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Journal of Cosmetic Dentistry

Promising Technology—Powerful & Precise

Clinical Memoirs, Creative Movement

Naoki Hayashi, RDT

CAD/CAM Ceramic Update

Markus B. Blatz, DMD, PhD

Summer 2013

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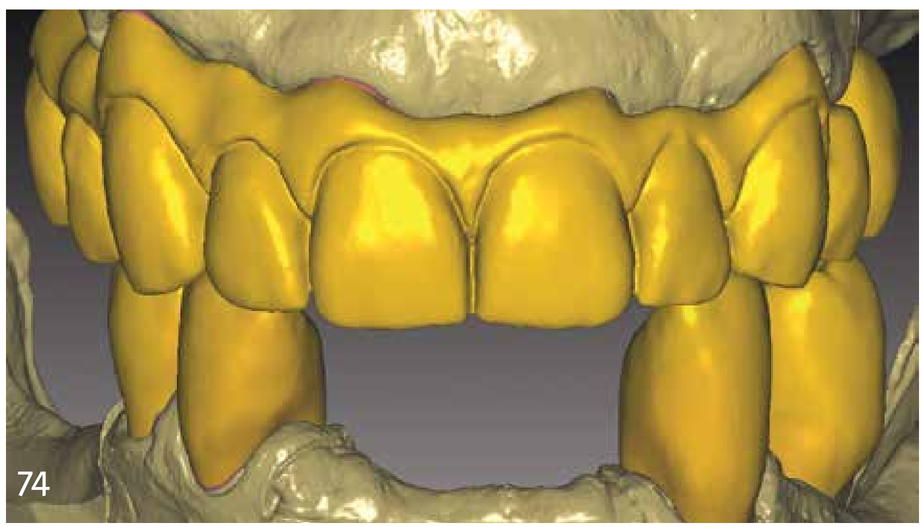

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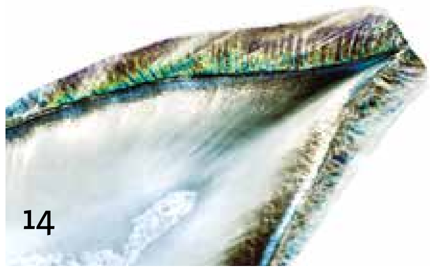

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"The esthetics of the first 15 years of CAD/CAM restorations is characterized by the attribute, *tooth-colored.*"

Werner H. Mörmann, Prof. Dr.Med.Dent.

Dr. Mörmann established the Department of Computer-Based Restorative Dentistry at the University of Zurich Dental School. Along with Dr. Marco Brandestini, he completed the construction of the first CEREC 1 unit.

Disclosure: The author receives grants/research support from VITA, but did not receive any financial remuneration for writing this article.

CAD/CAM—A Tool for Cosmetic Dentistry

In 1973, Dr. Bruce Altschuler described an experimental setup for the holographic 3-D scanning of teeth.[1] He anticipated that an advanced version of this appliance would be able to machine gold crowns. When François Duret presented his CAD/CAM system in 1985, he used a fiber-reinforced polymer for the machining of a crown.[2] I myself had Vita Mark I blocks of monochromatic feldspathic ceramic available for generating the first CAD/CAM inlay in restorative dentistry in 1985.[3]

The esthetics of the first 15 years of CAD/CAM restorations is characterized by the attribute, *tooth-colored.* I performed the first chairside CAD/CAM CEREC 1 veneer on a discolored central incisor in 1986. Though the scope for design was limited at that time, the ceramic veneer blended well with the surrounding dentition and hinted at high cosmetic potential. By now, CAD/CAM technology has triggered the development of a multitude of high- and low-translucency monochromatic as well as multicolored and 3-D structured blocks, extending the choice of esthetic ceramics. The design software then allows positioning of the restoration design relative to layered multicolored blocks or relative to dentin and enamel block structure in such a way that optimum blending in of shades and structure in crowns or veneers is obtained. The milled restoration thus lays an optimal foundation for customization. Some restorations just need surface texturing and polishing; others are characterized with stain and glaze or with cutback and layering.[4]

In a recent study,[5] our group found that all tested, permanent esthetic CAD/CAM block materials—whether zirconia, lithium disilicate, feldspathic, hybrid ceramics, or resin-based nanocomposites—behave similarly or better than natural enamel with respect to two-body and tooth brushing wear, which was not true for provisional acrylic polymer-block materials. Ceramics showed the best gloss retention compared to hybrid ceramics, nanocomposites, and acrylic polymers. Scanning electron microscopic inspection showed that CAD/CAM materials are to the core homogeneous; whereas light-cured, direct-filled resin-based composite throughout exhibited pores.[5]

Dentists and dental technicians today can choose from a variety of CAD/CAM systems and 3-D scanners. Intraoral 3-D scanners with true color information present natural-looking virtual 3-D models. Together with the virtual articulator (a work in progress), digital registration of jaw movements and muscle activity, 3-D radiographs, and cone beam computed tomography data and those from 3-D face scanners (smile) form a comprehensive set of data representing the "virtual dental patient."[6] This offers the potential to analyze, plan, design, and fabricate single as well as multiple restorations in form, function, and esthetics completely from digital data.

CAD/CAM has introduced unprecedented highly esthetic and high-strength ceramics, and through that it has become an essential tool for cosmetic dentistry.

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CBCT 3-D Imaging—Preventing Failures

Dov M. Almog, DMD

Dr. Almog is the chief of the Dental Service in the VA New Jersey Health Care System. He also is an instructor and lecturer. Dr. Almog established the first dental imaging center on the East Coast, at the University of Rochester Eastman Dental Center in the 1990s.

Disclosure: Dr. Almog did not report any disclosures.

Up Front *provides a forum for influential leaders to share their opinions. In this issue, we welcome Dr. Dov Almog, who explains why precision in 3-D imaging is essential. The views expressed in Up Front reflect the opinions of the author. They do not imply an opinion on the part of* jCD *or the AACD.*

The move toward CBCT 3-D imaging has been a paradigm shift, especially for oral implantology, where measurements and anatomical relationships are more precise.

Cone beam computerized tomography three-dimensional (CBCT 3-D) imaging is making significant inroads into every discipline in our profession,[1,2] expanding the horizons of clinical practice by adding a third dimension to craniofacial treatment planning. CBCT 3-D imaging captures a volume of data and, through a reconstruction process, it constructs images without distortion, magnification, and/or overlap of anatomy. Different slices and views are possible with just one exposure, taking much of the "guesswork" out of oral implantology.

The diagnostic realm of preoperative examination in oral implantology has been frequently reviewed and researched.[3,4] The etiology of implant failures associated with confining our preoperative examination to 2-D radiographic images rather than CBCT 3-D imaging **(Figs 1 & 2)** has been demonstrated in a wide variety of cases.[5,6] Such implant failures include:

- perforation of the maxillary sinus
- perforation of the mandibular canal
- perforation of the nasopalatine canal
- perforation of the lingual cortical plate in the posterior region of the mandible
- perforation of the buccal concavity in the alveolar bone in the anterior region of the maxilla

1 Perforation of the maxillary sinus and the CBCT cross section slice of the left sinus perforation.

- invasion of safe distance from the adjacent teeth and at times compromising natural teeth
- implant fractures due to compromises in the prosthetic crown-to-root ratio by being too conservative and staying farther away from the mandibular nerve canal.

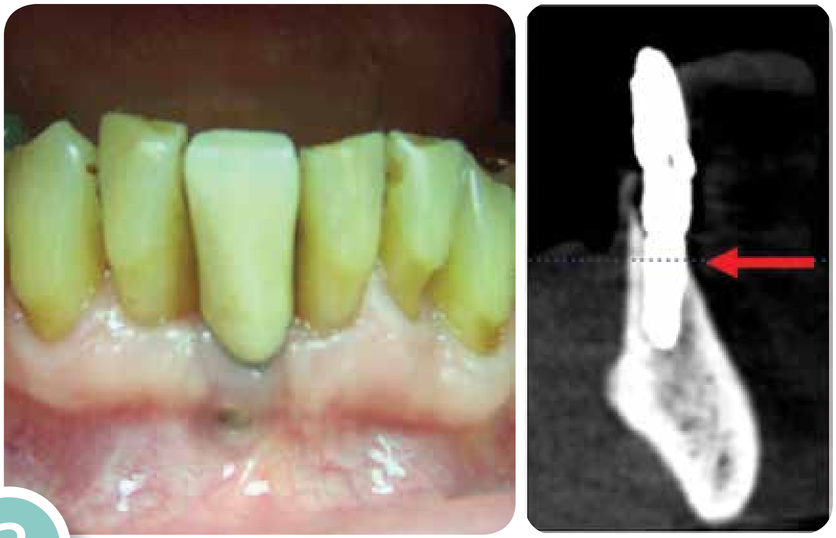
The move toward CBCT 3-D imaging has been a paradigm shift, especially for oral implantology, where measurements and anatomical relationships are more precise. CBCT 3-D imaging uses advanced technology to provide more complete anatomical information on a patient's oral and maxillofacial region, leading to enhanced treatment planning and more predictable outcomes.

Furthermore, while the overall success rate of dental implants is high, accomplishing predictable reconstruction and esthetic results for single or multiple tooth replacements is challenging. As implants become an increasingly viable treatment for replacing missing teeth, we may encounter more random anatomic conditions.

However, a large number of practitioners—including generalists and specialists—with different levels of proficiency, who saw the opportunity to move into these sophisticated oral implantology arenas, continue to overlook the advantages of CBCT 3-D imaging. The reasons as to why they continue to overlook these advantages range from the cost and know-how associated with the introduction of CBCT 3-D imaging technology into their practice, the additional cost to their patients associated with referrals to local facilities that adopted this technology, and last but not least, the professional confidence that some practitioners have that outweighs their belief in potential failures. As a result, we are observing a variety of abnormal complications associated with implants.

2 Implant impingement on an adjacent tooth.

As implants become an increasingly viable treatment for replacing missing teeth, we may encounter more random anatomic conditions.



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Dehiscence and fenestration and the CBCT cross-sectional slice through the implant dehiscence.

In terms of cosmetic dentistry, there are tricky situations associated with the anatomy of the anterior maxillary and mandibular alveolar bone. In these cases, CBCT 3-D imaging will nearly always unveil whether the alveolar "triangle of bone" is a positive implant receptor site, representing the theory developed by Dr. Scott Ganz.[7] Serious complications associated with confining our preoperative diagnostic imaging to 2-D radiographic images in the anterior maxillary and mandibular regions include dehiscence and fenestration of the buccal cortical plates **(Fig 3)**. The CBCT 3-D imaging eliminates most surprises, allowing the practitioner to plan for bone grafting beforehand when necessary and to discuss the treatment options, including the associated supplementary costs with the patient. A 2-D panoramic image would not reveal this option in advance.

In conclusion, practitioners obtain less precise dimensions from traditional 2-D intraoral and extraoral radiographic images. Traditional 2-D radiographic images generally exhibit distortions in terms of faulty magnification, overlap of anatomical structures, and imprecise clarity of images. Therefore, the dimensions or determination of precise anatomical structures relationships are inaccurate. In addition to that, 2-D radiographic images do not allow for 3-D virtual rendering and/or computer-aided implantology. The use of computer-aided implantology systems to manufacture a surgical stent results in greater precision as far as implant position and trajectory. The accuracy of the implant position and trajectory is significantly more precise with the 3-D surgical guide than with the freehand method.

Preoperative assessment of implant sites with CBCT 3-D imaging before dental implants are placed will reveal information not available from 2-D radiographic images such as panoramic or periapical radiographs. CBCT 3-D captures a volume of data, and through a reconstruction process it provides images with complete anatomical information, leading to more predictable treatment outcomes that make us more competent.

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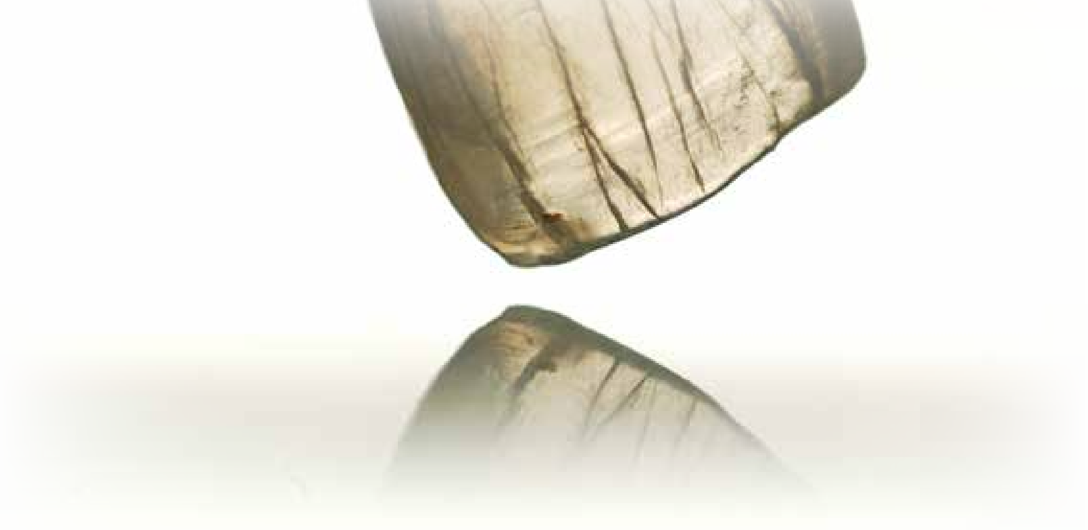
Clinical Memoirs, Creative Movement

Naoki Hayashi, RDT

"I love to work with nature, which inspires me in creating esthetic restorations."



My interest in photography developed when I started taking photographs of patients' teeth in the process of fabricating their restorations. I read extensively about photography and also asked knowledgeable people to share their tips for taking beautiful images. Being a perfectionist, I experimented on my own and took photographs of dental restorations. I love to work with nature, which inspires me in creating esthetic restorations.

I studied more about nature through my photography and learned about harmony, balance, anatomy, symmetry, surface texture, value, hue and chroma. This helped me immensely in creating restorations that are more lifelike to complement patients' smiles.

When documenting my clinical images in order to improve my dental work, I always think: What can I do better to make my restorations come as close to natural teeth as possible? My best guide, of course, is nature itself; photographing teeth and nature under different conditions has helped to improve both my dental technician and photographic skills.

It is crucial that our partner dentists appreciate our skill and also have a discerning eye for beauty. The dentists I work with are excellent photographers themselves and we continue learning from each other to provide highly functional and esthetic smiles for our patients.

We can help alleviate patients' concerns about their mouths; then, we can create a beautiful new smile. I also believe that our patients' happiness with their new smiles can make others smile as well.

I hope my books, *Past<<FUTURE—Envision 77 Heart Beats*, and *A Diary Through the Lens* will help dentists and dental technicians to understand how different aspects of nature are helpful in creating balanced, beautiful restorations.

The cover image was taken by Naoki Hayashi, RDT, with a Nikon D3/Nikkor (Tokyo, Japan) 105mm f/2.8 ED-IF AF-S VR Micro 1/200s f29.0 -2/3EV at 105.0mm, ISO 200.

To see Mr. Hayashi's visual essay, please turn to page 42.

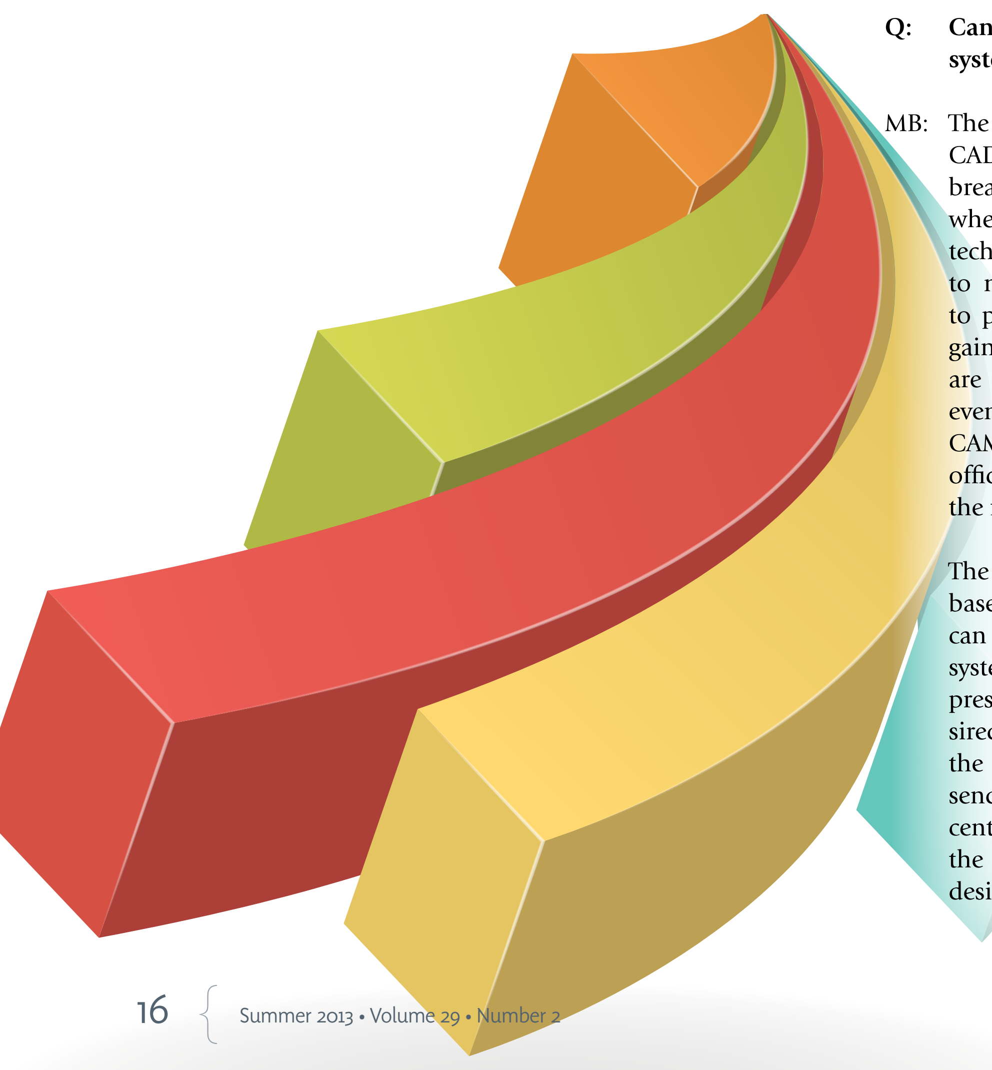
Changing Perspectives

CAD/CAM Ceramic Update

Markus B. Blatz, DMD, PhD

Dr. Markus Blatz will be speaking at the 30th Annual AACD Scientific Session in Orlando, Florida. The title of his course is "The CAD/CAM Ceramic Update." In this Q&A, Dr. Blatz shares his perspectives on the new developments of CAD/CAM and the clinical possibilities that surround them.

"The pace of new developments and number of CAD/CAM systems entering the market is simply breathtaking."



Q: Can you offer a general overview of CAD/CAM systems and tell readers which you prefer?

MB: The pace of new developments and number of CAD/CAM systems entering the market is simply breathtaking. In fact, it has become quite overwhelming for many practitioners and laboratory technicians to keep track of these advances and to make a conscious decision when it comes to purchasing a system. And while some have gained tremendous in-depth knowledge, there are many others who are still confused about even the basic functions and workflow of CAD/CAM technology in the dental laboratory and/or office. For the latter, allow me to clarify some of the fundamental functions and applications.

The first differentiation is between laboratory-based and chairside CAD/CAM systems. These can be further categorized by open and closed systems. The scans are made from a model, impression, or directly in the oral cavity. The desired framework or restoration is designed on the computer screen and that information is send to a manufacturing unit, milling machine/center, or production site. With a closed system, the raw data obtained by the scanner and the design made on the computer is not freely accessible to the clinician or technician. It must be forwarded to a fabrication unit or center as specified by the manufacturer. The data/design obtained with an open system can be accessed and fed to various milling units or production centers. Therefore, the advantage of the open systems is that one is not limited to one or a few milling and production options. However, if units that are not necessarily recommended by the manufacturer are used, the entire workflow and ultimate outcome becomes the responsibility of the technician. This is why many closed systems claim that they can provide a better quality product due to a standardized and more calibrated manufacturing process. It is indeed true that each component of the digital workflow has to play in concert with the other components to achieve optimal quality of the end product.

The first piece involved in the workflow is the scanner. Laboratory and chairside scanners have undergone significant improvements over the last few years and can now provide stunning accuracy with user-friendly design and handling. This is especially true for new chairside scanners. Besides tremendously increased scanning accuracy and speed, they have become significantly smaller and are now almost the size of a regular handpiece. One of the systems we are evaluating right now simply plugs into a tablet computer device, which makes it extremely versatile.

The next component, the design software, has also become much more user-friendly in the recent past and is a far cry from the often cumbersome and expert-only programs we had just a few years ago. Most steps are now fully automated and allow a material- and patient-specific restoration and framework design. These restorations can then be either fabricated directly in the office, a dental laboratory, or at an industrialized manufacturing/milling center.

Finally, even phases that may be perceived to be less important at the end of the digital chain, which is the restoration fabrication, all add up for the quality, precision, and longevity of the end product. For example, sharpness of the milling burs and temperature calibration of the sintering ovens play a fundamental role not just for the fit, but also for the physical properties and functional success of the definitive restoration.

At the present time, most of the available chairside systems are used preferably for single-unit and short-span restorations, while laboratory systems can typically handle everything up to full-mouth reconstructions.

A few years ago, I founded the Penn Dental CAD/CAM Ceramic Center at the University of Pennsylvania. There, we are using and evaluating a number of different laboratory and chairside CAD/CAM systems. Unfortunately, it is not possible to point to the "best" CAD/CAM system since all of them have advantages and disadvantages and none of them can do everything. You can expect all reputable systems to provide excellent accuracy, and manufacturers are constantly improving the various systems and their components.

If you send your impressions to a laboratory for fabrication of CAD/CAM restorations, you may not have much control over their handling and system selection. If you are in the market for an intraoral scanner or chairside system, however, it is important to get as much information on as many different systems as possible. Since, as mentioned earlier, the various CAD/CAM systems have different features and possibilities, you should make your selection based upon your specific needs and practice composition. This includes types and numbers of restorations done in your practice. You also need to decide if you wish to fabricate restorations directly in your office with a chairside or in-office laboratory milling system.

Q: What can we expect in terms of differing contemporary CAD/CAM materials, as well as their pros and cons?

MB: For me, one of the most exciting aspects of CAD/CAM technology is the wide range of materials available. Today, we can mill or fabricate virtually any dental material. This includes all the different ceramic materials, from silica-based glass-ceramics to high-strength ceramics such as zirconia. Due to their optical, chemical, and mechanical properties, ceramics are preferred by many clinicians for a variety of indications from laminate veneers to multiple-unit full-coverage restorations. Composite resin materials have gained popularity specifically for inlays and onlays, where they seem to be more user-friendly than the more brittle ceramic materials. There is much excitement about the relatively new material group of so-called "hybrid ceramics," which typically contain great amounts of silica as well as polymers and may combine some of the advantages of ceramics and composites. Other materials that are used in combination with CAD/CAM technology are metal alloys, resins, and even waxes.

We increasingly use CAD/CAM-fabricated provisional restorations, which serve as great tools not only to maintain the space, but also to provide valuable information for the final restoration from an esthetic and functional standpoint. The acrylic materials that are typically used for those provisionals are much more homogeneous and stronger than the typical cold- or heat-cure provisional materials.

They can also be polished far more easily and provide a much smoother and less plaque-adhering surface, as we have shown in some of our studies (these very recent studies have not been published yet; I will be presenting the exciting new data in Orlando). Another great feature with CAD/CAM provisionals is the fact that the design information is already in the computer and can be used for the design of the definitive restoration or framework. It is also very simple to remake such a restoration in the exact same manner and as many times as needed in case of fracture, failure, or change in design. CAD/CAM provisionals are advantageous for implant-supported full-mouth rehabilitations. **Figures 1 through 5** illustrate the application of CAD/CAM provisionals for two central incisor full-coverage crowns.

Q: What materials do you recommend for these different situations?

a. Inlays/Onlays

MB: I was trained and have practiced as a faculty member for several years in Germany, where inlay and onlay restorations are quite popular. My personal preference for tooth-colored inlay/onlay restorations is silica-based ceramics, such as porcelain or lithium disilicate, which can easily be resin-bonded. Many colleagues, however, are not comfortable with the brittleness of ceramic inlay/onlay materials and prefer indirect composites, which have also shown excellent long-term success. This is actually one of the indications where the new hybrid ceramics may show some real advantages over the more traditional materials.

b. Crowns

As with all my material and technique selections, I make that decision based upon the patient's needs. Unfortunately, similar to what I mentioned about CAD/CAM systems, there is no one material that can do everything. One has to look at the physical properties and the esthetic features of the material and make a selection based upon the patient's situation, esthetic expectations, and functional prerequisites. Silica-based glass-ceramics, for example, provide excellent optical and esthetic features but only low fracture strength. For crown restorations, they need support from a metal alloy or high-strength ceramic coping. High-strength ceramics, such as zirconia, provide significantly better physical properties but lower translucency. Lithium disilicate ranks in between and has, therefore, become extremely popular for single crowns. I am very curious to see how full-contour zirconia and the new hybrid ceramics will clinically perform in the long term.

The clinical situation shown in **Figures 6 through 9** demonstrates what I mean by patient-based material selection. Any of the materials mentioned above would probably be feasible in the hands of the skilled dental technician. The determining factor in this situation, however, is the existing cast-gold post and core **(Fig 6)**. A highly translucent material may not adequately mask that core. It was, therefore, decided to fabricate a CAD/CAM zirconia coping and take advantage of its limited translucency and whitish appearance to mask the core and mimic the value of the adjacent teeth after whitening. A feldspathic veneering ceramic was fired onto the coping for optimal esthetics. We actually tried two options: with and without a porcelain shoulder **(Fig 8)**. Ultimately, we cemented the one with the zirconia shoulder, which, through its higher value, provided a better soft-tissue color.

Q: When seating/cementing restorations, what is your method of choice?

MB: This again depends on material properties and patients' needs. Silica-based ceramic materials require resin bonding and must therefore be adhesively bonded with composite resin luting agents and the appropriate tooth and restoration bonding steps. Conventional cementation protocols with glass-ionomer, resin-modified glass-ionomer, or self-adhesive resin cements are my preference for full-coverage, high-strength ceramic crowns with adequate retention. Whenever resin bonding is needed (e.g., compromised retention or a resin-bonded restoration type), composite resin luting agents and adequate bonding agents/pretreatment steps are necessary. High-strength ceramics do not contain silica and therefore are not etchable with hydrofluoric acid. Also, silane coupling agents are not useful. However, special adhesive primers are available and crucial to provide strong, durable chemical and mechanical bonds between composite resin cements and high-strength ceramics.

Q: How do you see CAD/CAM advances affecting the precision of the design and fabrications when it comes to implants?

MB: Accuracy and passive fit is crucial for implant survival and success. This is where CAD/CAM technology has a significant advantage over traditional fabrication methods. As shown by many other groups, we have also published a number of research studies that clearly show the high accuracy of CAD/CAM-fabricated implant components. This is especially true for multi-unit and full-mouth reconstructions, where traditional fabrication methods such as casting are significantly less accurate.

Figure 1: Preoperative situation of two endodontically treated central incisors that require full- coverage crowns.

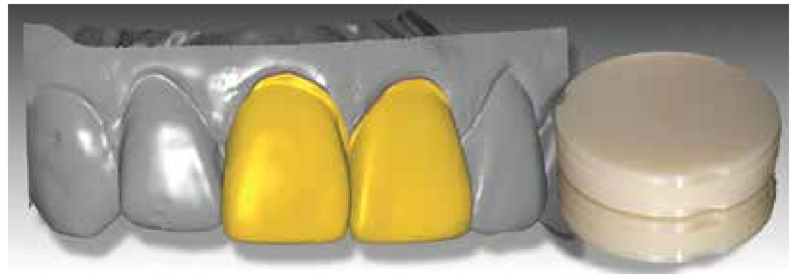


Figure 2: Before preparation, CAD/CAM shell-type provisional restorations are designed and milled out of one block of CAD/CAM acrylic material. The homogeneous material provides increased strength and improved polishability.

Figure 3: CAD/CAM provisional restorations on the model.

Figure 4: Crown preparations of the two central incisors.

Figure 5: The CAD/CAM provisional restorations relined and inserted with a provisional cement. They serve as an excellent tool to assess esthetic and functional parameters before fabrication of the final restorations. The information on the computer is helpful in designing and selecting the most appropriate material for the definitive restorations.

Figure 6: An example of patient-based material selection. A material that can mask the existing cast-gold post and core but also mimic the optical properties (i.e., value) of the adjacent teeth after tooth whitening is required.

Figure 7: CAD/CAM coping design on the computer screen.

Figure 8: Two porcelain-fused-to-zirconia crowns were prefabricated and tried in to select the most appropriate design: zirconia shoulder or porcelain shoulder.

Figure 9: Postoperative view. The crown with the zirconia shoulder provided better esthetics of the surrounding gingiva.

Several systems allow the integration of CAD/CAM technology already in the treatment-planning stage to select and precisely place the implants through guided surgery. These steps are followed by the precise fabrication of a CAD/CAM provisional or definitive implant restoration or overdenture bar.

For whatever reason, some people believe that the high accuracy achievable with CAD/CAM technology in the laboratory allows them to be somewhat less accurate with their clinical techniques. The contrary is actually true: greater accuracy in the laboratory requires greater accuracy in the dental office. Especially for implant-supported restorations, accurate impression-taking techniques and implant-transfer protocols are fundamental for success, especially in combination with CAD/CAM technology.

Q: **What does current scientific evidence show when it comes to the essential integration and long-term outcome of this new technology?**

MB: While CAD/CAM technology has become increasingly popular over the last few years, possibly spurred by the overall increased use of computer technology in our professional and personal lives, it is actually not that new. Some of the systems have been on the market for more than two decades and have evolved over this time into the excellent products that are available today. CAD/CAM is a fabrication method that provides proven accuracy and great versatility when it comes to material selection. The scientific evidence clearly supports that. Some of the materials used in combination with CAD/CAM technology, however, have come to the market only very recently, with great marketing but little science. Some of them, unfortunately, have very limited or no scientific confirmation and we are learning our lessons "on the go."

With veneered zirconia crowns, for example, we learned that, contrary to initial claims, veneering porcelains and firing protocols must be very different from the ones used for porcelain-fused-to-metal (PFM) restorations to avoid chipping and fractures. Now, with proper veneering porcelains and firing parameters, success rates have greatly improved. In two of our own studies,[1,2] we have looked at more than 2000 posterior crowns made in private practices and found no difference in long-term success rates between porcelain-fused-to-zirconia and PFM crowns after seven years. Other materials, such as lithium disilicate, already have a long clinical track record, even though not necessarily in combination with CAD/CAM.

I genuinely believe that CAD/CAM technology will change our perspective and discussion about restoration longevity, at least in some areas. One of the main reasons for our frustration with failures is the difficulty in exactly recreating restorations or teeth. If we can, for example, mill a CAD/CAM complete

Figure 10: Preoperative situation with two missing central incisors. The patient did not want dental implants but still requested the least invasive approach.

Figure 11: Two single-retainer resin-bonded fixed partial dentures were fabricated from zirconia with CAD/CAM technology.

Figure 12: Postoperative labial view of the ceramic resin-bonded fixed partial dentures after adhesive bonding with composite resin and special zirconia primer.

Figure 13: Postoperative image, right lateral view.

Figure 14: Postoperative image, left lateral view.

denture out of an acrylic material in one piece, it is very simple to duplicate and fabricate the exact same denture as many times as one wishes in the event of a failure.

Q: What do you feel is the biggest fear dentists and lab technicians have regarding the use of CAD/CAM? What do they need to realize to overcome it?

MB: Some faculty members in my department are quite excited about and already involved in CAD/CAM technology, while the majority is still hesitant. For some, it is fear of new technologies in general. Most of them, however, just don't see any advantage or reason for changing the techniques they have become accustomed to over many years. I believe their biggest fear is of the steep learning curve involved in using this technology. While most procedures are faster with CAD/CAM technology, it does take time and effort to learn a new technique and to become experienced and efficient with it. Once they understand the actual benefits in terms of speed, accuracy, and versatility, they usually make the move.

Many, however, are simply waiting for further improvements, especially in intraoral scanners, and want to see how the market evolves before they are willing to make a decision to purchase a specific system. To those I say that it is wise to thoroughly assess the options. However, there never is a "good time" and one should get involved as early as possible in what is, without a doubt, the future of dentistry.

It is interesting to see how easily our students, being brought up in the digital age, embrace these technologies. Therefore, we started teaching about CAD/CAM technology and intraoral scanners in our preclinical courses.

Q: What are you planning to discuss at your AACD 2014 Orlando presentation that attendees won't want to miss?

MB: During my presentation, I will focus on the exciting clinical possibilities of CAD/CAM technology and associated dental materials, from porcelain laminate veneers to implant-supported full-mouth rehabilitations made from zirconia. An understanding of the evolution and composition as well as physical and optical properties of CAD/CAM materials, especially ceramics, is key to adequate material selection and to achieve ultimate esthetic and functional success. Laboratory and clinical handling of these materials, including cementation and adhesive resin bonding, will be the main topics of my discussion. Combining material properties, esthetic features, and adhesive concepts allows for innovative treatment options, such as CAD/CAM all-ceramic resin-bonded fixed partial dentures **(Figs 10-14)**. They can be applied as an excellent alternative to traditional protocols and I will explain when and how to do them.

All these topics will be supported by scientific evidence and the numerous research studies we have conducted in our own laboratories and clinics.

I am very excited to being part of this meeting and look forward to seeing you in Orlando!

Acknowledgments

The dental laboratory technology shown in Figures 2, 3, 5, 11, 12, and 15 was performed by Michael Bergler, MDT (Philadelphia, PA). The dental laboratory work shown in Figure 9 was done by Cusp Dental Laboratory (Malden, MA).

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"Some of the systems have been on the market for more than two decades and have evolved over this time into the excellent products that are available today."

Dr. Blatz is the chair and professor of restorative dentistry, Department of Preventive and Restorative Sciences, School of Dental Medicine, University of Pennsylvania, Philadelphia.

Chairside Customization with CAD/CAM

Recreating a Mirror Image When Restoring a Single Central Incisor

Marshall W. Hanson, DDS, AAACD

Key Words: Accreditation, indirect restoration, single incisor, minimal preparation, lithium disilicate, Case Type II

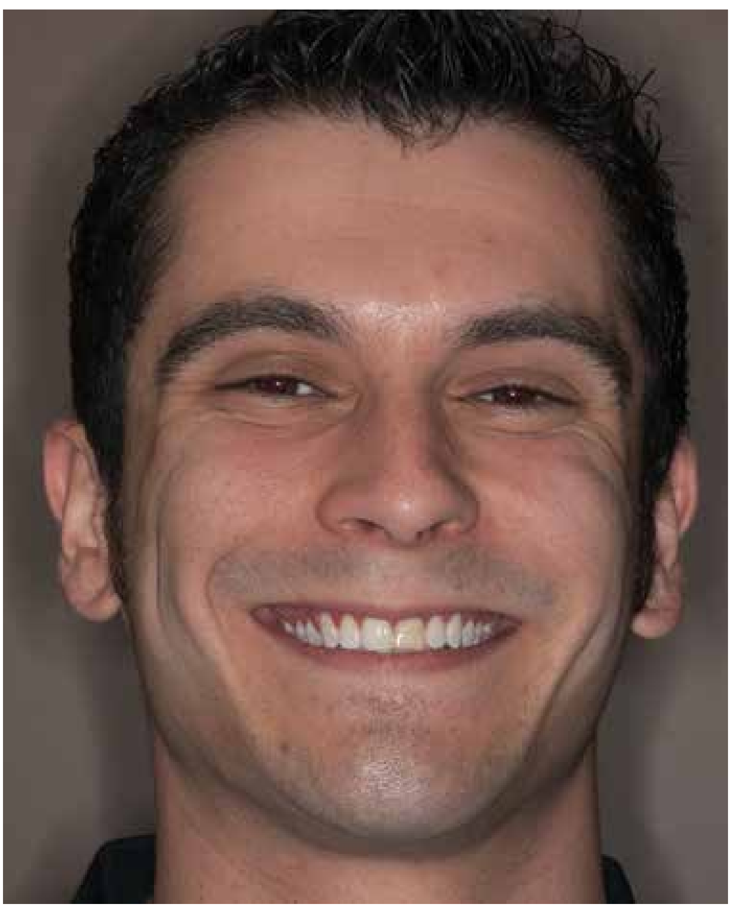

Figure 1: Preoperative full-face view.

Figure 2: Preoperative retracted 1:1 right lateral view.

Figure 3: Preoperative retracted 1:1 left lateral view.

