and gold. J Prosthet Dent 25:299-306, 1971.
20. Sozio RB and Riley EJ, The shrink-free ceramic crown. J Prosthet Dent 49:182-7, 1983.
21. Geller W and Kwiatkowski JJ, The Willi's Glass crown: A new solution in the dark and shadowed zones of esthetic porcelain restorations. Quintessence of Dent Technol 11:233-42, 1987.
22. Sorensen JA, Choi C et al, A clinical trial of all-ceramic crown restorations. Signature 1996, spring, pp 12-7.
To request a printed copy of this article, please contact/ George C. Cho, DDS, USC School of Dentistry, Los Angeles, CA 90089-0641.

CDA JOURNAL, VOL 26, Nº2

# Clinical Experiences With Bonded Porcelain Laminate Veneers

By George C. Cho, DDS; Terry E. Donovan, DDS; and Winston W.L. Chee, BDS

**ABSTRACT** Bonded porcelain veneers can provide successful esthetic and functional long-term service for patients. The purpose of this article is to describe the authors' clinical experiences with veneers over the past decade and to outline the procedures required to achieve predictable success with this conservative esthetic restorative modality. It is hoped that the authors' experiences and those of others will encourage practitioners to consider more routine use of this type of restoration in many of their more complex reconstructive cases.

AUTHORS

**George C. Cho, DDS,** is an assistant professor and director of clinical education for advanced education in prosthodontics at the University of Southern California School of Dentistry.

**Terry E. Donovan, DDS,** is an associate professor and executive associate dean at the USC School of Dentistry. He is also chairman of the Department of Restorative Dentistry and co-director of advanced education in prosthodontics.

**Winston W.L. Chee, BDS,** is an associate professor and the Ralph W. and Jean L. Bleak Professor of Restorative Dentistry at the USC School of Dentistry. He is also director of implant dentistry and co-director of advanced education in prosthodontics at USC.

In the early 1980s, the bonded porcelain veneer was introduced to the profession amidst considerable skepticism regarding its potential for longevity in the harsh oral environment.[1,2] Since that time, longitudinal studies as well as personal experience have demonstrated that these restorations can provide extremely successful esthetic and functional long-term service for patients. Based on this initial positive experience with bonded restorations, more-extensive applications have been used cautiously with certain patients in the past several years, and again the results achieved have been gratifying.

The purpose of this article is to describe the authors' clinical experiences with veneers over the past decade and to outline the procedures required to achieve predictable success with this conservative esthetic restorative modality. It is hoped that the authors' experiences and those of others will encourage practitioners to consider more routine use of this type of restoration in many of their more complex reconstructive cases.

Bonded porcelain veneers have a number of significant advantages over either metal-ceramic or all-ceramic crowns.[7-9] One of the most important advantages is that they are extremely conservative in terms of tooth structure (**Figure 1**). Metal-ceramic crowns require reduction of 1.2 mm of tooth structure on the labial surface and 1 mm on the lingual. Most all-ceramic restorations require 1.5 mm of reduction circumferentially around the tooth. Bonded veneers require only 0.5 mm reduction on the labial surface, and

CDA JOURNAL, VOL 26, Nº2

usually none on the gingival two-thirds of the lingual surface.

It has become increasingly apparent that conservation of tooth structure is a major factor in determining the long-term prognosis of any restorative procedure and that the extensive reduction of tooth structure required for conventional restorations is a major contributing factor in the rather high long-term failure rate often experienced with them.

Another remarkable advantage of porcelain veneers is their durability. As long as sufficient tooth structure remains to provide adequate support for the bonded porcelain and sufficient enamel remains for retentive purposes, the incidence of fracture is very low. 10-13 This may well be a result of the tooth's ability to resist flexure because of the minimal tooth reduction required, although more research is necessary in this area.

An additional major advantage of porcelain veneers associated with these minimal reductions is lack of potential for pulpal involvement. Similarly, the periodontal response with porcelain veneers is outstanding (**Figure 2**).[14-19] This is primarily because the restorations can blend in imperceptibly with the cervical tooth structure thereby allowing the cervical margins to be kept in a supragingival position.20 Optimally, these cervical margins should be placed in enamel; however, with contemporary dentin bonding systems, margins can be successfully placed on dentin/cementum when necessary.21 Also important to excellent periodontal response is the fact that overcontour of the restoration is not required to obtain esthetics (when proper tooth preparation is done).

Excellent esthetics can be achieved with minimal reduction because of the exceptional covering ability of the porcelains used (Shofu Opal Porcelain, Shofu Dental Corp., Menlo Park, Calif.), the scattering effect of the luting resin (Opal Luting Composite, 3M Dental, St. Paul, Minn.), and the fact that there is no dark metallic oxide that needs to be masked by bright opaque porcelains (**Figures 3 and 4**). It is important that the clinician understand the limits of the porcelain veneer restoration in improving esthetics with extremely dark, stained teeth, such as in severe tetracycline staining. Because of the lack of thickness of the porcelain, the final result in these cases is often compromised, with the veneers exhibiting very high value and lack of vitality because of the use of underlying opaque porcelains (**Figure 4**). In these situations, metal-ceramic crowns may be the restorations of choice. With less severe staining, good results with porcelain veneer restorations can be obtained with slightly more aggressive tooth preparations.

One of the keys to success with bonded porcelain veneers is adequate tooth preparation. Many clinicians have advocated little or no preparation. This will most certainly lead to inferior esthetic results and may well compromise strength and the periodontal response.

Labial reduction of 0.5 mm is recommended, terminating in a chamfer margin in a slightly supragingival location. A depth-cutting diamond (Brasseler USA, Savannah, Ga.) is useful for providing the proper depth reduction (**Figure 5**).[22] If the tooth is to be neither lengthened nor shortened, the incisal edge is reduced 0.75 mm to 1 mm, and the lingual surface of the tooth reduced 1 mm past the prepared incisal edge. The lingual finish line is in the form of a shoulder 0.5 mm in depth.

On maxillary teeth, the location of the lingual finish line is determined by whether the mandibular incisors are to be restored. If the mandibular teeth are to be restored with crowns or veneers, the finish line on the maxillary teeth is carried gingivally past the point of centric occlusion contact with the mandibular incisal edges.

If the mandibular teeth are not going to be restored, the lingual finish line is 1 mm from the prepared incisal edge as stated previously (**Figure 6**). Carrying the preparation over the incisal edge limits the path of placement of the veneers but has two important advantages. The veneers can be more esthetic when this is done, and incisal translucency can be created if indicated (**Figure 7**).

The second potential advantage is that some clinicians feel such veneers may be stronger than veneers that terminate at the incisal edge, and the incidence of fracture and/or debonding due to shear stress may be reduced.

Teeth can be lengthened using bonded porcelain veneers.[23] In determining just how much a tooth can be lengthened, the lessons learned with metal-ceramics can be used. The critical guideline is that there should never be more than 1.5 mm of unsupported porcelain, whether the porcelain is supported with enamel or metal. In certain cases, teeth have been lengthened by as much as 2 mm, but in these cases the patients are informed that there is a calculated risk. Teeth that need lengthening of more than 2 mm require crowns. Occlusal considerations may modify these guidelines in specific clinical situations.

Bonded porcelain veneers have been traditionally used to esthetically restore discolored teeth, teeth with multiple composite resin restorations and malposed teeth, and to correct space problems such as a diastema. More recent indications for veneers are to develop

anterior guidance prior to reconstruction of the posterior teeth and to restore moderately worn dentitions. This has been accomplished numerous times in the past several years, and use of veneers in these situations is now considered routine treatment, provided that sufficient tooth structure remains to support the bonded porcelain.

