INTRODUCTION
How do we, as clinicians, meet the challenge to continually maintain competence in a constantly changing technological environment? How do we leverage new technologies to simultaneously improve the predictability of successful patient outcomes and increase profitability? When do we recognize that a technology-driven protocol offers enough improvement to justify the initial increased cost and learning curve necessary to adopt that procedure into a practice?

Digital Smile Design (DSD) is a technological breakthrough that can improve patient and laboratory communication, increase case acceptance, and provide a more predictable protocol for a successful cosmetic outcome. However, DSD is not simple and requires collaboration with a master ceramist for the vision to be brought to life. The ceramist also must have digital fabrication workflows in place.

This author admits to not being technologically savvy, yet has successfully incorporated these techniques into daily practice. This case report will serve to explain state-of-the-art real-time digital design, linking 3-D prosthetic planning with fundamental principles. In addition, this article will present proven communication techniques and outline the specific procedural steps, from diagnosis to wax-up to the final fabrication and delivery of the completed ceramics.

CASE REPORT
Diagnosis and Treatment Planning
A 34-year-old female patient presented for a functional and aesthetic assessment of her dental condition. She received a comprehensive exam, full-mouth series of radiographs, and a periodontal evaluation and diagnostic photos. Her medical history indicated that she had esophageal reflux, which was controlled with an over-the-counter medication. A clinical evaluation revealed a canted and gummy smile, with her right vermillion border being more apical than that on her left with a full smile. Her teeth were yellow, rotated, eroded, and chipped (Figure 1). Many teeth exhibited cupping (Figure 2), indicating that the erosive component was outpacing the frictional damage. She presented with a deep bite, a hypermobile lip, and a vertical maxillary excess.

A treatment plan that included orthodontics and orthognathic surgery was presented. This was refused by the patient as she was seeking a simpler, quick solution to her situation. Since the gingival levels needed to be equalized in order to attain harmony, she was referred to the periodontist, and crown lengthening was planned.
A digital design for a surgical template was fabricated from polymethyl methacrylate (PMMA) to guide this surgery, and a wax-up for the provisional composite prototypes was created. Records, including a face-bow and bite sticks, were taken for communication to the ceramist.

**Digital Smile Design**

The ceramist uses a natural smile photo and identifies landmarks on the photo and correlates this with the same landmarks on the digital design. It is critical that the photo is taken with the patient looking straight into the camera lens with a big smile, allowing the best evaluation of facial landmarks (Figure 3). Custom templates of tooth libraries that have various shapes and styles are then evaluated. Using Keynote software, they are placed over the preoperative smile. Adjustment and fine-tuning by the user (ie, the ceramist) occurs until initial design for treatment communication in 2 dimensions is completed. This has been considered state of the art for many years (Figure 4). With the integration of full 3-D digital designs, using software programs (such as the 3Shape Dental System), these 2-D images can be entered as overlays into the actual 3-D design. The translucency of the design can be turned up or turned off (Figure 5). This allows analysis of the relationship between the design proposal and the original preoperative condition.

![Figure 3. A straight, big smile allowed for facial landmark identification for Digital Smile Design.](image)

![Figure 4. In Keynote, templates were chosen and modified for initial design in 2-D.](image)

![Figure 5. Design overlay was placed in 3Shape Dental System. Translucency can be turned off, allowing analysis of pre-op and digital design proposal.](image)

![Figure 6. Design proposal showing where crown lengthening needed to occur.](image)

This case clearly showed the areas that needed to be crown lengthened during the periodontal surgery (Figure 6). Moving these digital prototypes into the full-face photo using the same landmarks executes a virtual try-in (Figure 7). The ceramist and the dentist can communicate via email or TeamViewer in real time. Once agreement has been reached, the PMMA overlays are milled and fit to the model. Contours and surface morphology can be refined by hand at this point. It is also possible to mill the same file out of a white wax and
glue it to a second model as a diagnostic wax-up. The milled PMMAs can be used as an aesthetic preview to help visualize what would be possible with complete treatment. They can also be used as a template to guide the periodontist in the crown lengthening procedure. It is important to note that this design is done prior to surgery, so after the gingival remodeling of periodontal surgery has been completed, the milled wax-up would need to be fit to a new model exhibiting the final gingival position (Figure 8). This can be done by hand, with milled wax from the previous design, or a new diagnostic wax-up can be completed post-surgery.