> **Arguably one of the most esthetically demanding tasks a restorative dentist may encounter is restoring a discolored single central incisor with an indirect restoration that mimics nature and blends imperceptibly with the surrounding dentition.**

Introduction

Arguably one of the most esthetically demanding tasks a restorative dentist may encounter is restoring a discolored single central incisor with an indirect restoration that mimics nature and blends imperceptibly with the surrounding dentition. Typically, a significant part of that challenge is communicating the subtle details of the case to an off-site ceramist. With the advent of scanning digital impressions, in-office milling units, and small ceramic ovens, the clinician now is able to immediately design, fabricate, and customize the restoration chairside with the patient. Advances in technology and materials have made success with this type of case—an otherwise often challenging task—more predictable.

Patient Complaint and History

A 32-year-old male presented with the chief concern of a discolored front tooth **(Figs 1-3)**. His work managing a local fitness center engaged him in close personal communication with clients, and he had become self-conscious about the displeasing look of the tooth. It had been broken in a traumatic incident when he was younger and subsequently bonded many years ago. The patient stated that his gums bled occasionally during brushing. He also admitted that it had been quite a few years since his last examination and cleaning. His medical history revealed no significant findings and his oral cancer screening was within normal limits.

Diagnosis

Upon clinical examination, periodontal infection was evident. Generalized moderate gingival inflammation, due to bacterial plaque, had left the gums puffy, red, and tender to the touch **(Figs 4 & 5)**. There was no temporomandibular joint dysfunction, popping, clicking, or masticatory discomfort. A complete radiographic series was taken and evaluated. There was no radiographic or clinical evidence of active caries. With the exceptions of moderate gum disease and the esthetically displeasing front tooth, the patient was in overall good health.

Figure 4: Preoperative smile, right view.

Figure 5: Postoperative smile, right view.

Esthetic Evaluation

An esthetic evaluation of the front two teeth **(Figs 6 & 7)** revealed the following:

- tooth #9 had a much lower value than #8
- marginal gingival inflammation and redness
- the incisal edge of #9 was longer, compared to tooth #8
- the bonding on #9 had discolored and had begun to deteriorate
- tooth #9 had a subtle rotation and slightly overlapped tooth #8 on the mesial
- the incisal embrasures were generous, especially on the distal of the central incisors.

Discussion and Treatment

Two viable options to restore tooth #9 back into harmony with the rest of the anterior dentition were considered and discussed with the patient: direct resin bonding, or an indirect porcelain laminate veneer. The limitations and benefits of each option were thoroughly discussed. The patient expressed his desire to select a material that would discolor the least and would endure the best over time. It was determined that indirect ceramic restoration would be the treatment of choice to achieve the patient's esthetic desires and restorative needs. A treatment plan was presented to the patient as follows:

- periodontal tissue management
- photographic workup, model analysis, and diagnostic wax-up
- indirect restoration of tooth #9.

Figure 6: Preoperative retracted 1:1 view.

Figure 7: Postoperative retracted 1:1 view.

Treatment Description

Initial Treatment

Initial treatment consisted of two parts: achieving gingival health, and collecting and organizing the appropriate records to adequately plan the restorative component of the case.

First, periodontal tissue management was immediately initiated; this consisted of localized deeper periodontal scaling and a general dental prophylaxis. Second, a detailed photographic documentation, incorporating AACD's Accreditation photographic series and other detailed diagnostic images, was made. Polyvinyl silane (PVS) impressions were taken to create duplicate casts for model analysis and a diagnostic workup. A Kois Dento-Facial Analyzer (Panadent; Colton, CA) also was used to generate an earless facebow transfer, and served as a "T-reference" for mounting the casts and orienting the occlusal plane. Subsequently, a wax-up was completed on the articulated models and Sil-Tech putty matrices (Ivoclar Vivadent; Amherst, NY) were formed as preparation reduction guides as well as a stent for the provisional veneer.[1] The functional occlusion also was evaluated to ensure proper anterior guidance. Once the desired functional and esthetic outcome had been verified on the models,[2] we were ready to begin the clinical restoration of tooth #9.

Restorative Phase

The preparation appointment began with a minor occlusal equilibration to establish and confirm centric holding contacts on all posterior teeth and remove any centric relation to maximum intercuspation slide or interferences identified during the model analysis. Ensuring that there is a balanced and peaceful masticatory system is a key component to the longevity of any type of restorative work.[3] Next, tooth #9 was roughly prepared to permit complete seating of the provisional stint, which was filled with temporary crown material (Luxatemp, DMG America; Englewood, NJ) and placed over the tooth. This was allowed to set for 1.5 minutes, locking it into place. Depth-cut burs (Brasseler USA; Savannah, GA) were then used to uniformly achieve the depth of preparation through the provisional material. This technique serves as a useful guide when preparing misaligned or crowded teeth. In this case, it helped to ensure that adequate restorative space was achieved to manage the color change of the darker tooth.[4] Given that a ceramic thickness of about 0.2 to 0.3 mm is generally needed for each shade change,[5] and that the original tooth shade to the desired final shade was the difference of about two shades, a 0.7-mm depth-cut bur was used across the mid-facial, providing uniform restorative space for the restoration while still maintaining the preparation in enamel.

Final Impression

Once the preparation had been refined, the tooth was cleaned and left moist so that a stump shade photograph could be taken for reference. A dual-cord technique was then used to prepare the teeth for the final impression. (Note that the use of an impression and a model are not always necessary. A digital scan can be done intraorally, and the use of the model can be skipped altogether. However, for scheduling purposes and for the clinician's convenience, impressions and models were used in this case.) A final PVS impression was taken along with a bite and a T-reference record. The prototype-style temporary was created using the putty matrix from the diagnostic wax-up and temporary crown material. The prototype was trimmed, polished, and detailed, and the patient was rescheduled for the delivery of the restoration.

The impression was poured in die stone and prepared for scanning with the CEREC Bluecam (Sirona Dental; Charlotte, NC). The stone model of the prepared teeth and the stone model of the diagnostic wax-up were scanned. These digitally rendered models, with the help of the CEREC computer software, were merged to guide the digital design of the new restoration.

Material Selection

The material selection and computer-aided design/computer-aided manufacturing (CAD/CAM) fabrication of the restoration for this case were chosen to more predictably control the end result and achieve the goals set out for the patient.

There are many types of materials on the market today that could have been used to restore this case, and certainly more than one of those options could have yielded a successful result. However, a monolithic, high-translucency lithium disilicate (IPS e.max, Ivoclar Vivadent) was selected for this partial-coverage restoration, offering the clinician the following advantages:

- **Strength:** Lithium disilicate offers a ceramic flexural strength much stronger than other leading esthetic ceramics such as leucite-reinforced or feldspathic glass ceramic. This additional strength can instill confidence in both the clinician and the patient in terms of durability, and consequently, in the overall inherent value of a final restoration that has an increased potential to endure over time.[6,7]
- **Esthetics:** Lithium disilicate, as a monolith, can be a highly esthetic enamel replacement when planning for thin partial-coverage restorations on minimally prepared teeth with favorable color.[8] Enamel, like monolithic porcelain, is uniform in color, but gives the perception of a gradation of character from the gingival to the incisal, due to the transition of its thickness from about 0.3 to 0.4 mm at the gingival, to 1.1 to 1.4 mm at the incisal. When the thickness of the monolithic restorative material is managed after the pattern of enamel, a very natural-looking result can be created.
- **Bondability:** Lithium disilicate can be easily prepared and successfully bonded to enamel in fashion similar to feldspathic or leucite-reinforced ceramic.[8]

Fabrication

This material was selected for use in connection with CAD/CAM technology, allowing the final restoration to be created chairside with the patient. This combination offers the following advantages to the clinician indirectly restoring a single incisor:

- **Mirror-image predictability:** When the clinician is restoring a single central incisor, it is critical to the overall esthetics of the case that the restoration be a near-identical mirror image in dimensions and contours to the contralateral central incisor. CAD/CAM can digitally scan the adjacent central and precisely replicate its mirror image in form for the new proposed restoration. Mirror-image replication can be a huge advantage when striving for predictable esthetics in a case of this type.
- **Chairside customization:** With the introduction of CAD/CAM and small in-office ovens for the crystalizing, staining, and glazing of materials like lithium disilicate, clinicians can easily modify these restorations on site. Chairside customization, enhancing shade match by adding maverick colors and incisal characteristics, can help create predictable esthetic results. The added benefit of having the contralateral tooth as an immediate reference and guide aids the clinician in this artistic pursuit of a "natural" restoration.
- **Full control over the final restoration:** Careful management of the details important to the case, such as contact length, embrasure form, and surface texture during the design and finishing of the restoration, can also be very helpful to the clinician desiring predictability in the end result.

Given the esthetic demands and artistic challenges associated with restoring a single central incisor, especially one with a lower value than its contralateral counterpart, it behooves the clinician to draw upon all tools available that can increase predictability for success in these types of cases.

CAD/CAM AND DIGITAL DESIGN

The three-dimensional digital models acquired through by scanning digital impressions were manipulated in a series of steps within the software, to create a proposal for the final restoration, replicating in form a near-identical mirror image of the contralateral central incisor **(Figs 8-10)**. The interproximal contact strength and margins were refined and the final proposed design was carefully evaluated, approved, and submitted for milling.

Ingot Selection

Ingot selection in this case was made after carefully evaluating the incisal third of the contralateral tooth. The color of the middle and gingival third of the tooth is influenced more by the combination of the underlying tooth structure and the thickness of the final restoration. In these areas, the clinician has to do some "mental color mixing." One must take into account the thickness of the restoration planned, the color of the prepared tooth, and the shade of the ceramic, blending the three together. Custom shade guides can be designed to make this easier to visualize. The thinner the restoration, whether 0.3 mm or 1.0 mm, the more the underlying color of the prepared tooth will affect the manifestation of its final value and hue. Given these parameters, a high-translucency BL2 ingot (IPS e.max) was selected for two reasons. First, the BL ingot series was favored in this case because it is slightly more opaque and less translucent than the B1 ingot series, which will block out a darker tooth underneath.[6] Secondly, even though a BL2 by itself would appear brighter than the target color of the surrounding natural tooth, it is easier to tone down a tooth (as in this case with a sunset color stain) from a bleach shade down to an A1 or even an A2 than it is to take an A1 ingot up to a bleach shade.

Milling and Refining

The computer design was milled with precision out of a 14-mm, partially crystallized, lithium disilicate block. The block is only partially crystallized at the initial stage, because the milling would otherwise take significantly more time if the material were in its fully crystallized or "hardened" state. The milling process

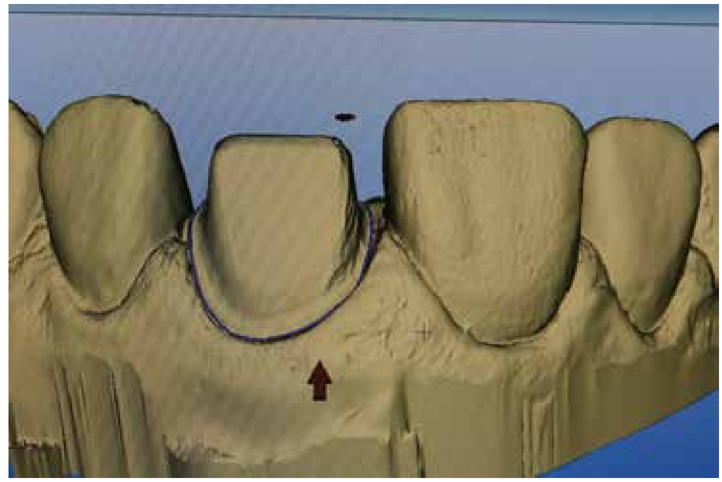

Figure 8: Digital model of prepared tooth #9, rendered with CEREC software from images acquired using Sirona's Bluecam.

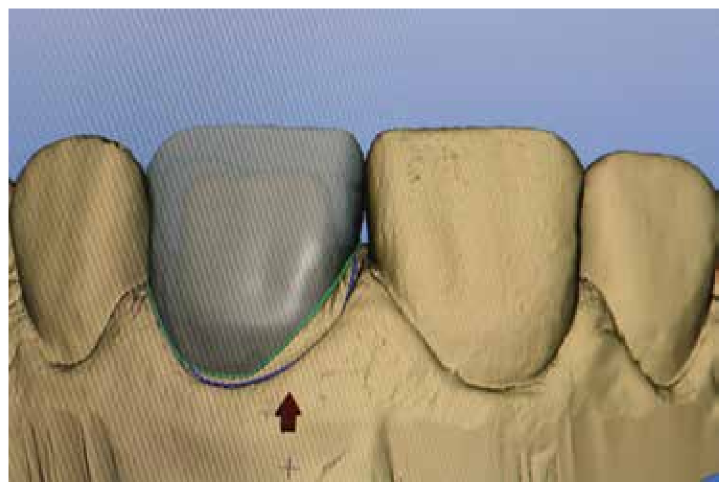

Figure 9: Digitally replicating the mirror image of the contralateral tooth form of #8.

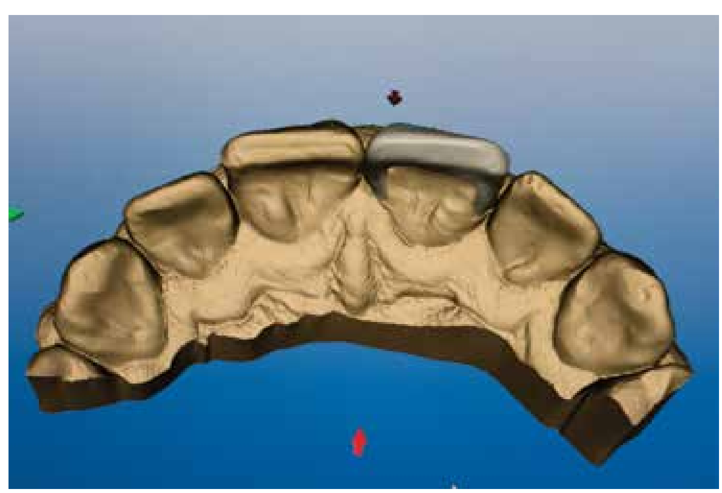

Figure 10: Incisal view of digital proposal.

Can a speed crystallization program still ensure the material quality?

IPS e.max CAD HT/LT	IV Specification	IV 19:50 crystallization	IV 14:50 speed crystallization	Other speed programs t<14.5 min
*Flexural strength (typical mean values) [MPa]	360 ± 60	✓	✓	✓
linear thermal expansion [µm/mK^{-1}]	10.5 ± 0.5	✓	✓	✓
Crystalline phases	LS_2 ($Li_2Si_2O_5$) Li_3PO_4	✓	✓	Risk of residual lithium metasilicate (LS)
Optical properties	A-D standard	✓	✓	Potential loss of chroma; increase of brightness and opacity
* Chemical solubility [µg/cm^2]	<100	✓	✓	Risk of residual LS; higher

*According to ISO 6872:2008

Figure 11: Speed crystallization programs under 14 minutes have shown to undermine desired material properties. (Figure adapted from a presentation, "Optimizing Esthetics with IPS e.max" given by Jeffrey Smith III, CDT, at Cerec 27.5 in Las Vegas, Nevada, August 2012.)

takes about 10 minutes to complete, after which the milling sprue is removed by hand with a fine diamond bur. The restoration can then be tried on a model or intraorally for marginal and proximal contact fit, verification of occlusion, and surface refinement prior to crystallization and customizing. Surface refinement can be accomplished with fine or very fine diamond burs, impregnated rubber wheels, and fine sanding disks. Slow speed, light touch, and water while refining the surface help to prevent fractures and also help to avoid overheating the ceramic material.[9] In this case, for example, the definition in the facial lobes and the horizontal scribe lines that were seen as reflective surface texture in the 1:1 images **(Figs 6 & 7)** were added post-milling by hand, with fine diamond burs prior to crystallization and customizing with stains and glaze.

Crystallization and Customizing

Some of the color customization can be done in this "lavender" partially hardened state prior to full crystallization in the oven. By using close-up photographic images viewed on a computer monitor, or chairside looking at the contralateral tooth for reference, gingival and incisal characterization can be applied. In this case, for example, note the white, grey, and orange/sunset colors, which were added at the incisal edge using a fine brush **(Figs 4 & 5)**. Liquid mediums and clear glaze can be mixed into the stains to tone them down or to allow for a "watercolor-like" surface blending/bleeding technique. These colors can be baked in over multiple firings (multiple thin layers are preferred to fewer thick layers of glaze or stain) until the desired look is accomplished and previewed with the patient upon the final try in of the restoration.[9] A final clear glaze over any characterization can help protect and seal in the subtle details in color previously added to "naturalize" the restoration.

For lithium disilicate, various firing cycle programs can be found for in-office ovens. Caution should be used with respect to "short" or "speed" firing times and parameters when customizing and crystallizing a restoration. Some shortened firing cycles (often faster than 19 minutes) can potentially leave a lithium disilicate restoration's crystallization incomplete, making the ceramic more opaque than desired **(Fig 11)**. Shortened firing cycles can also fail to fully evaporate the solvent in the "paint-on" stain and glaze, leading to premature breakdown of the surface finish and color. For this case, three different firings were done prior to cementation. An incisal wash with grey stain and a gingival and proximal warming with a sunset stain were incorporated into the restoration with the first firing. White characteristics were placed for the second firing, and for the final third firing a clear surface glaze was added, sealing the color in. All firings were performed at the standard 26-minute firing cycle recommended for IPS e.max CAD.[9]

Delivery and Cementaion

At the delivery appointment, the prototype was removed and the prepared tooth was cleaned thoroughly and micro etched. The restoration was then tried in dry to assess fit and contacts. The precision of the digital design and milling resulted in no adjustments being necessary. Prior

Figure 12: Postoperative retracted maxillary occlusal view. Note the mirror-image symmetry possible with CAD/CAM.

Figure 13: Postoperative retracted 1:2 right view.

to the second firing, intraoral and chairside custom stains were tested and applied to further replicate the character of the adjacent tooth. Then, after try-in approval, the restoration was fired and glazed a third and final time.

After cooling, the restoration was cleaned, and prepared for bonding. It was internally etched with 4% hydrofluoric acid for 20 seconds, rinsed, and dried. The internal aspect was then treated with a silane coupler, Monobond (Ivoclar Vivadent) for 60 seconds, air-dried, coated with unfilled bonding resin, and air-thinned.

The tooth surface was also prepared for bonding. An Isolite (Santa Barbara, CA) was used for isolation and humidity control. Adjacent teeth were covered with white nonstick tape and only tooth #9 was etched for 15 seconds with 38% phosphoric acid, rinsed, and lightly dried with cotton pellets and vacuum so as not to desiccate the tooth. It was rewetted with chlorhexidine and blotted dry with cotton pellets. Bonding agent was applied to the tooth and air-thinned to remove solvent. Variolink B 0.5 cement (Ivoclar Vivadent) was applied to the internal aspect of the restoration and it was seated. Once proper positioning of the restoration was confirmed, a tack cure was performed with a Sapphire curing light with a 2-mm tacking tip (DenMat; Lompoc, CA) and the excess cement was removed with floss and a #12 scalpel blade. A final cure was then completed. The occlusion was optimized and the patient was rescheduled for a follow-up appointment and postoperative photographs **(Figs 12-15)**.[10]

Figure 14: Retracted 1:1 right view, post-treatment.

Figure 15: Retracted 1:1 left view, post-treatment.

Figure 16: Preoperative full-smile view.

Figure 17: Postoperative full-smile view.

Figure 18: Preoperative retracted 1:2 view.

Figure 19: Postoperative retracted 1:2 view.

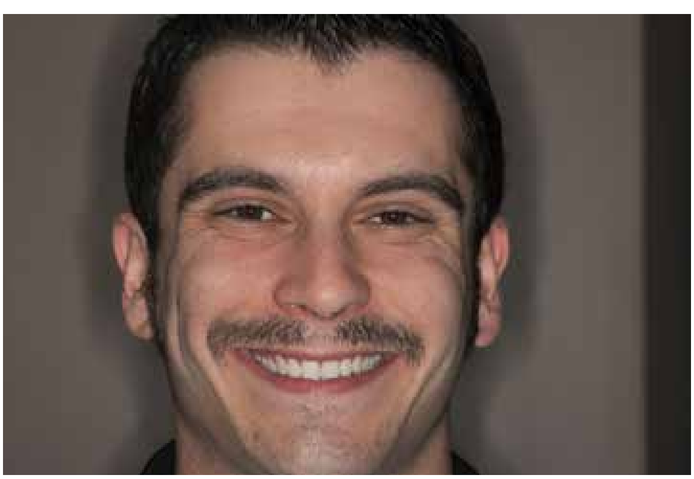

Figure 20: Postoperative full-face view.

> **"There are many aspects of computer-aided digital dentistry that prove advantageous when the clinician is indirectly restoring a single central incisor."**

When comparing the before and after images side-by-side **(Figs 16-20)**, the achievement of the two main goals of treatment can be visually evaluated. First, the resolution of the marginal inflammation and the return to gingival health is apparent. Second, the replication of a true-to-life tooth form and the harmonious blend of the ceramic with the natural dentition are evident.

Summary

There are many aspects of computer-aided digital dentistry that prove advantageous when the clinician is indirectly restoring a single central incisor. The symmetrical mirror-imaging contour, control of emergence profiles, surface texture, subtle color nuances and characteristics, and marginal fit can all be easily controlled, accomplished, assessed, and fine-tuned in the digital designing and chairside finishing steps inherent in this technological process. These advantages, when utilized and managed properly, can make creating a successful restoration, even with challenging cases, more predictable for the clinician and the patient.

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Dr. Hanson is an AACD Accredited Member. He can be contacted at mhanson07@gmail.com

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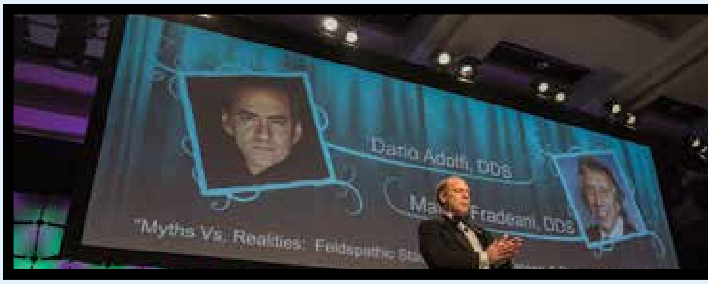
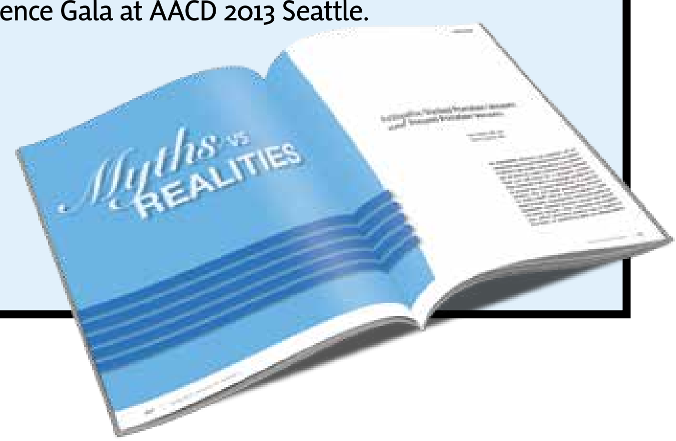
jCD Award



This award is given to the author(s) of an exclusive *jCD* article published within the established year. Articles are nominated and the "best" is determined by the Awards & Recognition Committee.

The AACD congratulates Dr. Dario Adolfi (São Paulo, Brazil) and Dr. Mauro Fradeani (Pesaro, Italy) for their article, "Myths vs. Realities: Feldspathic Stacked Porcelain Veneers and Pressed Porcelain Veneers" (*jCD*, Vol. 28, No. 1, Spring 2012). Dr. Adolfi and Dr. Fradeani each were recognized with a statuette at the Celebration of Excellence Gala at AACD 2013 Seattle.



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In dentistry there is no correct answer or one formula that would be appropriate for all clinical cases. If there was an answer that would mean that all the individual patients will be satisfied with the result. Then additionally, we must determine whether the treatment method was the best option for them. Keep in mind that we cannot always select the best or the ideal treatment. In an actual clinical case, majority of the time the treatment options that technicians work with are very restricted. But even with the option limitation, we must consider to strive for the optimal result for the patient.

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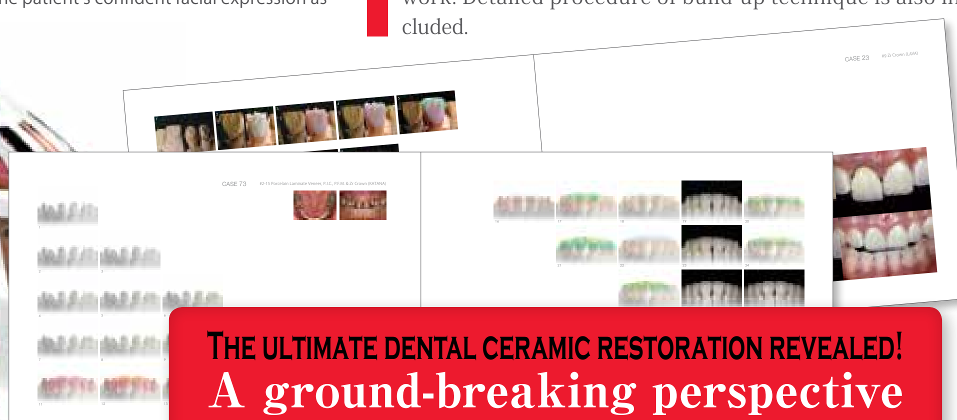

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Examiners' Commentary

Achieving an Admirable Result

James H. Peyton, DDS, FAACD

> "Ideally, a single central incisor should be restored to match the value, color, shape, texture, and all the subtle characteristics of the contralateral tooth."

The restoration of a single central incisor is one of the most challenging procedures a dentist must perform. Ideally, a single central incisor should be restored to match the value, color, shape, texture, and all the subtle characteristics of the contralateral tooth. When all these factors are achieved and the restoration is completed, it is beautiful to behold and the dentist can truly consider himself or herself to be an artist.

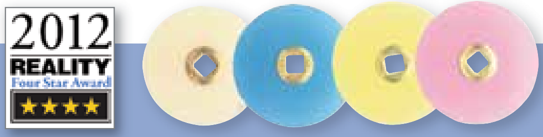
Dr. Hanson did such a nice job matching the central incisors that he should consider himself to be an artist. The basic factor for a successful Accreditation case is to look at the maxillary anterior teeth; if it is difficult to perceive the restoration, then it should be considered to be Accreditation-level work and should pass. This Case Type II was excellent and was passed by all the examiners. However, no restoration is perfect. The examiners made the following comments:

- Criterion #53: Value is slightly low.
- Criterion #61: Margin is visible.
- Criterion #54/56: The incisal translucency and halo effect are inappropriate.

Overall, Dr. Hanson did an excellent job in restoring a single central incisor and this case deserved to pass for Accreditation. Impressively, Dr. Hanson was able to successfully wear the dual hats of a laboratory technician and a cosmetic dentist. Very few dentists have this unique ability, but it is great to see a creative dentist expand our horizons. The technique described in his article might be considered a "niche" procedure (at this time), because only a highly advanced dentist using CAD/CAM and someone highly skilled with porcelain staining could obtain such a wonderful result. However, the ability to see and replicate the subtle differences in color and texture as well as matching the basic contour of the teeth are vital to any dentist or laboratory technician. **jCD**

Dr. Peyton is an AACD Accredited Fellow and has been an AACD Accreditation Examiner since 2000. A part-time instructor at the UCLA School of Dentistry, he practices in Bakersfield, California.

Disclosure: The author did not report any disclosures.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Getting it RIGHT the First Time

Improving Visual Communication Through Cross-Polarized Digital Photography

Panos Bazos, DDS
Michel Magne, MDT

Introduction

It has long been said that “A picture is worth 1000 words.” However, in dentistry, a cross-polarized image may be worth even more.

Ever since dentistry moved into the digital era, interest in photographic techniques aimed at improving the accuracy and objectivity of dental shade evaluation and laboratory communication has steadily increased.

To minimize critical errors in clinical practice, it is necessary to develop reproducible imaging modalities that maximize the visual data acquired.

To minimize critical errors in clinical practice, it is necessary to develop reproducible imaging modalities that maximize the visual data acquired.

Lose Unwanted Glare with Cross Polarization

It is difficult to accurately assess individual tooth shade characteristics, because ordinary flash photography has inherent limitations due to the physics of light: Glare tends to blur distinctions between surface and sub-surface dental characteristics. Cross-polarized photography eliminates unwanted specular reflections that obscure the fine details of dental structures while providing a glare-free, in-depth image **(Fig 1)**.

Enhance Visual Perception by Contrast Elevation

This imaging technique enhances and facilitates visualization of the base dentin shade and the subtle enamel characteristics, immediately providing a chromatic map with a naturally enhanced contrast. Hyper cross-polarized images can be obtained in-camera using a VIVID color profile (Epson America; Plainfield, IN) or by increasing contrast 100% in a generic imaging software program (e.g., Adobe Photoshop CS6) **(Fig 2)**.

Practical Setup with a Magnetic Interface

Typically, polarization filters are screw-threaded into place, making it a challenging task to swiftly change setups in the middle of clinical documentation. For that reason, the cross-polarized filter was designed to magnetically attach to the flash, making placement an effortless task, providing the correct orientation of the filter, and ensuring that the bilateral twin flash polarizers are always positioned perpendicular to the lens polarizer. This interface guarantees consistency, repeatability, and predictability during the photographic workflow, quickly connecting or disconnecting on demand in a simple and ergonomic motion **(Fig 3)**.

Figure 1

Non-cross-polarized.

Cross-polarized.

Figure 2

Non-cross-polarized.

Cross-polarized.

Hyper cross-polarized.

Figure 3

Magnetic attachment.

Figure 4

Acquiring data.

Figure 5

Final control.

Figure 6

Bleaching control.

Common Cross-Polarized Image Applications

Extensive indications and applications in the dental field may include the following:

- Elimination of specular reflections and halation for unobstructed viewing **(Fig 1)**.
- Decalcification assessment and clinical observation among enamel lesions, primarily surrounding orthodontic brackets as a diagnostic aid.
- Enamel subsurface shade mapping of characteristics and nuances.
- Enamel crack detection and assessment **(Fig 1)**.
- Chromaticity assessment for restorative shade selection with conventional or custom shade tabs **(Fig 4)**.
- Verification of optical integration of the interim or permanent restorative prosthesis **(Fig 5)**.
- Bleaching evaluation **(Fig 6)**.
- Translational application in oral medicine and oral pathology for mucosal assessments, diagnostics, and guided surgical excision.
- Medico-legal child abuse assessment.
- Forensic applications.

Summary

Cross-polarized photography, when used with a standardized image workflow, is a practical technique that has considerable potential for improved documentation, shade estimation, and visual communication among restorative team members. The authors believe it is a novel technique that provides added value to digital dental images, clarity, and objectivity. **jCD**

Cross-polarized photography, when used with a standardized image workflow, is a practical technique that has considerable potential for improved documentation, shade estimation, and visual communication among restorative team members.

Dr. Bazos received his DDS degree from the USC School of Dentistry in 2000. He maintains a private practice limited to esthetics and restorative dentistry in Athens, Greece. He lectures nationally and internationally.

Mr. Magne is president and director of 901 Michel Magne, Dental Laboratory and Dental Education in Los Angeles, California. He lectures nationally and internationally.

Disclosure: Dr. Bazos is the developer of polar_eyes digital dental photography.

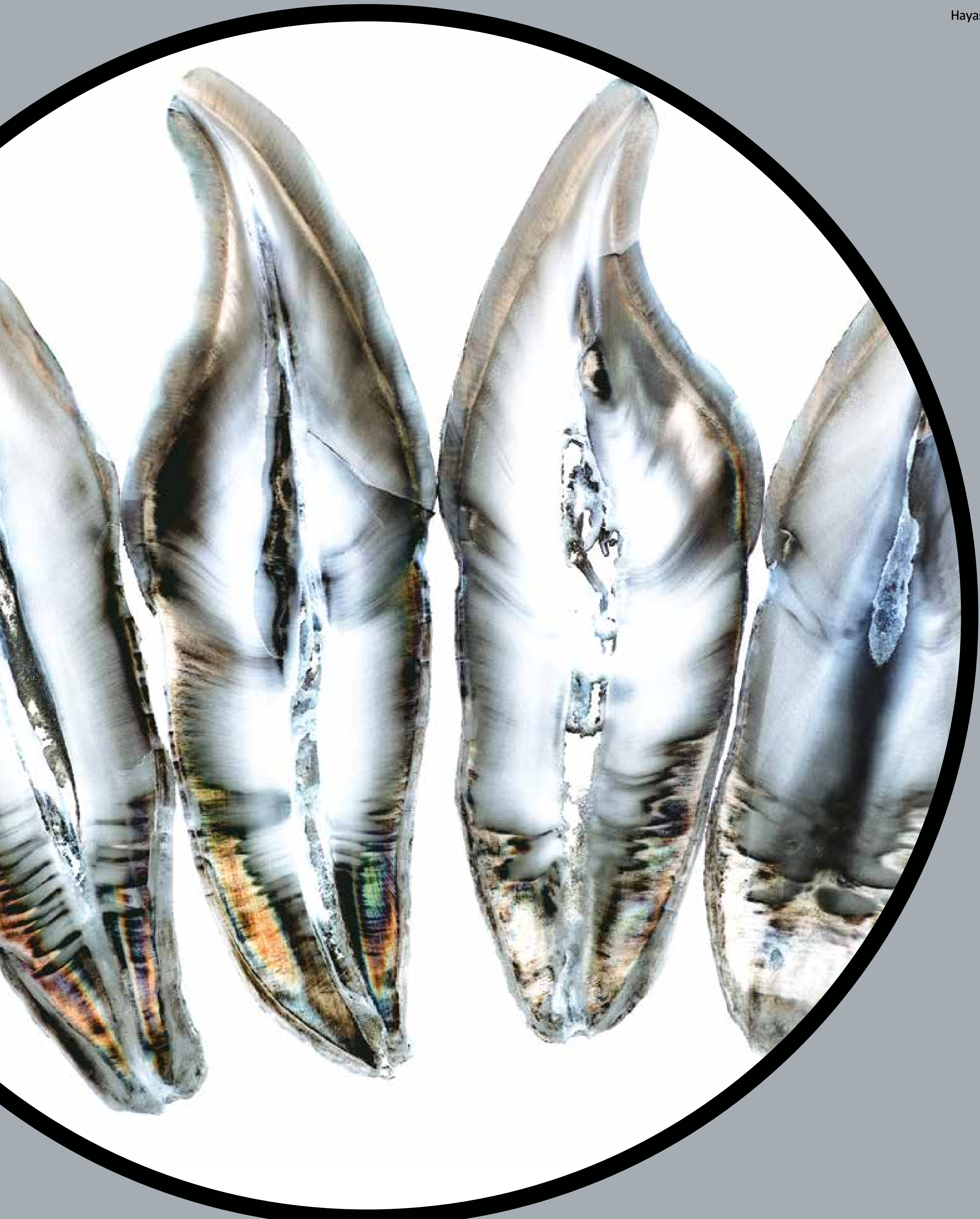
Artistry and Knowledge

Effort and a Big Dream Can Take You Anywhere

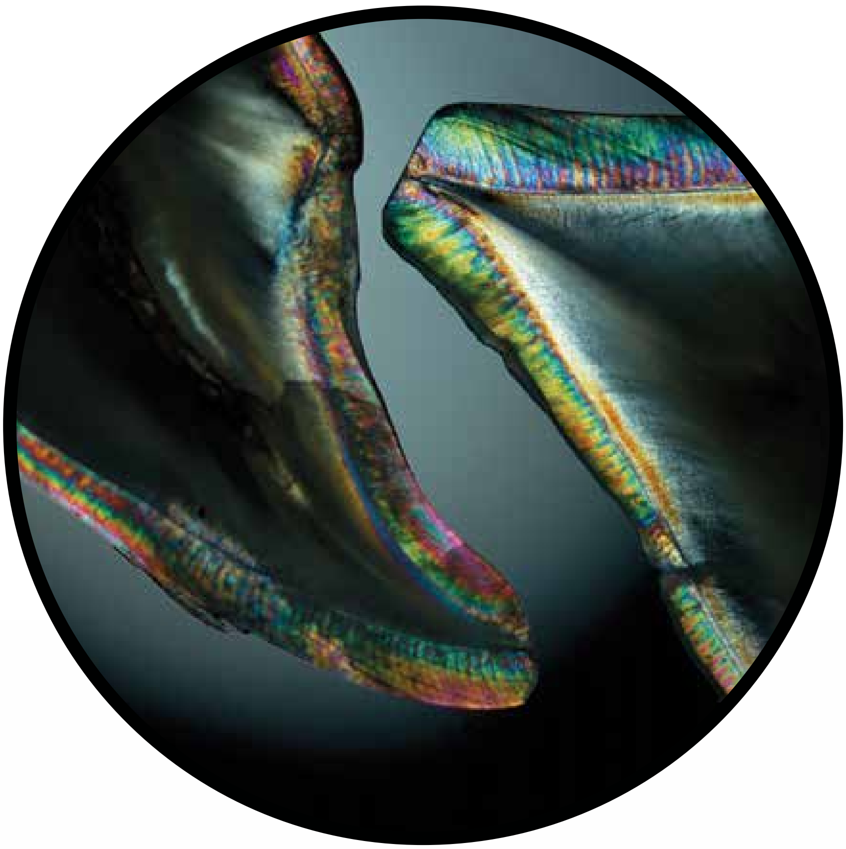
Naoki Hayashi, RDT

Introduction

A restorative prosthodontic treatment that fails to achieve good esthetics is no longer acceptable today. As we perform esthetic restorative treatments, some patients desire "shiny, white, and beautiful teeth," while others want "teeth that suit me best and make me look good." Every person has individual lip dynamics, circumstances, preferences, and values. One thing, however, is certain: We always want to be attractive and liked by others. The functional and esthetic prostheses that dental technicians are responsible for fabricating must satisfy patients' requirements when they smile.



balance, dentin, structure



Creating Dental Prostheses

Dental technicians fabricate restorations to replace missing or imperfect teeth according to specifications given by dentists, therefore helping dentists to restore patients' stomatic health. In some cases, when patients are not happy with their natural tooth contours, alignment, or shape, we have to remove healthy tooth structure. This helps dental technicians to create prostheses to aid in functional and esthetic reconstruction of the shape, contours, and shade of teeth and dentition

Our responsibility is to make these prostheses in accordance with nature, for which neither specifications nor formulas exist. If they are manufactured based upon simply any formulas or specifications, the result will not match nature and will be of limited quality.