When veneers are to be used to establish anterior guidance in conjunction with a posterior rehabilitation, a specific sequence of treatment should be followed. First, diagnostic casts should be mounted in an articulator of choice and a diagnostic wax-up completed. This will give an indication of the amount of tooth lengthening required to establish function and the desired esthetic result. It will also indicate whether it is desirable to increase the vertical dimension. This wax-up can be duplicated in gypsum and a polypropylene matrix fabricated on the duplicate cast. Tooth-colored photo-cured acrylic resin can be used to form a try-in restoration to preview the final esthetic result prior to irreversible tooth preparation.

In the majority of reconstructive cases, it is preferable to establish the anterior guidance first, and then to complete the posterior rehabilitation with cusp inclines in harmony with the established anterior guidance. Generally this will entail preparation of the 12 anterior teeth at one appointment. The final, optional, step in preparation of the veneers is the breaking of interproximal tooth contact using diamond-impregnated strips. Removal of the interproximal contacts facilitates laboratory steps but necessitates the fabrication of provisional restorations, which is readily accomplished using a clear matrix and light-cured acrylic resin (Unifast, G.C. America, Scottsdale, Ariz.). Impressions are made in a (poly) vinyl-siloxane impression material and the veneers are fabricated in the laboratory. Research has demonstrated that use of the platinum foil technique for fabrication of the veneers results in optimum marginal interity.[24-26]

Use of a medium to high viscosity resin luting agent (Opal Luting Composite, 3M Dental, St. Paul, Minn.) is highly recommended.[27] Many clinicians believe this type of agent provides superior esthetics because of light scattering, strength, and optimal wear resistance. Most importantly, it also makes cleanup of the excess resin infinitely easier than when lower viscosity luting resins are used. The veneers are first tried in with water to determine the optimum shade match with the adjacent teeth. If the shade match is perfect, then a clear resin can be used for final cementation. If the shade need to be modified, chemical cure resins can be evaluated until fit and color are approved. Then, the resin is removed and the veneers cleaned using acetone and water. The teeth are then etched, and the veneers are cemented in place using the matching light-cured resin. When six anterior veneers are placed, generally, the centrals are cemented first, then the cuspids, and finally the lateral incisors.

When cementing a veneer with this type of luting agent, the restoration can be pressed into place, and the proper fit verified. Then, the incisal one-third can be exposed to 10 seconds of light to tack it in place. At this point, almost all excess cement can effectively be removed using a gold foil knife or sharp scalpel, without the risk of removal of cement from under the margins of the veneer. The rest of the veneer is then exposed to sufficient light to completely cure the resin cement.

With the authors' patients, a strict recall protocol is followed to ensure that all the excess cement is removed. The patient is appointed one week after cementation, and any areas where small amounts of tooth-colored cement remain are detected using inflammation of the gingival tissues as an indicator (Figures 8A and B). The patient is then recalled again one week later for additional evaluation. Usually the tissue will be immaculate at this appointment, but occasionally one or more additional areas of irritation are disclosed. As stated previously, the soft tissue response to porcelain veneers is generally outstanding once all excess cement is located and removed.

Once the anterior veneers have been luted in place, the posterior reconstruction can proceed in a conventional manner. If the vertical dimension has been increased using the veneers (Figures 9A and B), posterior support must immediately be provided by means of an occlusal splint and later with quality provisional restorations followed by the definitive crown restorations. (**Figures 10A and B**).

Often patients present with anterior teeth requiring restoration in which some teeth can be restored with veneers but insufficient tooth structure remains on others so that crowns are indicated. Many clinicians have stated that it is not advisable to mix veneers and crowns, as a precise color match is not possible using such dissimilar materials. The authors' experience has been that it is possible to mix and match veneer and crown restorations (Figures 11A and B). The authors prefer to complete the metal-ceramic restorations first and then match the veneers to the result obtained.

For patients who have a high esthetic demand and require porcelain veneer restorations, an overlay acrylic resin provisional shell can be fabricated prior to initiating tooth preparation. This shell often helps predict the final

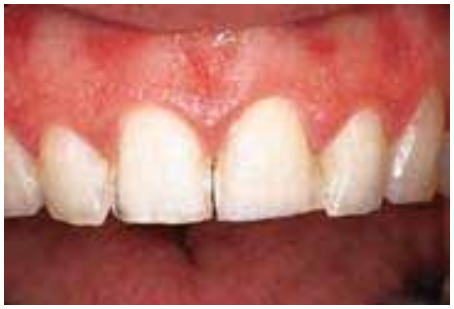


**Figure 1.** Typical tooth preparation for porcelain laminate veneers illustrating the conservative nature of the preparation.

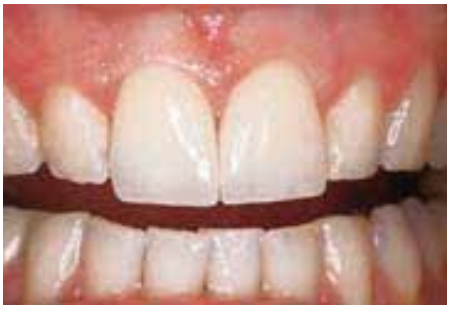


**Figure 2.** The soft tissue response to veneers is almost universally excellent because of the supragingival placement of the cervical margins as seen on both central incisors.

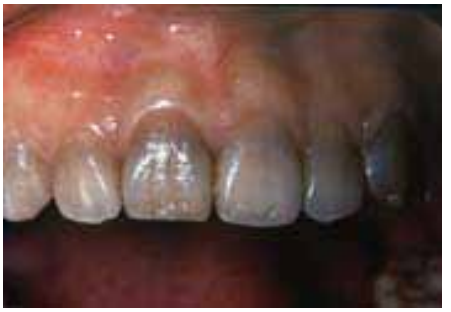


**Figure 3.** Preoperative view of severe tetracycline stained teeth.

**Figure 4.** The teeth in Figure 3 have been restored with porcelain laminate veneers. Although the final result is not perfect, it is a significant improvement over the preoperative appearance, and minimal tooth structure has been removed.

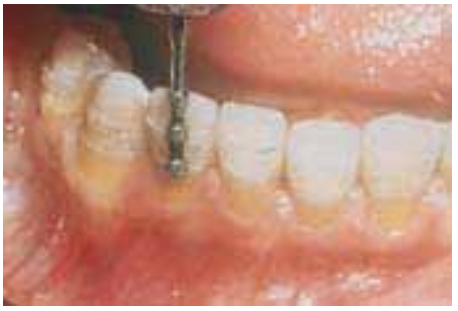


**Figure 5.** A depth-gauging instrument is useful in controlling labial reduction.

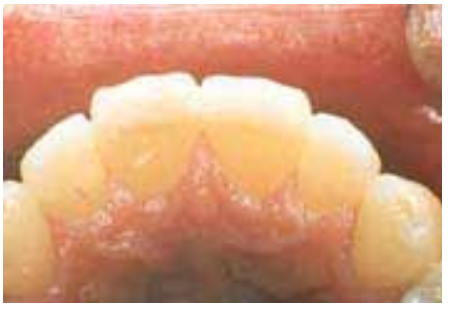


**Figure 6.** When the opposing teeth are not restored, the lingual finish line on maxillary veneers is 1 mm past the prepared incisal edge, permitting natural tooth contacts in maximum intercuspal position.