**Preoperative Try-In**

The accuracy of the digital design technique was evaluated and verified by placing the templates over the facial of teeth Nos. 4 to 13. When the template was positioned correctly, it was noted that tooth No. 11 extended apically beyond the template. Crown lengthening on tooth No. 6 was the treatment selected to correct this height discrepancy. To communicate the desired position to the surgeon, a black marker was used as a reminder that no gingival tissue was to be removed in this area (Figure 9). This also aids in verifying the height of tooth No. 6 when equalizing the right and left canine height.

![Image 1](image1.png)

**Figure 7.** Digital prototypes placed in full-face photo for virtual try-in and communication between ceramist and dentist.

![Image 2](image2.png)

**Figure 8.** In order to create provisional prototypes at the preparation appointment, milled wax from the previous design must be fit to a new model that exhibits the final post-op gingival position.

![Image 3](image3.png)

**Figure 9.** Verifying polymethyl methacrylate surgical template accuracy. (Note canine height discrepancy.)

![Image 4](image4.png)

**Figure 10.** First surgery: template height guided the surgical incisions.

**Surgical Protocol**

The surgical template was positioned intraorally to guide the crown lengthening surgery. The template provided the surgeon with the specific tissue heights that would be necessary for a successful outcome. Incisions were made with a No. 15c Bard-Parker blade to match the length created in the digital design phase and...
communicated through the surgical template (Figure 10). Once the tissue was removed from teeth Nos. 6 to 11, the bone level, relative to the new gingival tissue height, was assessed. Osseous reduction was accomplished in that segment with a flapless approach using a piezoelectric bone surgery unit (Piezosurgery Touch [Piezosurgery Incorporated]).

Tactile sensation combined with visual feedback facilitated removing the amount of bone necessary to provide a 3.0 mm distance from the newly created gingival margin to the osseous crest. The bone was thin, allowing for easy removal with very little heat generation. Using this technique, no sutures were necessary in the anterior, providing an aesthetic benefit to the patient postoperatively. In the posterior segments, the bone was deemed too thick to utilize a flapless approach. Thick bone is a relative contraindication to the technique described above, as it is easy to leave a lip of bone resulting in a crater. Further, heat generation can more readily become an issue in a flapless environment when there is thick bone present. Resorbable sutures were used in the posterior to replace the flap.

**Porcelain Preparation**

At the post-op evaluation appointment, gingival harmony and symmetry were confirmed (Figure 11). Of course, the previously noted hypermobile asymmetrical lip display on a full smile was still present. The preparation appointment was then scheduled.

The patient presented with rotated laterals and an enamel deficiency on both the facial and lingual surfaces of the teeth due to erosion. This necessitated a choice for full-coverage restorations to augment this biostructurally compromised dentition.

![Figure 11. Surgery final: verification that contra-lateral gingival harmony was attained.](image1)

![Figure 12. Circumferential loss of enamel dictated full-coverage prep design. Note the stump shade differences.](image2)

Local anesthetic was administered. The provisional addition silicone (Siltech [Ivoclar Vivadent]) stint, fabricated from the digital design, was filled with a bis-acryl temporary material in a bleach shade (Luxatemp Automix Plus Bleach [DMG America]) and placed in the mouth. The patient previewed and then approved this direct prototype. Depth cuts were placed using diamond depth-cut burs (Brasseler USA RWMIN.3/.5/.7) across the gingival and middle third to establish the amount of facial reduction. Then incisal edge depth cuts were
placed to ensure 2.0 mm removal of enamel from the desired postoperative incisal edge.\textsuperscript{3,4} A modified shoulder (Brasseler USA BR8847KR.016) preparation was done with the margins placed at the free gingival margin. After completing the preparations, a face-bow (Panadent), MIP bites (Megabite [DenMat]), bite sticks, and vinyl polysiloxane (VPS) impressions (Take 1 Advanced [Kerr]) were done. Stump shade (shade of the prepared tooth structure) documentation (Figure 12) was also done as another important part of the communication with the ceramist. The bis-acryl provisional restorations were then fabricated and documented with photographs.