Since we are already handicapped compared to nature, before we even start creating restorations we need to utilize everything possible. While we obviously cannot create restorations without first developing a treatment plan, the requirements placed upon dental technicians are diverse and complicated, like nature itself. The restorations must be imperceptible to others and must be in accordance with the wishes of contemporaries and the needs of the times.

When creating dental prostheses, the author focuses upon following the structure of natural teeth. When fresh, beautiful transparency and opacity of natural teeth catch our eye, it is because of the balance attained between the dentin and the enamel of natural teeth. Dental technicians must have a thorough understanding of the structure and the characteristics of natural teeth, and we must represent the balance correctly.

enamel, skin, hydration effect

origins — our passion

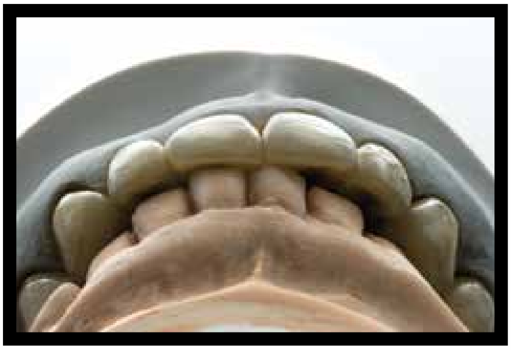
Even more important than the previous is the patient's lip form. When we speak, our lips create various forms. The completed dental prostheses (especially anterior teeth) must look beautiful and in a proper balance with whatever form our lips may take, and restorations must look balanced with different lip dynamics.

The author considers that success or failure of an esthetic dental restoration should not be evaluated based only upon a view in which the lips are open. The appearance of the anterior teeth depends greatly upon the frame (i.e., the lips, whose form changes indefinitely), and the restored anterior teeth must look beautiful in balance with any lip form and when seen from any angle. The restorations also must not be too noticeable.

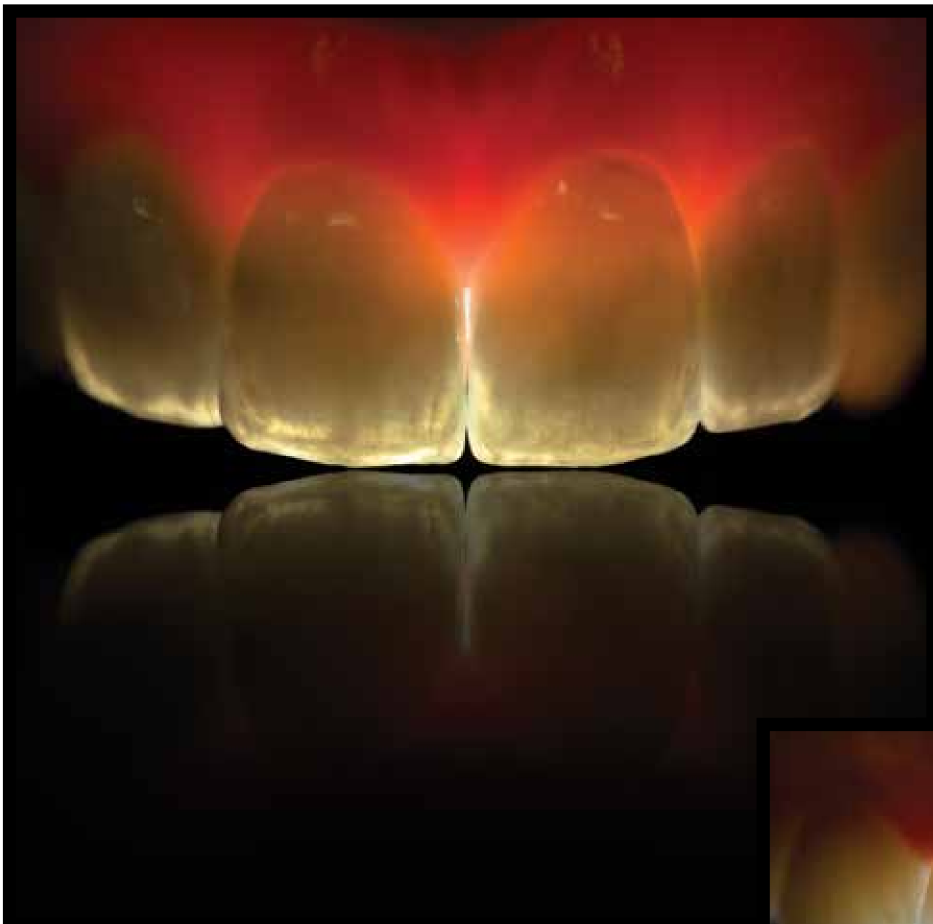
designing porcelain buildup

flow on the model

"Our responsibility is to make these prostheses in accordance with nature, for which neither specifications nor formulas exist."

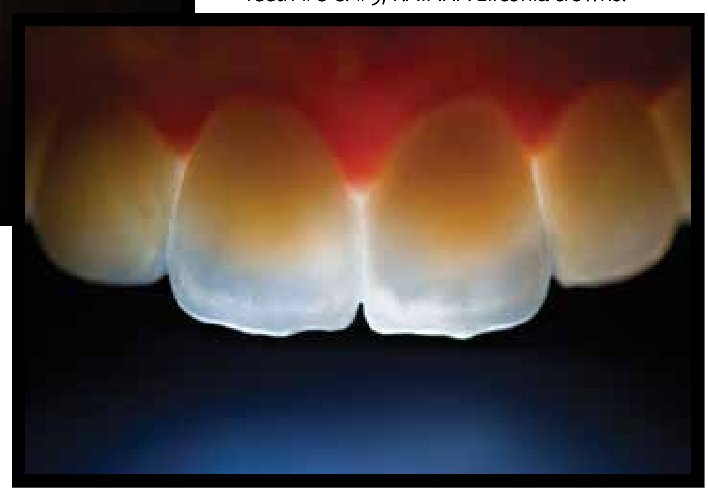


Teeth ##7-10, KATANA zirconia crowns (Kuraray Noritake Dental; Nagoya City, Aichi, Japan).



ceramic art

Teeth #8 & #9, KATANA zirconia crowns.



art — the outcome of our effort

Teeth #7 & #10, EX-3 laminate veneers (Kuraray Noritake).

Conclusion

Attaining beauty gives people confidence and makes them happy. Although the definition of "beauty" is fluid, the quest to achieve it—regardless of its ideal at the time—is eternal. It is immensely satisfying for all of us engaged in dentistry to help patients to realize this goal.

The images in this article present examples from the author's daily clinical cases. Many cases present with various difficulties, but the author believes that the fastest way to achieve the best goal is to perform each step carefully and accurately.

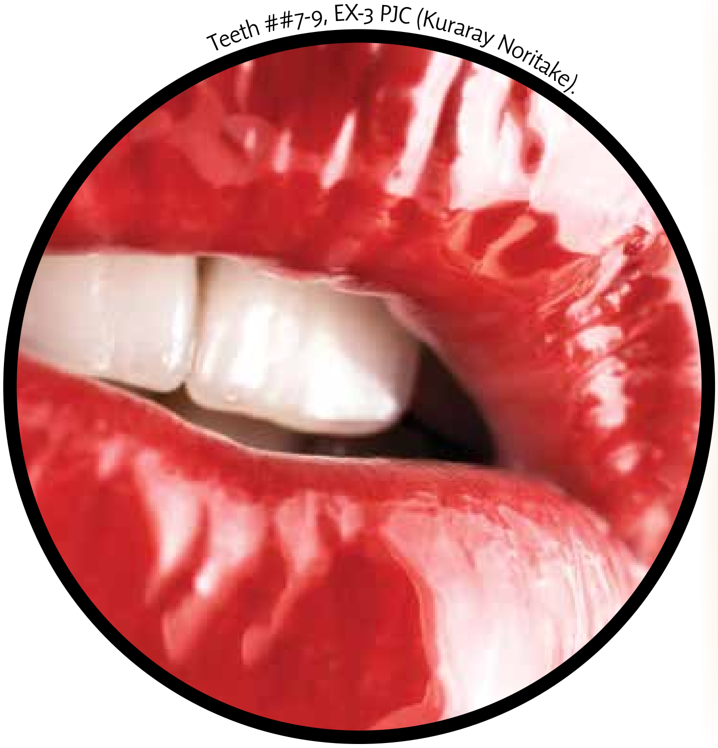
When giving people beautiful smiles in addition to functional prosthodontic treatment, dentists and dental technicians must possess artistry as well as sound knowledge of and techniques in dentistry. Perceptions of beauty are so diverse and also vague that no one true definition is possible. The most valuable things when attempting to replicate nature are to use intuition freely under a given environment to complete an artistic and creative product and, simultaneously, to analyze the current case calmly to design a treatment plan; this is what "esthetic dental treatment" is about.

Teeth #8 & #9, KATANA zirconia crowns.

lip dynamics

Maxillary full reconstruction with CZR crown and veneers combination (Kuraray Noritake).

Teeth ##7-9, EX-3 PJC (Kuraray Noritake).



In addition to technique, tooth anatomy, relationships between shapes and contours, basic functional movements, histology, and knowledge of the physiology of the whole body are all of great significance. To resolve the difficult issue of functional esthetics, we must cooperate with each other and always pay attention to these factors. Thereby, we enhance our appreciation for beauty as much as possible.

When we produce an excellent result, the patient appreciates it with a broad smile. This means that there will be as many smiles as there are dentists and dental technicians. **jCD**

expressions — "heartbeats"

"Although the definition of 'beauty' is fluid, the quest to achieve it — regardless of its ideal at the time — is eternal."

Mr. Hayashi is a master ceramist and vice president of Ultimate Styles Dental Laboratory in Irvine, California.

Disclosure: The author did not report any disclosures.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Myths vs. Realities

Digital Impressions: A Dentist's and a Laboratory Technician's Perspectives

John F. Weston, DDS, FAACD
Matthew R. Roberts, CDT, AAACD

Introduction

Are you ready for digital dentistry? The *jCD* recognizes that you may have many questions regarding the advancing technology in digital impressions. Therefore, we reached out to experienced AACD members and educators Dr. John F. Weston and Mr. Matt Roberts, for their perspectives regarding digital impressions. They both have successfully integrated this technology into their current workflow. The *jCD* is pleased to offer you both a dentist's and a laboratory technician's viewpoints.

Are you ready for digital dentistry?....

Key Words: digital impressions, scanning, analog impressions, model-free fabrication

Opening Remarks from Dr. John Weston

It is rare to read any dental publication lately without seeing news about digital impression systems. While the majority of dental offices have not yet adopted this technology, digital scanning is gaining in popularity as prices move downward and more dentists come to understand the accuracy and efficiency of these systems. But many misconceptions are still prevalent among the dental community. This is quite understandable, given that the digital impression-taking process is so different from what most dentists are accustomed to. Surveys show most doctors would like to integrate this technology if price and ease of use are demonstrated; this is what drives the market to continue with improvements in hardware and software. Currently, there are eight systems on the market from six different companies, with more on the horizon. This article will attempt to dispel some of the most common myths currently circulating about these systems.

Myth

It is difficult to scan and capture all of the teeth.

Reality

Capturing all the teeth in an arch is dependent upon two things: total time allotted to capture the data and accessibility to all areas of the mouth via the scanning wand. Many of the systems on the market are able to obtain full arch impressions after some experience.[1] Some utilize a scanning contrast medium of powder or liquid and others do not; either way, scanning more teeth obviously takes longer than a typical single crown or "quadrant" digital impression. However, clinicians quickly become more efficient and comfortable the more they use the technology and are better able to scan more difficult cases. Full arch data are required when using digital impressions for fabrication of many dental prosthetics including orthodontic aligners, bite guards, snore guards, removable partial dentures, and larger multi-unit restorative cases. As a result, having the ability to capture all of the teeth will become increasingly important for full digital impression integration **(Figs 1 & 2)**.

Figure 1: Near full-mouth digital case.

Figure 2: Use of powder.

Myth

The scanner is too large to access the entire mouth.

Reality

While many of the scanning wands are considered large and cumbersome to some extent, the trend shows devices are getting smaller and more efficient.[2] It is definitely possible to capture almost all areas of the dental arch, with the exception of the distal surface of second molars, with many of the current wands. It must be noted that this is also a difficult area to impress using traditional analog impressions. Most of the time, a clear occlusal surface with minimal buccal and lingual is sufficient. When the second molar is the tooth to be restored or the distal contour of a second molar is required, wand size becomes a major factor, narrowing the choices available. However, when the second molar is prepared, scanning this area is much easier because the distal contour is now a flat surface and converging toward the occlusal. As wands get smaller and capture technology improves, access to challenging areas of the mouth will improve even more, with digital scanning likely becoming the choice for impressions in difficult areas **(Figs 3-5)**.

Myth

The need for tissue retraction/tissue management is not as important as with conventional impressions.

Reality

Retraction is just as important with digital scanners.[3] In other words, a camera can see only what the clinician can see. If tissue, moisture, or debris is covering a margin, the camera is unable to scan the area. However, the amount of retraction that is required in many cases is less when using digital scanners. If the margin is visible, even slightly, the camera will see it.[4] Most clinicians find that adequate retraction can be achieved using retraction pastes and/or very small diameter retraction cord. Retraction systems used for analog impressions also work well, including lasers and zirconia-tipped high-speed instruments. In addition, subtle differences in tissue and tooth can be visualized using the various imaging tools available on the systems for accurate margin marking and placement. Some systems also employ color-rendering technology for easier distinguishing of tooth structure and tissue. Whether margins are marked in the laboratory or by the clinician, when it comes to accurately distinguishing margins, slight tissue retraction is required **(Figs 6-10)**.

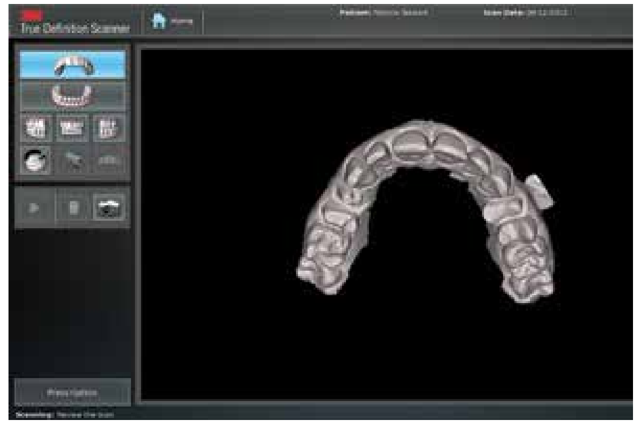

Figure 3: Full arch scan completed with True Definition scanner.

Figure 4: iTero (top) and LYTHOS (bottom, Ormco; Orange, CA) digital scanner wands.

Figure 5: Intra-oral scanner (Cyrtina; Zwaag, The Netherlands).

Figure 6: Use of retraction paste.

Figure 7: Zirconia tissue trimmer.

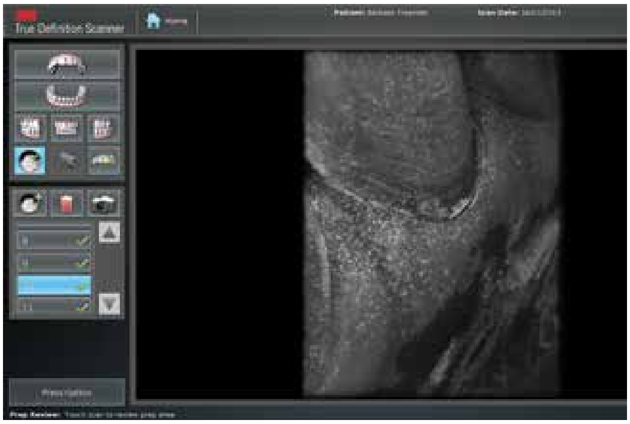

Figure 8: Subtle differences in tissue and tooth shown.

Figure 9: Color rendering used to show differences in teeth and tissue.

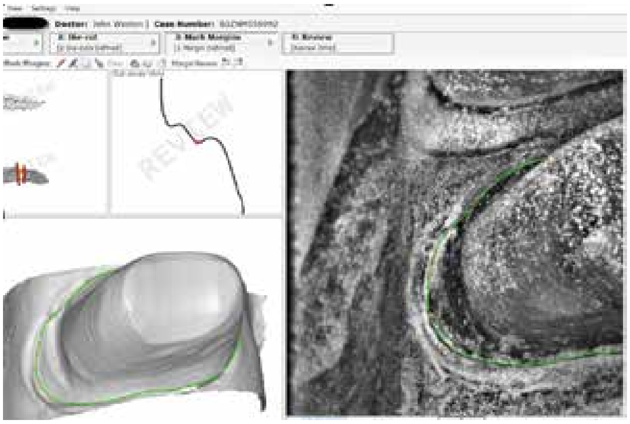

Figure 10: Example of cross-sectional margin marking.

Figure 11: Example of an accurately scanned veneer case on an additive stereolithography (SLA) model.

Myth

Digital impressions are not as accurate as conventional impressions.

Reality

Studies show digital data are far superior to traditional polyvinyl silane or rubber base impressions.[5,6] An optical image will always be more precise than an analog negative. With the added ability to manipulate the images for viewing of margins and preparation details, one can hardly ignore that digital impressions provide the ability to improve the quality of our restorations. We also know that stone plaster distorts as it sets. Traditional impressions can be subtly distorted with no way to absolutely determine this clinically until the restoration is tried in the mouth.[3] Patients swallow and move around, trays can bend, and moisture can silently contaminate the area while we wait for final set.[7] With optical scans, movement is not a factor and moisture is detected easily as it can be seen, cleared away, and an accurate scan completed.[1] Once the data are captured, we know they are accurate.[8] A comparison would be our ability to now easily visualize, manipulate, and diagnose more accurately using digital radiographs over traditional analog films **(Fig 11)**.

Myth

Digital impressions cannot be used for implants.

Reality

All of the systems currently on the market can be used to capture permanently seated custom and stock abutments for any implant system. A handful of the systems are also able to utilize scan bodies for accurate fixture-level impressions and complete digital design of abutments and subsequent restorations. "Model-free" custom abutment and final crowns can be designed at the same time, eliminating steps and improving accuracy.[9] In addition, since implant restorations are inherently unforgiving with regard to fit, the accuracy of digital impressions are well suited for this technology. Either way, recording implant data is an important aspect for digital impressions, and we will see more workflows coming on line with all systems in the very near future **(Figs 12-14)**.

Figure 12: Digital impression of a scan body.

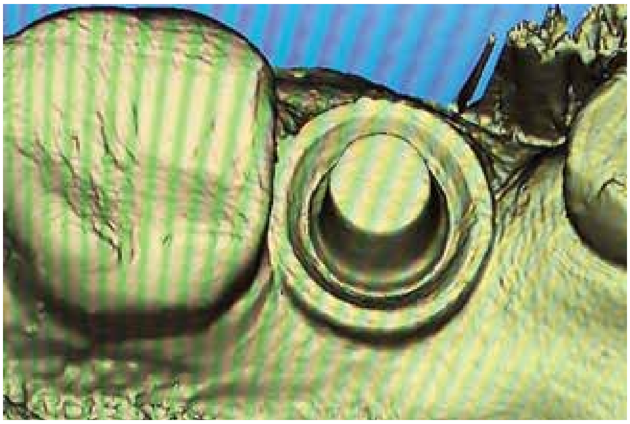

Figure 13: Digital impression of an implant abutment.

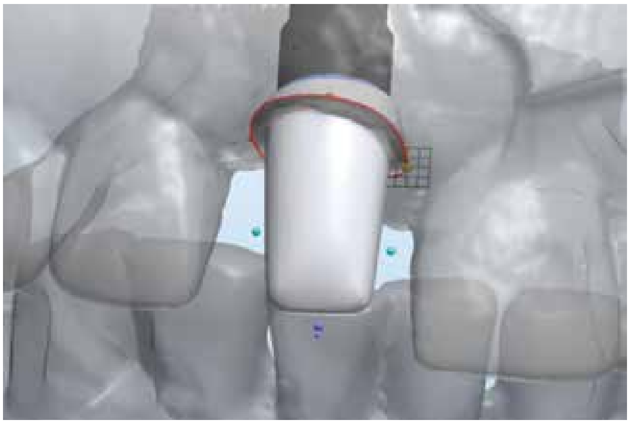

Figure 14: Digital abutment design.

Myth

Digital impressions are not reliably faster than elastomeric impressions.

Reality

Most systems on the market, once fully implemented, save time due to faster impression making.[8,10,11] There is a learning curve and one has to look back at the time and training that was required to master analog impressions. In most cases, after a few weeks of consistent use, most clinicians will be faster with digital scans. This is not just due to increased skill level but from a reduction of re-makes. Most digital systems allow you to visualize the impression as it is being made including the ability to go back and "stitch-in" missing pieces of data. This saves time when compared to a complete re-do with analog impressions. Once fully implemented into the office workflow, a typical quadrant scan averages 30 to 60 seconds, with full arch scans inside of a few minutes.[11] When using analog systems, multiple impressions due to voids and distortion are not uncommon and result in more time and increased use of materials. Even experienced clinicians can have occasional re-takes when using analog systems. This is not a factor with digital. Once you have the image on the screen, there is no need for a re-take. The real time savings becomes evident at delivery. Whether using chairside milling or lab-fabricated, restorations made via digital impressions typically show improved fit with minimal adjustments.[12]

Myth

Digital impressions cannot be used for porcelain veneers or cross-arch dentistry due to inaccuracy.

Reality

Most systems on the market were designed for classic single or double tooth quadrant dentistry. Some are specifically designed for model-free in-office milling with the option to connect directly to the clinician's laboratory for traditional model-based or model-free fabrication.[13] Not all systems on the market have the accuracy or detail to predictably fabricate multiple units and cross-arch dentistry, bridges, or implant bars.[14] Normally these cases require very accurate scanning and models, equivalent to high-density stone models used in precision analog dentistry.[15] Currently, when models are required, they are fabricated primarily using reductive or additive processes. Clinicians should investigate the abilities of digital scanning systems so they purchase the one that best suits their needs. If planning digital workflows for cross-arch and anterior cases, accurate models will most likely be required **(Figs 15-17)**.

Figure 15: Accurate SLA model shown on a veneer case.

Figure 16: Preoperative; digital scanned veneer case.

Figure 17: Postoperative; digital scanned veneer case.

Conclusion

As described here, the rapidly evolving technology of digital scanning systems is opening new doors for dentists. With current scanners that are smaller, faster, and capable of more indications than the first generation of this technology, many dentists are now revisiting their initial assessments of the suitability of these tools for their practices. While a digital scanner is no crutch for poor technique, its use can help dentists quickly identify and correct hard and soft tissue management issues before they become a problem in the model or final restoration. Digital impression systems are likely to reinforce the importance of excellent preparation and tissue retraction while using digital scanners to efficiently create a wide variety of very accurate restorations and other prosthetics.

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While a digital scanner is no crutch for poor technique, its use can help dentists quickly identify and correct hard and soft tissue management issues before they become a problem in the model or final restoration.

Dr. Weston is an Accredited Fellow of the AACD. He is the owner of and practices at Scripps Center for Dental Care in La Jolla, California.

Disclosure: Dr. Weston receives honoraria from 3M ESPE for teaching courses that use their products.

Key Words: digital impressions, tissue retraction management, impression accuracy, implant digital scans

Mr. Roberts Shares his Experience with Digital Impressions from a Laboratory Perspective

Although digital impressions have been around for quite a while, and most practitioners are aware of their existence, there seems to be a general lack of information about their advantages. While it appears that a small group of dentists in the U.S. are successfully using digital impressions for their day-to-day dentistry, the vast majority are still sitting on the sidelines using tried-and-true conventional impression techniques. It seems their reasons for not adopting the new impression technology are varied: some are simply reluctant to incur the expense of the new systems, while others are not integrating due to a misunderstanding of what is available or myths about what digital impressions will and will not do. I will try to shed some light on these myths.

Myth

The need for tissue retraction/tissue management is not as important as with conventional impressions.

Reality

Digital impressions are not a magic solution to maintaining an isolated field prior to taking an impression. It is equally important to control bleeding, sulcular fluid, and tissue during the impression process when working with digital or conventional impressions. The difference occurs when you are unsuccessful on your first impression attempt. With conventional impression material, you have to retake the entire impression to recover the missing detail on one of two marginal areas; with the newest generation of digital impressions you can simply rescan the area with the problem and add those data to the original digital impression. On cases that are hard to isolate, the digital impression can be taken incrementally as each tooth is isolated, thus eliminating the need to have perfect isolation on an entire arch at one time for the impression. A further benefit in some of the software is that it can be programmed to identify areas of inadequate reduction at the time of the impression, allowing the dentist to go back and reduce further, then rescan just that area and add it to the impression **(Figs 1 & 2)**.

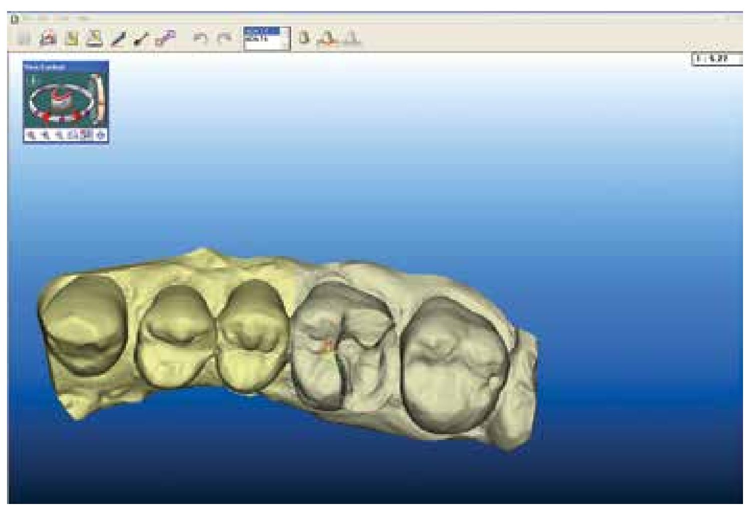

Figure 1: iTero digital impression of an inlay preparation on tooth #14.

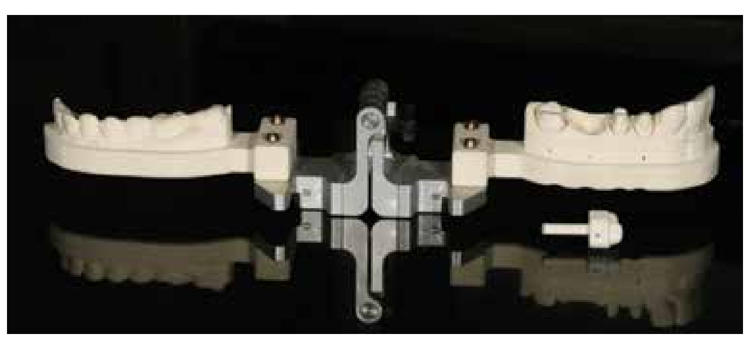

Figure 2: In the iTero system, models are milled from the digital impression at a milling center, and then shipped to the user.

Myth
Digital impressions are not as accurate as conventional impressions.

Reality
As with many areas of dentistry, there are various studies[1,2] and opinions relating to accuracy in the digital impressions. I have worked successfully with iTero impressions (Align Technology; Santa Clara, CA) since its introduction in 2005 with very good clinical results. We have used these impressions for both single units and bridgework with equal success. Although not a published study, conventional and digital impressions were taken on many cases, the restorations were fabricated on the digitally generated models, and then fit back to the stone dies from the conventional impressions. We observed no difference in fit between the two impressions techniques.

Myth
Digital impressions cannot be used for implants.

Reality
This is certainly a myth. Both the CEREC Omnicam (Sirona Dental; Charlotte, NC) and iTero systems are capable of taking implant impressions. A scan abutment is attached to the implant and the digital scan is completed. The software identifies the location of the implant based upon the position of the scan abutment; the models can then be fabricated with an implant abutment in that position. Many of the digital impression companies either already offer this or have working prototypes to solve this need.[3] As with every aspect of new technology, a dentist looking to purchase a digital impression system should be certain that the system being considered offers the features needed for the intended use in practice **(Fig 3)**.

Myth
Digital impressions are not reliably faster than elastomeric impressions.

Reality
Digital impressions can be faster than conventional impressions. I have seen demonstrations where full-mouth impressions were taken, including bite registrations, in under two minutes with the new color TRIOS system from 3Shape (New Providence, NJ). The CEREC Omnicam is equally fast **(Figs 4-6)**.

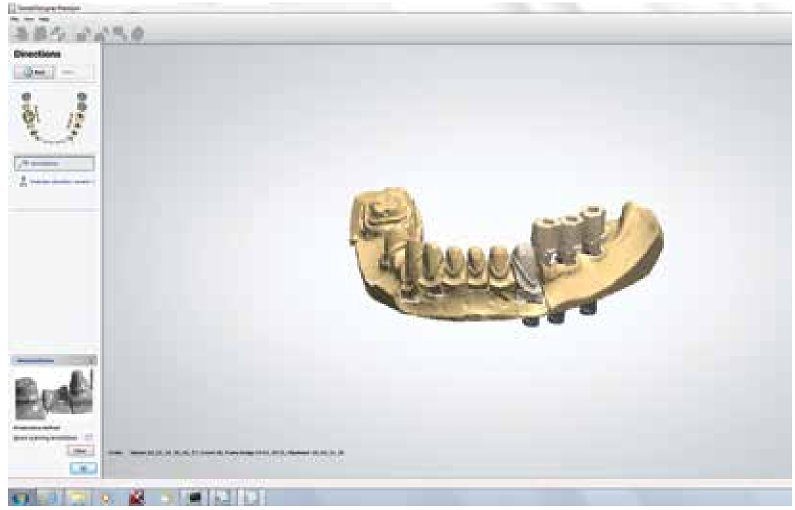

Figure 3: Implant impressions are created by attaching "scan bodies" to the implants prior to completing the digital scan. The software recognizes the position of the implant from the position of the scan body. The 3Shape laboratory scan here shows three scan bodies in the lower left quadrant.

Figure 4: Although this case was completed with a scan of a laboratory model, a digital impression would have allowed the digital design process to begin much more quickly, avoiding the model fabrication time.

Figure 5: TRIOS digital impressions also capture color. Although in a screenshot like this the impression could be mistaken for a color photo, it is actually a three-dimensional image of the full mouth.

Myth

Digital impressions require messy powdering of the mouth.

Reality

Some systems do still require powder and some do not. Many of the lower-cost systems do require powder. The more expensive systems are powder-free.[4]

Summary

Digital impressions are here to stay. Anyone who questions this should try to remember the last time they loaded a roll of Ectachrome into a camera, or developed x-ray film in their office. When considering purchasing a digital impression system, the consumer should try as many as possible to find one that fits his or her individual needs. Systems range in price from around $15,000 to more than $40,000, and have many significant differences in size and capability. Ease of use in the mouth varies and software options also vary from system to system **(Fig 7)**.

Figure 6: Models of the digital impressions can be printed with various 3-D printing systems. Restorations can then be conventionally fabricated or digitally designed.

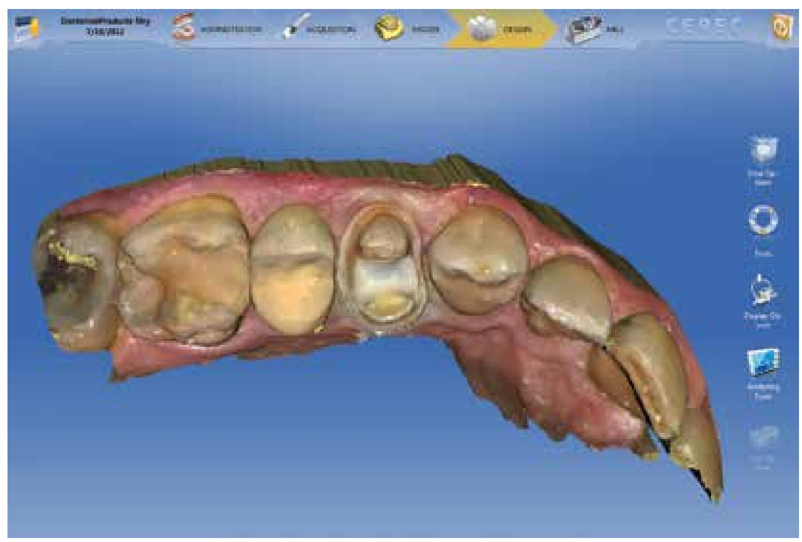

Figure 7: The CEREC Omnicam takes color images without powdering teeth. The user can choose to print a model or design and mill a restoration to be tried in directly in the mouth.

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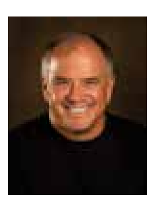
Digital impressions are not a magic solution to maintaining an isolated field prior to taking an impression.



Mr. Roberts is an AACD Accredited Member and is the owner of CMR Dental Lab in Idaho Falls, Idaho.

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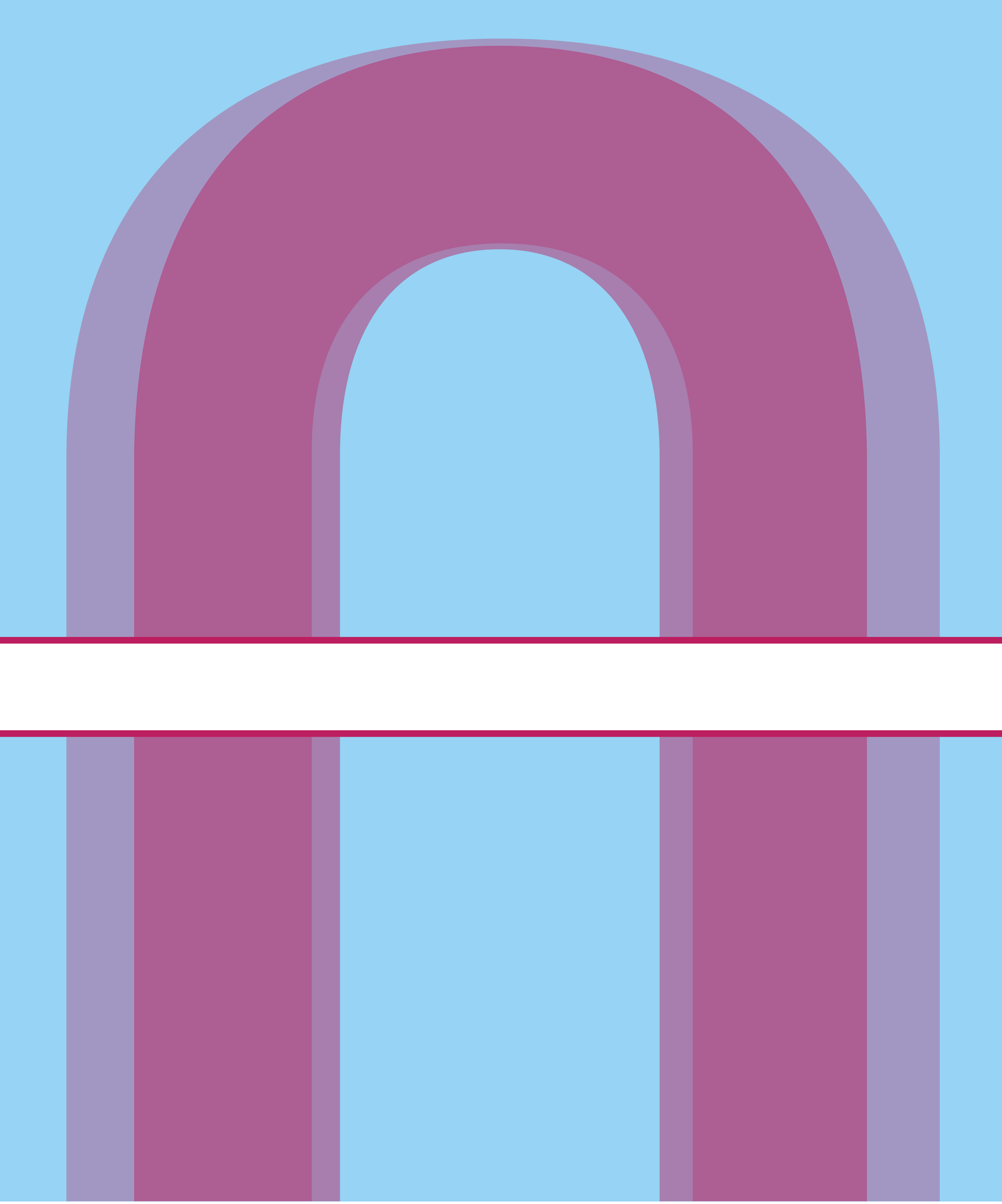

TREATMENT of a Class III Malocclusion

Utilizing an Implant-Supported, Fixed Removable Milled Bar Overdenture

Jeff H. Bynum, DDS

Key Words: implant, milled bar, overdenture, orthognathic surgery

Abstract

Orthognathic surgery is often recommended for the adult patient presenting with a skeletal malocclusion and a desire to restore the teeth to a more ideal esthetic and functional relationship. For the patient who also presents with a compromised existing dentition requiring removal of all or multiple teeth within the arch, it may be possible to manage the skeletal malocclusion with the use of dental implants and a milled bar overdenture. This case discusses the treatment of a Class III malocclusion and a compromised maxillary dentition with implant therapy and a milled bar overdenture to achieve the appropriate esthetic and functional parameters and effectively eliminate the need for orthognathic surgery. Diagnosis, treatment planning, surgery, and prosthetic work are addressed.