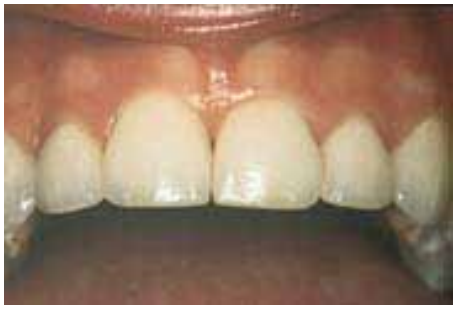
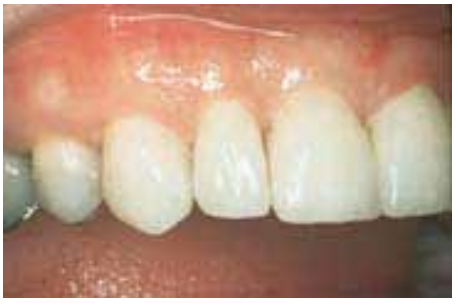


**Figure 7.** Reducing the incisal edge allows for reproduction of natural translucency.



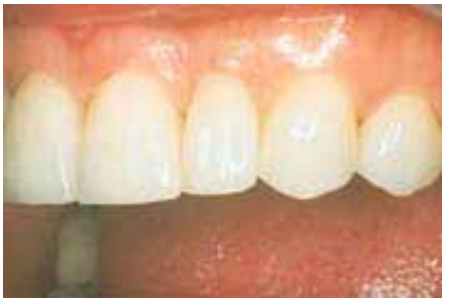


**Figure 8A and 8B.** As shown in Figures 8A and B, recall of a patient one week after cementation often will allow detection and removal of slight amounts of excess tooth-colored resin cement. Usually minor irritation of the soft tissue will disclose the location of the excess cement.

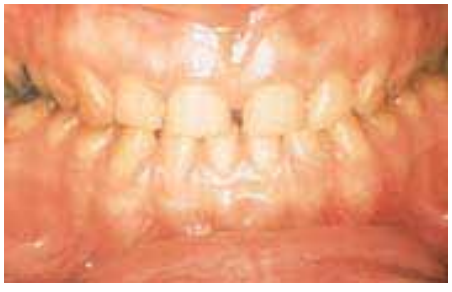
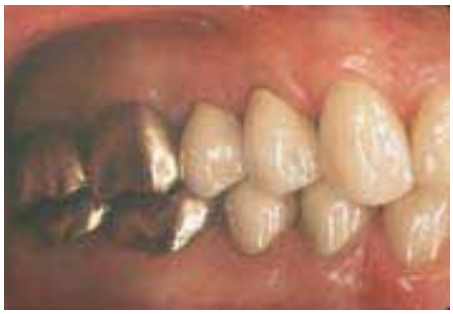
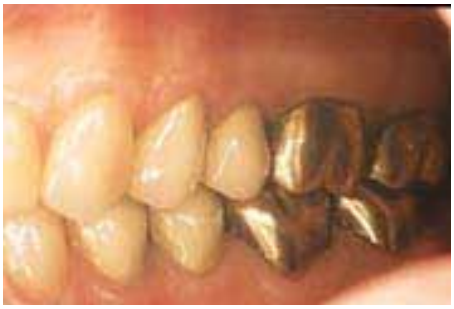


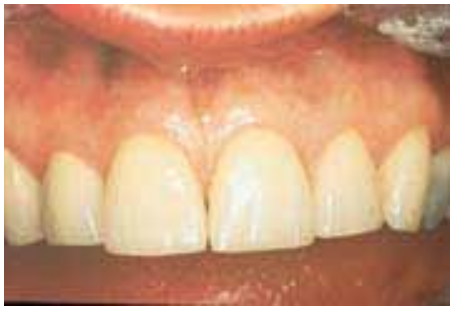
**Figure 9A.** This "before" photo shows a patient on whom veneers were placed on both the maxillary and mandibular anterior teeth. The restorations were placed to increase the vertical dimension and to provide anterior guidance for a posterior rehabilitation. Crown lengthening was also done to aid in the final esthetic result.

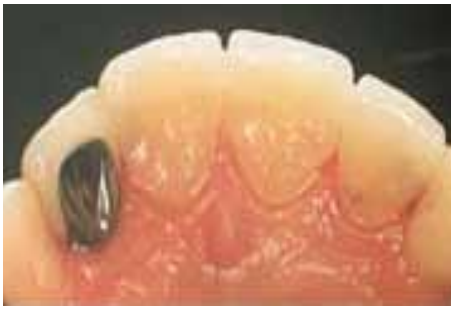
**Figure 9B.** The "after" photo.





**Figures 10a and b.** Figures 10a and b show the posterior restorations in the patient shown in Figure 9. Metal-ceramic crowns with porcelain buccal margins were placed on the premolars and complete gold crowns on the molars.





**Figures 11a and b.** As shown in Figures 11A and B, a metal-ceramic crown with a porcelain labial margin was placed on the right lateral incisor, while both central incisors and left lateral incisor were restored with porcelain veneers.

esthetic result, and can be modified using esthetics and phonetics and then used as a guide for the laboratory technician (**Figure 12**A). A diagnostic wax-up of the proposed increased length is made on the diagnostic casts. The cast is duplicated, and an overlay acrylic resin shell provisional is fabricated (**Figure 12b**). This overlay shell is then clipped onto the unprepared teeth and evaluated for proper esthetics and phonetics (**Figure 12c**). At this time, the patient may take the overlay provisionals and evaluate the new length at his or her convenience and elicit a response from family members and friends. Once the length has been accepted by the patient, treatment can continue with confidence by the patient, dentist and laboratory technician with everyone fully understanding the final

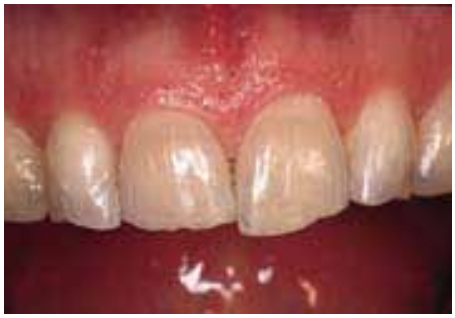


**Figure 12a.** This patient requested lengthening of his central incisors.

**Figure 12b.** An overlay acrylic resin shell provisional was fabricated to preview the anticipated result.

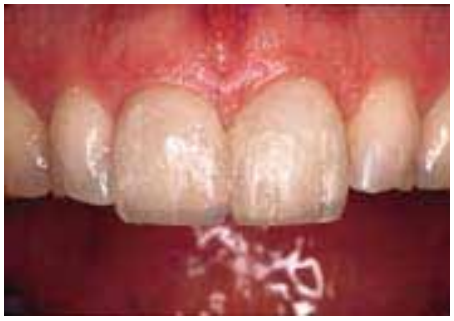


**Figure 12c.** The overlay acrylic resin shell provisional is tried on the teeth and the correct length ascertained through esthetics and phonetics prior to any preparations.

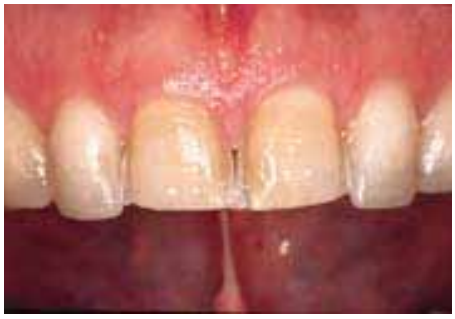


**Figure 12d.** The central incisors have been prepared and the lateral incisors slightly lengthened with direct composite resin.