The patient returned 2 days later for an aesthetic re-evaluation and an occlusal analysis. The right side prototypes were noted to be slightly different than the left in outline form, length of the lateral, and the shape of the incisal embrasures. She was unsure of which side she preferred, so a second re-evaluation was scheduled for one week later. At that time, a detailed laboratory prescription with shape, form, incisal translucency, and surface texture was created. Photos and impressions/models were taken of the approved provisionals along with new face-bow records and bite. These were then delivered to the ceramist for digital design of the definitive porcelain restorations.

**Digital Design of Porcelain Restorations**

Photo orientation is critical to aesthetic digital design. The patient must be looking straight at the camera while displaying a full smile. This photo is imported into the design software and a level horizon is defined using the interpupillary line. The software then levels the image, and additional parallel lines are added to evaluate gingival symmetry and incisal plane. These lines greatly help in the evaluation of the orientation of the composite prototypes and diagnose any desired changes to be made in the definitive porcelain restorations. In this case, the ceramist noticed that the provisionals canted slightly to the patient’s left and the gingival levels were more canted and apical on the patient’s left as well. The incisal plane appeared higher on the left and lower on the right (Figure 13). The patient’s facial image was then synched to the digital scan by distinguishing landmarks common to the photographs and the digital scan. The restorative design was superimposed on the facial image. The design was then modified and developed to optimize integration of facially generated aesthetics and function for the definitive lithium disilicate (IPS e.max [Ivoclar Vivadent]) restorations (Figure 14).

**Figure 13.** Image was leveled to interpupillary line followed by addition of parallel lines to evaluate gingival symmetry, incisal plane, and vertical midline.

**Figure 14.** Landmarks synched patient’s image to digital scan, followed by previewing of porcelain design superimposed into the facial image.
Anterior palatal anatomy dictates form and function. By using an adjustable virtual articulator, mimicked from the real world, we were able to evaluate and optimize the functional envelope prior to milling (Figure 15). An image showing the provisional in blue and the final design as a translucent overlay aided in analysis of how closely the provisional adhered to the position of the final restorations (Figure 16). Small corrections could be made to midlines, incisal edges, and contralateral symmetry. These discrepancies were noted by the patient, and she asked for the appropriate corrections in the final restorations. The dentist, prior to milling of the restorations, approved the final digital design.

A Multi Ingot BL2 (Ivoclar Vivadent) was chosen by the ceramist in order to obtain the final color of 010-020, chosen by the patient. The digital design can be either milled in ceramic or it can be milled in wax to allow pressing of the restorations. Milled wax requires a traditional lost-wax casting process, which is more labor intensive than milled ceramic, but it has a few advantages. Wax can be milled and pressed much thinner than ceramic can be milled, which was not a factor with this patient. However, the Multi Ingot BL2, which had the ideal optical properties for this patient’s needs, is only available in pressable ingots and not in millable ceramic blocks, so the case was milled in wax and pressed.

After the wax was milled, it was checked for fit and contour on the model and any hand finishing needed could be completed at this time prior to pressing. After pressing, the restorations were fit back to the model where minor contour adjustments and final surface morphology were created. The restorations were selectively cut back for any desired effects that needed ceramic layering. Although the Multi Ingots have some incisal translucency, cutting back just the facial-incisal area and creating some additional effects with a traditional “ceramist with a porcelain brush” technique created additional natural translucency (Figure 17). The Multi Ingot family is good at covering moderately discolored restorations due to its increased opacity in the gingival one third. And yet, this ingot requires little, if any, layering with its more translucent incisal third. The overall result of less layering is a stronger all-ceramic restoration. This is because a much higher percentage is composed of the 400 MPa LiS2 pressed lithium disilicate material and a very low percentage is made up of the weaker (100 MPa) layering ceramic. Internal effects were layered into the incisal area with powdered ceramics. The basic color of the ingot while seated on a composite die to replicate the effect of the underlying tooth color was evaluated and modified via staining. Final contour, glaze, and polish were accomplished and the restorations were delivered to the dentist (Figure 18).