Introduction

The Angle Class III skeletal malocclusion is a skeletal growth abnormality characterized by mandibular prognathism, maxillary retrognathia, or a combination of both.[1,2] Originally, Class III malocclusions were primarily attributed to an overdevelopment of the mandible; however, cephalometric analysis indicates that maxillary retrognathia is responsible for up to 60% of cases. These patients often clinically exhibit a concave facial profile, retrusive nasomaxillary area, and prominent lower third of the face. The maxillary arch is often narrower than the mandibular arch, and the overjet and overbite can range from reduced to reverse.[3]

Much of the literature focuses upon orthodontia, appliance therapy, and other non-surgical therapies for the adolescent.[4] For the adult, orthognathic surgery typically is recommended. The type of surgical treatment depends upon the etiology of the malocclusion and may include sagittal split osteotomies, segmental osteotomies, Leforte I osteotomies, or some combination of the aforementioned.[5]

For the adult Class III malocclusion patient who presents with other dental compromises and associated risks, management of the malocclusion is possible with implant therapy and a milled bar overdenture.[6,7] Without the use of implants to create stability and retention, placing denture teeth beyond the limits dictated by the patient's anatomy can create instability of the prosthesis.[8] The appropriately fabricated milled bar can effectively create an artificial crest of the ridge, allowing the denture teeth to be placed beyond the traditional anatomic landmarks. The prosthesis can then be fabricated in a more esthetic and functional position for the Class III malocclusion patient without subjecting the patient to orthognathic surgery.

This clinical essay presents an Angle Class III skeletal malocclusion case treated with implant therapy and a milled bar overdenture in lieu of orthognathic surgery, with marked functional and esthetic results.

Figure 1: The patient was not pleased with his existing bridgework.

Figure 2: Interpretation of cephalometric data revealing a retrognathic maxilla.

Case Report

A 68-year-old male presented for comprehensive examination and treatment **(Fig 1)**. His medical history consisted of controlled Type II diabetes and no known drug allergies, current medications, or contraindications for dental treatment. His dental history revealed tooth loss associated with caries. He presented with a failing maxillary fixed partial denture spanning from #8 to #16. He reported discomfort in the area of #13 while chewing hard, sticky foods.

The patient was also concerned with the appearance of his teeth. He had never been pleased with the appearance of his existing bridgework. Orthognathic surgery had been recommended by previous dentists to correct the skeletal malocclusion and improve esthetic outcomes. Interpretation of cephalometric data revealed a retrognathic maxilla (Nasion-A point to Frankfort Horizontal plane angle (Na-FH of 82° and ANB <1°) **(Fig 2)**.

Diagnostic Opinion

Periodontal

A clinical and radiographic examination revealed American Academy of Periodontology (AAP) Type III classification with bone 2 to 4 mm from the cemento-enamel junction **(Fig 3)**.

A mucous retention cyst was noted in his right maxillary sinus and evaluated by an ear/nose/throat physician specialist. No treatment was indicated for this finding. Periodontal findings included slight bleeding on probing and probing depths less than or equal to 3.0 mm.

Risk: Moderate[9,10]
Prognosis: Fair[9,10]

Biomechanics

The patient had a history of restorative dentistry and missing teeth due to biomechanical compromises. He presented with active carious lesions on two teeth (#6 and #13) supporting the long-span bridge (#8-#16). Tooth #8 also appeared to have

Figure 3: Preoperative radiograph showing AAP Type III.

internal resorption. The mandibular teeth exhibited no active caries but had several questionable restorations and areas of structural compromises **(Fig 4)**.

Multiple structurally compromised teeth were noted. Tooth #13 exhibited irreversible pulpal pathology and #4 showed signs of pulpal pathology. Class II mobility was noted on the abutments supporting the maxillary fixed partial denture. The three abutment teeth supporting the fixed partial denture showed evidence of cement fatigue and resultant recurrent caries **(Fig 5)**.

Risk: High
Prognosis: Poor to hopeless

Figure 4: Several questionable restorations and areas of biomechanical compromises.

Figure 5: Maxillary arch displaying several notable concerns.

Figure 6: Bilateral mandibular tori were noted.

Function

Bilateral mandibular tori were noted and posed no contraindication for treatment **(Fig 6)**.

Although the patient reported difficulty in chewing hard, sticky foods, this difficulty was attributed to the discomfort associated with the active apical pathology. Some attrition was noted on the mandibular anterior teeth. The wear on the anterior teeth was attributed to the end-to-end anterior occlusal scheme previously established in an attempt to manage the Class III malocclusion.

The extremely long-span bridge showed no evidence of fracture or chipped porcelain and had been in function for more than 20 years. The right lateral view demonstrates the skeletal Class

III malocclusion **(Fig 7)**. The patient stated that the wear seen on the lower incisors had not noticeably changed in the past five years. The functional system was not displaying signs of active breakdown, leading to a diagnosis of acceptable function.

Risk: Low
Prognosis: Good

Dentofacial

The patient displayed no maxillary teeth with the lips in repose. Only 1 to 2 mm of each visible tooth was displayed in a full smile. Lip mobility was only 3 mm and less than average **(Fig 8)**. Asymmetries of the gingival architecture were not evident without retraction. The patient expressed a desire to display more tooth structure when speaking and smiling.

Risk: Low
Prognosis: Good

Treatment

The patient had previously been given a treatment plan of a mandibular bilateral sagittal split osteotomy to reduce his "prognathic mandible." Cephalometric analysis showed a retrognathic maxilla. Both surgical and restorative options were explored and discussed as a way of treating the retrognathic maxilla. The patient chose to reject the orthognathic surgery because: (1) even with an improved skeletal relationship, he would still require implant therapy to replace missing teeth; and (2) it was felt that his esthetic objectives could be met utilizing the implants. The implant option would minimize the number of surgical procedures and the consequent healing time and sequellae. It was decided to proceed with maxillary implants and a milled bar overdenture. This option appropriately managed the patient's risk factors and susceptibility for disease and fulfilled the treatment goals, which were as follows:

- Decrease the high biomechanic risk by eliminating periapical infection and caries.

These patients often clinically exhibit a concave facial profile, retrusive naso-maxillary area, and prominent lower third of the face.

Figure 7: Skeletal Class III malocclusion.

Figure 8: Less-than-average tooth visibility and lip mobility.

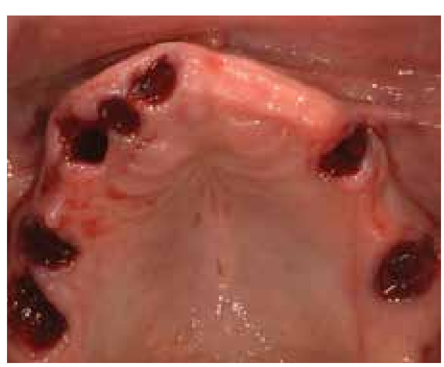

Figure 9: All of the remaining maxillary teeth were carefully extracted.

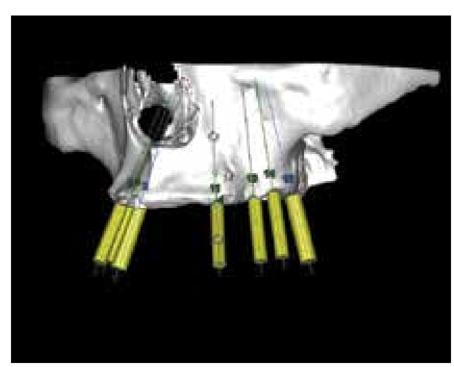

Figure 10: A 3-D implant treatment plan was established.

- Improve and enhance the smile by increasing tooth display in repose and full smile.
- Create a prosthesis that allows for long-term esthetics, stability, cleansability, function, and repairability.

All of the remaining maxillary teeth were carefully extracted using periotomes, luxators, and proximators **(Fig 9)**.[11] Site optimization techniques were utilized in all sites where the buccal plate thickness was less than or equal to 1 mm.[12,13] A human cortical and cancellous mineralized allograft (MinerOss, BioHorizons IPH; Birmingham, AL) was delivered into the extraction sockets, and an absorbable collagen wound dressing (CollaPlug, Zimmer Dental; Carlsbad, CA) was sutured over each site.

A three-dimensional (3-D) cone beam-computed tomography image was obtained (i-CAT, Imaging Sciences Int.; Hatfield, PA), and 3-D implant treatment planning was utilized (Simplant, Materialise Dental; Glen Burnie, MD) to accurately plan the proper placement of the implants to facilitate the desired prosthesis **(Fig 10)**. A temporary treatment denture was fabricated and worn by the patient during the post-extraction, three-month healing period.

After adequate healing, implants were placed according to the preoperative plan (BioHorizons Maestro, BioHorizons) **(Fig 11)**. The implants were allowed to heal for three months, after which time an open-tray impression was made and all appropriate diagnostic information was relayed to the laboratory (RE Bourke; Redmond, WA).

A wax rim was fabricated to establish the desired position of the maxillary incisal plane, horizontal and vertical positions of the anterior teeth, and maxillary posterior occlusal plane **(Fig 12)**. The canines were positioned level with the lip in repose.[14] The development of the maxillary occlusal plane was established based upon esthetics and dentofacial parameters.[15,16] Orthodontic therapy would be performed to align the mandibular teeth to coordinate

Figure 11: Implants were placed after satisfactory healing.

Figure 12: A wax rim was fabricated to establish the desired position.

Figure 13: The rim was previewed with a full smile.

functionally with the facially generated maxillary occlusal plane.

The wax rim can be previewed with a full smile **(Fig 13)**. Establishing the maxillary incisal plane relative to the canines positioned level with the maxillary lip in repose increases the amount of teeth displayed with a full smile for this patient. The patient's low lip line affords the opportunity to move the vertical position of the maxillary teeth down in the face and increase the amount of maxillary tooth display.

The milled bar was fabricated by the laboratory with bilateral attachments cast into the milled bar framework (MK1 Dental-Attachment GmbH; Zetel, Germany) to allow the overdenture to be fixed in place during function **(Fig 14)**. The security of the combination of the attachments with the milled bar allowed the teeth to be positioned in a position dictated by esthetic and functional parameters. Passive placement of the milled bar on the implants was assured with a try in, and the esthetics of the denture were verified prior to final processing.

The bar was delivered with a passive fit, and the screws were torqued to the manufacturer's recommendation of 30 Ncm. The bar was extended well over the crest, allowing the teeth to be positioned beyond the traditional bony landmarks. This enabled an increase in tooth display without compromising the stability of the denture **(Fig 15)**.

The intaglio surface of the denture was milled to allow for a precise and secure fit over the bar, and the attachments were easily engaged by the patient. This allowed for a fixed overdenture prosthesis that had the ability to be removed for cleaning purposes **(Fig 16)**. During the planning stages of implant placement, accommodation for the space requirements of the attachments as well as preparation for visual shielding of the access hole used to engage retention were considered.

The simple placement of a key into the access opening for the attachment will disengage the frictionless, positive

Figure 14: A milled bar was fabricated and placed.

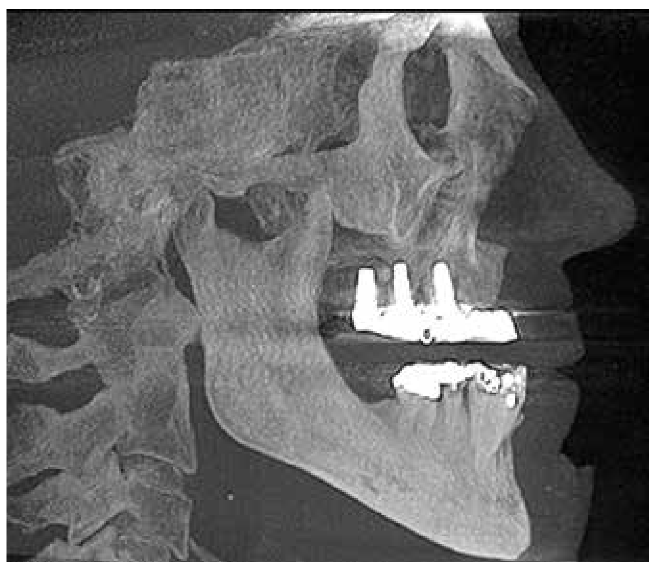

Figure 15: Radiograph showing the bar with a passive fit and labial position relative to the crest of the ridge.

Figure 16: The removable fixed overdenture prosthesis.

locking axle from the housing **(Fig 17)**. Once both sides are disengaged, the denture becomes easily removable for repair and cleaning. Upon being placed back in the mouth and seated over the bar, the axle is easily engaged with the patient's finger or thumb and sits flush with the denture base.

Orthodontics on the mandibular arch was used to level the mandibular occlusal plane and establish a functional intra-arch relationship **(Fig 18)**. The functional and esthetic parameters, determined by the dento-facial analysis and esthetic parameters, remained constant on the maxilla. The active phase of mandibular orthodontia was completed in approximately 10 months, and the patient is actively maintaining this relationship by wearing a clear, hard plastic retainer.

The postoperative close-up full smile shows a more desirable amount of tooth display **(Fig 19)**. The patient was pleased with the enhanced esthetics, stability of the restoration, and alleviation of pain. He was also pleased that the results were achieved without the need to advance the maxilla via orthognathic surgery.

Figure 17: Placement of a key to enable disengagement of prosthesis for removal.

Figure 18: Orthodontics used to level occlusal plane and establish function.

Figure 19: Postoperative full smile showing more tooth display.

Summary

The patient's postoperative full smile two weeks post-treatment demonstrated a marked improvement in facial esthetics **(Fig 20)**. Patients with skeletal malocclusions have compound challenges when attempting to improve dentofacial parameters. Orthognathic surgery has traditionally been utilized to correct skeletal malocclusions in an attempt to achieve more idealized results. In the case of a compromised dentition, adding implant therapy and a milled bar overdenture made it possible to move the crest of the ridge to a position that allowed for placement of the maxillary teeth in a more desirable esthetic and functional position. This patient was able to avoid the risks associated with orthognathic surgery, reduce and manage his susceptibility for disease, and achieve a restoration that fulfilled his goals for improved esthetics and functional longevity.

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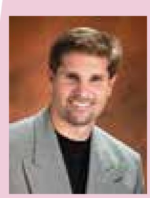
Figure 20: The patient's two-week postoperative full smile, showing an improvement in facial esthetics.

This patient was able to avoid the risks associated with orthognathic surgery.



Dr. Bynum is a clinical instructor at the Kois Center, Seattle, Washington; and at the Ickert Teaching Centre, Langley, British Columbia, Canada. He maintains a private practice in Valrico, Florida.

Disclosures: The author did not report any disclosures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REHABILITATION of a Deteriorated Oral Situation

CAD/CAM-Designed Fixed and Removable Zirconia Restorations

Nico M. Buehler, Dr.Med.Dent
Carlo P. Marinello, Dr.Med.Dent, MS

> "A fixed complete denture composed of monolithic zirconia and partially veneered by glass-ceramic in the front area was planned for the upper jaw."

Abstract

A patient with an extremely poor dental situation, characterized mainly by missing molars, increased tooth mobility, and irregular tooth position/distribution, requested an esthetic and functional prosthetic rehabilitation with minimal surgical intervention. In the presented case, CAD/CAM technology using zirconia for fabricating a partially veneered fixed complete denture was planned for the upper jaw. A partially veneered removable complete denture on telescopic retainers was planned for the lower jaw. This article describes the fabrication of a fixed complete denture in the upper jaw as well as a removable complete denture in the lower jaw. The clinical and the technical laboratory steps are presented.

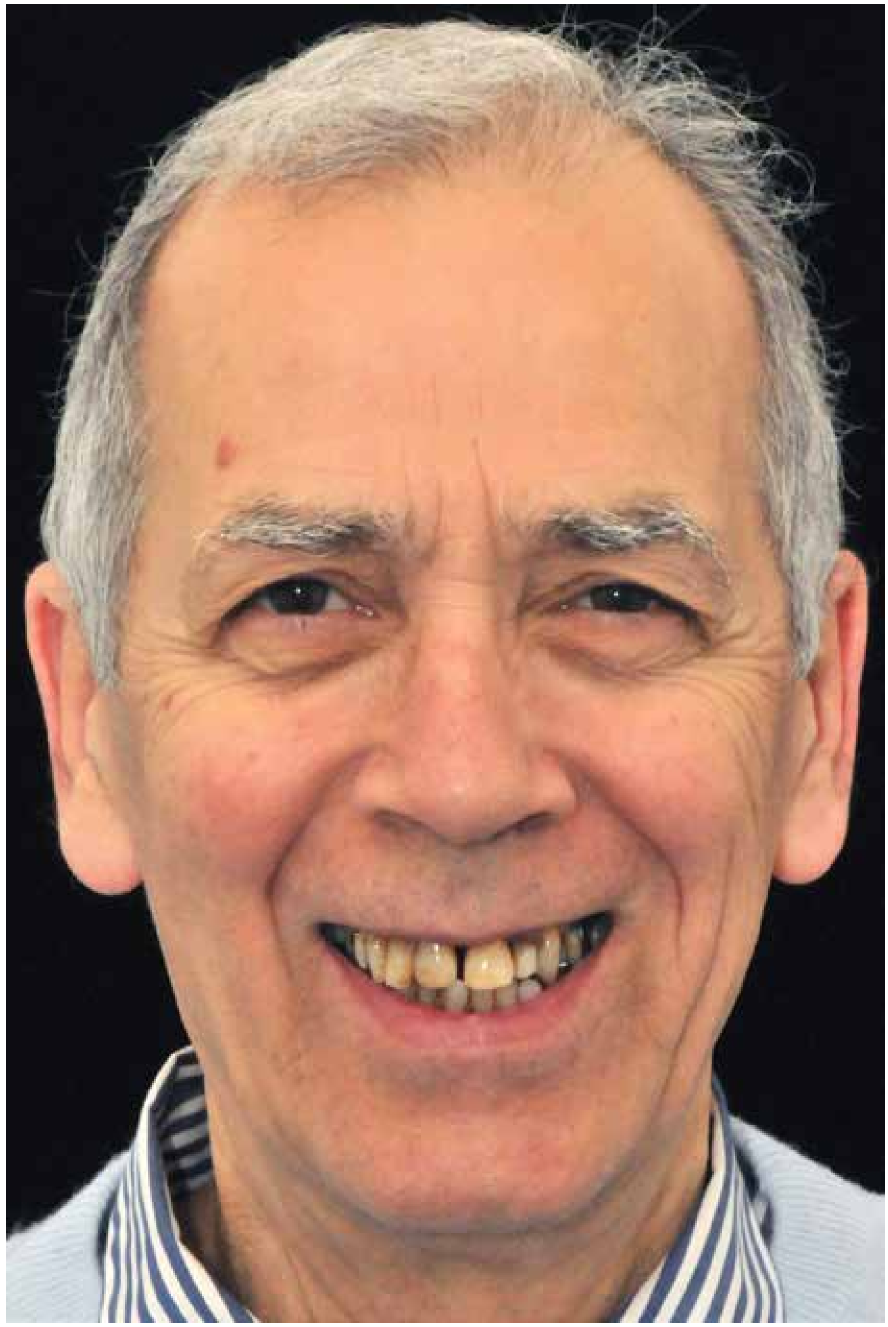

Figure 1: Extraoral view before treatment.

Key Words: full ceramic, zirconium dioxide, CAD/CAM

> "At the beginning, the patient was treated minimally by using composite resin and a removable partial denture in the upper and lower jaw."

Patient History and Clinical Findings

The 68-year-old patient was very disturbed by the state of his dentition **(Fig 1)**. His unhappiness was due both to esthetic and functional reasons. He wanted stable chewing conditions, brighter teeth, and more regular tooth positions without the necessity for any orthodontic treatment or surgical intervention. He was also upset by the visible open interdental spaces in the front region. The patient was healthy and a non-smoker. Caries and periodontitis were responsible in the past for the loss of all molars, three premolars, and a lateral incisor in the upper jaw. At the beginning, the patient was treated minimally by using composite resin and a removable partial denture in the upper and lower jaw.

The patient's oral hygiene was considered to be insufficient, documented by a high plaque and sulcus bleeding index of 78% and 82% respectively.

Esthetically insufficient porcelain crowns, endodontic treatments (#5 and #13), insufficient composite resin restorations (##6-12), caries, and increased probing depths (#7 and #13) were present in the upper jaw.

Caries (#21, #24, #25, #28), as well as insufficient amalgam fillings (#27, #28) was present in the lower jaw. The front teeth exhibited increased periodontal probing depths with advanced attachment loss; they were insufficiently splinted by composite resin. Teeth #21, ##23-26, and #28 were non-vital. Teeth #7, #13, #21, and ##23-26 had an unfavorable long-term prognosis due to caries and periodontitis **(Figs 2 & 3)**.

Figure 2: Intraoral view before treatment.

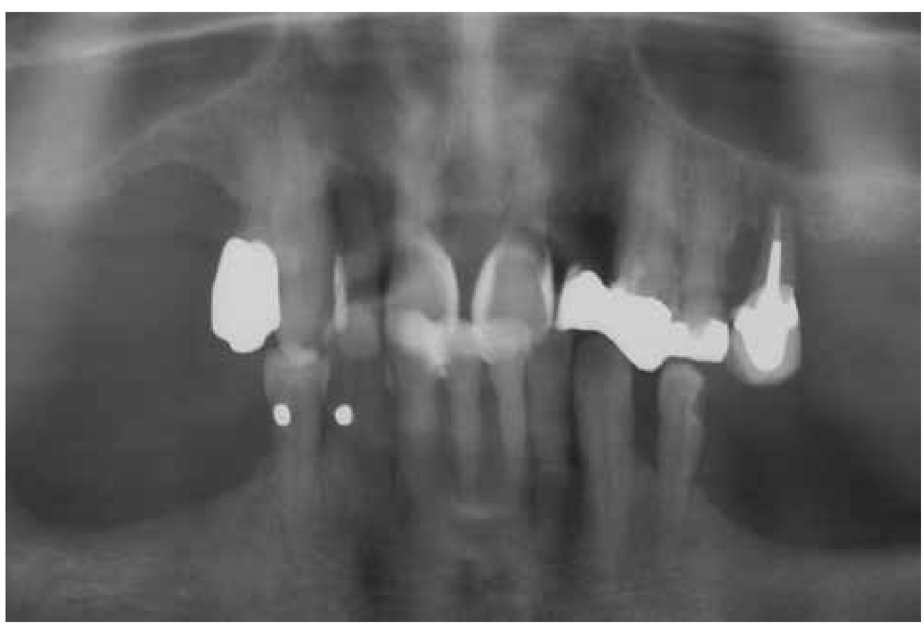

Figure 3: Intraoral view before treatment.

Treatment Plan

A fixed complete denture composed of monolithic zirconia and partially veneered with glass-ceramic in the front area was planned for the upper jaw. Teeth #5, #6, #8, #9, #11, and #12 were planned as abutments.

Because only three reliable abutment teeth were available in the lower jaw, an implant was planned on the left side of the mandible (#20). Teeth #22, #27, #28 and the implant would be responsible for retention and support of the removable complete denture on copings, both made of monolithic zirconia. To facilitate prosthetic tooth positioning and to replace the missing papillae in the front area, the restoration would be augmented by pink-colored porcelain in the upper and lower jaw.

Clinical Procedure

The patient was informed in detail about the intended treatment plan. Oral hygiene instruction and dental hygienist support were established. After extraction of the non-preservable #7, #13, #21, and ##23-26, an immediate removable complete denture was fabricated for the upper and lower jaw. The original vertical dimension was adopted **(Fig 4)**. The computer-aided design/computer-aided manufacturing (CAD/CAM)-duplicated lower immediate complete denture served as a radiological guide and surgical stent for the implant in the lower jaw **(Fig 5)**.

The implant (3.5 x 13 mm Nobel Replace, Nobel Biocare AB; Gothenburg, Sweden) was placed eight weeks after the teeth were extracted. Three months after implant placement a final impression (Impregum, 3M ESPE; Seefeld, Germany) was taken using custom-made trays **(Figs 6 & 7)**. The master casts were mounted in an articulator by

Figure 4: Temporary immediate complete dentures.

Figure 5: CAD/CAM-duplicated lower immediate complete denture in transparent resin as x-ray or surgical template.

Figure 6: Clinically stable situation of the upper jaw, ready for impression.

Figure 7: Clinically stable situation of the lower jaw, ready for impression.

Figure 8: Intraoral view of the clinical try in of the diagnostic setup.

Figure 9: Extraoral view of the clinical try in of the diagnostic setup.

clinically determining the vertical and horizontal dimensions (SAM 2P, SAM Präzisionstechnik GmbH; Gauting, Germany).

In the laboratory, a diagnostic tooth setup in wax was prepared for the upper and lower jaw using resin prosthetic teeth (PhysioSET TCR/Bonartic TCR, Candulor AG; Wangen, Switzerland). The setup was clinically evaluated and adapted **(Figs 8 & 9)**. Based on corrections of the clinical try in, a prototype of the future restoration was produced. The progress of treatment was documented photographically to facilitate communication between the dental practice, the dental laboratory team, and the patient.

Figure 10: Scan of the master casts without setup.

Figure 11: Scan of the master casts with setup.

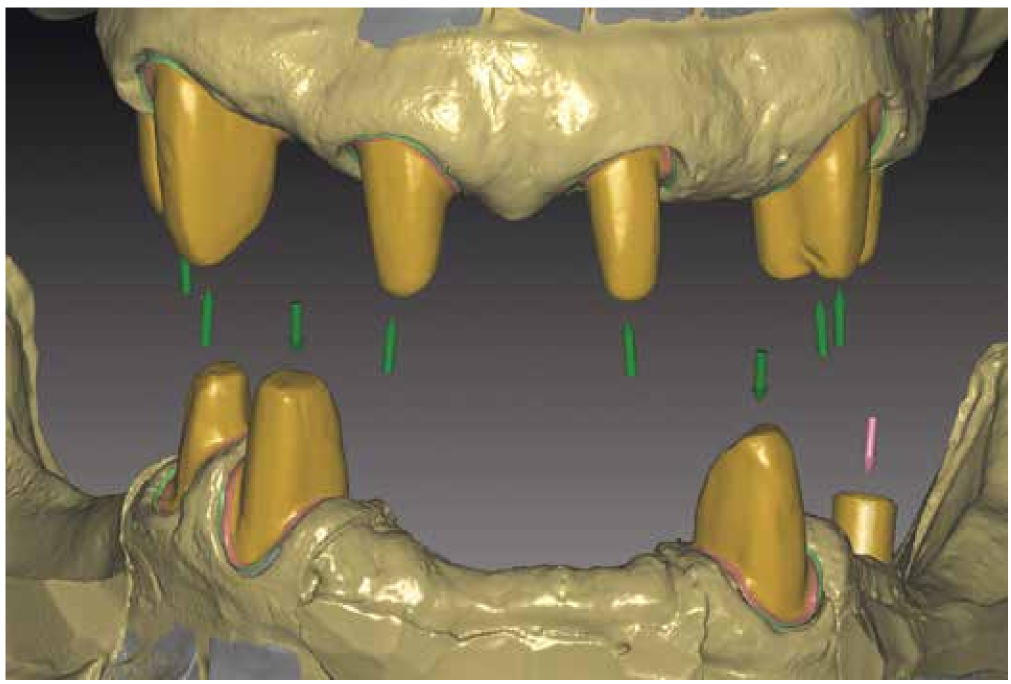

Figure 12: Inspection of the virtual master casts and the working parameters.

Technological Procedure

Prototype Fabrication

Based on the diagnostic setup, an acrylic resin prototype was fabricated by CAD/CAM for the mandible and the maxilla to test it under clinical conditions. If necessary, the prototype could easily be modified by either the dentist or the technician. Here, the prototype served as a temporary solution to ensure the quality of the final treatment and the patient's acceptance.

CAD/CAM

The basis of CAD/CAM technology is the digital three-dimensional collection of data (camera using light-stripe triangulation), which is then displayed on a screen using CAD. The subtly powdered master casts assembled in the articulator were scanned, first without and then with the setup in place **(Figs 10 & 11)**. A CAD/CAM-based milling technique (5-TEC, Zirkonzahn; Gais, Italy) was used. The collected data of the master casts and the wax-up were displayed virtually on the screen. The outline, the cement layer dimensions, and the emergence profile of the primary crowns were inspected **(Fig 12)**. The framework was designed in the upper jaw with a fixed complete denture on natural teeth #5, #6, #8, #9, #11, and #12. The telescopic primary crowns were then designed in the lower jaw **(Figs 13 & 14)**.

After having also designed the superstructures, these were fabricated using CAM in the upper jaw as an acrylic resin prototype, and in the lower jaw as final telescopic abutments made of zirconia. The data were transmitted to a milling machine connected to the CAD system. The reconstructions were milled based on prefabricated acrylic resin or zirconia blocks. Next, the telescopic abutments made of zirconia were colored manually using immersion coloring and then sintered and polished. The implant telescopic abutment had to be adhesively connected with a titanium base in the laboratory **(Figs 15 & 16)**. Then the telescopic abutments in the lower jaw were repositioned on the master cast and rescanned. The joint dimensions between primary and secondary structure were evaluated **(Fig 17)** and the secondary structure (removable complete denture) was defined **(Fig 18)**.

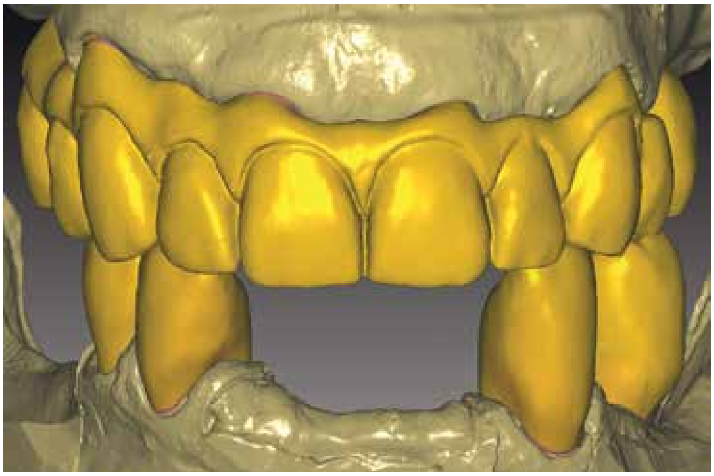

Figure 13: Virtual design of the primary structure of the upper jaw (fixed complete denture).

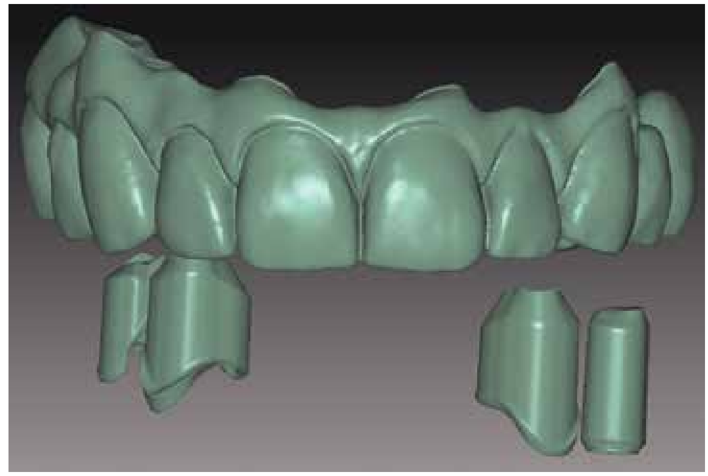

Figure 14: Virtual design of the fixed primary structures in the lower jaw (telescopic crowns of #22, #27, #28 and implant abutment in Region 20).

Figure 15: Zirconium dioxide telescopic abutments of the lower jaw from basal view.

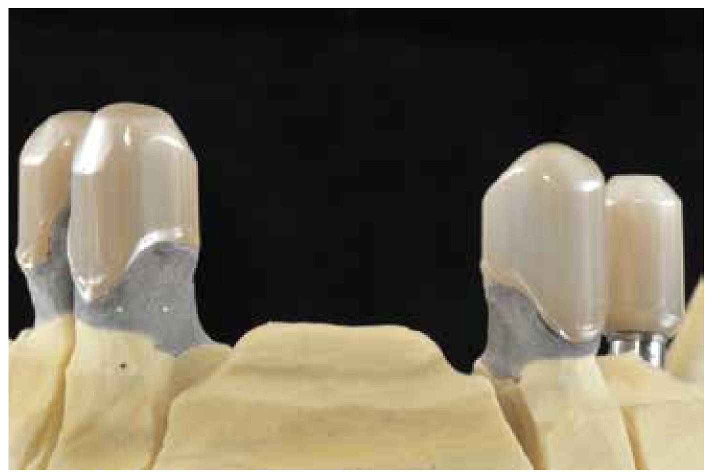

Figure 16: Zirconium dioxide telescopic abutments repositioned on the master cast.

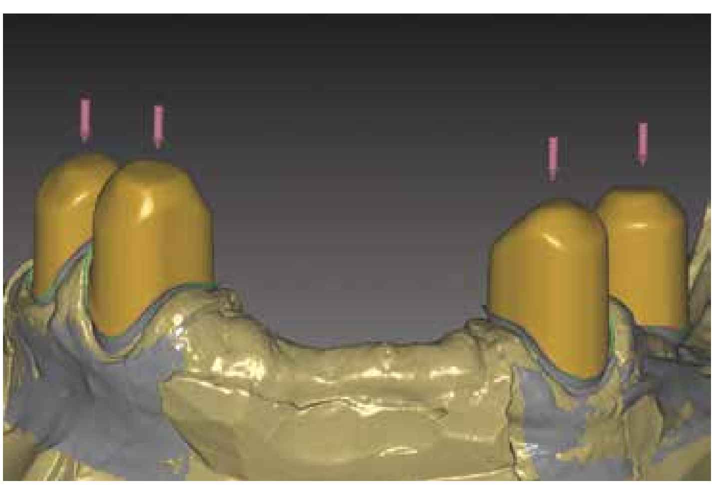

Figure 17: Definition of the joint dimensions and insertion direction between primary and secondary structures.

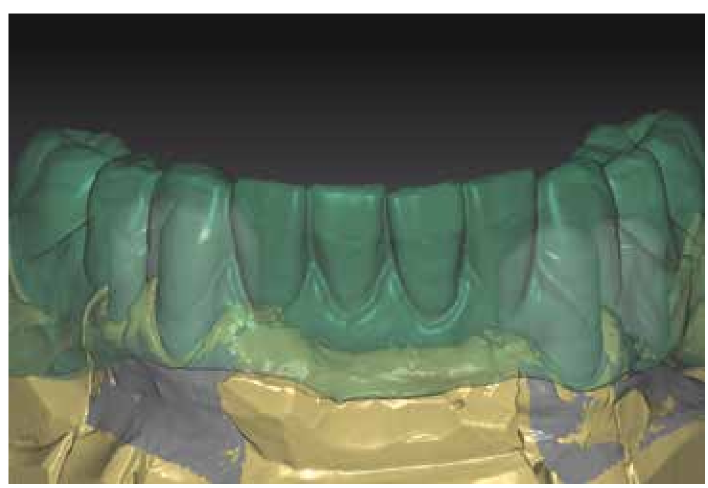

Figure 18: Form design of the prototype in the lower jaw.