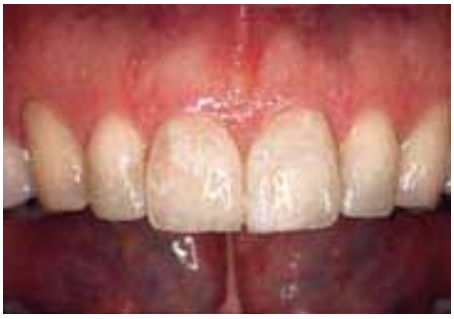


**Figure 12e.** The acrylic resin shell provisionals have been relined and placed over the preparations without temporary cements.

**Figure 12f.** The final restorations have been in place for one month.

treatment objectives with respect to length, contour, texture and color (**Figures 12d through f**).

It is important to keep in mind that veneers have definite limitations.[28] They should not be used when insufficient enamel remains to provide adequate retention. Large Class IV defects should probably not be restored with veneers because of the large amount of unsupported porcelain and the lack of tooth-colored backing. The amount of unsupported porcelain should be carefully evaluated in cases with a large diastema before committing to restoration with veneers. Darkly stained teeth are not optimally restored with veneers as explained previously. The prognosis for veneers in bruxing patients has been the subject of much speculation. Certainly, bruxing patients at a minimum should be instructed to use a night guard after final restoration.

## Summary and Conclusions

More than 10 years of experience have established bonded porcelain veneers as a predictable functional and esthetic restorative service. Use of such restorations in major reconstructive cases has proven successful and is indeed indicated. Veneers can also be successfully mixed and matched with conventional metal-ceramic crowns when indicated. Clinicians are encouraged to consider bonded porcelain for the routine restoration of anterior teeth.

References
1. Horn HR, Porcelain laminate veneers bonded to etched enamel. *Dent Clin North Am* 27:671-84, 1983.
2. Calamia JR, Etched porcelain facial veneers: a new treatment modality based on scientific and clinical evidence. NY *J Dent* 53:255-9, 1983.
3. Crispin BJ, Full veneers: the functional and esthetic application of bonded ceramics. Compendium 15:284-8, 1994.
5. Nixon RL, Mandibular ceramic veneers: an examination of diverse cases integrating form, function and aesthetics. Pract Periodontics Aesthet Dent 7:17-26, 1995.
6. Hornbrook DS, Porcelain veneers: optimizing esthetics while re-establishing canine guidance. Compend Contin Educ Dent 16:1190-4, 1995.
7. Friedman MJ, The enamel ceramic alternative: porcelain veneers vs. metal ceramic crowns. J Cal Dent Assoc 20:(8)27-33, 1992.
8. Friedman MJ, Current state-of-the-art porcelain veneers. Curr Opin Cosmet Dent 1993:28-33.
9. Pippin DJ, Mixson JM and Soldan-Els AP, Clinical evaluation of restored maxillary incisors: veneers vs. PFM crowns. *J Am Dent Assoc* 126:1523-9, 1995.
10. Strassler JE and Nathanson D, Clinical evaluation of etched veneers over a period of 18 to 42 months. J Esthet Dent 1:21-8, 1989.
11. Calamia JR, Clinical evaluation of etched porcelain veneers. Amer *J Dent* 2:9-15, 1989.
12. Jordan RE, Suzuki M and Senda A, Clinical evaluation of porcelain laminate veneers: a four-year recall report. J Esthet Dent 1:126-37, 1989.
13. Karlsson S, Landahl I et al, A clinical evaluation of ceramic laminate veneers. Int J Prosthodont 5:447-51, 1992.
14. Friedman MJ, Multiple potential of etched porcelain laminate veneers. *J Am Dent Assoc* special issue Dec 1987:83E-7E.
15. Christensen GJ and Christensen RP, Clinical observations of porcelain veneers: a three-year report. J Esthet Dent 3:174-9, 1991.
16. Reid JS, Kinane DF and Adonogianaki E, Gingival health associated with porcelain veneers on maxillary incisors. Int J Paediatr Dent 1:137-41, 1991.
17. Garber D, Porcelain laminate veneers: 10 years later. Part 1, Tooth preparation. J Esthet Dent 5:56-62, 1993.
18. Dunne SM and Millar BJ, A longitudinal study of the clinical performance of porcelain veneers. Brit Dent J 175:317-21, 1993.
19. Kourkouta S, Walsh TT and Davis LG, The effect of porcelain laminate veneers on gingival health and bacterial plaque characteristics. *J Clin Periodontol* 21:638-401, 1994.
20. Materdomini D and Friedman MJ, The contact lens effect: enhancing porcelain veneer esthetics. J Esthet Dent 7:99-103, 1995.
21. Lacy AM, Wada C et al, In vitro microleakage at the gingival margin of porcelain and resin veneers. J Prosthet Dent 67:7-10, 1992.
22. Nattress BR, Youngson CC et al, An in vitro assessment of tooth preparation for porcelain veneer restorations. *J Dent* 23:165-70, 1995.
23. Wall JG, Reisbick MH and Johnston WM, Incisal-edge of porcelain laminate veneers restoring mandibular incisors. Int J Prosthodont 5:441-6, 1992.
24. Sorensen JA, Strutz JM et al, Marginal fidelity and microleakage of porcelain veneers made by two techniques. J Prosthet Dent 68:448-20, 1992.
26. Sim C and Ibetson R, Comparison of fit of porcelain veneers fabricated using different techniques. Int J Prosthodont 6:36-42, 1993.
27. Costello FW, porcelain veneer adhesive systems. Curr Opin Cosmet Dent 1995:57-68.
28. Sheets CG and Taniguchi T, Advantages and limitations in the use of porcelain veneer restorations. J Prosthet Dent 64:406-11, 1990.
To request a printed copy of this article, please contact/ George C. Cho, DDS, USC School of Dentistry, Los Angeles, CA 90089-0641.

CDA JOURNAL, VOL 26, Nº2

# IPS Empress Crown System: Three-Year Clinical Trial Results

By John A. Sorensen, DMD, PhD; Creighton Choi, DDS; Mete I. Fanuscu, DDS; and Wayne T. Mito, CDT

**ABSTRACT** The IPS Empress system is a highly esthetic hot pressed glass ceramic material for fabrication of single crowns. Adhesive cementation of the system not only contributes to the esthetics but is necessary for increased strength of the crown. The purpose of this prospective clinical trial was to evaluate the longevity of 75 adhesively cemented Empress full crowns. An additional aim was to assess the adhesive cementation methodology and potential side effects.

At the three-year point, one molar crown fractured for a 1.3 percent failure rate. The resin cementation technique that was employed exhibited a low incidence of microleakage with few clinical side effects. There was a 5.6 percent incidence of postcementation sensitivity, with all symptoms subsiding by eight weeks. None of the crowns in the study required endodontic therapy.

AUTHORS

**John A. Sorensen, DMD, PhD,** is the ODA Centennial Professor of Restorative Dentistry and director of the Clinical Research Center at Oregon Health Sciences University, Portland. He was formerly and associate professor and director of advanced prosthodontics at the University of California at Los Angeles.

**Creighton Choi, DDS,** is an adjunct assistant professor at UCLA. He also maintains a private practice in Beverly Hills, Calif.

**Mete I. Fanuscu, DDS,** maintains a practice limited to prosthodontics, in Istanbul, Turkey. He is formerly a research assistant at UCLA.

**Wayne T. Mito, CDT,** is a senior research associate at Oregon Health Sciences University. He is formerly a staff research associate in the advanced prosthodontics program at UCLA.