Delivery Appointment
The 10 maxillary lithium disilicate (e.max) full-coverage crowns (teeth Nos. 4 to 13) and 4 mandibular (teeth Nos. 23 to 26) lithium disilicate (e.max) veneer restorations were placed intraorally for aesthetic evaluation using try-in gels (Variolink Esthetic [Ivoclar Vivadent]). Once approved, the restorations were removed and
cleaned by applying a universal cleaning paste (Ivoclean [Ivoclar Vivadent]) to the internal surfaces, then rinsed with water. The intaglio surfaces were then treated using a universal primer (Monobond Plus [Ivoclar Vivadent]), the (mandibular) teeth were etched (SELECTIVE HV ETCH [BISCO Dental Products]), and a bonding adhesive (ALL-BOND UNIVERSAL [BISCO Dental Products]) was applied. Next, the maxillary crowns were bonded into place with using Variolink Esthetic (dual-cured) and the lower veneers were cemented in using Variolink Esthetic (light-cured).

**Figure 17.** Multi Ingot BL2 (IPS e.max [Ivoclar Vivadent]) was cut back on the incisal facial to allow room for layered ceramic and produce internal effects.

**Figure 18.** On composite die for verification of color, surface texture, and translucency.

**Figure 19.** Post-op note: crooked smile, contralateral gingival harmony, and lifelike emergence profiles, tooth contours, and color.

**Figure 20.** Exceptional dentofacial results using 3-D prosthetic planning.

The occlusion was evaluated by having the patient close into maximal intercuspation to verify that all posterior
teeth displayed bilateral and simultaneous forces. Movement in all excursive directions was also evaluated. The software had identified areas where occlusal clearance was minimal and the maxillary lingual porcelain was fabricated thin. Adjustment occurred by recontouring the opposing mandibular porcelain.

With the patient sitting up, thick blue articulating paper (Bausch) was placed and the chewing cycle was mimicked. Lateral streaks on the canines were maintained and all lateral streaks on the posterior teeth were removed. All streaks on the lingual of the central incisors in the chewing envelope were carefully adjusted along with the facials of the lower incisors with evaluation from a frontal perspective so the aesthetics and length were preserved. Sibilant sounds were verified and no lisp was present. Finishing and polishing of all surfaces of ceramic (Dialite [Brasseler USA]) was completed, then post-op photos (Figures 19 and 20) and records for Essix retainers and a maxillary flat plane occlusal splint were taken. (Note: The patient had reported intermittent, nocturnal bruxism and still wants to ensure longevity of her restorations.)

CLOSING COMMENTS
This case displays a state-of-the-art technology that can alter the way a dentist performs even a familiar and otherwise successful procedure. An evaluation of clinical parameters will prevent problems before their occurrence. The technology allows corrections to be made during the procedure and before cementation, because errors will become visible in the provisional design. The final outcome is more aesthetic, functionally sound, and shows improved longevity and predictability.

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References


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Predictably Successful Endodontics

Introduction

Dr. Herbert Schilder used the title “Predictably Successful Endodontics” to describe many of the lectures he gave during the course of about a 40-year timeline. In the most simple and direct way, these words promise long-term treatment success that is not only possible but also attainable. Central to predictably successful treatment are those factors that serve to influence the retention of critically essential teeth. In the present state of endodontic development, the mechanical steps to achieve predictably successful results include access preparation, glide path management, shaping canals, 3-D disinfection, and filling root canal systems (Figure 1).

Perhaps the most important factor that serves to influence clinical treatment success is to recognize that pulpal degeneration occurs within an oftentimes complex anatomical space. Pulpal breakdown and disease flow occur along anatomical pathways and generally move in a coronal to apical direction. Secondary to pulpal breakdown, a lesion of endodontic origin (LEO) forms in the bone adjacent to a portal of exit. 1 In virtually all instances, LEOs will heal following endodontics because, like the extraction, clinical treatment is directed toward eliminating all the pulp, bacteria when present, and their related irritants.