Before milling the acrylic resin prototypes, the occlusion was inspected in the virtual articulator **(Fig 19)**. Then the structure was virtually embedded in an appropriately sized acrylic resin block and milled. The CAM-milled acrylic resin prototypes **(Fig 20)** were veneered and polished with the corresponding requirements in the area of the mucosa using pink-colored resin (Anaxdent GmbH; Stuttgart, Germany) **(Fig 21)**.

Cementation

In the clinic, the zirconia telescopic abutments were definitively fixed on the natural teeth with glass-ionomer cement (Ketac Cem, 3M ESPE) and on the implant by tightening the screw to a torque of 25 Ncm.[1] The screw channel was closed by placing white non-stick tape and by overlying tooth-colored composite resin (Tetric Evoceram, Ivoclar Vivadent; Schaan, Liechtenstein). The fixed prototype reconstruction in the upper jaw was temporarily cemented (Temp Bond, Kerr; Orange, CA), while the removable prototype reconstruction in the lower jaw was retained by the telescopic abutments. The prototype reconstruction was supervised during a follow-up period of several months, until stable clinical conditions and patient satisfaction were achieved **(Fig 22)**.

For fabricating the definitive reconstructions in the upper and lower jaw, the tested prototype situation had to be reproduced with an alginate impression. Then the stone cast models of the prototype situation were scanned. The new data were virtually superimposed on the existing data of the prototype situation. By doing this, the clinical modifications became visible and would be introduced in the final CAM fabrication in green stage monolithic zirconia. Therefore, a stand base connected to the superstructure was important for a later, stress-free sintering and a long-term cooling process **(Fig 23)**.

Before sintering the superstructure, esthetically demanding mucosal aspects and labial surfaces of the canines and incisors were manually cut back by approximately 0.5 to 1 mm and subsequently color primed by a brush technique (Color Liquids, Zirkonzahn). The work would be dried by infrared light and then sintered at 1600°C for eight hours and cooled down according to a defined protocol **(Fig 24)**.

The superstructure was separated from the stand base, sandblasted (2.5 bar), and cleaned using a steam jet. The esthetically and functionally critical mucosal and labial surfaces were minimally coated with glass ceramic (ICE-Zirkon-Keramik, Zirkonzahn) and fired

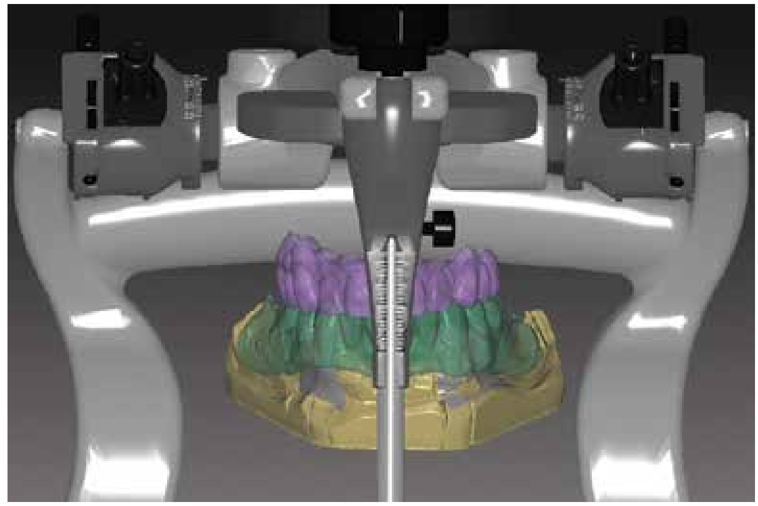

Figure 19: Occlusion testing in the virtual articulator.

Figure 20: CAM-milled resin prototypes in unfinished state.

Figure 21: Intraoral view of the prototypes' reconstruction.

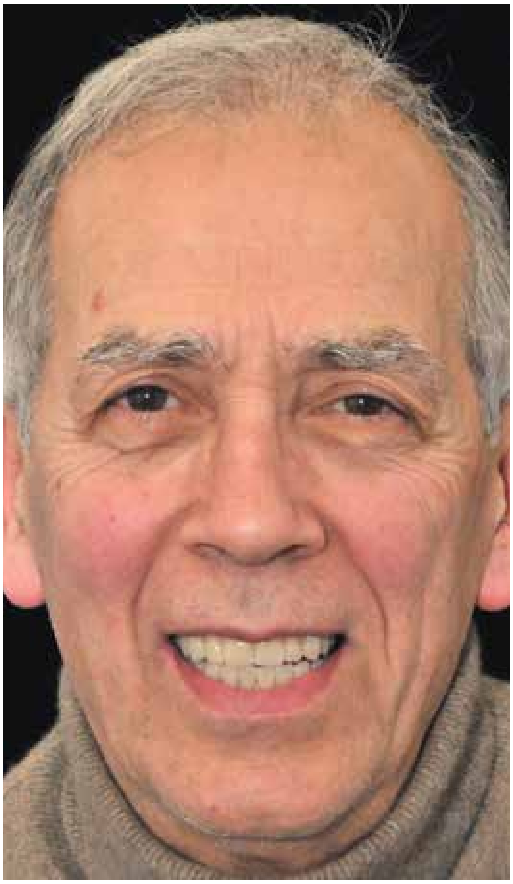

Figure 22: Extraoral view of the prototypes' reconstruction.

Potential disadvantages of zirconia superstructures in the presented case include open questions, such as:

- What if a framework fracture occurs?
- What if a reline of the removable superstructure in the lower jaw is necessary?
- What happens to the occlusal zirconia surfaces in the long term?

Figure 23: CAM-milling of the zirconium dioxide reconstruction along with stand base.

Figure 24: Work after cutback, priming, and sintering.

Figure 25: Labial veneering using glass-ceramic.

Figure 26: Restoration after end of treatment from intraoral-frontal view.

(Fig 25). The option to further characterize the superstructure by surface painting (ICE-Zirkon-Malfarben Prettau) is available. In this case, stain firing was done, followed by a glaze firing with glaze mass (Glaze, Zirkonzahn) as well as manual polishing.

The fixed complete denture in the upper jaw was definitively cemented by glass-ionomer cement. The removable complete denture in the lower jaw was seated on the zirconia telescopes **(Figs 26-33)**. The patient was informed about the handling of the dentures, the required regular check-ups, and the necessary oral hygiene. After two years of follow up the situation seems stable and shows no need for clinical adjustments.

Discussion

A case with an esthetically and functionally unsatisfactory intraoral situation was rehabilitated with a zirconia-based fixed, tooth-supported complete denture in the upper jaw; and a removable, mixed tooth- and implant-supported complete denture in the lower jaw. The result can be considered esthetically and functionally acceptable.

At present there is little clinical research on such restorations.[1-3] Also, long-term clinical data are lacking.[4] The long-term stability of zirconia restorations is generally considered to be good[3,5,6] insofar as monolithic structures[7] are involved. In terms of avoiding chipping, full-contour zirconia restorations might be an interesting and more stable alternative to conventional veneered zirconia frameworks or CAD/CAM-produced veneers for restorations with zirconia frameworks,[8] as shown in vitro.[9]

Long-term experience exists in regard to conventional CAD/CAM-fabricated restorations in general (not those made of monolithic zirconia). Although CAD/CAM-technology itself is well established, for monolithic zirconia restorations there are still open questions to be answered by long-term data. A literature review by Harder and Kern shows that reconstructions based on CAD/CAM perform equal to conventional ones.[6] Clinical three-year observational studies on zirconia-based fixed partial dentures and single crowns are available.[10] They show comparable results to porcelain-fused-to-metal, which is still considered to be the gold standard.[11] CAD/CAM restorations allow the fabrication of cost-effective solutions with a consistent material quality, and a standardized high precision.[12]

Potential disadvantages of zirconia superstructures in the presented case include open questions, such as:

- What if a framework fracture occurs?
- What if a reline of the removable superstructure in the lower jaw is necessary?
- What happens to the occlusal zirconia surfaces in the long term?

Although there is ongoing research in vitro and in vivo on these questions, only clinical studies involving an adequate number of clinical cases during at least five years of observation will show the clinical efficacy of zirconia in the long term.

Acknowledgment

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Figure 27: Fixed complete denture from intraoral-occlusal view.

Figure 28: Removable complete denture from intraoral-occlusal view.

Figure 29: Restoration after end of treatment from intraoral-lateral left view.

Figure 30: Restoration after end of treatment from intraoral-lateral right view.

Figure 31: Primary parts (telescopes) after end of treatment from intraoral-occlusal view.

Figure 32: X-ray image after end of treatment.

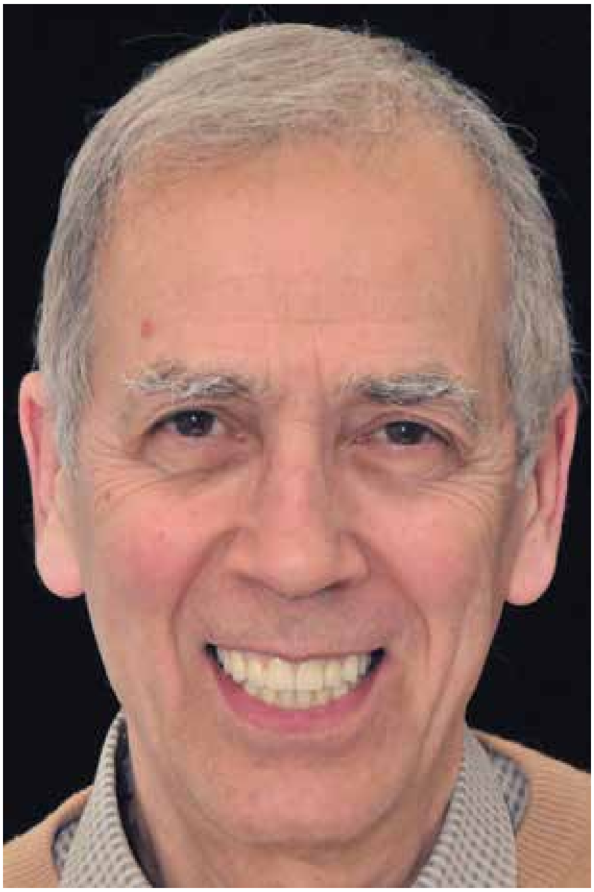

Figure 33: Restoration after end of treatment from extraoral view.

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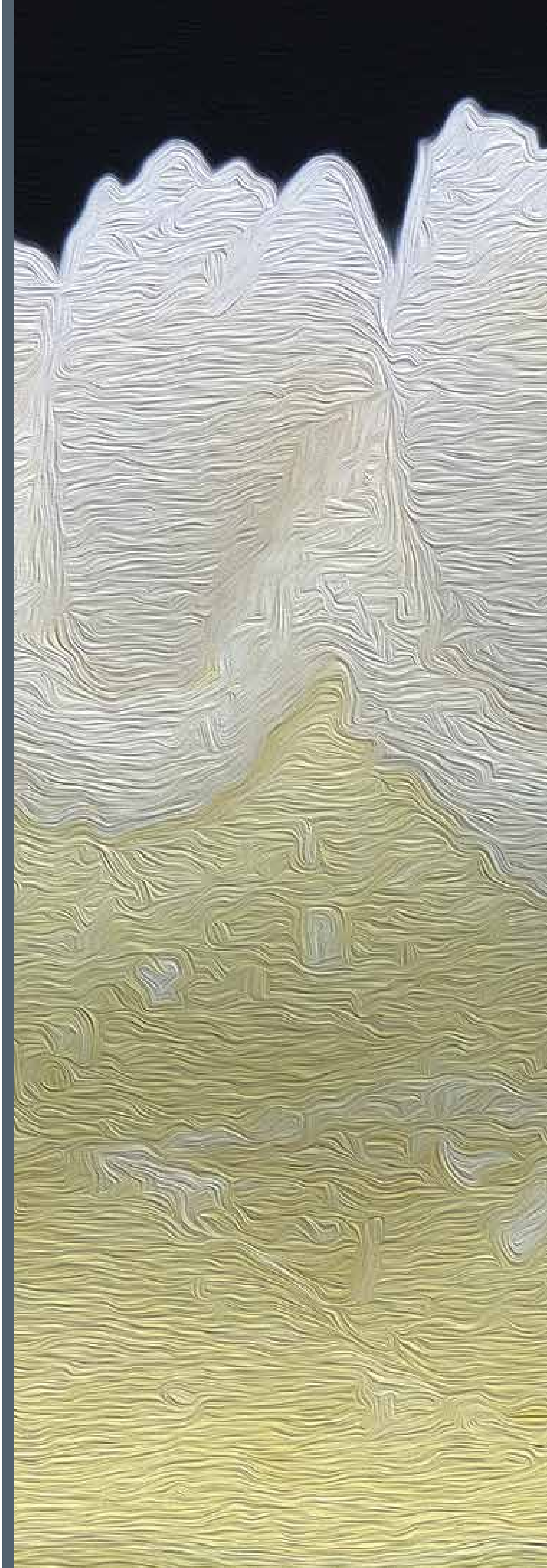
Disclosure: The author did not report any disclosures.

Increasing VDO and the Use of CAD/CAM

Prosthodontic Principles and the Full-Mouth Reconstruction

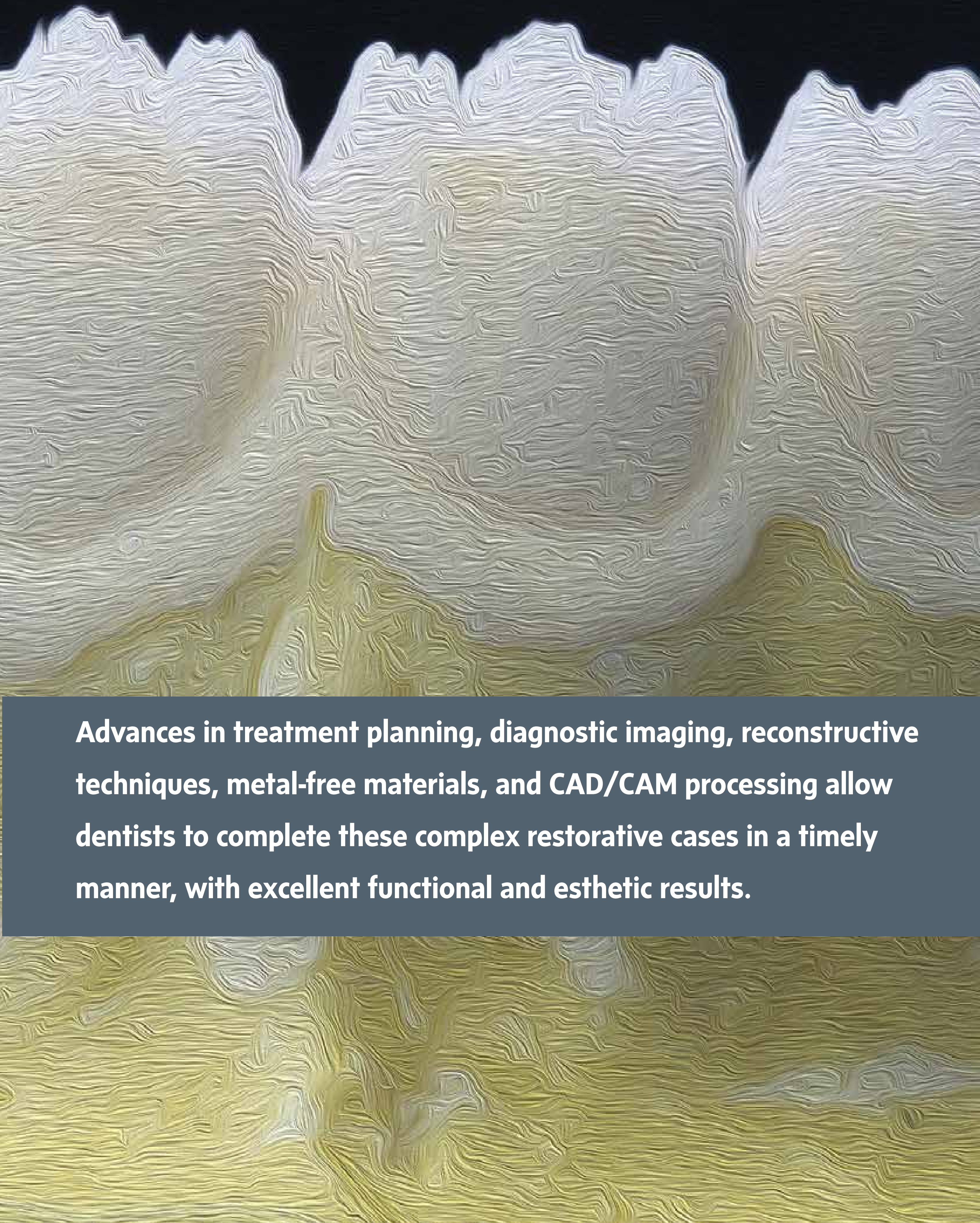
Jonathan L. Ferencz, DDS, FACP



Abstract

This article describes the treatment of a young adult female with severe enamel erosion and the resultant loss of vertical dimension of occlusion (VDO). Her chief complaint was the appearance of her anterior teeth. The prosthodontic rehabilitation required to restore her VDO necessitated treating her posteriors with full coverage to create the needed space anteriorly. Pressed monolithic lithium disilicate was used for the posteriors and the lower canines. After the posteriors were completed and cemented, the maxillary anteriors were restored with computer-aided design (CAD) lithium disilicate using the E4D system and the lower incisors were restored with pressed lithium disilicate veneers. All of the restorations were fabricated with monolithic lithium disilicate and stained and glazed to achieve the desired esthetic outcome.

Key Words: erosion, vertical dimension, monolithic lithium disilicate, CAD/CAM



Advances in treatment planning, diagnostic imaging, reconstructive techniques, metal-free materials, and CAD/CAM processing allow dentists to complete these complex restorative cases in a timely manner, with excellent functional and esthetic results.

Introduction

An increasing number of patients are presenting at dental practices with visible signs of tooth wear and erosion accompanied by complaints of tooth sensitivity. Many different factors can contribute to premature tooth wear and its resulting sensitivity. These can include extrinsic causes, such as a highly acidic diet containing large quantities of certain fruits and beverages such as orange juice, wine, and soft drinks[1]; and also pathological aspects that can cause wear, such as acid erosion from repeated regurgitation (i.e., bulimia or gastric reflux disease).

Dental acid erosion can be caused by acids repeatedly contacting the surfaces of teeth without adequate neutralization. In small doses, the acid that contacts the teeth is neutralized by saliva, restoring the oral environment to a stable pH and thus inhibiting erosion. During repeated contact, such as results from gastric reflux disease, acid is no longer neutralized by saliva. As a consequence, the enamel and underlying tooth structures are eventually weakened.

Several case studies have implicated gastric reflux as the probable reason for tooth wear.[2-4] This can lead to increased sensitivity and, in extreme cases, wear that results in loss of vertical dimension of occlusion (VDO).[5]

Loss of VDO can be problematic functionally, parafunctionally, and esthetically. Patients who present with loss of VDO can demonstrate alterations in bite force, temporomandibular joint (TMJ) loading, neuromuscular activity/stability, and an esthetic loss of occlusal facial height.[6] Dentoalveolar form also is often compromised, as a loss in VDO typically correlates with a compensatory elongation of alveolar tissues.[7,8] Cumulatively, this may translate into a patient requiring full-mouth reconstruction to restore the "collapsed appearance" of facial esthetics, oral function, and parafunctional capabilities.

The need to restore tooth structure, function, and esthetics in patients presenting with lost VDO can create challenges for dentists. These cases require reconstruction of esthetic form, as well as a harmonious occlusal relationship.[9,10] If form and function are not properly restored, the patient will not receive both esthetic and physiological benefits from the restorations.

These cases are also challenging from patient management and treatment sequencing perspectives. While the patient may be more concerned with the esthetics of his or her smile and believe the anterior teeth should be restored first, loss of VDO requires an increase in vertical dimension—and thus requires restoration of posterior teeth first—prior to addressing any cosmetic concerns in the esthetic zone (i.e., anterior teeth).[6]

It is also important to carefully consider materials when devising the treatment plan in order to provide optimum masticatory viability. The materials chosen must withstand the masticatory forces as well as provide an esthetically pleasing outcome that satisfies all patient and practitioner requirements.[9] Advances in treatment planning, diagnostic imaging, reconstructive techniques, metal-free materials, and computer-aided design/computer-aided manufacturing (CAD/CAM) processing allow dentists to complete these complex restorative cases in a timely manner, with excellent functional and esthetic results.[11]

This article demonstrates the manner in which a full-mouth reconstruction was undertaken to increase a patient's lost VDO in a phased manner. In particular, treatment was initiated in the posterior region. Additionally, a combination of lithium disilicate all-ceramic fabrication processes (e.g., IPS e.max Press and machined IPS e.max CAD, Ivoclar Vivadent; Amherst, NY) was used.

Challenges of Full-Mouth Rehabilitation Cases

From a prosthodontic perspective, treating a patient with a loss of VDO requires an advanced, phased treatment plan. This is an extremely important step because in cases where mixed restorations are used, the dentist must ensure that all the restoration types and materials are properly selected and compatible from the standpoint of occlusal wear. They must also be placed at the correct intervals to ensure stable, esthetically pleasing results.

In general, the posterior teeth should be restored first. The addition of VDO alters overall occlusion. Patients may be more concerned about the appearance of anterior teeth, but functionally and parafunctionally, restoring anterior teeth first usually is ill advised. A restoration placed without considering the anticipated and altered occlusal contacts and anatomy is a restoration that is likely to fail.[6]

Additionally, in this type of case, to create adequate space for anterior teeth (e.g., additional incisal edge length), proper height of VDO must first be created. Translated to proper planning and treatment, this is best accomplished by temporizing and finalizing the posterior restorations first, then adding anterior tooth restorations to complete a full-mouth rehabilitation. To achieve stability during function and parafunction, all quadrants of the posterior teeth must be prepared and temporized simultaneously. These requirements include stable TMJs, as well as equally and evenly distributed forces across all teeth.[12]

When executing changes in VDO, it is possible to see that even minute adjustments can greatly alter a patient's overall occlusion. Therefore, the vertical dimension must be increased only within the patient's tolerance.[13]

Diagnostic tools such as articulated casts and wax-ups are utilized to fabricate provisional restorations for these patients. These casts are built upon to determine the new occlusal scheme, as well as the overall shape, length, and contour of the proposed restorations. They then enable creation of provisional restorations that allow patients to "test drive" the anticipated changes.

Provisional restorations must be fabricated for—and worn by—the patient before final restorations are placed. This allows a new occlusal plan to be tested and determined safe for the patient prior to placing definitive restorations. Any necessary adjustments that are to be made to enhance proper occlusion or patient comfort can occur in the weeks before the restorations are cemented into place.

Additionally, other challenges with full-mouth reconstructions have involved successfully combining restorations fabricated from different materials, and/or which were fabricated using different processes. In the past, when dentists and laboratories utilized mixed restorations (i.e., pressed ceramics and CAD/CAM-processed monolithic restorations), the results were less than optimal. A difference in optical properties that occurs among dental materials during processing often left the final appearance of two restorations with the same chemical makeup, processed in different ways, dramatically different. For instance, a pressed restoration could appear significantly more translucent than a CAD/CAM "milled" restoration.

In recent years, however, advances in metal-free materials and processing have led to the increased use of lithium disilicate for various types of restorations. Due to its unique optical properties and excellent durability, it has become a viable material for mixed restorations that blend seamlessly in the esthetic zone.

Digital technology has also increased the dentist's and laboratory's capabilities to create and duplicate custom smile designs. The increasing availability and wide variety of chairside digital imaging equipment allows dental teams to accurately capture all aspects of tooth arrangement, form, surface texture, and color of provisional restorations. This digital record can be saved, after which the information can be applied with CAD/CAM software and machining technology to "clone" restorations for the patient in the future.

Case Presentation

Clinical Findings

A 30-year-old female with a history of gastric reflux presented with a significant loss of enamel due to acid erosion **(Figs 1-3)**. She was concerned with the esthetics of her smile, as well as the "collapsed appearance" of and sensitivity of all of her teeth **(Figs 4 & 5)**. Clinical examination revealed extensive loss of enamel. In addition to the maxillary anteriors, there was loss of enamel on virtually every tooth except the maxillary second molars. The maxillary anteriors had extensive bonding on their facial surfaces, as did the maxillary premolars. The loss of tooth structure on the palatal aspect of the maxillary anteriors made it nearly impossible to restore without restoring

Figure 1: Full-facial preoperative view of the patient in natural smile.

Figure 2: Preoperative close-up view of the anterior teeth showing wear.

Figure 3: Close-up retracted preoperative view of worn teeth.

This was a long and challenging appointment, because it was imperative that all four quadrants be completed during the same visit.

Figure 4: Preoperative occlusal view of the maxillary arch.

Figure 5: Preoperative occlusal view of the mandibular arch.

Figures 6-8: Diagnostic casts were made of the patient's preoperative condition.

Figures 9-11: View of the diagnostic wax-up demonstrating the proposed increased vertical dimension.

the lost vertical dimension to the posterior teeth. Diagnostic casts were created and analyzed **(Figs 6-8)**, and a diagnostic wax-up was made **(Figs 9-11)**. The critical step in the diagnostic phase of this case was the wax-up, which revealed that the only way to restore the missing tooth structure in the anterior region would be to increase the VDO on the posterior teeth to create sufficient room to restore the anteriors.

Unfortunately, many patients do not understand that in order to improve the appearance of the anterior teeth, a phased treatment plan is required, with the posterior teeth reconstructed first to increase the lost vertical dimension. In this case, the collapsed vertical dimension resulted from the loss of 1-mm to 2-mm of enamel on the posteriors caused by the acidic erosion from the patient's gastric reflux. Once the posteriors were restored to an increased vertical dimension, the anterior teeth could be separated by approximately 3 mm, which would create the room necessary to increase the length of the maxillary anteriors and allow a more pleasing and attractive smile.

Treatment Plan

Based upon an analysis of the patient's occlusion and collapsed vertical dimension, the following treatment plan was developed:

- extraction of #13
- placement of full-coverage lithium disilicate restorations (IPS e.max) on ##3-5, #12, #14, ##18-22, and ##27-31
- increasing the vertical dimension by approximately 1 mm in the molar area to create sufficient room in the anterior region to restore the patient's teeth to their original length
- placement of full-coverage lithium disilicate crowns (IPS e.max) on ##6-11
- placement of lithium disilicate veneers (IPS e.max) on ##23-26 to enhance the patient's esthetics.

Clinical Protocol

After the extraction site of #13 healed **(Fig 12)**, all of the posterior teeth were prepared for crown restorations and temporized. This was a long and challenging appointment, because it was imperative that all four quadrants be completed during the same visit. This would provide the patient with an altered occlusal relationship at an increased vertical dimension.

The patient tolerated the procedure well and was allowed to function in the provisionals for six to eight weeks to test the new vertical dimension. Other than being slightly self-conscious about the appearance of her anterior open bite, she reported no problems. She had no TMJ symptoms, no muscular symptoms, and had no problems with function. With the new occlusal relationship created and tested, the posterior crown restorations could be finalized. The right side was restored first **(Fig 13)**, followed by the left side **(Fig 14)**, with full-contour, monolithic pressed lithium disilicate crowns (IPS e.max). The patient was very comfortable with the finalized posteriors and liked the color of the minimally stained monolithic crowns. As planned, the new occlusal relationship created space for restoring the anteriors **(Figs 15 & 16)**.

Figure 12: Tooth #13 was extracted.

New impressions were taken to enable the wax-up of the anteriors **(Fig 17)**, which was duplicated in silicone **(Fig 18)**. The teeth were prepared on the cast to create the anterior provisional restorations. A tooth reduction guide was constructed to allow for conservative reduction of only the amount of tooth structure needed to create the esthetic arrangement demonstrated in the wax-up **(Fig 19)**. Provisional restorations were then fabricated for the anterior teeth **(Figs 20-22)**.

The anterior teeth were then prepared **(Figs 23 & 24)**. The provisional were tried in **(Fig 25)**, relined **(Fig 26)**, and seated into place **(Fig 27)**. The patient was allowed to function with the anterior provisionals for two weeks.

When the patient returned to the office, she reported that she loved the new appearance of her smile and had no recommendation for changes **(Figs 28 & 29)**. It was decided that the temporaries were so good that they could serve as a mock-up or guide for the final crowns.

The most effective way to copy the contour, surface texture, and arrangement of the temporaries was to scan them. For this case, the E4D scanner (D4D; Arlington, TX) was used to scan the patient's provisional restorations and save the images as a mock-up or clone for the final crowns **(Fig 30)**. Her preparations were also scanned **(Fig 31)**, and the cloned image of her approved provisional was applied to create a "custom tooth library" for her final anterior restorations **(Fig 32)**.

Figure 13: Right lateral view of the posterior IPS e.max crown restorations in place.

Figure 14: Left lateral view of the posterior IPS e.max crown restorations in place.

Figure 15: Retracted intercuspation view demonstrating the amount of anterior interocclusal space obtained by increasing the vertical dimension by 1 to 1.5 mm in the molar region.

Figure 16: Close-up, upward angle view demonstrating the interocclusal space obtained by increasing the vertical dimension by 1 to 1.5 mm in the molar region.

Figure 17: A wax-up was created for use in creating the anterior provisional restorations.

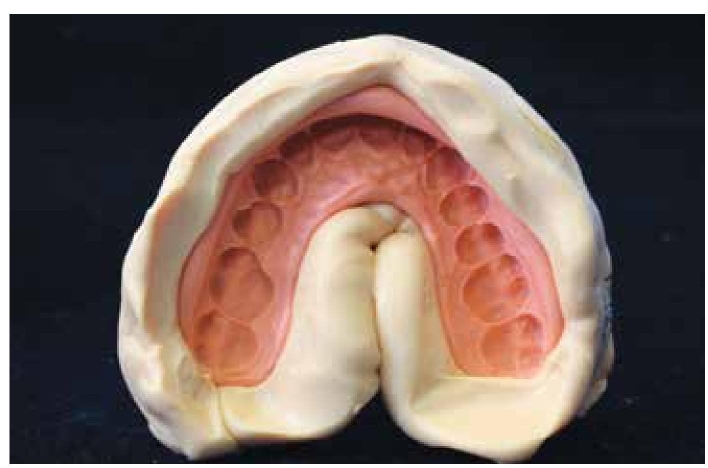


Figure 18: A silicone impression was made of the wax-up.

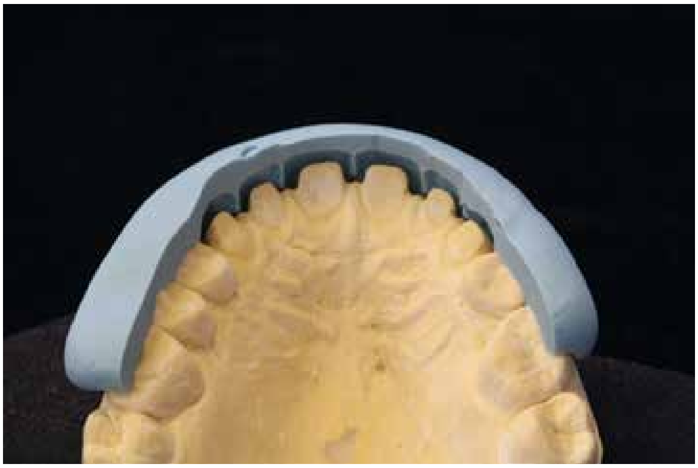


Figure 19: A preparation guide was created to facilitate tooth reduction.

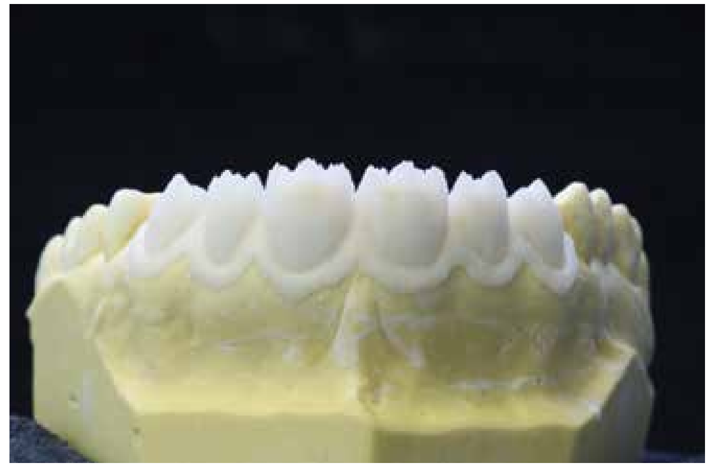


Figure 20: The anterior provisional restorations prior to application of the enamel colored acrylic.

Figure 21: Enamel acrylic was added to the provisional restorations.

Figure 22: The completed maxillary anterior provisional restorations.

Figure 23: The patient's anterior teeth prior to preparation.

Figure 24: The prepared teeth with the retraction cord in place.

Figure 25: The processed provisional was tried in prior to relining.

Figure 26: The provisional restorations were relined prior to seating.

Figure 27: The maxillary anterior provisional restorations were seated into place.

Figure 28. Close-up view of the provisionals after two weeks, with the patient showing her natural smile.

Figure 29: Close-up retracted view of the maxillary anterior provisional restorations after two weeks.

The materials chosen must be able to withstand masticatory forces, and the treatment must be planned and completed in a specified protocol in order to achieve predictable, long-term results.

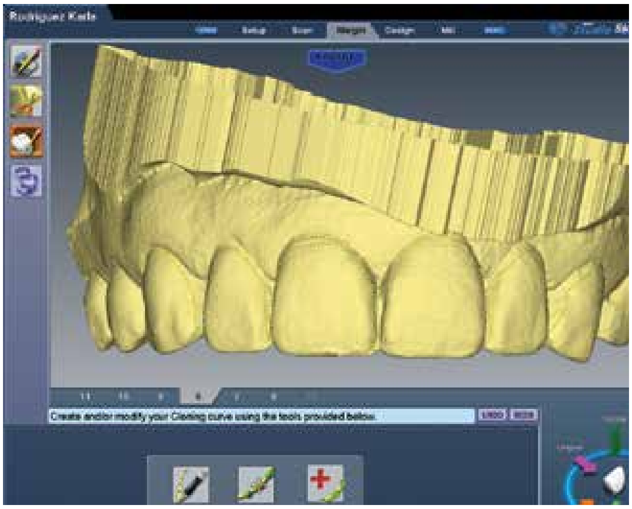


Figure 30: The provisionals were scanned and would be used as clones for the final crown restorations.

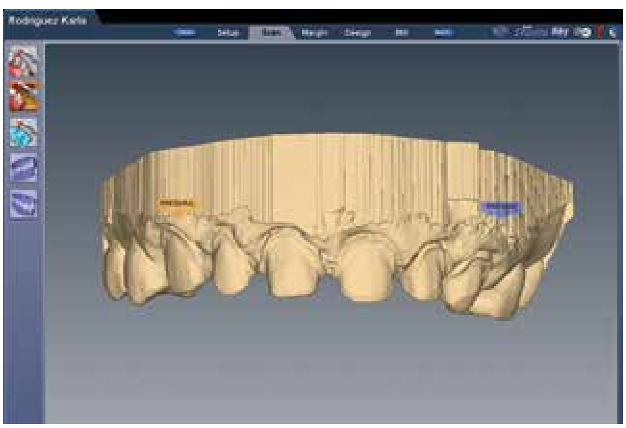


Figure 31: The scanned maxillary preparations.

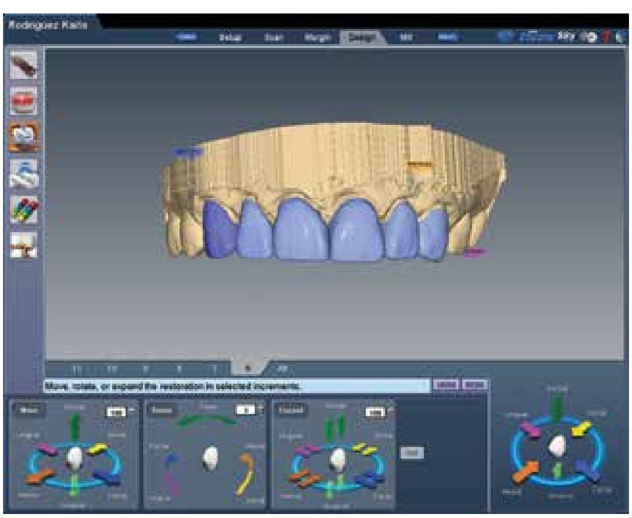


Figure 32: The final crown design prior to milling from a monolithic IPS e.max block and slight staining to match the patient's posteriors.

The maxillary anterior restorations were milled from a monolithic lithium disilicate block (IPS e.max CAD) and slightly stained to match the patient's posteriors, which she liked very much. Upon completion, the maxillary anterior restorations were cemented, and the pressed lithium disilicate veneers for the lower incisors (IPS e.max Press) were placed to modify color and increase length that had been lost.