The IPS Empress system (Ivoclar North America, Amherst, N.Y.) was offered in the early 1990s as a new standard of excellence in esthetic fixed prosthodontic materials. The fabrication methodology involves a lost-wax investment technology for the hot pressed ceramic system that dental technicians are familiar with.[1,2]

The Empress system combines a highly translucent dentin shaded glass ceramic with a translucent adhesive resin composite cement. The high translucency of the system facilitates placement of margins less intrusive to the sulcus for a harmonious tissue-restoration interface and nearly invisible margins (**Figure 1**). This combination offers excellent esthetics and less invasive tooth preparation for more predictable achievement of high quality esthetic fixed prosthodontics. The system is so translucent that a shade selection and die material were developed to match the shade of the underlying tooth structure (**Figures 2 and 3**).

The Empress all-ceramic system achieves its strength by means of several factors. Leucite crystal reinforcement provides a flexural strength of the parent pressed ceramic of about 125 MPa.[3] An approximate 45 percent increase in strength by compression bonding is created by a slight difference in coefficient of thermal expansion between parent ceramic and either veneering or stain and glaze ceramics.[4] The adhesive cementation technique further increases the overall restoration strength by a clinically unknown factor.[5-7] Still, the strength values of this all-ceramic system

are one-tenth that of metal-ceramic systems and one-third that of high strength core ceramics such as In-Ceram (Vident, Brea, Calif.).[4] The question arises: Does the adhesive cementation system sufficiently increase the strength of the cemented crown to provide predictable long-term clinical longevity? Although the principal reason for using these all-ceramic systems is esthetics, the system must have adequate strength to insure clinical longevity. The authors believe that although esthetics may not demand it, an all-ceramic system should be strong enough for predictable use for restoration of posterior teeth.

## Literature Review

Since metal-ceramic restorations are the standard of care for esthetic fixed prosthodontic restorations, they should be the criterion for comparison with the new all-ceramic systems. Metal-ceramic restorations made up 70 percent to 80 percent of all fixed prostheses placed in the 1980s. 8 Few clinical studies have been performed on metal-ceramics. Leempoel and colleagues 9 studied the survival rate of crowns in Dutch general practices. For 1,323 anterior metal-ceramic crowns, survival rates at five years were 95 percent and at 10 years were 82 percent. For 2,011 premolar metal-ceramic crowns, survival rates at five years were 98 percent and at 10 years were 97 percent. Coornaert and colleagues 10 followed 2,181 metal-ceramic units over seven years and observed a 2.4 percent failure rate. The follow-up rate was 85 percent during the seven-year study, with most failures occurring within one year after cementation. A failure rate of 2.8 percent for metal-ceramic crowns was observed over seven years at the University of Zurich.[11] At the five-year point, these clinical studies on metal-ceramic full-coverage restorations suggest a maximum failure rate of 2.8 percent to 5 percent. This 5 percent failure rate is, therefore, the maximum allowable failure rate criterion in evaluating all-ceramic systems.

Clinicians have been skeptical of new all-ceramic systems for good reason. In private practice, the clinical performance of many of the ceramic systems have fallen far short of manufacturers' claims about their products. The following is a summary of results on earlier all-ceramic systems.

Linkowski[12] evaluated 224 Cerestore (Ceramco, Johnson & Johnson) crowns cemented with zinc phosphate and glass ionomer. At two years, they observed a failure rate of 3 percent for anteriors and 21 percent for posteriors. When 106 Dicor (Dentsply, York, Pa.) crowns cemented with zinc phosphate were evaluated at the three-year point by Moffa and colleagues,13 the incidence of fracture was 35 percent for molars, 12 percent for premolars and 3.5 percent for anteriors. Erpenstein14 evaluated a total of 159 Dicor crowns cemented with zinc phosphate. At two years, they found failure rates of 3 percent for anteriors, 13 percent for premolars and about 36 percent for molars. In spite of the excitement generated by advertising, these new all-ceramic systems were no better than McLean's Platinum foil porcelain jacket crown.[15] In 1983, he recorded failure rates of 2.1 percent for incisors, 6.4 percent for premolars and 15.2 percent for molars at the seven-year follow up. Even for the original feldspathic porcelain jacket crowns, Leempoel and colleagues 9 estimated that 25 percent would fail over 11 years.

For a more recently developed all-ceramic crown material, Jeneric/Pentron 16 claimed that metal-ceramics were on the endangered list and would become an outdated "dinosaur" because of the tremendous strength of Optec material. This could ostensibly not only be used for single crowns but also for fixed partial dentures with veneer abutment preparations. Christensen and Christensen 17 tested 40 FPDs with a variety of retainer designs and at two years found an 80 percent failure rate for posterior FPDs and a 22 percent failure rate with full crown retainers on anterior FPDs. It does not appear at this time that metal-ceramic technology can be relegated to the category of "dinosaur."

On a positive note, Hankinson and Cappetta studied 158 Optec crowns (Jeneric/Pentron) that were adhesively cemented.[18] At up to five years they observed a failure rate of 0 percent for anteriors, 2.3 percent premolars and 24 percent for molars.

While the resin cementation system offers some great clinical advantages such as outstanding esthetics, reduced microleakage by sealing of margins[19,20] and strengthening of the ceramic crown, it does have some disadvantages. First, margins can be placed only minimally subgingival otherwise sulcular fluids will contaminate the bonding surfaces. Second, the technical procedures and moisture control are much more demanding than conventional procedures. Atraumatic tissue-tooth preparation and noniatrogenic periodontal principles must be followed for provisional restorations to prevent bleeding gingival tissues at the time of cementation. Third, the dental assistant must be highly organized in passing the brushes with the correct adhesives in the correct order for delivery by the dentist.

The Empress system must be adhesively cemented for maximum strength. Failure to comply with the above listed factors in adhesive cementation may seriously compromise the longevity

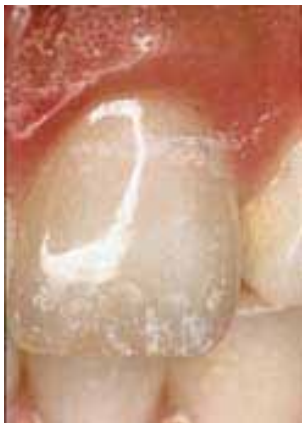


**Figure 1.** Disappearing margin achievable because of translucent ceramics and resin cementation. Margin located only 0.5 mm subgingival.

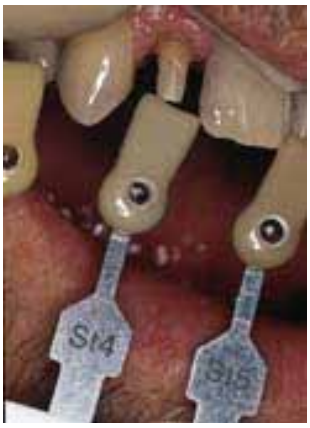



**Figure 2.** Because of the high translucency of ceramic, the shade of the tooth preparation can be recorded with the Stumpmaterial Shade Guide.

**Figure 3.** Cemented Empress crown illustrating translucency achieved with a low value shade.

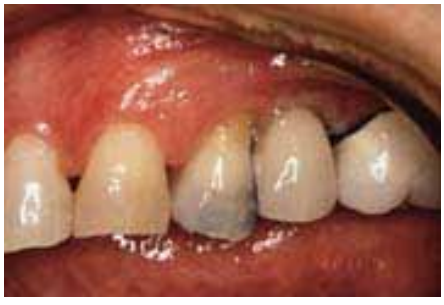


**Figure 4.** Tooth No. 12 has large amalgam filling, breakdown of tooth, recession exposing dentin. Potential problems if margins established subgingivally.