Figure 1. This collage of post-treatment endodontic images shows the results and importance of treating root canal systems.

Another factor influencing success is the often misunderstood concept of minimally invasive endodontics (MIE). 2 Specifically, there has been a one-sided clarion call for dentists to cut small-sized access cavities, or to minimally shape canals, or to not shape canals whatsoever. Yet, the quintessential goals of clinical endodontics are to eliminate all organic substrate and fill root canal systems. With the current technology available, these essential goals require preparation of well-shaped canals that, in turn, promote 3-D cleaning and filling root canal systems (Figure 2). This article will focus on the current concepts for cutting access cavities and shaping canals in the context of balancing the endodontic objectives with the concept of MIE.

Endodontic Access
The goal of the endodontic cavity preparation is to gain access to the pulp chamber and the underlying root canal system. Endodontic access is the first mechanical step that will significantly influence a series of subsequent steps that serve to guide each case to a successful conclusion. With a thoughtful plan, the mechanical objectives are to penetrate, funnel, and create straight-line access to any given orifice. Upon identifying an orifice, the internal axial walls should be flared, flattened, and finished. Importantly, coronal interferences are eliminated to improve radicular access.

Figure 2. A 30-year recall image of teeth Nos. 12 and 14 (palatal root) reveals predictably successful interdisciplinary treatment results.

Figure 3a. A clinical photograph shows the orifices of these shaped canals smoothly blending into the axial walls of this funneled and finished access preparation.

Figure 3b. A 20-year recall image demonstrates 3-D endodontics and a protective restoration promoting long-term success.

Figure 4. This post-treatment film reveals flowing multiplanar shapes to length. Note the 6 filled furcal and apical portals of exit.

Figure 5. This animation shows the ProTaper Sx (DENTSPLY Tulsa Dental Specialties) file brush-cutting on the outstroke. The inset image emphasizes relocating the ML canal away from furcal danger.
Figure 6. This µCT image reveals a third system originating off the anastomosis between the MB1 and MB2 canals. *(Courtesy of Dr. Frank Paqué; Zurich, Switzerland.)* My 25-year recall of the buccal roots of tooth No. 3 depicts similar MB root anatomy and the long-term outcome of interdisciplinary treatment.

Figure 7a. This µCT image shows a maxillary central incisor root canal system *(Courtesy of Dr. Frank Paqué; Zurich, Switzerland.)* My pre-op film reveals an endodontically failing anterior bridge abutment. Note a gutta-percha point tracing a sinus tract to a laterally positioned lesion of endodontic origin.

Figure 7b. The left post-treatment image shows the importance of treating root canal systems. The right image is a 22-year recall showing the inevitable potential for healing following complete treatment.

Figure 8a. My 1983 pre-op radiographic image reveals coronally broken down and endodontically involved teeth.

Figure 8b. A µCT image of a maxillary first bicuspid shows 3 systems and an anatomically broad isthmus between the
Nos. 5 and 6. Buccal and lingual canals (Courtesy of Dr. Frank Paqué; Zurich, Switzerland.) My post-treatment film reveals the buccal and lingual systems are joined by a deep and broad isthmus that extends to mid-root. Note the buccal and lingual canals bifurcate at mid-root and the lingual system bifurcates in its apical one third.

Figure 8c. A 27-year recall film in 2010 demonstrates predictably successful interdisciplinary results.

An effective access preparation allows files to be easily inserted directly into orifices, reagents to be strategically dispensed, and, regardless of the obturation method, root canal systems to be filled. In furcated teeth, the access preparation is widest on the cavo surface of a tooth and progressively funnels toward the pulpal floor. All unsupported dentin and enamel should be removed, as leaving this hard tissue has not been shown to strengthen teeth. Leaving trapped tissue, debris, or residual sealer within the access preparation is known to contribute to staining and discoloration of the clinical crown following treatment.