The papilla, although healthy, was a bit blunted, probably due to gingival retraction during preparation and digital impression and then once again during final cementation. The final photographs were taken soon after cementation **(Figs 33-36)**. The author is certain the papilla will fill the space, because the contours of the crowns are correct. Closing the space with an addition of ceramic in the case of a healthy 30-year-old would not be the author's first choice, since in most cases this slight triangle usually fills with a healed papilla. In addition, the patient was happy with the esthetics.

Summary

When performing an occlusally complex full-mouth reconstruction, proper treatment planning, phasing, sequencing, and material selection are imperative for long-term success. The materials chosen must be able to withstand masticatory forces, and the treatment must be planned and completed in a specified protocol in order to achieve predictable, long-term results.

In this case, all posterior teeth were restored with IPS e.max Press lithium disilicate to increase the loss in VDO. Only then could the anterior maxillary incisors be restored with IPS e.max CAD lithium disilicate, cloned from the provisional anterior restorations. Excellent esthetics were achieved using this material and a combination of fabrication processes. No layering was required; only staining and glazing were performed to achieve ideal color matching with the posterior restorations and lower incisor veneers.

Acknowledgment

The author thanks the laboratory technicians responsible for fabricating the restorations featured in this case, Pasquale Fanetti and Marisa Papandrea (NYC Prosthodontics, New York, NY).

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Figure 33. Retracted view of the completed case after the maxillary anterior restorations were cemented and the four mandibular incisors were restored.

Figure 34. Close-up retracted view of the maxillary anterior teeth restored with IPS e.max CAD monolithic crowns to replace lost enamel to improve the esthetics. The papilla will fill the "black triangle," because the contours of the crowns are correct.

Figure 35. Postoperative full-facial view of the patient showing her natural smile.

Figure 36. Close-up postoperative view of the patient's smile showing enhanced length and esthetics.

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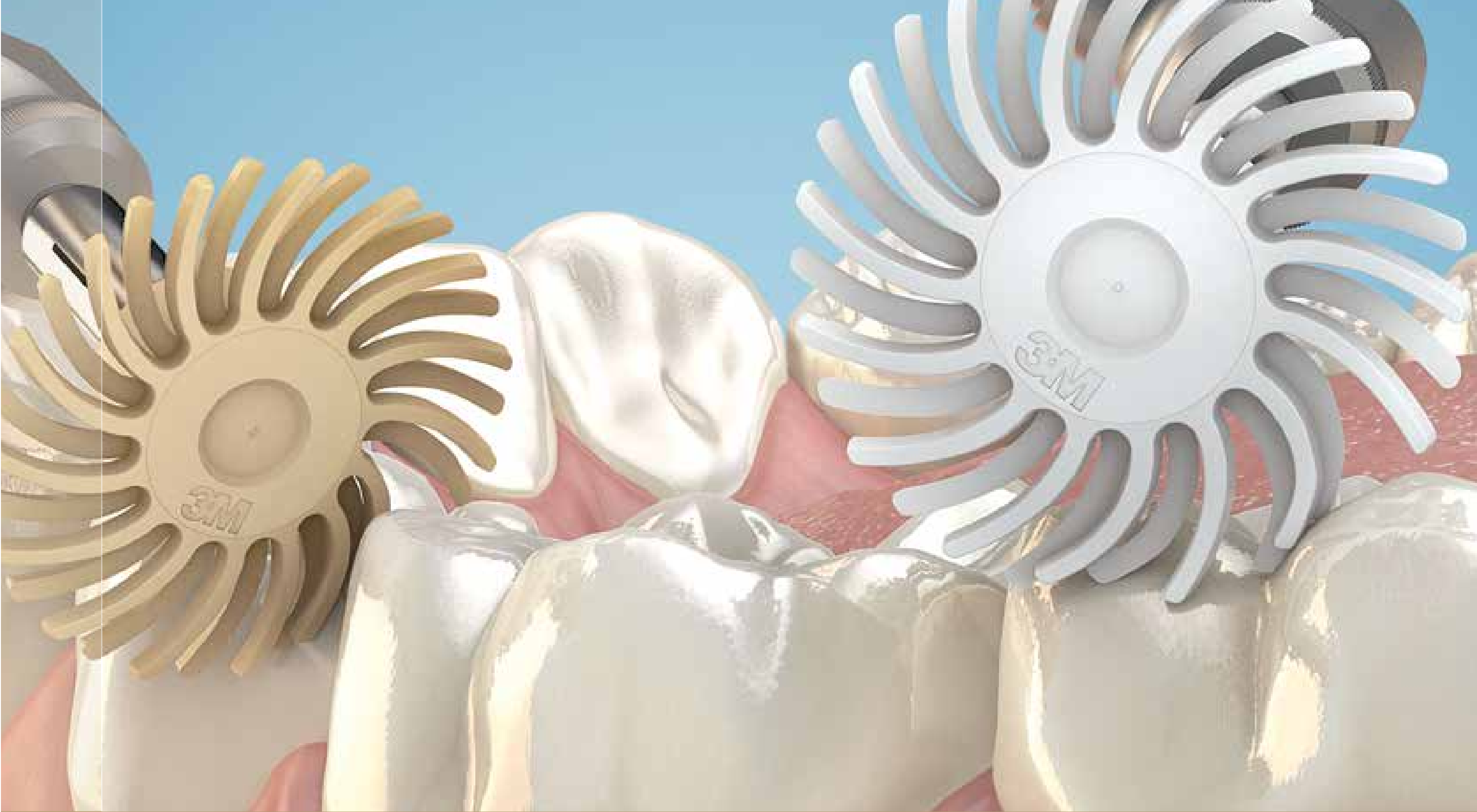
Dr. Ferencz is a clinical professor of prosthodontics and occlusion in the Department of Advanced Education in Prosthodontics at The New York University College of Dentistry. A Diplomate of the American Board of Prosthodontics, Dr. Ferencz maintains a private practice in New York City.

Disclosure: The author receives honoraria from Ivoclar Vivadent and Quintessence.



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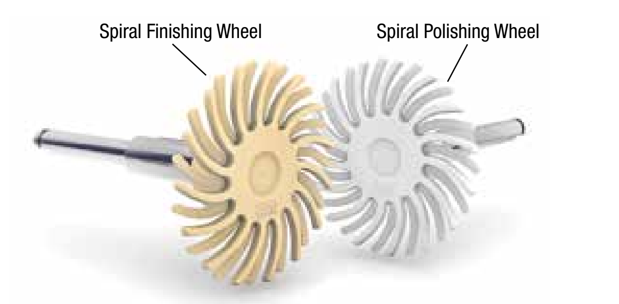

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Smile Analysis

Converting Digital Designs to the Final Smile: Part 2

Lee Culp, CDT, AAACD
Edward A. McLaren, DDS, MDC
Lida C. Swann, DDS

Abstract

Restoration design has entered a new technological age. However, observation remains key to replicating nature and working within the artistic parameters of smile design. Parameters include tooth shape, proportion, and anatomy; as well as color, value, and translucency. This article, the second in a two-part series (Part 1 appeared in the Spring 2013 issue of *jCD*), addresses tooth anatomy, morphology, and the various laboratory applications for digital design.

Key Words: smile design, digital dentistry, tooth anatomy, dental treatment planning, CAD/CAM dental restorations

"The way anterior and posterior teeth have been analyzed and characterized for the last 50 years has not been effective, as some of those methods have correlated the shape and morphology of the teeth to the shape and proportion of the head."

Introduction

The fabrication of restorations has entered a new technological age, moving from two-dimensional to three-dimensional (3-D). Restoration design—whether it is a framework, full-mouth rehabilitation, or all-ceramic—now can be completed on a computer.[1] This article, the second in a two-part series (the first part of which appeared in the Spring 2013 issue of *jCD*), addresses tooth anatomy, morphology, and the various laboratory applications for digital design.

Teeth are actually very difficult to recreate. The way anterior and posterior teeth have been analyzed and characterized for the last 50 years has not been effective, as some of those methods correlated the shape and morphology of the teeth to the shape and proportion of the head. However, individuals with a square head do not necessarily have square teeth; rounder-faced individuals do not necessarily have round teeth, etc. There are no specific gender or ethnic differences between teeth.[2]

The American Academy of Cosmetic Dentistry has published guidelines[3] directing the artistic parameters of smile design, with the goal of esthetically replicating nature. Observation is fundamental to this endeavor, as is a true understanding of patient expectations.

In a very pleasing smile arrangement, the maxillary central incisors tilt in, the laterals tilt in slightly more, and the cuspids tilt in. In the mandibular arch, the anterior teeth tilt out slightly, while the cuspids tilt in **(Fig 1)**.

There are three planes on a tooth and three shapes on the labial surfaces of the tooth: convex, flat, and concave. There are different tooth shapes: round on the mesial, round on the distal, square on the mesial, square on the distal, and square on the mesial and distal.[4]

While the trend may be to create symmetrical inclinations among the teeth, they do not have to match to achieve natural esthetics. Tooth shape and proportion are controlled by root shape, root rotation, bone, and tissue preparation. The midline's facial harmony significantly affects tooth esthetics. When the midline matches (e.g., height of contour to the mesial), discrepancies among other esthetic aspects become unimportant. When two teeth are identical in length, angulation, midline, mesial/distal contours, and gingival sculpting, the irregularities of the surrounding teeth do not detract from the overall esthetics **(Fig 2)**. However, with some patients, a closer examination of the other teeth shows one is more square and the contralateral is rounder; one tooth is tilted in and the other down **(Fig 2)**.[5-7]

Tooth Anatomy

All tooth anatomy is imparted in the front of the tooth, but what constitutes the front of the tooth has to be clearly identified and defined. This is predicated on understanding where the contacts and embrasures should be positioned relative to proper tooth anatomy. Embrasures must be properly angled, as well as opened mesially or distally, depending upon the anatomical buildup that is required. Once that is identified, primary anatomy can be established, followed by secondary anatomy.[8-10]

It is important to note that characteristics of secondary anatomy, such as texture and luster, can change the perception of the tooth shape and value. Restorations that are smooth appear translucent and lower in value. Rougher restorations, because of the manner in which light reflects off the front, appear more brilliant but less translucent, despite possessing the same translucency. The various kinds of textures—broad, horizontal striations; narrow, horizontal striations; vertical striations; and a dimpled texture over the front of the tooth—create various visual characteristics.[8-10]

Digital Dentistry

Although basic dentistry has not changed a great deal in the past 20 years, innovative materials and equipment are continually enhancing the dental field. Due to its state-of-the-art applications, creating strong and esthetic ceramic restorations in a single appointment utilizing computer software, computer-aided design/computer-aided manufacturing (CAD/CAM) technology has become synonymous with digital dentistry. CAD/CAM is an innovative tool for creating a restoration designed on a computer. Digital dentistry, on the other hand, encompasses communication, high- and low-resolution data, 3-D photography, and computer programs that provide dentists with the ability to create digital restorations and digital patients through the collection of data and the utilization of various software sets. The compilation of traditional data for planning and treating patients, including demographic data, clinical measurements, observation, clinical analysis, thermal data, and color data, has been expanded to include digital data, intraoral photos, scan data, cone beam data, and digital x-rays for digital planning and restorative treatment.[11,12]

Traditionally, a digital restoration was a zirconia coping built up with modifiers, dentins, and enamels, sculpted by hand, ground down where necessary, baked, then stained and glazed. Today, a dentinal structure can be milled from a lithium disilicate block and enamel added; or a block of ceramic pre-layered with gingival dentin and incisal, and milled using CAD/CAM technology, shows no discernible difference from the former two restorations **(Fig 3)**. The only difference is time. The first was labor-intensive, the second less so and, as expected, the machine-milled restoration was the quickest and easiest of all to produce.

CAD/CAM

The attainment of perfection in the duplication of natural dentition is the ultimate goal in contemporary esthetic dentistry. Understanding the complex relationship between tooth form and function, and how they relate and combine to create the esthetics of natural dentition, is the basis of study for achieving predictable success in oral reconstruction. As patients become more educated about modern dentistry's advances

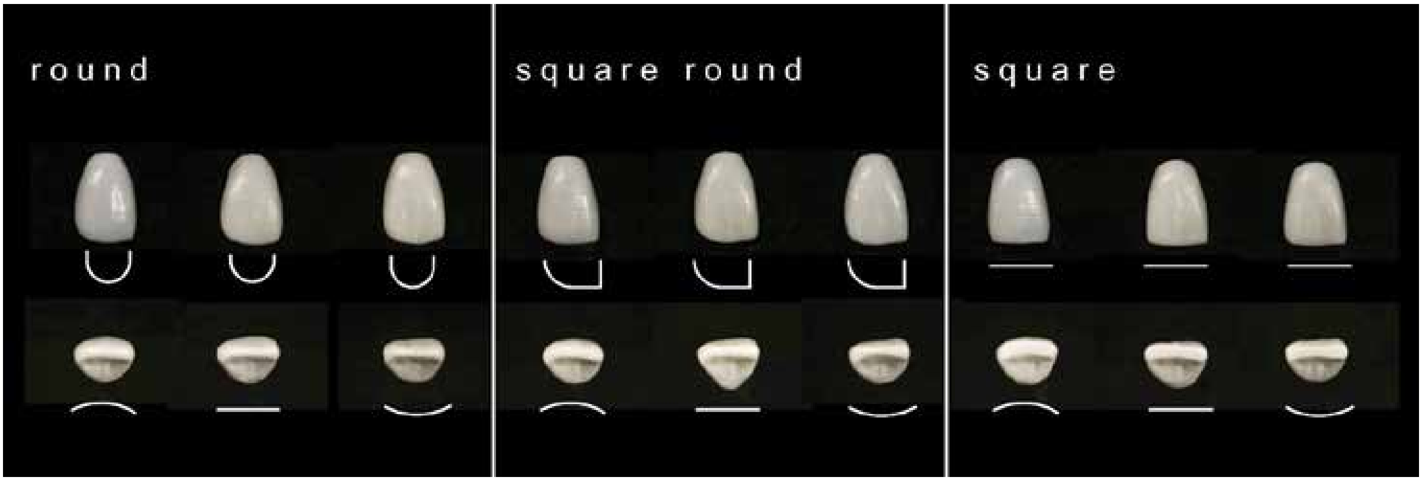

Figure 1: Culp Classification of Anterior Tooth Shapes.

Figure 2: All-ceramic restorations, showing natural shape nuances that create a more natural tooth arrangement.

Figure 3: All-ceramic restorations showing three different types of fabrication methods. Left: Milled e.max CAD restoration (Ivoclar Vivadent; Amherst, NY), with only enamel layering. Center: Milled Empress Multi CAD full-contour restoration (Ivoclar Vivadent), with surface stain and glaze. Right: Zirconia coping, fully layered with several different dentin and enamel ceramics.

> **"As dentistry evolves in the digital world, the successful incorporation of computerization and new acquisition and manufacturing technologies will continue to provide more efficient methods of restoration fabrication and communication..."**

(as a result of television makeover shows and professional and over-the-counter bleaching systems), their motivation and desire for natural, esthetic restorative dentistry is increasing at a dramatic rate. Dentists and technicians are now fulfilling these patient demands, but still use dental laboratories and restorative techniques that do not always offer predictable efficiency and quality.

Based upon technology adopted from the aerospace/automotive, and even the watch-making industry, CAD/CAM is becoming accepted due to its increased speed, accuracy, and efficiency. Today's CAD/CAM systems are being used to design and manufacture metal, alumina, and zirconia frameworks, as well as all-ceramic full-contour crowns, inlays, and veneers that are stronger, fit better, and are more esthetic than restorations fabricated using traditional methods. As dentistry evolves in the digital world, the successful incorporation of computerization and new acquisition and manufacturing technologies will continue to provide more efficient methods of restoration fabrication and communication, while at the same time retaining the individual creativity and artistry of the skilled dentist and technician. The utilization of these new technologies—along with the evolution from "hand" design to "digital" design, with the addition of the latest developments in intraoral laser scanning, materials, and computer milling/printing technology—will only enhance the close cooperation and working relationship of the dentist/laboratory team.

More than 20 different CAD/CAM systems have been introduced as solutions for restorative dentistry. The introduction of digital laboratory laser-scanning technology, along with its accompanying software, allowed the dental laboratory to create a digital dental environment to accurately present a real 3-D virtual model that automatically takes into consideration the occlusal effect of the opposing and adjacent dentition. It also has the ability to design 32 individual full-contour anatomically correct teeth at the same time. These systems essentially take a complex occlusal scheme and its parameters and condense the information, display it in an intuitive format that allows dental professionals with basic knowledge of dental anatomy and occlusion to make modifications to the design, and then send it to the automated milling/printing unit. For the dental laboratory profession, the introduction of digital technology effectively automated—or even eliminated—some of the more mechanical and labor-intensive procedures (waxing, investing, burnout, casting, and/or pressing) involved in the conventional fabrication of a dental restoration, giving the dentist and technician the ability to create functional dental restorations with a consistent, precise method.

Digital Case

The patient presented with a desire to have his anterior teeth restored and to have a more esthetic shape and color, while retaining the natural color nuances of his posterior teeth **(Fig 4)**. A comprehensive examination was done to evaluate the patient's periodontal and occlusal/functional needs, as well as his overall oral health. Even though there was extreme tooth discoloration, basic tooth structure was found to be satisfactory for restoration. After esthetic and functional evaluation, it was deemed necessary to use full-coverage preparations and restorations to successfully restore both esthetics and anterior guidance and function.

As with any restorative process that will change tooth shape, position, and function, a diagnostic workup (wax-up) was completed. After the patient, dentist, and technician all agreed to the proposed changes the clinical preparations were completed, and a copy of the wax-up was created for the temporary restorations, for the intraoral evaluation. Once provisional restorations were approved it became the technician's responsibility to copy the temporary restorations, and recreate them into the final ceramic restorations.

Summary

This article provided an overview of the possibilities of digital smile design, using computer design software, for the design of the milled diagnostic wax-up, the milled polymethylmethacrylate (PMMA) provisional restorations, and the final milled e.max lithium disilicate ceramic restorations **(Figs 5-23)**.

The dental profession currently regards CAD/CAM technology as just machines that fabricate full-contour ceramic restorations or frameworks. Digital dentistry represents a new way to diagnose, treatment plan, and create functional esthetic restorations for patients in a more productive and efficient manner. CAD/CAM dentistry will only further enhance the dentist/assistant/technician relationship as we move together into this new era of patient care.

Automation has been slow in coming to dentistry and although new equipment has been introduced to make our jobs easier, we still create complex dental prosthetics using old techniques. And, even though the "lost wax" technique is still a tried-and-true method of fabrication, there will come a day in the near future when all frameworks and full anatomical crowns will be designed on computer. Only then will we truly realize the wonder and power of dental CAD/CAM technology that was introduced so long ago.

Figure 4: Patient's preoperative condition, showing anterior wear and tooth discoloration.

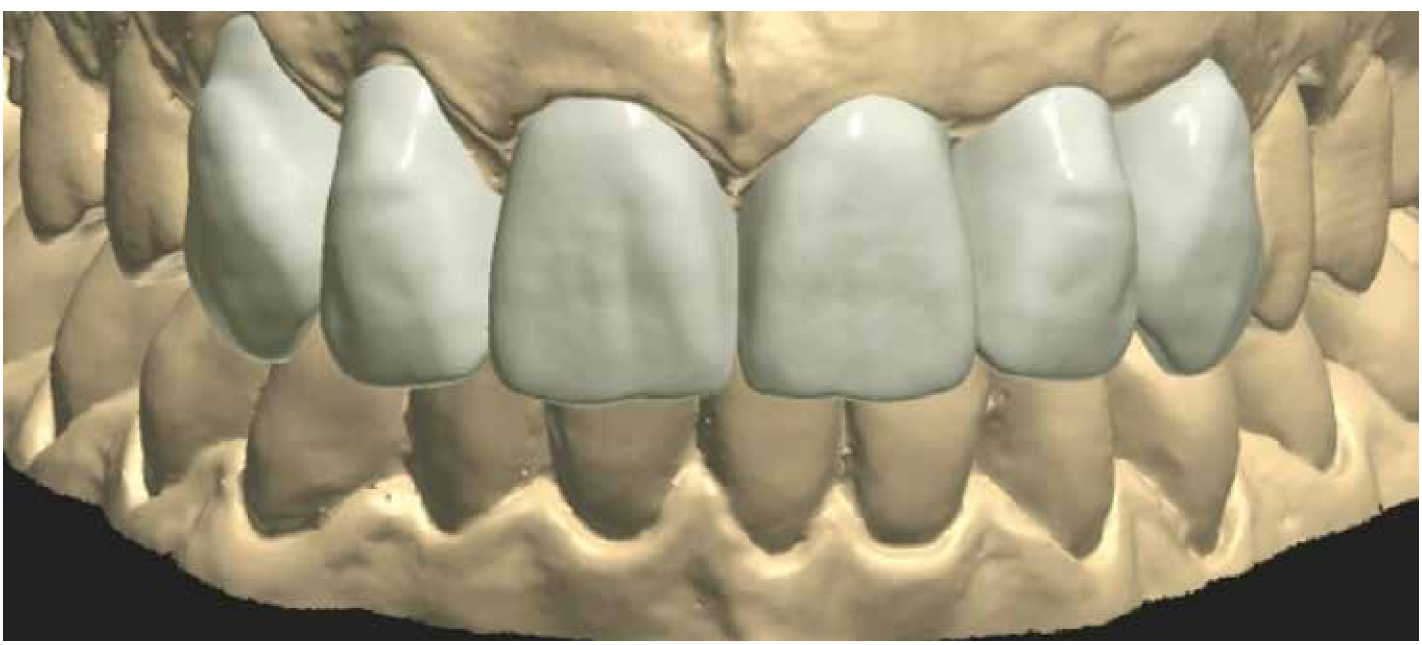

Figure 5: Digital design for diagnostic wax-up.

Figure 6: Milled diagnostic wax-up.

Figure 7: Completed digital diagnostic wax-up.

Figure 8: Maxillary full-coverage crown preparations.

Figure 9: Mandibular full-coverage crown preparations.

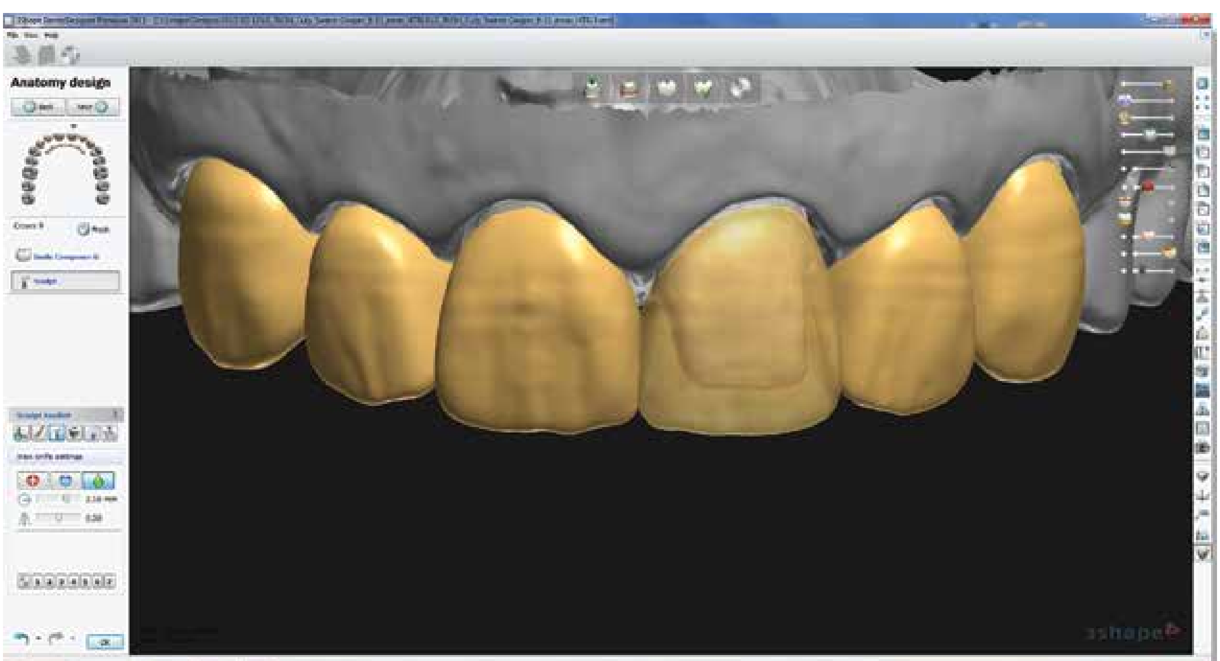

Figure 10: Digital design for laboratory-milled PMMA provisional restorations.

Figure 11: Milled PMMA provisional restorations, with light-cured stains and glaze applied.

Figure 12: Intraoral view of seated provisional restorations.

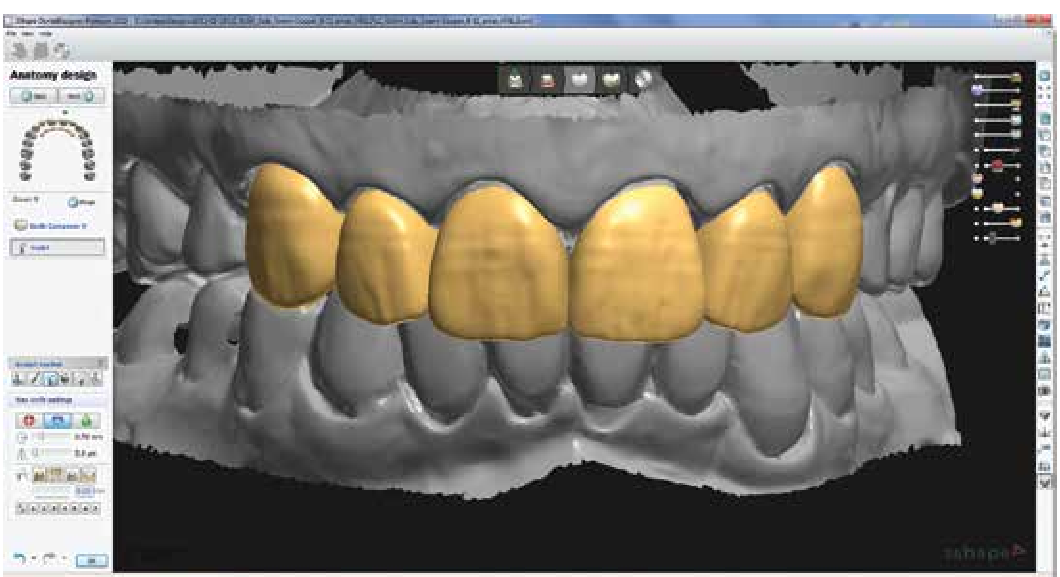

Figure 13: Digital design for final milled maxillary all-ceramic e.max CAD restorations.

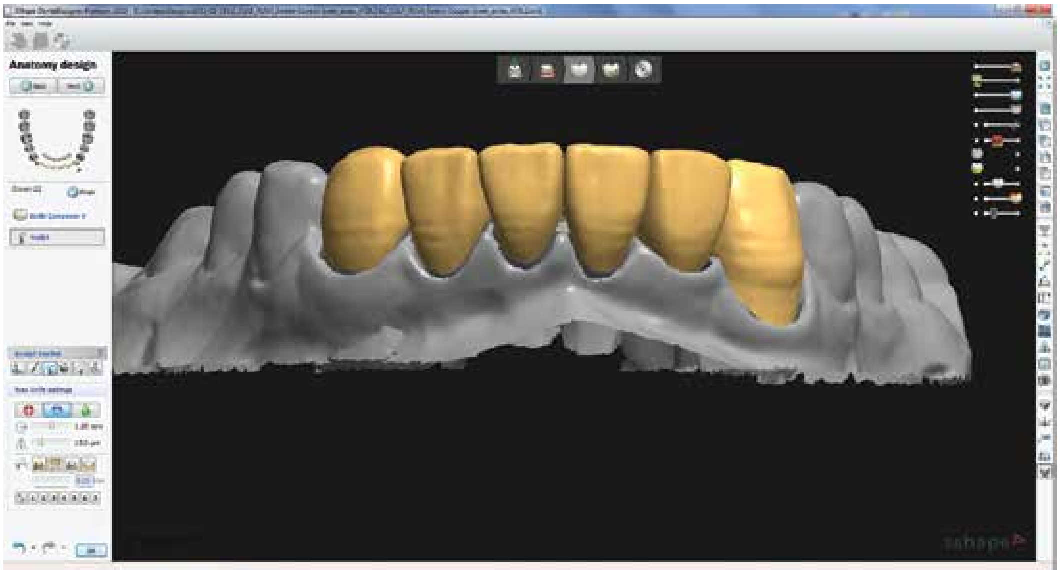

Figure 14: Digital design for final milled mandibular all-ceramic e.max CAD restorations.

Figure 15: Digital articulator with restorations, to check functional movements.

Figure 16: Milled maxillary "blue stage" e.max CAD restorations.

Figure 17: Milled mandibular "blue stage" e.max CAD restorations.

Figure 18: e.max CAD restorations after "crystallization" process.

Figure 19: Stain and glaze of e.max CAD restorations.

Figure 20: Postoperative image of cemented mandibular all-ceramic restorations.

Figure 21: Postoperative image of cemented maxillary all-ceramic restorations.

Figures 22 & 23: Final view of digitally designed and milled e.max CAD anterior restorations, showing excellent fit, form, and natural esthetics.

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The clinical dentistry shown in this article was performed by Dr. Swann. The digital and technical dentistry was done by Mr. Culp.

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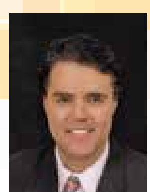
"Once provisional restorations were approved it became the technician's responsibility to copy the temporary restorations, and recreate them into the final ceramic restorations."

Mr. Culp is an adjunct faculty member at the University of North Carolina (UNC) School of Dentistry. He is an instructor at UNC, Chapel Hill, North Carolina, and practices in Dublin, California, and Raleigh, North Carolina.

Disclosure: Mr. Culp receives an honorarium from Ivoclar Vivadent.



Dr. McLaren is the director of the UCLA Center for Esthetic Dentistry. He maintains a private practice in Los Angeles, California.

Disclosure: Dr. McLaren did not report any disclosures.

Dr. Swann is a resident in the Department of Prosthodontics, UNC at Chapel Hill.

Disclosure: Dr. Swann did not report any disclosures.

> "CBCT helps eliminate many of the problems that can occur with conventional radiographic procedures."

Cone Beam CT

Applications for the Cosmetic Dentist

Dale A. Miles, DDS, MS FRCD(C)

Abstract

Cone beam computerized tomography (CBCT) information has become a necessary part of precise implant planning. Although not yet the standard of care, implant procedures that are restoratively driven can no longer be done precisely enough with conventional imaging modalities. Cosmetic dentists, because of the nature of the exacting procedures they perform, will find that planning and performing implant cases using CBCT will become the only way to manage their cases, both large and small. However, with this added precision comes added responsibility since the CBCT data volumes, no matter what size the field of view captured, dictate that clinicians re-educate themselves to be able to use this advanced imaging modality. In addition, they will encounter many anatomic and pathologic findings with which they may not be familiar. The re-education process is necessary to reduce the risk and liability that comes with adopting this amazing technology.

Key Words: cone beam computerized tomography/ CBCT, field of view/FOV, risk and liability

Introduction

Are cone beam computerized tomography (CBCT) and cosmetic dentistry oxymorons? Not really. Certainly almost all dentists performing cosmetic dentistry procedures today are placing restorations on implant fixtures. The restorative or prosthetic-driven implant case is fast becoming the de facto standard in dentistry. When replacing even a single crown in the anterior region of the mouth, if it is implant-supported, success will start with precise imaging of the bone to support the implant. The final crown depends upon the emergence profile created by the implant itself. So form, function, and pleasing esthetics—the goals of the cosmetic dentist—will be made easier if you start from sound, precise imaging information. It is not that complicated. In addition, cosmetic dentists who take on more complex cases are constantly restoring patients with edentulous spaces, often also supported by multiple endosseous implant fixtures. Here also then, precision will be the key to success.

CBCT has become essential for dentists performing large reconstructive cases to achieve the best long-term results. From imaging the proposed implant sites to establishing the correct orientation of the implant for the emergence profile to correctly establish both form and function, dentists can perform the procedures in-office using CBCT machines, implant-planning software, and surgical guide construction software to achieve the most ideal result. Again, it is not that complicated, it just takes time, a little education, and the financial commitment. Happily, the dentist does not actually have to own his or her own CBCT machine to enter this world; the data sets from these machines can be provided from a radiographic imaging service or a colleague who already owns a machine.

A Few Guiding Principles

CBCT helps eliminate many of the problems that can occur with conventional radiographic procedures, which can be fraught with errors of acquisition, errors of chemical processing (if conventional film is being used), and errors of interpretation and measurement.

The data from any CBCT machine is reconstructed in the machine software in a one-to-one ratio.[1-4] This eliminates any problems introduced by intraoral, panoramic, or other radiographic modalities such as tomography, with respect to magnification. There are none, period. It is not necessary to measure against a known object in the intraoral software or place a tool over a panoramic with known magnification to try to calculate the precise length of the proposed site or the width. And, with three dimensional (3-D) information, it is possible to also see the implant site in all three anatomic planes of section (axial, sagittal, and coronal). The software used to plan the implant site also understands these anatomic relations so that when the orientation length and/or size of the implant are modified, the program software allows for precise visualization of the site, with no magnification. What could be easier?

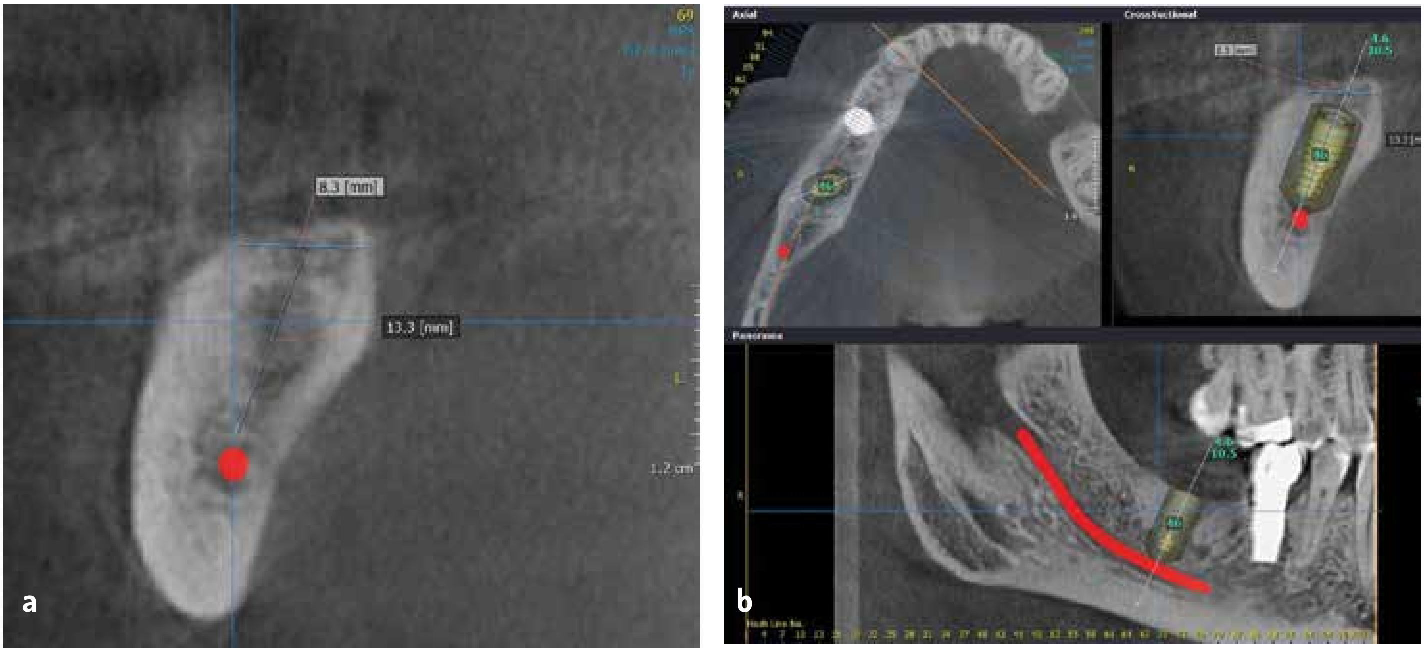
In addition, those who have already attempted to place implants using conventional radiography have been cautioned to leave a "safety zone," usually approximately 2 mm, to avoid anatomic structures and locations that could cause a problem for the patient. With CBCT, the software programs allow for measurement to within 0.1 mm with precision. When I lecture, I tell clinicians that the only error is "how much 'shake' is in my mouse." So in those cases when you hoped you could have at least one more millimeter of implant length, you can probably have it. What could be more precise? **Figures 1a, 1b, and 2** are images made in simple, intuitive contemporary implant-planning software showing a proposed site in 2-D grayscale, 3-D reconstructed color with measurements, and orientation of the proposed fixture easily identified. This is the type of information that can be presented to patients to help educate them about how precise and simple an endosseous implant procedure can be, and how it will allow you to restore the edentulous area exactly and esthetically.