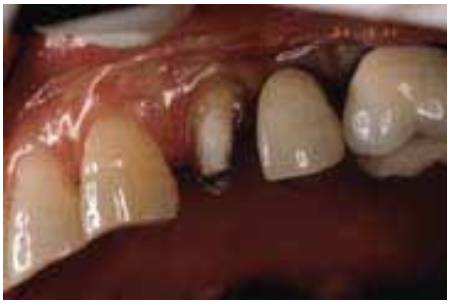


**Figure 5.** Circumferential shoulder with all margins placed supragingivally especially facially and distally where recession was more pronounced.

**Figure 6.** Pressed ceramic core with veneer ceramic applied.

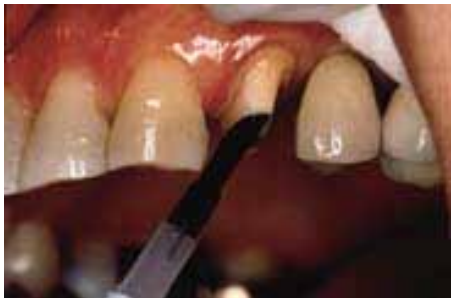


**Figure 7.** Crown etched at chairside following external and internal crown adjustments.

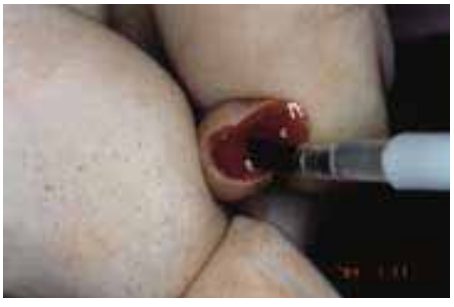


**Figure 8.** Two stages of Syntac dentin adhesive applied: Syntac Primer applied for 15 seconds and dried; Syntac Adhesive applied for 15 seconds and dried.

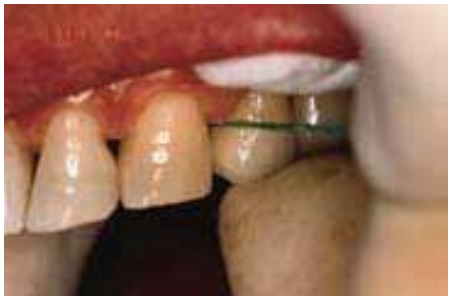


**Figure 9.** As much excess cement as possible removed prior to polymerization. Waxed dental floss pulled through proximals to remove excess cement at gingival embrasures.

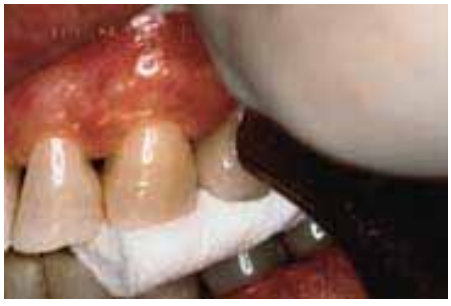


**Figure 10.** With as much excess cement as possible removed, the cement is light-cured.

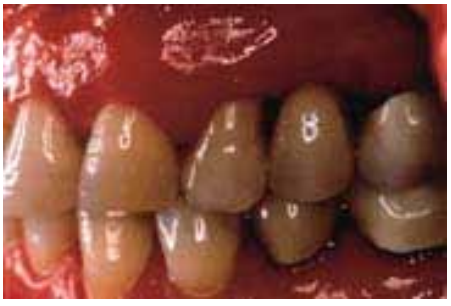


**Figure 11.** Completed Empress crown No. 12. Translucent ceramics and adhesive cementation allow margins to be placed supragingivally.

of the Empress restoration. It is not suggested that conventional cements can withstand gingival bleeding, sulcular fluids or saliva during cementation, however, because of the larger number of steps for adhesive cementation and extended period of time that it must be maintained contamination free. Resin cementation is considered a technique-sensitive procedure. Adhesive cementation includes:

- Phosphoric acid etching of enamel, rinsing and drying;
- Application of Syntac Primer for 15 seconds and drying;
- Application of Syntac Adhesive for 15 seconds and drying;
- Application of Heliobond unfilled resin and air thinning;
- Mixing of the dual-curing resin cement, placement in the crown and seating onto the tooth; and
- Removal of excess cement prior to polymerization.

A drawback frequently cited by clinicians but nearly undocumented by clinical studies is the reported high incidence of postcementation sensitivity accompanying resin cementation. Therefore, evaluation of the adhesive cementation and potential side effect such as tooth sensitivity, microleakage, cement discoloration and pulpal problems are a critical part of a clinical study on adhesively cemented ceramic crown systems.

The purpose of this prospective clinical trial was to evaluate the longevity of 75 adhesively cemented Empress full crowns. An additional aim was to assess the adhesive cementation methodology and potential side effects.

## Materials and Methods

Patients were recruited from the greater Los Angeles area and treated at the School of Dentistry Clinical Research Center at the University of California at Los Angeles. All of the Human Subject Protection Committee guidelines were followed. To be accepted into the study, patients had to have teeth adjacent to those to be restored and opposing teeth or fixed prosthodontics. Second molars were not tested in this study, following the ceramic system restoration protocol (Ivoclar North America, Amherst, N.Y.). Due to the moisture sensitivity of the resin cementation technique, teeth to be restored were rejected if the margins were located greater than 1 mm subgingivally.

### *Tooth Preparation*

All teeth were prepared with a flat-ended diamond, aiming for 1.3 mm of axial reduction and 1.5 mm to 2.0 mm for incisal or occlusal reduction. This preparation requirement is similar to that for metal-ceramic full-coverage restorations. The margin design was a shoulder configuration with a rounded axial-gingival line angle (**Figures 4 and 5**). The shoulder margin design provides the strength and most accurate marginal fit. When a round-ended diamond is used, if the tooth is penetrated more than half the diameter of the bur, lipping results. A flat-ended diamond can penetrate the tooth to varying degrees and still produce a shoulder configuration that is free of lipping. The bulk reduction was performed with a flat-ended diamond followed by refinement of the margin with tissue-protecting, end-cutting burs. The margins were finalized with hand instruments to achieve a smooth, clean and linear finish line.

### *Fabrication Techniques*

The full-ceramic crown restorations were pressed in the appropriate shade of colored ingots and veneered with 0.4 mm to 0.8 mm of ceramic material (**Figure 6**). In the more critical esthetic cases, the composite resin stump material was placed in the coping to represent the dentin shade.

### *Delivery and Adjustment Protocol*

The provisional crown restorations were removed, the temporary cement was debrided, and the teeth were cleaned with cleaning paste (Syntac Cleaning Paste, Ivoclar Vivadent, Amherst, N.Y.). Proximal contacts were evaluated and adjusted when it was necessary. The internal adaptation and marginal integrity were evaluated (Fitchecker, GC America, Chicago, Ill.), and any areas of binding were adjusted until the fit was determined to be excellent. Lastly, the occlusion and the contours were adjusted. If any adjustment were made, the crowns then were glazed. The dimensions of the crown restorations were measured at eight points using a digital micrometer.

### *Cementation Procedure*

The internal surfaces of the full-coverage crown restorations were etched with hydrofluoric acid gel (IPS Ceramic Etching Gel, Ivoclar Williams, Amherst, N.Y.) thoroughly rinsed and dried (**Figure 7**). Silane coupling agent (Monobond-S, Vivadent, Amherst, N.Y.) was applied to the etched ceramic and gently dried after 60 seconds. Unfilled resin (Heliobond, Ivoclar Vivadent) was applied and air thinned.