The goals of endodontic access and the concept of MIE are compatible and should coexist. Namely, access cavities should not be needlessly restrictive or excessively large; rather, the outline form and preparation should be just right. Ideally, access objectives are confirmed when all the orifices in furcated teeth can be visualized without moving the mouth mirror (Figure 3). The concept of MIE encourages maximizing healthy tissue, but—and this is most important—MIE does not mean compromising the endodontic treatment goals. To use an automotive analogy, it is illogical to repair a car’s engine through the tailpipe, rather than simply lifting the hood. A restrictive access preparation compromises finding orifices and effectively treating underlying root canal systems. Further, when the access preparation is too small, it becomes needlessly difficult to place files, instruments, and devices into underlying canals, or to visualize internal fractures and their extent of propagation. Histological evidence demonstrates that eliminating coronal interferences serves to protect dentin on the furcal side of multirooted teeth.

Working through a restrictive access preparation elevates frustration and serves to compromise each and every subsequent step that comprises start-to-finish endodontics.

On the other hand, access cavities that are prepared too big structurally weaken natural or restoratively revised crowns and contribute to fractures and the premature loss of teeth. Overprepared access cavities, with or without internally gouged axial walls, weaken tooth structure. Irregular axial walls compromise vision and frequently make it more difficult to insert instruments into any given orifice because of an iatrogenic ledge within the access cavity itself. In the instance of multivisit endodontics, provisionalization may become...
compromised in access preparations that exhibit reverse funnels.

Neither modern-day endodontic practice nor the concept of MIE dictate which rotary cutting bur, diamond, or ultrasonically driven instrument should be used to initiate, rough-in, or competently finish any given access preparation. When preparing the access cavity, serious clinicians recognize that it is not the type of bur that is most important. What is most important is that the clinician understand the access concept, recognize the orientation between the crown and root, and appreciate the relative position of the pulp chamber from tooth to tooth (Figure 4).6

Anatomical examination of the coronal-most aspect of virtually all canals in furcated teeth consistently reveals they are not centered within the mesiodistal dimensions of roots. Rather, the coronal-most aspect of these canals are positioned closer to the furcal-side concavity of the root. The clinician should deliberately use a brushing motion, on the outstroke, to eliminate triangles of dentin and intentionally relocate this aspect of the canal away from external root concavities (Figure 5). Histological evidence demonstrates that removing triangles of dentin results in more radically centered final preparations, which, in turn, makes teeth more fracture resistant.5,7

Protecting furcal-side dentin comes at the expense of selectively removing cervical dentin. Restorative dentistry has identified the biological, mechanical, and aesthetic guidelines required for any coronal preparation, which are based on the material utilized. Experienced dentists appreciate that, in the instance of full coverage, the buccal and lingual aspects of a circumferential ferrule are superior at resisting vertical and lateral occlusal loading than the mesial and distal aspects of the ferrule. The concept of MIE recognizes the importance of maximizing furcal side dentin, which protects against weakening roots, strip perforations, and longitudinal fractures.

Endodontic Canal Preparation

The mechanical necessity for preparing or shaping canals has long been recognized as an essential step in endodontic treatment. Yet, the concepts concerning the role of canal preparation have differed markedly based on the development of endodontics at any given point in time. During the past decades, root canal preparation has been described in different ways, including instrumentation, biomechanical instrumentation, and chemomechanical instrumentation. Each has something to offer, has been described in its own way, and is intended to forward the thinking and actual manner in which root canals are prepared. However, none of these instrumentation concepts convey the actual objectives of root canal preparation.

In 1974, Dr. Schilder precisely described the mechanical objectives for preparing a canal that, when fulfilled, would ensure the biological goals for long-term success.8 It is noteworthy that these objectives were published long before any proposal of the more contemporary concepts of minimally invasive dentistry and, more recently, MIE. The paradox for dentists is, whereas the Schilderian objectives have undergone rigorous scientific and clinical scrutiny for more than 40 years, MIE is a concept that has yet to be defined, has no clinical guidelines, and is currently being exploited with virtually no published scientific evidence.