For those who worry about the "diagnostic responsibility," I will, under "Liability Issues," address another principle called field of view (FOV); that is, the amount of anatomy captured and what you must be able to identify within that FOV. It is easy but not quite as straightforward as manufacturers suggest.

Current State of the Art for CBCT

The image receptors or detectors for CBCT machines still basically come in two "flavors."[5-6] Most machines used digital receptors called flat panel detectors or thin-film transistors (TFTs). One or two, for example the Galileos (Sirona Dental; Charlotte, NC) and the NewTom (Verona, Italy) still use image intensification. It has been my experience that those machines using an image intensification capture device are excellent at capturing the patient's soft tissue as well. Unfortunately, this often translates into increased scatter, which, especially in the 3-D color reconstructed renderings of patients, results in artifacts that can be unesthetic. **Figure 3a** is an example of this problem.

Manufacturers may also state that "the smallest voxel size results in the highest degree of resolution." This is true to some extent, and manufacturers of all machines have made great strides in giving us CBCT devices with selectable voxel sizes, so that high-resolution scans can be made using voxel sizes of about 0.1 mm in size, at slightly higher x-ray dose, or selected in sizes up to 0.4 mm (such as one might use for an orthodontic case on a child), which results in a much lower dose in most cases with most machines. However, voxel size is not the only parameter that determines the image quality of a CBCT scan.



Figures 1a & 1b: a. 2-D cross-sectional, grayscale image measuring the width and height of a proposed implant site. b. Inferior alveolar nerve canal "painted" in red with selected implant fixture in place.

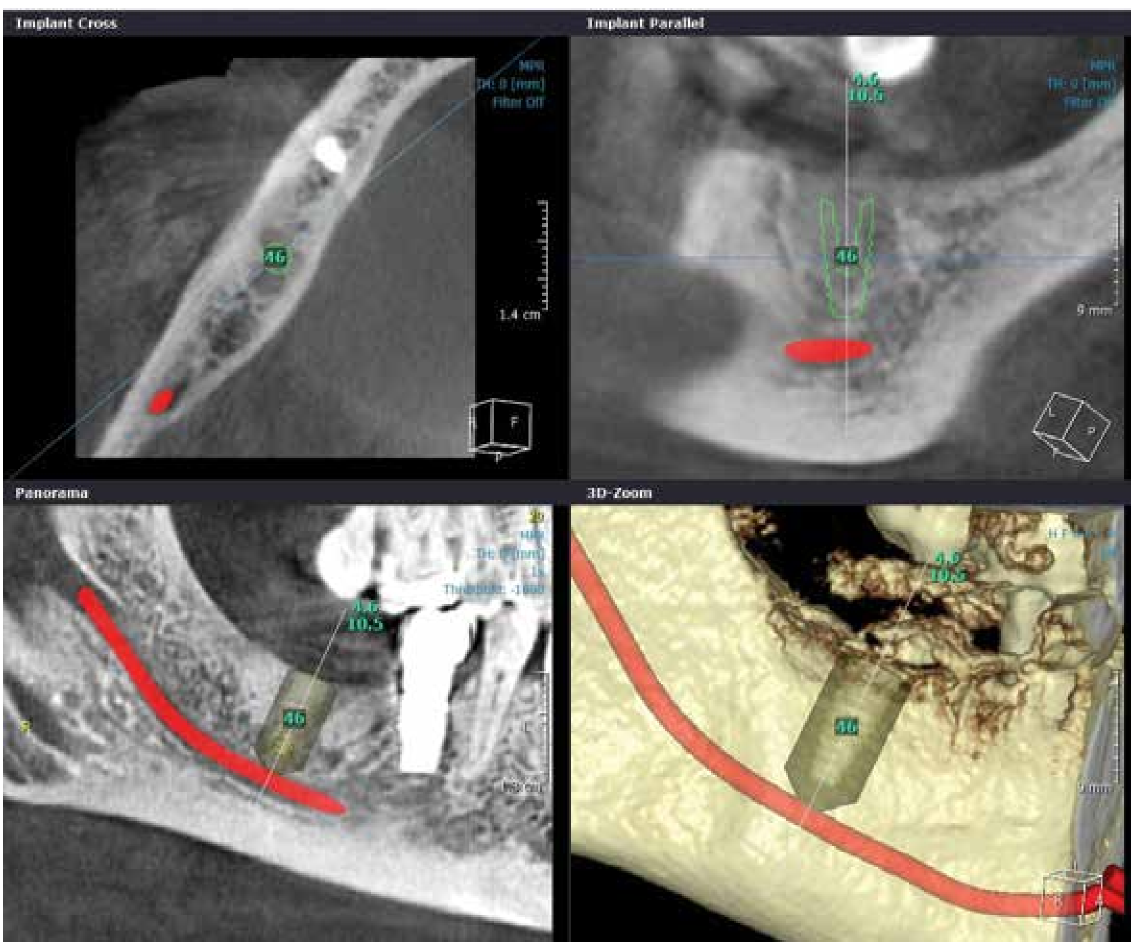


Figure 2: Grayscale and 3-D color images to verify that the implant fixture will not contact the inferior alveolar nerve, using the "verification tool" in the OnDemand3D software.

> "Cosmetic dentists must re-educate themselves to understand both the pros and cons of this valuable diagnostic imaging modality."

Other factors include the following:

- type of image detector
- reconstruction algorithm
- focal spot size of the anode
- kilovoltage potential (kVp) and milliamperage-seconds (mAs)
- type of head positioner
- bit depth of capture.

The discussion of these parameters is beyond the scope of this article, but these parameters and an understanding of them should be part of the due diligence that dentists perform before purchasing or using CBCT.

Of course, the data from CBCT examinations can be translated into another computer format, stereolithography tessellation language (STL), for use with computer-assisted design/computer-assisted manufacturing (CAD/CAM) devices. However, this is the format of the data necessary to instruct a milling device to create a coping or a crown restoration. In addition, the STL translated format language is used in stereolithography for creating surgical guides of great precision and ease of use. This computer language format also allows surgeons to mill replacement body parts such as mandibles, and temporomandibular joint (TMJ) condyles. Some laboratories charge additional fees for conversion of the CBCT digital imaging and communications in medicine (DICOM) data into STL format for use in the milling machines. Some third-party, "standalone" surgical guide software can automatically convert the data from the captured CBCT information.

My opinion is that general dentists performing cosmetic and reconstructive procedures involving implants should do so only by using CBCT data and surgical guides for placement of the implant fixtures. This makes protocols precise, predictable, and successful. Doing so without cone beam data or a surgical guide, even in a single implant case, ultimately leaves the clinician with a higher degree of liability.

Simple Software Solutions

There are many third-party software solutions for implant planning and viewing CBCT data sets. For implant planning, most of the software solutions are a "one-trick pony"; that is, they can be used for implant planning and virtually nothing else. Others, like the one used to demonstrate **Figures 1 and 2** can be used for more than just implant planning. **Table 1** summarizes many of the implant software solutions available, including those that can do more than implant planning and surgical guide production (the boldface items in **Table 1**).

Impact on Practice

Cosmetic dentists are continuing to embrace implant procedures for which CBCT imaging will be practical and beneficial. **Table 2** provides information from the AACD's 2011 survey on procedures.[7] In the second set of findings, more than 50% of those responding indicated that they would increase the revenue they generate from implant procedures during 2012.

It is clear that whether you, as a cosmetic dentist, decide to purchase a CBCT machine or not, you will definitely benefit from the data from these devices for implant planning.

Liability Issues

There is some truth to the belief that with decreased FOVs comes decreased diagnostic responsibility. This concept is certainly put forward by the manufacturers of machines that allow for small FOV capture. However, small or limited FOV machines may not be appropriate for larger cases or for cases involving contralateral arches, such as an implant being placed in the right maxilla and in the left mandible at the same time. In addition, if a clinician was replacing an edentulous space for an upper or a lower second molar, there could be anatomy captured that might be unfamiliar to them. **Figures 3b and 3c** show a small FOV machine used to capture a maxillary molar region and condyle.

Some might choose to simply skip the condyles. However, if even a single tooth that has been missing for many years is restored to function, and the patient has pre-existing osteoarthritic changes on a condyle that are subclinical in their symptomology, this condyle might become symptomatic when the tooth is again restored to function. Instead of dealing with a patient with TMJ pain after implant placement, it might have been possible to examine the condyles for arthritic changes and let the patient know beforehand that their subclinical disease might become symptomatic when their function was restored, but that that could be treated with over-the-counter anti-inflammatory medications. The second scenario (informing the patient of a potential problem ahead of time) is far more palatable to everyone concerned.

With the adoption of CBCT into your practice there is the expectation that you will "retool" and re-educate yourself to be able to confidently look at all of the data in the CBCT volume so that you recognize abnormal findings and refer the patient when appropriate. This is in addition to the education that you will have to undertake to use available implant planning and diagnostic viewing software.

Table 1: Implant software comparison.

Company	Platform	Surgical guide support	Guided implant placement	Type of software	Cost
Cybermed – OnDemand ondemand3d.com	open	teeth, tissue, bone	yes	**implant, 3D, full diagnostic package**	$4500-7000
3D Diagnostic 3ddx.com	open	teeth, tissue, bone	yes	implant planning only	N/A
Anatomage – InVivo5 anatomage.com	open	teeth, tissue, bone	yes	**implant, 3D, full diagnostic pakage**	N/A
Blue Sky Plan blueskybio.com/pages/overview_3	open	teeth, tissue, bone	yes	implant planning only	free software download
CoDiagnostix dental-wings.com	open	teeth and tissue	yes	implant planning only	N/A
Keystone Dental – EasyGuide keystonedental.com/products/easyguide	open	teeth and tissue	pilot guide only	implant planning only	$4700
IDent ident-surgical.com/asp/index.asp	open	teeth and tissue	yes	implant planning only	$7000*
Nobel Biocare – NobelClinician nobelbiocare.com/en_us/products-solutions/treatment-planning-guided-surgery/default.aspx	closed	teeth and tissue	yes	implant planning only	$6150
Facilitate – Simplant materialisedental.com/materialise/view/en/3106193-Product+overview.html	open	teeth, tissue, bone	yes	implant planning only	$4450-8750
Sicat – Sirona sirona.com/en/products/digital-dentistry/integrated-implantology/	open	teeth and tissue	yes	implant planning only	$8900
VIP3 – BioHorizons biohorizons.com/dental-implant-company.aspx	open	teeth and tissue	no pilot guide	implant planning only	$3495

(Note: Dollar amounts were converted from euros at a rate of 1 USD = 0.0764029 euro.) * financing plan offered on Web site.

Table 2: Revenue comparison due to implant procedures.

Compared to the revenue generated by **implant procedures in the year previous, this year showed:**			
(530 responses)	an increase	221	42%
	a decrease	86	16%
	little change	223	42%
Do you expect the revenue generated by **implant procedures in the coming year to:**			
(530 responses)	increase	283	53%
	decrease	37	7%
	stay about the same	210	40%

Source: AACD Survey 2011.[7]

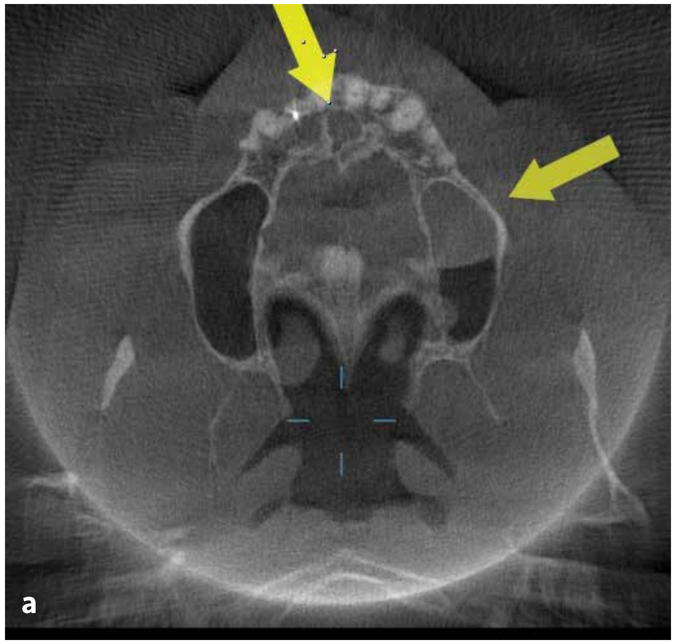
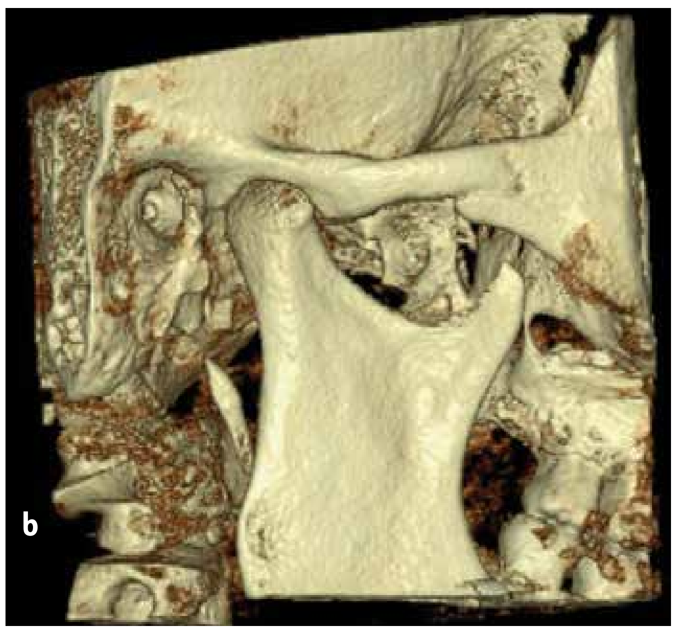


Figure 3a: Axial slice from a popular scanner using image intensification. The yellow arrows depict the nasopalatine foramen (enlarged, top arrow) and a small mucous retention cyst in the left maxillary sinus (right yellow arrow). Note the soft tissue scatter around the outside of the slice. This "noise" can interfere with precise interpretation of some regions of the scan in some cases, especially in air spaces.



Figures 3b & 3c: b. 3-D color reconstruction of TMJ condyle. Second molars are captured. c. Axial slice through condylar head. See anatomy labeled; but remember, the teeth are only a few centimeters below the "blue cross" in the maxillary arch.

Diagnostic Responsibility

Oral and maxillofacial radiologist (and attorney) Dr. Bernard Friedland wrote:[8]

"While there are no legal cases specifically concerning the matter of the scope of interpreting a CBCT scan, the issue can fairly be regarded as settled. A CT is no different than any other image—a dentist cannot read only part of a panoramic film, or only part of a lateral cephalogram. For example, should an orthodontist miss an enlarged sella turcica resulting from a tumor on a lateral cephalogram,[13] the dentist reading the cephalogram cannot offer as an excuse in any legal proceeding that "I read only part of the film" or "I read the film only as it relates to the orthodontic diagnosis and treatment." The dentist is obligated to read all of the film. That this is accepted to be the standard within the profession is borne out by a recent editorial in the orthodontic literature."[9]

This sentiment was echoed by the American Academy of Oral and Maxillofacial Surgery in their publication *Fortress Guardian*.[10]

However, although there is no case law that can be cited to show that a dentist might be negligent for not reading the scan, there indeed are cases involving dentists placing implant fixtures in locations other than where they were intended. I have been involved in several of these cases. To date, all such cases in which I have been involved have been settled out of court, because no dentist wants to have his/her name in the National Practitioner Data Bank with a judgment against them for improper treatment.

I would never claim that every CBCT scan must be read by an oral and maxillofacial radiologist. There are just too many scans, and a limited number of radiologists in our specialty. However, as stated above, dentists must re-educate themselves to be able to examine the data in the scans and be comfortable that they can distinguish abnormal findings from normal ones. A simple description of their findings in the referral to another specialist is the standard of care according to the American Dental Association's Principles of Ethics and Code of Professional Conduct, Section 2.b, Consultation and Referral: *"Dentists shall be obliged to seek consultation, if possible, whenever the welfare of patients will be safeguarded or advanced by utilizing those who have special skills, knowledge, and experience."*[11]

What this means to me is that any radiographic finding in the entire scan data about which there is a question should be investigated further by a specialist. And, no matter whether it is a small or large FOV, there will be radiographic features for which many general dentists will not have an explanation. These cases must be referred. Again, as stated above, just because there is a small FOV does not mean there will not be a significant finding since you can move this volume two locations, which capture structures with which you may not be familiar.[9, 12-14]

As for a machine with a large FOV (greater than 8 x 8 cm), you may wish to consider developing a relationship with an oral maxillofacial radiologist or a radiology reading service to read your scans to limit your liability. It takes time to review the volume data no matter what size the scan, and some clinicians will just not have the time to look at all the data that they capture. But, all of the slice data in every CBCT scan must be reviewed so that nothing is missed. I tell general dentists that they have to find their "comfort level" with reviewing the scan data. With a little training, the dentist should be able to establish a radiographic interpretation review protocol for themselves and the office.

Summary

Many cosmetic dentists will adopt CBCT imaging or the data obtained from CBCT machines into their practices for a variety of procedures, especially those related to implant planning, placement, and restoration. To do this properly and precisely, cosmetic dentists must re-educate themselves to understand both the pros and cons of this valuable diagnostic imaging modality. Those who do will be rewarded both financially and professionally. Perform due diligence to determine whether it is cost-effective to own the machine, or more appropriate to simply order scans. Train yourself to the point where you are comfortable with examining the data in the scans. If you are doing a large number of scanned procedures and do not have the time to examine all the data in the scan that is not related to the implant procedure, it would be appropriate to refer the scans to a specialist for review as a way of reducing your risk and liability of findings that could affect the patient in ways you did not anticipate.

Do not be afraid, be informed, and consider adopting this incredible technology to help you and your patients.

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"Do not be afraid, be informed, and consider adopting this incredible technology to help you and your patients."

Dr. Miles is adjunct professor of oral and maxillofacial radiology at Arizona School of Dentistry, Mesa; and the University of Texas Dental School, San Antonio. Dr. Miles maintains a full-time practice in Fountain Hills, Arizona.

Disclosure: Dr. Miles is a consultant for Planmeca USA, and Cybermed International.

TIPS for Making a Great Impression—Digitally

Planning a Shift to Digital Impressions

Christopher D. Ramsey, DMD, AAACD

Introduction

Digital dental impression scanning is proof that the dental industry is rapidly evolving as never before. This evolution is changing the way that practices, laboratories, and patients view their relationships with each other. In fact, it has been said that the ability to capture an accurate digital record of the visible intraoral hard- and soft-tissue components without the use of difficult, labor-intensive elastomeric impression material is a “game changer.”[1] Patients no longer have to worry about messy, uncomfortable impressions, because digital impression scanning means the process is now quicker, easier, cleaner, and more comfortable.[2]

Among the digital impression-taking technologies are those that use an intraoral scanning device that is either laser-supported or video-based, making it easier to capture an image.[3] Each system is different, so many things should be considered before purchasing one. These include chairside time required, laboratory communication, desirability of a one-visit treatment, and standardized quality control.[4] To judge the performance of a system, examine the resulting marginal fit and integrity of the fabricated restoration, among other factors.[5]

Whether a practice already has a digital scanning system in place, or is looking to integrate one in the near future, here are some helpful tips for making a great impression using a digital scanning system.

To judge the performance of a system, examine the resulting marginal fit and integrity of the fabricated restoration, among other factors.

Stay Current

The need for precision and accuracy will continue to be critical, as will patient-friendly clinical procedures. As technology improves, it is natural for our techniques to progress with these developments. The need to keep up to date, while producing ideal impression and model properties will remain imperative. I have noticed in my practice that digital impressions remove a lot of variables, such as bubbles, pulls, and voids, as well as human error. For me, it increased productivity and improved my workflow. While a digital scanning system can be beneficial to any practice, you may not feel ready to introduce one. Other points to consider are whether your current laboratory is using digital impression software and whether digital scans will replace your traditional impression materials, or merely supplement them.[3]

Research the Options

There are several types of digital scanning systems on the market, and clinicians need to do their homework to find out which will work best with their practice workflow. They also should check with their laboratory technicians to get their opinions as well.[6] Practices should consider if they want to buy an open system, in which data are presented in an industry-standard format (such as STL), or a closed system, in which data can only be interpreted by equipment from the same manufacturer.[5]

Plan for the Future

Whether a practice already has a digital impression scanning system in place, or is thinking about upgrading, the future of the practice should factor into purchasing or upgrade decisions.[7] Where will the practice be in five years? Ten? Is chairside milling in its future? Is the practice open to the possibility? Even if you are not entirely sure of where you want your practice to be in the next decade, it is important to know the different possibilities you may want to explore so you can purchase an appropriate system with flexibility.

Develop a Budget

Decide how much the practice can afford to spend. Right now, the competition for the digital impression scan market is heating up. This means that dentists, as consumers, will benefit over the next few years as prices fall and case fees for users are reduced.[1]

Involve the Entire Team

New technology integration needs to include training, which in my practice was an easy transition. Your whole staff will need to be well versed in the process, since it is important for them to be able to explain the process to patients, even front desk staff, since they may be explaining the technology to new patients. Digital impression scanning is a great way to attract new patients.[8]

Involve the Patient

While using a digital impression scanner, engage the patient in what you are doing. Explain how you no longer need to use messy impression material, and elaborate on the benefits of the new system, such as a quicker impression appointment or how the intraoral scanner can be more accurate. Patients will appreciate being treated with the latest technology, and this can also help with higher levels of patient case acceptance and co-diagnosis.[9]

Maintain Proper Techniques and Preparation

Just because the scanner is digital does not mean that dentists can cut corners. Even though digital impressions eliminate some of the negatives of conventional elastomer impressions, issues such as proper soft-tissue management and isolation of tooth preparation margins are still important.[10] Similarly, different scanners require different types of preparation work. For example, if a practitioner prefers to prepare below the gum line, he or she may want to try out different scanners to see which one scans slightly better at subgingival levels than others. It is essential to follow basic prosthodontic principles and proper tissue management protocols in order to capture a high-quality digital impression (e.g., blood and saliva control, as well as tissue retraction).

Don't Use Digital Scanners Just for Teeth

Digital dentistry is opening up whole new worlds, and digital scanning is no exception. Many digital impression scanners can be used for implants as well as teeth.[11,12] Dentists should keep this in mind, since the technology may allow them to provide new services or expand existing ones (Figs 1-2).

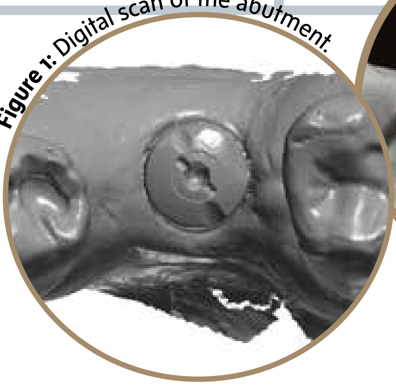

Figure 1: Digital scan of the abutment.

Figure 2: SLA model from digital scan.

Don't Rush

Digital impression scanners can reduce the time it takes to make an impression, but they should not be used simply to rush your cases. Even if you have the model completed in less time than before, depending on the system you choose, you may still need to send it to the lab.[13] This could take several days. Just because you have a digital system does not mean your workflow will instantly speed up; however, careful treatment planning and scheduling will help.

Use the System to Become a Better Dentist

A digital impression scanner cannot compensate for bad technique, but it can be used to help dentists become better at what they do. Because the information being captured can be viewed instantly, dentists can see where they need to make improvements to the preparations, margins, or scans themselves.[14] This kind of instant feedback can prove invaluable in the long run, as it helps dentists correct any errors in the process and become more proficient and skilled in their techniques. On his instructional videotape, "The Perfect Impression," Dr. Gordon Christensen states that out of the 40 million impressions taken each year, 90% do not have all of the margins captured, which equates into 36 million crowns that do not have all of their margins captured every year (Christensen GJ. The Perfect Impression. Practical Clinical Courses. 2001).

Some Rules Apply

Some preparations for impression making, such as making sure teeth are dry through proper isolation, still apply with digital scanners. Saliva will create reflective areas that will distort the scan, so dry teeth are still required, even for digital scanners.[14] This is true regardless of whether or not a contrast medium is used.

Use Them to Your Advantage

Digital scanners indirectly improve the workflow of a practice in ways other than simplifying the impression-taking process. It provides your staff with more time to focus on patients and their care.[15] They won't be rushing to mail the impressions, since the files are sent digitally. Instead, they can focus on making sure the impressions are done correctly. The technology can also be used to allay the fears or concerns of patients who are uncomfortable with the traditional impression-taking process, such as those with a gag reflex, people with special needs, the elderly who may not be able to placed in reclined position, or those who have mouth-opening limitations.

Decide on the Restoration Before You Scan

If possible, this tip can save you time and effort. If you begin scanning with the ultimate restoration in mind, the system will automatically let you know if you have the proper margins or tooth reduction, as well as what other adjustments need to be made. Interestingly, dental schools are using digital scanners to train students to be better dentists, since these tools provide them with "instant feedback."

Give the Machine as Much Information as Possible

Digital scanners can make it easier to gather information, so dental professionals should make every effort to give the equipment as much information as possible, especially regarding contacts. Depending on the system chosen, different angles can be scanned as well as actual contact areas from adjacent teeth, which make for a better restoration fit.[15,16]

Hold Your Files

The great thing about digital dentistry is that it allows us to maintain records and data more easily than ever before.[15] Save cases for use as references in the future. They can be helpful in showing patients how much things have changed and can justify treatment recommendations when needed. Additionally, digital scanning allows dentists to create many more study models that are easier to store.

A LABORATORY TECHNICIAN'S PERSPECTIVE ON DIGITAL IMPRESSIONS

by Nelson Rego, CTD, AAACD
Santa Fe Springs, CA
The author did not report any disclosures.

- The investments for laboratories can be minimal, as labs typically work with just the margin marking software, I own the iTero margin marking software (Align Technology; Santa Clara, CA) because I have more clients who use the iTero system. Therefore, I need two things: the software and a computer to approve the margins.
- Service your dentist clients. I found that if you don't have the software, you could find other resources that do. For example, I found another laboratory that has 3M's (St. Paul, MN) margin marking software and for a nominal fee they mark the margins for me. This way I don't have to invest in two software systems and it is affordable. In addition, I am able to adapt to the changing needs of my clients.
- The technology works. I have been using the technology for six years and have completed roughly 2000 cases. In this time period, I never had to change the margin nor did I have any cases returned to me for additional work. This tells me the technology is accurate.
- Material efficiencies are a noticeable improvement. The durability in the milled polyurethane (iTero) and the stereolithography (SLA) models (3M) are tough and don't chip as easily as the stone die models do.
- As more clinicians and laboratories discuss and research digital impressions, currently it is gradually transitioning. In my lab only 2% of the cases that come in use this technology. I definitely see the benefits of digital impressions and it is proving to be cost effective for my lab.
- It can be helpful for those who are anxious during dental treatments or have an easily triggered gag reflex. There is no gooey material needed, as with traditional impressions, and there is a quicker chairside time. These patients should feel more at ease.
- It's no big deal. Integrating this new order into my lab was smooth. It comes in as a model and we just build the order to fit the model like a normal impression.
- You can use the software to your advantage. Once your system is in place, you can store the files and data into folders to cater to your custom order requests. For instance, if a dentist requests a certain laboratory technician's work, it will be easy for you or anyone in the lab to pull those files and recreate a wax-up originally done by any lab tech on your team.
- Bottom line: Get involved. Prices for laboratories to get started are very reasonable, or you can find a second lab to margin mark for them. Therefore, there is no reason not to participate.

Summary

Digital impression scanning is transforming the way dental practices serve their patients. Taking impressions is now easier and faster, and they are of better quality, with resulting restorations demonstrating an accuracy of fit and marginal integrity that has not been realized before.[12] It is essential to follow basic prosthodontic principles and proper tissue management protocols in order to capture a high-quality digital impression. Once it has been implemented, technology use should be maximized, both for restorations and for educational purposes.

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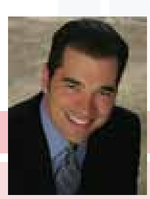


Dr. Ramsey is in private practice in Jupiter, Florida.

Disclosure: Dr. Ramsey is a product consultant for *THE DENTAL ADVISOR*, 3M, and Align Technology.

FOCAL Bleaching Technique

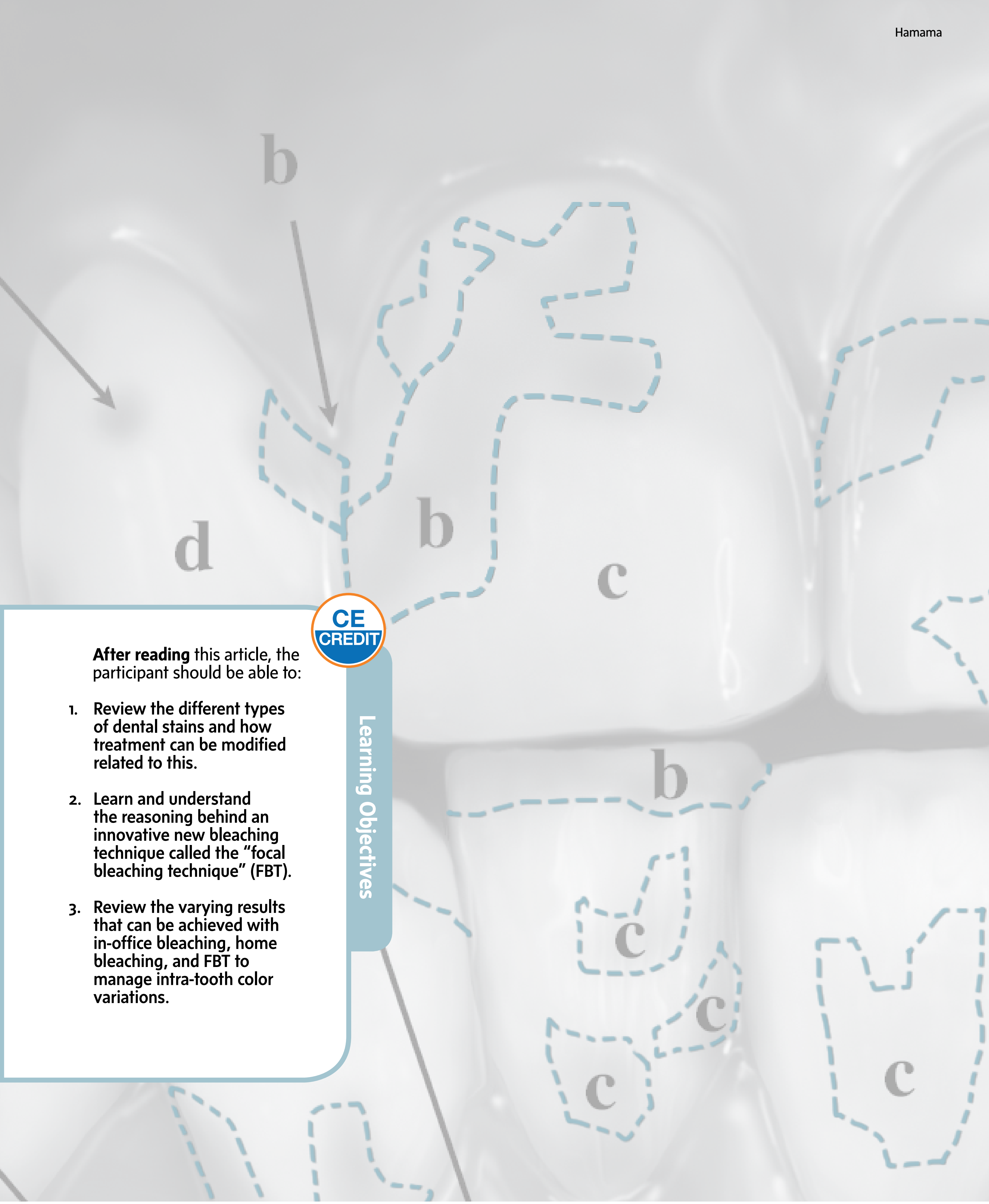
Determining Stain Distribution by Creating a "Bleaching Map"

Hamdi H. Hamama, BDS, MDS

Abstract

This study introduces the "focal bleaching technique" (FBT), which is designed to reduce the biological hazards of the application of the bleaching gel on dental tissues. It also can be considered as a direct application of minimal intervention dentistry concepts on bleaching. Drawing a "bleaching map" is a critical step preceding focal bleaching. This map is considered to be an important diagnostic tool that assists the clinician in determining the distribution of stain and developing a comprehensive treatment plan. The current study reports a clinical case of opaque fluorosis combined with brown discoloration treated with FBT. This case demonstrates the step-by-step procedure and limitations of this line of treatment. Using FBT changes the old concept of bleaching from simply that of whitening teeth to a systematic balancing of color between discolored and sound regions of the affected tooth. As with any clinical technique, it has some limitations; for example, the presence of "bleaching-persistent regions" that do not respond to the treatment and require another line of treatment (e.g., direct or indirect veneers). The current study revealed that using FBT guided with bleaching map can achieve better results compared to conventional bleaching methods.

Key Words: in-office, bleaching, discoloration, tetracycline, fluorosis



CE CREDIT

Learning Objectives

After reading this article, the participant should be able to:

1. Review the different types of dental stains and how treatment can be modified related to this.
2. Learn and understand the reasoning behind an innovative new bleaching technique called the "focal bleaching technique" (FBT).
3. Review the varying results that can be achieved with in-office bleaching, home bleaching, and FBT to manage intra-tooth color variations.

> FBT expands the bleaching from a conventional process of shade lightening to a systematic balancing of color between the stained and the normal tooth regions.

Introduction

Historical Background

Esthetics is the field that studies the nature of beauty and seeks to enhance the particular details of static and dynamic objects to make them more visually appealing.[1] The artistic nature of dentistry and the growing esthetic demands of dental patients have led to the specialty of "esthetic dentistry."

Treatment of tooth discoloration is one of the most important fields of esthetic dentistry. In ancient cultures and their artworks, white teeth symbolized beauty and good health. Past dental surveys revealed that 28 to 34% of surveyed subjects are dissatisfied with the color of their teeth and seek bleaching treatment.[2,3] Dental bleaching has been reported as the most conservative method of treating tooth discoloration.[4] Bleaching techniques have been markedly improved, from using pure chemical peroxides, until reaching the recent light/laser-assisted bleaching systems.[5]

In 1876, the first original work reporting the professional bleaching of stained teeth was written by M'Quillen,[6] who stated, "It is a somewhat remarkable and inexplicable fact that none of the textbooks which have been presented to the profession, so far as my observation goes, pay even the compliment of a passing notice to the means whereby discolored teeth may be improved in appearance." Furthermore, M'Quillen had reported that the most common cause of tooth discoloration was intrusion of hemoglobin into dentinal tubules, which turns the tooth color to pink "rosy tooth." M'Quillen used Labarraque's solution (liquor soda chlorinate), chloride of lime (calcium chlorinate powder), and chlorate of potash (potassium chlorate) as bleaching agents to improve the color of stained teeth.[6]

The first attempt to accelerate the bleaching process was introduced in 1918 by Abbot,[7] who used a high-intensity light source to raise the temperature of a peroxide-based bleaching agent. Another accelerating method was introduced in 1937 by Ames and Smithfield,[8] who used an external heat source. They also invented a specially designed hand instrument that was pre-warmed on a Bunsen burner and applied on the bleaching agent (the scientific name of the used bleaching agent was not clearly mentioned in their publication, however; they referred to it only as "liquid" or "solution") to accelerate the bleaching process.

Dentist-Supervised Home Bleaching

Bleaching has been a well-known treatment since 1989, after publications from Haywood and Heymann[9-12] about nightguard vital (dentist-supervised home) bleaching. Dentist-supervised home bleaching is a patient-dependent technique that requires a long time before achieving satisfactory results. Moreover, it fails in treating deeply stained teeth.

"In-Office" Vital Bleaching

Another professional bleaching strategy, "in-office" vital bleaching, was introduced in the last two decades to overcome the drawbacks of the dentist-supervised home bleaching technique. In-office bleaching is performed by chairside application of highly concentrated bleaching agents on discolored teeth with a special regimen. Nowadays, there are many attempts to accelerate the in-office vital bleaching process by using external photo-activation methods (e.g., light-emitting diodes [LEDs], lasers, mercury halide lamps, plasma arc, quartz halogen, and ultraviolet units), also called "power in-office vital bleaching" or "power bleaching." Incorporation of light-activation technology into dental bleaching techniques decreases the harmful effects of bleaching agents and reduces the treatment time.[13]

Stain Types

Tooth stains can be classified into two main groups: extrinsic and intrinsic. The extrinsic stain is defined as a temporary stain that can be easily removed with routine prophylactic cleaning and usually results from frequent intake of dark-colored beverages (e.g., coffee, tea, and cola) or smoking. Conversely, the intrinsic stain is defined as an endogenous stain that has been incorporated into the tooth matrix and cannot be removed via routine prophylactic cleaning. Intrinsic stains can be caused by systemic intake of certain drugs (e.g., tetracycline derivatives) during the period of tooth formation. Also, excessive intake of fluoride during childhood can lead to a pathological condition called *dental fluorosis*. Dental bleaching deals with intrinsic stains and tries to remove or dilute their effect on the general shade of the tooth.