Prior to cementation, the areas of enamel were mapped in the patient record, etched for 30 seconds with 37 percent phosphoric acid, rinsed thoroughly and then dried. Dentin Primer and Adhesive (Syntac, Vivadent) were applied for 15 seconds each and air dried (**Figure 8**). For Dual Cement (Vivadent), equal amounts of base and catalyst were mixed and applied in a thin layer in the crown. For Variolink (Vivadent), the appropriate shade of the luting cement base was determined and an equivalent

amount of thick viscosity catalyst was mixed and applied in a thin layer on the walls of the crown. The full crown was then seated onto the preparation with sustained finger pressure and held in place while excess cement was wiped away. Dental floss was passed between the teeth to remove excess cement interproximally (**Figure 9**).

The resin cement was light polymerized from all aspects (**Figure 10**). After 10 minutes of setting time, the excess cement was removed with a No. 12 scalpel blade followed by unwaxed dental floss. The occlusion and the proximal contacts were verified (**Figure 11**).

### *Recall Evaluations*

Measurements were made at baseline and recall visits scheduled annually. Evaluation appointments consisted of intraoral photographs, polyvinylsiloxane impressions of restored teeth and antagonist teeth and direct clinical measurements. Parameters measured included:

- General oral hygiene;
- Plaque index of tooth, cement and crown;
- Staining/discoloration of crown and cement;
- Interfacial staining;
- Secondary caries;
- Marginal integrity;
- Condition of crown; and
- Patient comfort with all teeth and crowns.

## Results

A total of 75 all-ceramic crown restorations were placed in 33 subjects. Subjects ranged in age from 17 to 69. Of the crown restorations placed, 47 were on anterior teeth, 15 on premolars and 13 on first molars. Dual Cement was used for luting the first 19 crown restorations; Variolink was used for the remaining 56 crown restorations.

At the three-year point, one molar crown fractured after 27 months of service. The failed crown exhibited minimal microleakage ruling out failure of the adhesive cementation. Unfortunately, the failed crown could not be retrieved.

Of the crowned teeth, 53 were vital with patients reporting postcementation sensitivity to cold liquid in three crowns. This calculates to a 5.6 percent incidence of sensitivity. All symptoms, which subsided in three to eight weeks, began within 24 hours of cementation. None of the patients reported any other pain. Symptoms occurred in one molar restoration cemented with Dual Cement and one molar and one premolar cemented with Variolink. None of the restored teeth required root canal therapy through the period of the study. Two restorations (2.7 percent) exhibited slight microleakage at the dentin-cement interface. No secondary caries was detected. No staining or discoloration of the cement was observed.

No staining or discoloration of the ceramic was noted. No change in the surface finish of the crowns was noted.

## Discussion

The high translucency of this ceramic material in conjunction with the resin cementation technique facilitates improved esthetic margin fabrication. This results in significantly less intrusion into the sulcus and improved long-term gingival health. Fixed prosthodontic procedures can be more easily performed when the margins are only slightly subgingival. The inherent esthetic properties of this resin-cemented, full-coverage crown system facilitates more predictable and easily achievable natural esthetics than metal-ceramic crowns.

While excellent esthetic results are attainable with these ceramic restorations, there is no question that the adhesive cementation procedure is complicated and extremely technique-sensitive. Two restorations (2.7 percent) exhibited slight microleakage at the dentin-cement interface. No secondary caries were noted. Therefore, the adhesive cementation techniques seem to be reliable. In terms of side effects, three abutment teeth experienced crown postcementation sensitivity. These symptoms were experienced as sensitivity to cold and subsided within eight weeks. None of the abutment teeth required endodontic treatment through the period of the study.

This postcementation sensitivity was found in 5.6 percent of the crowned teeth. Clinicians have anecdotally reported high rates of postoperative pain associated with resin-cemented ceramic restorations. Johnson and colleagues21 reported postcementation pain of approximately 29 percent for zinc phosphate cements. Therefore, the results of this study reflect favorably on the resin cementation technique.

Finishing of the margins with rotary instruments is difficult and will likely result in damage to the ceramic margin or gouging of the tooth structure apical to the margin. In gaining access for rotary instruments, damage to the soft tissue is also likely. In a well-fitting all-ceramic crown restoration, it is nearly impossible to polish a 60 m resin cement.[22] An efficient method for removal of polymerized excess cement is required. In the authors' experience, a No. 12 scalpel blade is a highly effective tool for removing this material. The sharp blade easily shears off the excess material even in concave areas that a straight rotary instrument cannot effectively access. Clinicians do not attempt to polish zinc phosphate, glass-

ionomer or polycarboxylate cemented crown restorations; therefore, the authors question why finishing should be attempted with resin cements. Removal of excess cement prior to light polymerization minimize the need for finishing resin-cemented ceramic crown margins.

Hankinson and Cappetta studied 158 Optec crowns (Jeneric/Pentron) that were adhesively cemented.18 At up to five years, a failure rate of 2.3 percent for premolars and 24 percent for molars was observed. This system is adhesively cemented and has a significantly higher leucite content than Empress.[23] What may account for the high failure rate exhibited in that study is the fact the ceramic crowns are fabricated by a traditional powdered buildup of the entire crown on a refractory die material. This probably introduces many more voids and defects that may act as the origin of failure for crack propagation.

Lehner and colleagues[24] reported a failure rate of 5 percent at two years for 78 Empress crowns. They did not always follow the adhesive cementation protocol. The present study followed the adhesive cementation protocol recommended by the ceramic manufacturer (Ivoclar North America) for every crown. Following the manufacturer's directions yielded a failure rate of only 1.3 percent for the Empress crowns. Relative to clinical studies on other all-ceramic crown systems, the results at three years for the Empress system are very favorable. In the present study, the protocol precluded full-coverage crown restorations on second molars. The one restoration that did fail was a first molar, indicating some caution be exercised in restoring molars.

## Conclusions

The study protocol called for crown placement on first molars, premolars and anterior teeth. At the three-year point in this clinical study on the Empress all-ceramic crown system, the following conclusions can be made:

- Of the 75 Empress crowns cemented, only one crown failed, for a 1.3 percent failure rate.
- The failed crown was a molar that fractured at 27 months.
- The resin cementation technique that was employed exhibited a low incidence of microleakage with few clinical side effects.
- Three crowns experienced postcementation sensitivity to cold, the symptoms of which resolved at a maximum of 8 weeks.
- This was a 5.6 percent incidence of postcementation sensitivity.
- None of the crowns in the study required endodontic therapy.
- The placement criteria of margins no greater than 1 mm subgingival facilitated achievement of a positive clinical outcome.