Tetracycline stains can be classified, according to their response to bleaching, into four categories: mild, moderate, severe, and intractable.[14,15] "Mild" degree can be observed as a yellow/gray stain uniformly distributed among the affected teeth, whereas "moderate" degree is noticed as uniformly distributed yellow/brown or dark gray stains. However, severe stains are characterized by blue-gray and/or black stains associated with significant banding across the labial surface of the tooth. Furthermore, Feinman[15] described the remaining heavy tetracycline stains that did not respond to bleaching treatment and require other treatment modalities (e.g., veneers) as intractable stains. Mild and moderate stains can be treated with dentist-supervised home bleaching as well as in-office vital bleaching. However, severe and intractable stains can be treated only with in-office vital bleaching.

Fluorosis is another common intrinsic stain classified by Feinman into three degrees: simple, opaque, and pitting.[15] Feinman reported that simple fluorosis can be observed as brown pigmentation on the smooth surface of enamel and can respond to bleaching. On the other hand, opaque fluorosis can be observed as flat gray or white flakes on the enamel surface. Moreover, opaque fluorosis responds poorly to bleaching, due to the difficulty of obtaining a final uniform tooth shade.[15] Furthermore, it has been reported that pitting fluorosis should be treated with combination of bleaching and veneering techniques.

Adverse Effects of Vital Bleaching on Tooth Structure

Tooth hypersensitivity is the most commonly reported adverse effect following vital bleaching.[16,17] Previous studies showed that hypersensitivity is a reversible condition that can last from 4 to 60 days after bleaching. The duration of hypersensitivity depends upon the contact time, concentration of the bleaching agent, and condition of the bleached teeth.[17,18] The irritation or accidental bleaching of oral mucosa is another adverse effect that can occur following the application of the bleaching gel. This problem can be reduced by using the appropriate tissue protection measures (e.g., rubber dam and light-cured and composite-based gingival protectors).

Power bleaching can significantly increase the intrapulpal temperature, particularly during the use of plasma arc and quartz halogen light units.[19,20] Although the elevation of intrapulpal temperature associated with laser photo-activation depends upon the type of laser. The lowest intrapulpal temperature rising was reported with argon and diode lasers (short activation period [60 seconds]), while the highest was recorded with a CO2 laser.[19,21] The LED activation method also can produce an elevation of the intrapulpal temperature, but this elevation is still within the acceptable range (below 5.5°C).[20] Increasing the intrapulpal temperature over the critical threshold (5.5°C) may lead to irreversible pulpitis and permanent damage of pulp tissues. Histological and morphological studies showed that bleaching agents can alter the topography and histological features of the enamel surface.[22-24] Furthermore, mechanical studies have shown that bleaching reduces the hardness of both enamel and dentin.[25,26]

Bleaching Map Concept

According to the bleaching map concept, every discolored tooth should be diagnosed and treated as a separate case, with careful monitoring of the distribution and degree of saturation of the stain as well as the regions of normal sound tooth structure. A bleaching map should be drawn for each tooth prior to bleaching, demarcating the deeply, moderately, and intermediately stained as well as sound tooth regions.

Rationale for Using the Focal Bleaching Technique

After reviewing the historical development of bleaching techniques, the author found that in-office vital bleaching technique was introduced to manage the inter-arch color variation of teeth (i.e., the discoloration does not involve all the teeth of the dental arch). However, it is not able to manage the intra-tooth color variation (i.e., the variability of color within the tooth itself). Power in-office vital bleaching provides a great advantage in limiting the application of the bleaching gel to the affected areas only (the FBT). This selective application cannot be achieved with a dentist-supervised home bleaching technique. A home bleaching technique requires applying the bleaching agent on the entire tooth surface, which results in lightening the color of both stained and normal tooth areas at the same level. This unselective whitening decreases the ability of the human eye to recognize the color difference before and after the treatment. Therefore, the FBT expands the bleaching from a conventional process of shade lightening to a systematic balancing of color between the stained and the normal tooth regions.

Feinman's classification was simple and he assumed distinct borders between the different staining degrees; however, most of the clinical cases showed complex combinations of staining, which consequently increased the complexity of treatment. This led to an increase in the demand for using selective bleaching protocols for treatment of such complicated clinical situations. Moreover, Feinman reported that "bleaching will lighten the teeth, but only relative to the initial color, so that striated discoloration will be less discolored but still striated."[15] This represents the most difficult challenge during treatment of banding discoloration with conventional bleaching techniques. However, if the selective FBT is

> A bleaching map should be drawn for each tooth prior to bleaching, demarcating all deeply, moderately, and intermediately stained as well as sound tooth regions.

applied, a marked reduction in demarcation between treated and sound regions will be achieved.

Previous bleaching protocols recommended performing a professional tooth cleaning, using micro brushes and abrasive diamond pastes prior to the bleaching process. This professional cleaning is performed to remove the extrinsic stains and surface fluoride-reach zone of enamel, which may reduce the effect of the bleaching agent on the tooth substrate.[14,27] However, using FBT limits the cleaning process to the stained areas only; this preserves the surface fluoride-reach zone, which plays a great role in caries prevention.

Furthermore, FBT decreases the biological, histological, and mechanical adverse effects of bleaching agents on tooth substrate. It also decreases the quantity of the bleaching agent, which consequently reduces the postoperative hypersensitivity, adverse effects on the pulp, and irritation of the mucosal tissues. Use of FBT also reduces the hazards of enamel cracking and infraction resulting from the non-essential application of the bleaching solution on the sound tooth areas. Studies have demonstrated that bleaching decreases the tensile and shear strength of the enamel surface.[28,29] Therefore, in cases of pitting fluorosis, which require a combination of bleaching and veneering treatments, FBT will help in maintaining good bonding to the bleached surface, due to the presence of remaining unbleached enamel surfaces.

FBT Protocol

The following section will demonstrate a step-by-step procedure for treating a clinical case of opaque fluorosis (combined with brown discoloration) using the FBT and guided with bleaching map **(Figs 1-4)**. Thirty percent hydrogen peroxide gel (WHITEsmile GmbH; Birkenau, Germany) was used and photo-activated with an LED photo-activation bleaching unit (DY410-B LED whitening light, Denjoy Dental; Changsha, Hunan, China). Region "a" was treated by applying bleaching gel three times successively for 20 minutes per application. Region "b" was treated by applying the gel twice (20 minutes each time). The gel was applied on region "c" just once for 20 minutes. Gel was not applied on the sound tooth surface of region "d."

Informed Consent and Professional Cleaning Process

In accordance with medical ethics, the entire treatment procedure should be discussed in detail with the patient; then a written informed consent should be signed by the patient before the initiation of treatment. This consent should include a statement that mentions the possibility of transient hypersensitivity of the bleached teeth and mild irritation of gingival tissues after treatment. It also should state that, if the patient's photographs are to be used in scientific publications or professional advertisements, they will be cropped to feature only the teeth. It also should state that the patient has the right to prohibit publication of these images. The stained areas of the discolored teeth should be selectively cleaned using a fine micro brush and dental prophylaxis cleaning paste without extending into sound tooth areas.

Treatment Planning

A standardized preoperative photograph should be taken 70 cm away from the patient at the level of the occlusal plane under ordinary white fluorescent light conditions (without using the dental unit light). This photograph will be used as the baseline of the treatment, and a raw photo for drawing the bleaching map **(Fig 1)**. The clinician should, for each tooth, carefully demarcate the normal tooth areas and mark them with the letter "d." Then, the most deeply stained regions should be marked with the letter "a." This should be followed by demarcating the moderately and intermediately stained regions with the letters "b" and "c," respectively **(Fig 2)**. Finally, the clinician should state the treatment plan for each tooth separately, determining the number of gel applications and the bleaching time for each specific discolored area **(Fig 2)**.

Definitive Treatment

Tissue-protecting measures should be taken; it is a well-established rule of bleaching and also recommended by the author to use a rubber dam and light-cured, resin-based gingival protectors. The bleaching agent should be applied on the target areas and then photo-accelerated using an appropriate photo-activation method. It is recommended to perform the bleaching in a multi-step process **(Fig 3)**, starting from the most discolored region (a) until reaching the intermediately discolored areas (c). After completing treatment, another postoperative standardized photograph should be taken under the same previously mentioned conditions and compared to the baseline photograph **(Fig 4)**. At this stage, the clinician should be able to determine the areas of persistent stain and decide whether another bleaching session is needed, taking into consideration the patient's satisfaction level. If the clinician decides to terminate the treatment, an anti-hypersensitivity gel should be applied on the tooth surface to reduce post-bleaching sensitivity. Finally, the patient should be given post-bleaching instructions and scheduled for a recall visit.

Figure 1: Preoperative view of a case of opaque fluorosis combined with brown discoloration treated with the "power focal in-office vital bleaching" protocol.

According to the bleaching map concept, every discolored tooth should be diagnosed and treated as a separate case, with careful monitoring of the distribution and degree of saturation of the stain as well as the regions of normal sound tooth structure.

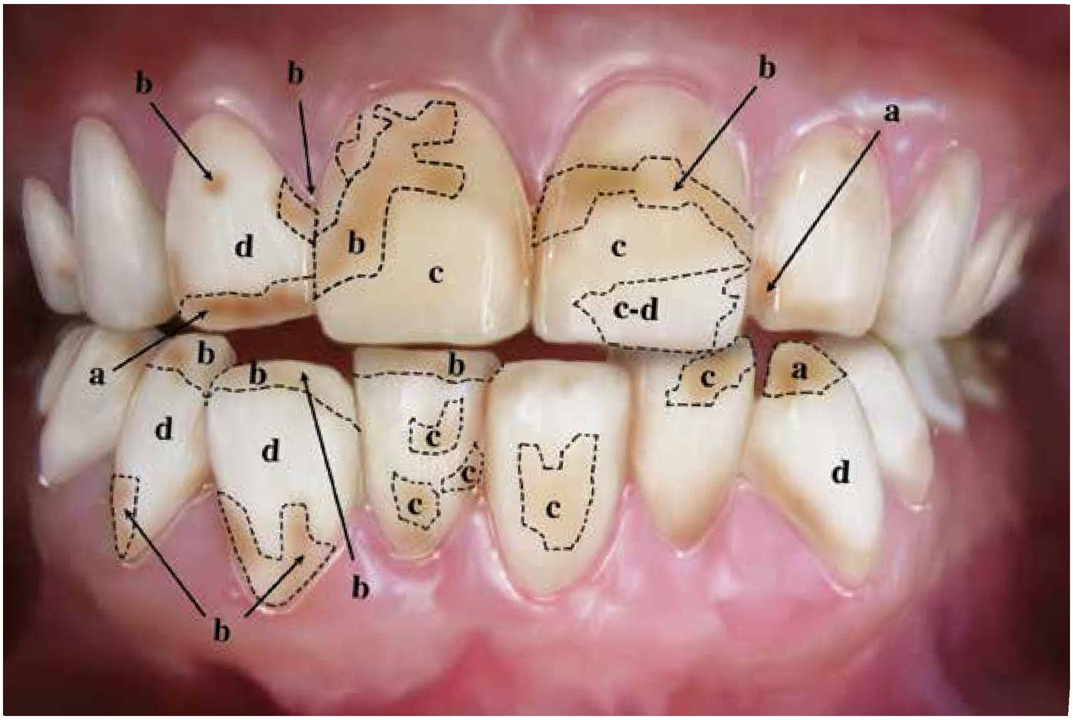


Figure 2: A "bleaching map" was drawn during the treatment-planning phase. (a) Deeply stained, (b) moderately stained, (c) intermediately stained, and (d) sound tooth regions.

> FBT decreases the biological, histological, and mechanical adverse effects of bleaching agents on tooth substrate.

Figure 3: A marked reduction of the stain can be observed on the deeply and moderately stained regions following the first step of the treatment, in comparison with the baseline stain.

Figure 4: Postoperative view of the treated case. The hand pointer shows a bleaching-persistent area; however, the patient's satisfaction rating for this result was 90%, and she preferred to terminate the treatment.

Challenges and Management of Persistent Stain Regions

Patients should be informed that the FBT does not guarantee a 100% success rate for removal of the stain; however, it can provide the maximum benefits with the least hazards. As with any other bleaching technique, the clinician should be able to determine the treatment endpoint, at which time the stain is considered persistent and an alternative form of treatment should be pursued. One of the acceptable alternative treatment modalities for bleaching-persistent areas is enamel microabrasion. This technique is performed by applying acidic water-soluble microabrasive gel (fine abrasive paste with hydrochloric [HCL] acid suspension) on the bleaching-persistent areas using silicone carbide rubber cups (or brushes) mounted to a rotary low-speed handpiece.[30-32] The low HCL concentration, fine abrasive particles, and gel nature of the microabrasion agent control the gel's flow and reduce its scratching effect on the enamel surface.[30]

Although microabrasion is a well-established technique, some authors refused to use enamel microabrasion. This may be due to its adverse effect on the enamel surface[33,34] and the consequences of confining its action to the most superficial enamel layer without penetrating the deep layers.[35] Therefore, the use of FBT preceding microabrasion can also restrict enamel microabrasion to the persistent areas only, which, consequently, reduces the hazards of applying the acidic abrasive gel on the intact sound tooth structure. If the persistent stains are not effectively removed via the aforementioned methods, a direct (or indirect) partial veneering should be the next line of treatment explored; this may achieve more satisfactory results. The selective bleaching protocol may be considered a time-consuming technique, particularly during the preparatory and treatment-planning phases, but this problem can be minimized with more training and practice. The standardization of photographs is another challenge. Therefore, the author recommends that clinicians who are interested in esthetically based treatments should enroll in courses to study the basic principles of dental photography.

Summary

The study discussed here revealed that using the focal bleaching technique (FBT), guided with a bleaching map, achieves better results than conventional bleaching methods. Also, the FBT can provide maximum treatment benefits with minimum risks.

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> "Use of FBT also reduces the hazards of enamel cracking and infraction resulting from the non-essential applica- tion of the bleaching solution on the sound tooth areas."

Dr. Hamama earned a Master of Dental Science degree in operative dentistry and endodontics from the Faculty of Dentistry, Mansoura University, Dakahliya, Egypt, where he also is an assistant lecturer in the Department of Conservative Dentistry. He can be contacted at hamdy@connect.hku.hk

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Analysis

Focal Bleaching Technique: Determining Stain Distribution by Creating a "Bleaching Map"

By Gary M. Radz, DDS, FACE

Today's in-office whitening treatments provide dental professionals with opportunities to enhance their patients' smiles in a minimally invasive way. They are fast, effective, and more comfortable for patients than earlier options. The bleaching map concept presented by Dr. Hamama, when used with a focal bleaching technique (FBT), can be an approach for planning the whitening process when regions of staining within a tooth are markedly varied, as well as when the level of discoloration is varied between teeth.

The FBT protocol described in the article for assessing areas of intratooth discoloration may benefit from the use of a combination of the subjective and objective tools available to determine tooth color. These tools also can be beneficial for measuring the extent of the whitening achieved from the FBT procedure, without risk of observer bias or fatigue.[1] Subjective tools include shade guides, and objective tools include spectrophotometry, which is a digital method for objectively assessing color change.[2]

Eliminating the influence of observer experience, external light, and the observer's physiological condition by using a combination of shade-taking methods likely could facilitate the accurate identification and differentiation between those areas of discoloration that Dr. Hamama terms "deeply stained," "moderately stained," and "intermediately stained." This is because spectrophotometry is not influenced by lighting conditions or user characteristics.

Accurately performing the bleaching map treatment planning tooth by tooth, as well as within a given tooth, will help to ensure the proper number of bleaching gel applications and correct light-activation times. Using the tools following the whitening procedure also will eliminate potential observer bias and provide a more accurate post-whitening shade change evaluation.

However, Dr. Hamama admits that FBT may be time consuming, and that, as with other tooth whitening methods, it may not be effective when treating persistent stains. Dentists may therefore wish to understand the optical properties of the stains being treated, as well as the mechanisms of action of the light-accelerated bleaching gel and the lights used to activate it. This will help to ensure that the appropriate gel is applied for an effective length of time, and is activated with a complementary light source for maximum effectiveness and patient safety.[2,3] **jCD**

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Dr. Radz is a clinical associate professor in the Department of Restorative Dentistry, University of Colorado School of Dentistry. Dr. Radz maintains a practice in Denver, Colorado.

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The 10 multiple-choice questions for this Continuing Education (CE) self-instruction exam are based on the article, "*Focal Bleaching Technique: Determining Stain Distribution by Creating a 'Bleaching Map,'*" by Dr. Hamdi H. Hamama. This article appears on pages 128-136.

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1. The key difference between the focal bleaching technique (FBT) and conventional bleaching is that

a. white demineralized areas will bleach faster and become whiter with the FBT.
b. conventional bleaching allows all shades of teeth to bleach equally well.
c. FBT seeks to balance the color between stained and normal tooth regions.
d. conventional bleaching only works on age-related tooth darkening.

2. The "bleaching map" employed with the FBT is used mainly to

a. review the treatment with the patient and lab technician.
b. show the patient areas that will not respond to treatment.
c. review the expected speed and outcome of the treatment.
d. guide the systematic balancing of color of the affected teeth.

3. When nightguard vital bleaching was introduced in 1989, the procedure was indicated for

a. dentist-supervised home bleaching.
b. chairside application of highly concentrated bleaching agents.
c. accelerated bleaching with the use of a specialized tray and a photo-initiator.
d. accelerated bleaching in-office using external photo-activation.

4. Incorporation of light-activation technology into dental bleaching techniques

a. decreases the harmful effects of bleaching agents but increases the treatment time.
b. decreases the harmful effects of bleaching agents and reduces the treatment time.
c. requires the use of a specialized custom tray and a photo-initiator.
d. increases the speed of both at-home and in-office power bleaching.

5. The goal of dental bleaching is to

a. remove or dilute the effect of intrinsic stains to the general shade of the tooth.
b. remove or dilute the effect of extrinsic stains to the general shade of the tooth.
c. reverse staining caused by the systemic intake of dark-colored beverages or smoking.
d. eliminate stains that cannot be removed via routine prophylactic cleaning.

To see and take the complete exam, log onto www.aacd.com.

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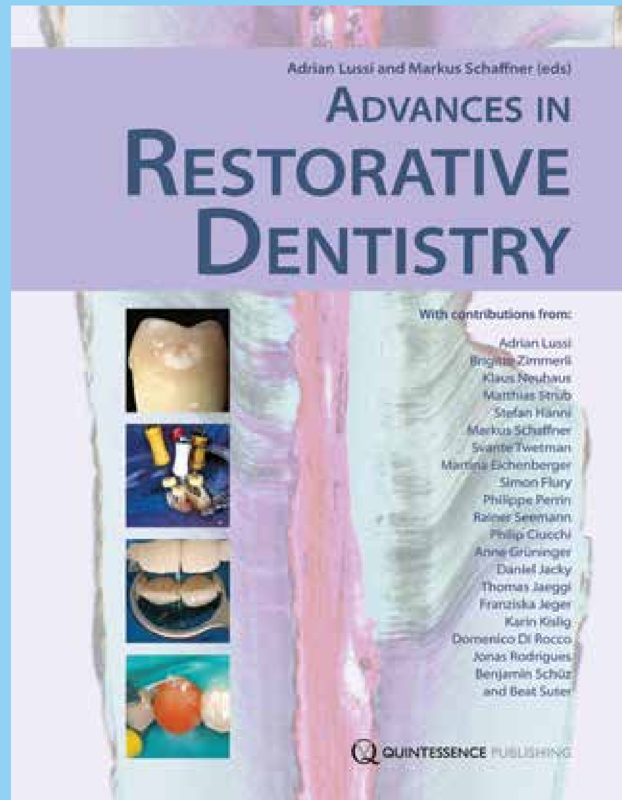

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Authors: Adrian Lussi, Dr.Med.Dent., PhD; and Markus Schaffner, Dr.Med.Dent.
Publisher: Quintessence Publishing

Advances in Restorative Dentistry offers an overview of current trends in preventive and restorative dentistry. It also addresses technologies that have been developed for a better understanding of biological principles and processes. The book focuses upon the following areas:

- structure and pathology of teeth
- aspects of prevention
- caries
- magnification aids in restorative dentistry
- damage to adjacent teeth with minimally invasive preparation
- bleaching
- dental erosion
- endodontology
- halitosis.

Numerous illustrations and highlighted key sentences are provided to make it easy to incorporate this knowledge into daily practice.

The authors take the above-mentioned areas and, with excellent illustrations and photographs, present a detailed account of the subject matter in a precise, easy-to-follow series of explanations.

Information about other areas of dentistry (e.g., periodontics, prosthodontics, oral surgery, implants) would have been helpful; however, these are addressed in other works. This particular book is as complete as it can be.

A Special Gift to *jCD* Readers:

Take advantage of a special offer from Quintessence Publishing! As an AACD member, you can receive a preview download of *Advances in Restorative Dentistry* and 25% off the regular price. Simply enter promo code JCD2013 at checkout. To take advantage of this discount, visit: http://www.quintpub.com/jcd/

Taking on Technology

Evaluations and Updates

Sabiha S. Bunek, DDS

Editor's Note: The information contained in this article does not imply endorsement from *jCD* or the AACD.

Taking on Technology

Technology is racing us into the future with advances that are helping to make dentistry more precise, productive, esthetically pleasing and, at the same time, more comfortable for the operator and patient. While this technological revolution is an exciting time for our profession, it continues to be confusing. Questions continually arise from clinicians, including the following:

- How does new technology change the way we practice dentistry?
- How do I know if I should invest in this technology?
- What problem does this technology solve?
- Sounds innovative, but is it really worth the investment?

The clinical consultants for *THE DENTAL ADVISOR* evaluate many products and different types of equipment, and have seen a number of innovations over the past few years. This article highlights a few of the recent innovations in technology that we find significant.

Figure 1: LED curing light (Bluephase Style).

Significant Innovations

LED Curing Light

Bluephase Style +++++ (Ivoclar Vivadent) (Fig 1)

Photoinitiator systems for dental resins have historically been based on camphorquinone (CQ). One downside of CQ is its inherent yellow color, which can lead to the "yellowing effect" of restorations.[1] As an alternative, many resins today are formulated with lighter photoinitiators, such as on trimethylbenzoyl-diphenyl-phosphine oxide (TPO) and phenyl-propanedione (PPD) **(Fig 2)**. It is important to note that CQ absorbs light in a different spectrum than TPO and PPD. Alternative photoinitiators absorb light in lower range than the wavelength emitted by most light-emitting diode (LED) curing lights. Therefore, curing resins containing alternative photoinitiators require the use of a broad-spectrum light for complete polymerization.[2]

The Bluephase Style LED curing light utilizes polywave technology, allowing it to achieve a broadband spectrum of 385-515 nm (similar to the spectrum of halogen lights). It polymerizes all current photoinitiators and materials on the market.

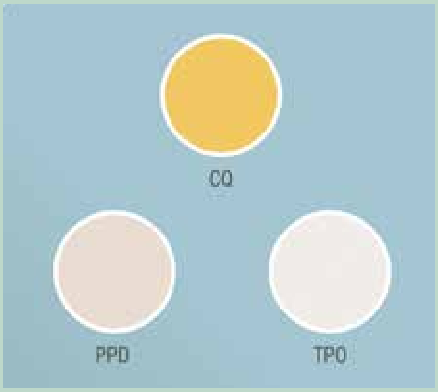

Figure 2: Camphorquinone is noticeably yellow when compared to other photoinitiators.

Therefore, there is no need to worry about incompatibility issues between your curing light and the resin material being used. Additionally, it is cordless, extremely lightweight, and ergonomic. The Bluephase Style was evaluated by 14 clinical consultants in more than 600 uses and received a 96% clinical rating.

> "Technology is racing us into the future with advances that are helping to make dentistry more precise, productive, esthetically pleasing and, at the same time, more comfortable for the operator and patient."

Handpiece

Midwest Stylus ATC +++++ (DENTSPLY Professional) (Fig 3)

Air-driven handpieces are capable of producing higher speeds than electric ones; however, when load is applied during use, stalling occurs.[3] The constant torque offered by electric handpieces overcomes this issue but some clinicians still have not made the jump to the newer technology, mostly due to the higher initial cost or the weight of the electric handpieces.[4]

The Midwest Stylus ATC has been around for several years, but the technology is still worth noting. It is a high-speed, air-driven handpiece but electrically controlled.[5] The speed-sensing intelligence (SSI) technology automatically optimizes power to virtually eliminate stalling without having to be monitored. It has the ability to adjust the speed when the bur is not under load to minimize wear on the bearings. The benefit to the dentist is the power of an electric handpiece only when you need it, with the size and weight of an air-driven one. Midwest Stylus ATC was evaluated by seven editors, and received a 96% clinical rating.

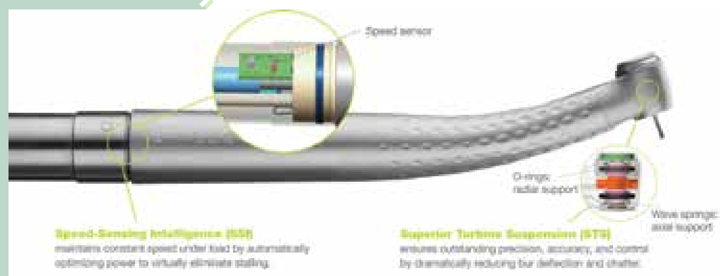

Figure 3: Handpiece (Midwest Stylus ATC).

Caries Detection

The Canary System (Quantum Dental Technologies) (Fig 4)

With current standards for detecting tooth decay (visual, manual probing, x-rays),[6] identifying early carious lesions that are below the surface is virtually impossible. The introduction of fluorescence-based caries detectors has been useful as an adjunct tool in early diagnosis but there are still some shortcomings with these systems (e.g., false positives, technique sensitivity, and inability to detect interproximal or decay around existing restorations).[7]

The Canary System is the newest caries detector on the market, and is used for early detection and monitoring of tooth decay on smooth enamel root, and occlusal and interproximal surfaces, as well as around existing amalgam and composite restorations. No isolation is necessary and stain or calculus will not affect the reading. The Canary System is unique in that it combines both laser luminescence (light), seen with many caries detectors, and photo-thermal radiometry (heat), enabling it to detect decay as deep as 5 mm inside the tooth. *THE DENTAL ADVISOR* is currently evaluating this technology, which looks promising. We will publish the report in a future issue.

Figure 4: Caries detection (The Canary System).

Resin Technology

SonicFill (Kerr Corp.)

Layering composite in 2-mm increments can be time-consuming and tedious. Fortunately, in the last two years, manufacturers have brought bulk-fill composite materials to the market to help simplify the restorative procedure. While SonicFill is not new to the market, it does represent a technology that has not been duplicated by its competitors.

SonicFill remains the only sonic-activated bulk fill material on the market, allowing for a bulk fill up to 5 mm in one step. It is only one of two bulk fill composites on the market that is strong enough to be used as a single posterior restorative. Its low viscosity allows for better adaption and the sonic activation minimizes voids in the composite.[8] Although *THE DENTAL ADVISOR* did not evaluate this product, our Biomaterial Research Center confirms the depth of cure can be achieved to 5 mm with this material.[9]

Digital Dentistry

Intraoral Scanners and Mills

Digital dentistry is continuing to gain acceptance. The actual scanning process has not undergone major advances but the hardware and software have, making them more appealing to the user. These technologies will continue to develop and allow more versatility for milling in-office and utilizing a laboratory. Below is a recap of some of the advances with digital impressioning systems we have seen in the past year.

- **3M ESPE:** At the end of 2012, 3M launched its new scanner, True Definition. Improvements from the previous model include open architecture, smaller wand, and a price point that was about half of all the other scanners on the market. 3M has also partnered with D4D Technologies to have a full chairside CAD/CAM solution through integrations with the E4D Design Center and E4D Mill.

  Sirona Dental Systems: Last year at the CEREC 27.5 meeting, Sirona announced that its new scanner, Omnicam, would be powder-free, utilize streaming capture, and render full-color models. Sirona now offers multiple options to clinicians, from chairside impressions only to a scan and mill model: CEREC AC, CEREC Omnicam, and Apollo DI. Three different mill options are also available.
- **Glidewell Laboratories:** The IOS FastScan wand was released last year. It uses laser line scanning, making it the only digital scanner that stays stationary in the mouth. The FastScan probe rests on teeth, and a 40-mm scan is completed in two seconds. Glidewell has also introduced the TS-150 for in-office milling.
- **Carestream Dental:** At the California Dental Association meeting in Anaheim this year, Carestream introduced the CS 3500 intraoral scanner. This system does not require powder, produces 3-D color images, and can be plugged into designated computers via USB cable. The CS 3000 mill will be introduced this fall for in-office milling.
- **3Shape:** At the 2013 International Dental Show in Cologne, Germany, it was announced that the powder-free TRIOS intraoral scanner would scan in color. TRIOS Pod was also introduced as a portable solution—a wand that can be hooked up to an iPad or other integrated monitors.
- **D4D Technologies:** The NEVO Design Center was recently launched, offering a newly designed E4D camera, as well as an option for portability. The Nevo scanner can be utilized with a powerful laptop, eliminating the need for a cart system.

Impression Material

Flexitime Fast & Scan ++++(Heraeus)

Although *technology* typically is thought of as relating primarily to high-technology "gadgets," there are many innovations that are related to products and materials. As technology changes and evolves, products are developed to complement these new environments.

Flexitime Fast & Scan is one of the first impression materials optimized for digital dentistry. For those who are sending impressions to a laboratory, this material is easily scanned for fabricating a restoration. In cases where intraoral scanning is difficult, Flexitime Fast & Scan can be used with chairside CAD/CAM systems to scan the impression and mill the restoration **(Fig 5)**. Twenty-eight consultants used Flexitime Fast & Scan, and it received an 86% clinical rating.

Interactive

Patient Education

Smile Guide Touch ++++1/2 (Digident) (Fig 6)

This is an interactive app for an iPad designed to simply present treatment options to patients. One challenging area in case presentation is how to accurately represent a case to patients using complex imaging software or a combination of diagnostic wax-ups and digital photographs. Smile Guide Touch is easy to use and allows a clinician to quickly show a patient the difference cosmetic dentistry will have on their smile. Smile Guide Touch was evaluated by 17 consultants and received a 91% clinical rating.

Summary

To conclude, as product and equipment evaluators for the dental profession, *THE DENTAL ADVISOR* clinical consultants are on the front lines of testing innovations and determining their application to dentistry, as we know it now, and in the future.

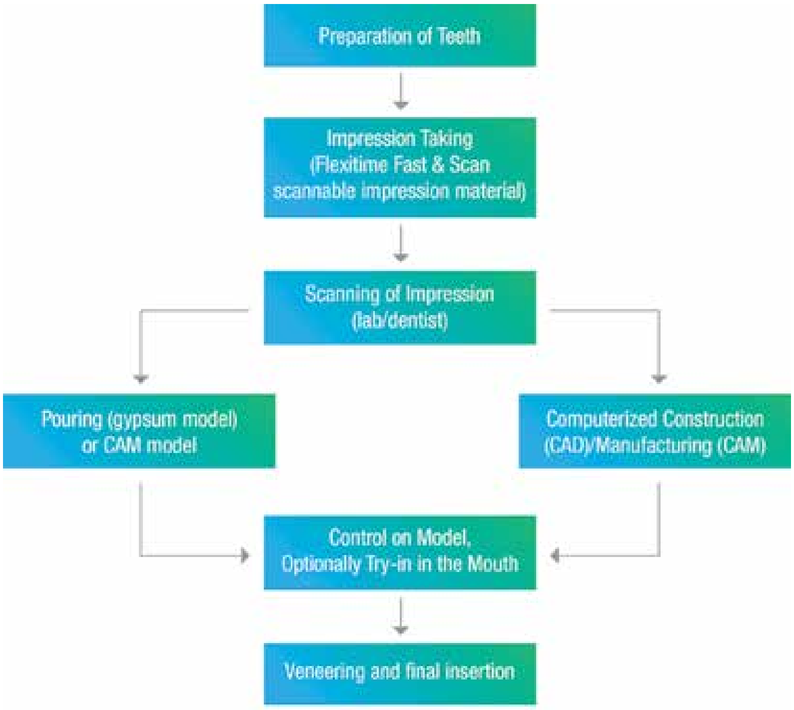

Figure 5: Digital workflow with scannable impression material.

Figure 6: Patient education (Smile Guide Touch).

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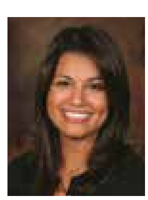

Dr. Bunek practices in Ann Arbor, Michigan. She is the editor-in-chief of *THE DENTAL ADVISOR*.

Disclosure: *THE DENTAL ADVISOR* conducts unbiased clinical/evidence-based evaluations based upon how a dental product or equipment performs in a general dentistry practice. Products are sent to a randomly selected group of 20-30 unpaid clinical consultants. The clinical consultant and his or her staff integrate the product into their daily routine, use the product regularly over a given period of time, and then complete a survey regarding the product.

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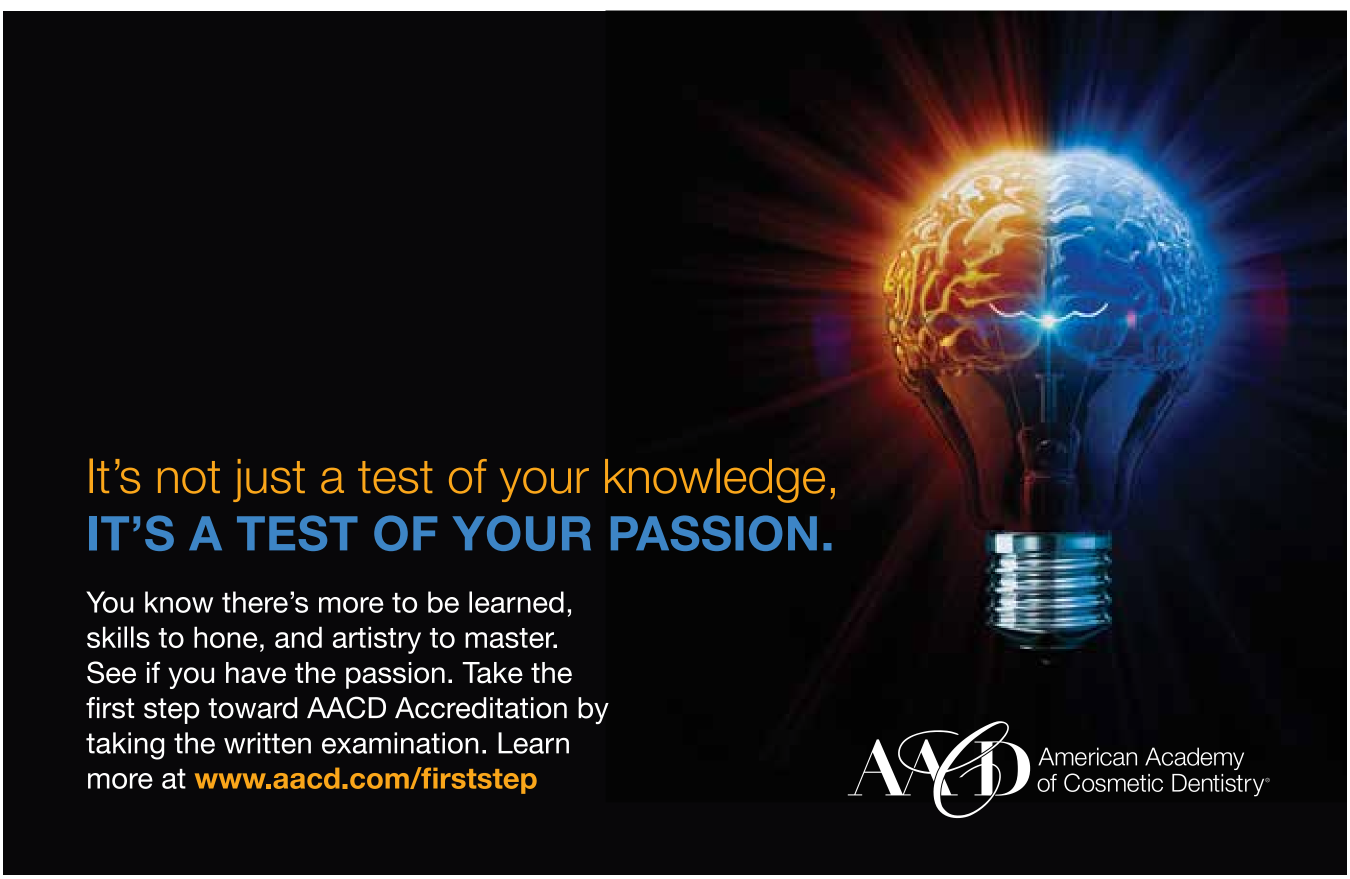


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