References

1. Wohlwend A, Swiss patent (CH-Pat. Anmeldung), No 668699-1986.
2. Wohlwend A, Verfahren und Ofen zur Herstellung von Zahnersatzteilen. European Patent (EU-Patentanmeldung) No 0231773 A, 1987.
3. Seghi R and Sorensen JA, Relative flexural strength of six new ceramic materials. Int J Prosthodont 1995;8:239.
4. Sorensen JA, Avera SP and Fanuscu MI, Effect of veneer porcelain on all-ceramic crown strength. *J Dent* Res 71:320, 1992. Abstract No. 1718.
5. Doering J, Jensen ME et al, Fracture resistance of resin-bonded etched porcelain full veneer crowns. *J Dent* Res 66:207, 1987. Abstract No. 803.
6. Eden GT and Kacicz JM. Dicor crown strength improvement due to bonding. *J Dent* Res 66:207, 1987. Abstract 801.
7. Malament KA and Grossman DG, Bonded vs. nonbonded Dicor crowns. Four-year report. *J Dent* Res 71:320, 1992 Abstract No 1720.
8. Anusavice KJ, Criteria for selection of restorative materials: Properties vs. technique sensitivity. In Anusavice KJ, ed, Quality Evaluation of Dental Restorations. Criteria for Placement and Replacement. Quintessence Publishing, Chicago, Ill, 1989, p 45.
9.Leempoel PJD, Eschen S et al, An evaluation of crowns and bridges in general dental practice. J Oral Rehabil 12:515-28, 1985.
10. Coornaert J, Adriaens P and DeBoever J, Long-term clinical study of porcelain-fused-to-metal restorations. J Prosthet Dent 51:338, 1984.
11. Strub JR, Stiffler S and Scharer P, Causes of failure following oral rehabilitation. Biological vs. technical factors. Quintessence Inter 3:215, 1988.
12. Linkowsky G, Klinische nachuntersuchung von schrumpfungsfreien porzellankronen (doctoral thesis). Zurich University, 18-23, 1988.
13. Moffa JP, Lugassy AA and Ellison JA, Clinical evaluation of a castable ceramic material. Three-year study. *J Dent* Res 67:118, 1988, Abstract No 43.
14. Erpenstein H and Kerschbaum T, Frakturrate von Dicor-Kronen unter klinischen bedingungen. Dtsch Zahnärztl Z 46:124-8, 1991.
15. McLean JW, The future of dental porcelain. In, John W. McLean, ed, Dental Ceramics. Proceedings of the First International Symposium on Dental Ceramics, Quintessence Publishing, Chicago, Ill, 26-8, 1983.
16. Optec HSP advertisement, Jeneric/Pentron. J Esthet Dent 1:20A, 1989.
17. Christensen RP and Christensen GJ: Service potential of all-ceramic fixed prostheses in areas of varying risk. *J Dent* Res 71:320, 1992, Abstract No 1716.
18. Hankinson J and Cappetta EG, Five years' clinical experience with a leucite-reinforce porcelain crown system. Int J Periodont Res Dent 14:138-53, 1994.
19. White SN, Sorensen JA et al, Microleakage of new crown and fixed partial denture luting agents. J Prosthet Dent 67:156-61, 1992.
20. Sorensen JA, Cruz M et al, Microleakage and marginal fidelity of gold inlays using new cements. *J Dent* Res 73:118, 1994, Abstract No 136.
21. Johnson G, Powell V and De Rouen T, Evaluation and control of postcementation pulpal sensitivity: Zinc phosphate and glass ionomer luting cements. *J Am Dent Assoc* 124:39, 1993.
22. Fanuscu MI and Sorensen JA, Pre- and postcementation fit of ceramic crown systems. *J Dent* Res 71:320, 1992, Abstract No 1717.
23. Denry IL, Rosenstiel SF and Hollaway JA, Characterization of crystalline leucite in feldspathic dental porcelain. *J Dent* Res 73:369, 1994, Abstract No 2139.
24. Lehner C, Studer S et al, Short-term results of IPS-Empress full-porcelain crowns. J Prosthod 6:20-30, 1997.

To request a printed copy of this article, please contact John A. Sorensen, DMD, PhD, Oregon Health Sciences University, School of Dentistry, 611 S.W. Campus Drive, Portland, OR 97201-3097.

CDA JOURNAL, VOL 26, Nº1

# No Refund Without Receipt

Robert E. Horseman, DDS

"As medicine goes, so goes dentistry." Most dentists believe this old saying to be true. Medicine introduced us to insurance, group practices and managed care, among other enlightened things. As a result, for better or worse, we've come to look to it for guidance in accepting new protocols. Dentistry's main claim to pioneering was when OSHA and "60 Minutes" singled us out as potential generators of a host of bad things. For this assumption, medicine willingly relinquished the lead.

Normally, though, it's kind of like playing "crack the whip" when we were kids. Whether perched on roller skates or ice skates, or just being a dentist, the position at the tail end of the activity is not the most stable place to be. While we owe a certain amount of gratitude to our fellow health professionals for pioneering third-party participation in our affairs, the latest inspiration to spring from the fertile minds of a certain medical faction is perhaps more than we countenanced.

We speak of PR, not the abbreviation for public relations or product recall, but for Patient Refund. Money-back guarantees are such a proven strategy in business that proponents of this concept argue that medicine's transformation into a bona fide business qualifies it for the same consideration.

Lord have mercy on us all! Who are these people questioning the sacred concept that the doctor gets paid no matter what? Well, Pogo was right, we have met the enemy and he is us. At the head of the "crack the whip" line is one of the nation's top fertility clinics, which began offering patients a partial refund if they didn't get pregnant. This is money we're talking about refunding, not eggs or sperm. Some urology groups are giving refunds to men whose vasectomy reversals didn't pan out. We assume that a refund for a vasectomy that didn't work in the first place would be more than just an apologetic, "Sorry, Dad."

Kaiser Permanente's Northern California Region is offering up to $25 of co-payment to members if they're not satisfied with their doctor visit.

Patient: "I'm not satisfied with my doctor visit."

Kaiser: "Whoa! Why not?"

Patient: "He kept me waiting two hours."

Kaiser: "That all?"

Patient: "No. He didn't even say he was sorry."

Kaiser: "We're sorry."

Patient: "Too late, I want my $25. Now."

Our ancient contention that "We're dealing with human tissue here, so no guarantee is given or implied" may be in

for some modification if this contingency fee thing catches on. A patient says three months after his prophy, "Hey, my tartar has come back."

Us: "Well, this is human tissue we're dealing with here, you know."

Patient: "So?"

Us: "Righto, just so you know. Here's your refund."

It has long been our policy with full denture cases that at the first sign of dissatisfaction, a full refund is given immediately. This prevents being shotgun-married to a predictably doomed partnership destined for a nasty divorce later on. The expansion of this anti-ulcer/nervous breakdown policy to all other disciplines of dentistry, however, is a sobering notion.

Dr. Geoffrey Sher, executive director of the Pacific Fertility Center, a proponent of the contingency fee idea, says, "The message we are sending people is very simple: We are so confident we can deliver, we can share the risk with you." Of course the risk he's talking about involves pregnancy, a pretty much black-and-white issue. You're either pregnant or you're not. Doesn't work that way with bridges, for example. At least for the doctor, there are about 10 criteria for a successful effort, with lots of uncertainty and gray areas. The patient may have only one criteria -- he either likes it or he doesn't.

Dr. Drew Altman, president of the Kaiser Family Foundation of Menlo Park, Calif., says, "I'm very much afraid of this. I hope it doesn't spread. I mean, what are we going to do next, offer consumers a set of free steak knives or pots and pans for their business?" We know what he means; we've already offered them unlimited use of the magazines and restrooms. Where will it all stop?

Critics view the trend as "over-the-top commercialism." Dr. Robert M. Tenery Jr., a Dallas ophthalmologist and member of the AMA's Council on Ethics and Judicial Affairs, states, "Doctors do the very best they can, and what happens after that is beyond their control." Not so sure is medical ethicist David Thomasma of Chicago's Loyola University. He says if medical professionals are serious about providing quality health care, they should be equally serious about providing a refund for not meeting expectations.

Dr. Sher adds, "I am completely willing to crusade this issue. I believe it's better for the patients. And I'm not alone. The minute the guard is dropped a little, others will come out of the shadows."

By "others" I have a sinking feeling he might be including the dental profession, those of us on the tail end of the whip. Are we going to have to post signs stating hypocritically, "Refunds cheerfully given"? Or "No refunds without a sales receipt"? Maybe "This office guarantees its work. If you are dissatisfied for any reason, return your filling in its original container and your decay will be refunded in full, no questions asked." I am reminded of that old Broadway hit, "Stop the World, I Want to Get Off!"

Who are these people questioning the sacred concept that the doctor gets paid no matter what?

We've already offered patients unlimited use of the magazines and restrooms. Where will it all stop?