Shaping refers to the conscious development of a preparation that is unique, specific, and appropriate for any given root canal and its corresponding root. Schilder used the expression “the look” to describe any well-shaped canal that appropriately enlarges, mechanically reproduces, and flows with the original anatomy of the root canal (Figure 4). Shaping canals creates sufficient space to hold an effective reservoir of irrigant that, upon activation, can penetrate, circulate, and digest tissue from the uninstrumentable portions of a root canal system.9 Histological μCT images emphasize the importance of shaping canals, which, in turn, facilitates the exchange of irrigants, 3-D cleaning, and filling root canal systems (Figure 6).10

Just like the endodontic access preparation, any given canal can be underprepared, overprepared, or prepared
just right in accordance with Schilderian principles. Histological examination of endodontic failures routinely demonstrate that underprepared canals, although instrumented, are neither shaped nor cleaned (Figure 7). Underprepared canals limit the effective exchange of irrigant into all aspects of the root canal system. Certainly, underprepared canals harbor residual pulpal remnants, oftentimes bacteria and debris that continue to be a major cause of post-treatment disease. Universally, underprepared canals rarely exhibit filled root canal systems. On the contrary, overprepared canals violate both the mechanical objectives of canal preparation and the concept of MIE. Coronally overprepared canals weaken roots, predispose to hopeless fractures, and invite strip perforations. Contrary to what has been reported, the Schilderian shaping objectives do not obligate dentists to make round canals in irregular cross sections, nor do they command dentists to shape canals to the radiographic apex (a frequently misused term). Further, there is a misunderstanding regarding preparing a canal to a continuous taper.

Virtually all nonmanipulated canals exhibit natural taper over their length. As such, good shaping techniques reproduce this original anatomical form, emphasize deep shape, and consciously focus on a more conservative tapered shape in the body of the root. More than a decade ago and long before the concept of MIE was introduced, the ProTaper system’s finishing files (DENTSPLY Tulsa Dental Specialties) were designed with fixed tapers from D1 to D3, then decreasing percentage tapers from D4 to D16 to conserve dentin in the body of the canal. For example, a regressively tapered Pro-Taper 25/08 Finishing file has a D16 diameter of 1.05 mm, whereas a fixed tapered 25/08 file would have a D16 diameter of 1.53 mm.

Another misunderstanding that continues to sabotage success is overenlarging the terminal extent of canals. Histological evidence demonstrates the importance of deep shape by showing a 40/06 preparation is no cleaner than a 20/10 preparation. It is interesting to note that the 20/10 file utilized in this study has a maximum flute diameter of 1.00 mm versus the 1.80 mm that would be expected if the fixed taper extended over the 16 mm of cutting blades. Important, overpreparing the foramen leads to wet canals, post-treatment flare-ups, surgeries, and extractions. Evidence is available that demonstrates that well-shaped canals that emphasize keeping the foramen as small as practical readily exchange irrigants throughout the root canal system. Overprepared canals, or what have been termed “freeways to length,” are the antithesis to Schilder’s mechanical shaping objectives.

Closing Comments
In the 40 years I have been practicing endodontics, I have not seen what has been termed as “an epidemic of fractured teeth,” even after routinely utilizing a microscope since 1988. What I have seen is a number of post-treatment failures resulting from not placing an effective coronal restoration. However, an article in the February 2013 issue of Dentistry Today, entitled “Fracture Resistant Endodontic and Restorative Preparations” by Dr. David Clark et al., attributes an endodontic failure to overfunneling the coronal two thirds of a canal. Yet, multiple photographs of this same extracted tooth show a large invasive Class II composite restoration with no protective cuspal coverage. Certainly, overprepared canals weaken roots, but it is undeniable that unrestored, endodontically treated posterior teeth left to occlusal loads frequently and hopelessly fracture.

In the above referenced article, the authors state that “intentional shaping directed toward achieving some kind of ‘look’ may result in a tooth that exhibits what many might characterize as ‘endodontic excellence’ yet is crippled in the process, even before the restorative needs are considered.” This statement is simply not accurate. The referenced figure in the article (Figure 19) shows a tooth that I endodontically treated, but the authors did not include a radiograph of the case with the completed restoration. For the record, following my endodontic treatment, the prosthesis was fabricated, placed, and a recall radiograph at 27 years demonstrates the interdisciplinary result (Figure 8).
Predictably successful endodontics is currently dependent on preparing the access cavity, shaping canals, and cleaning and filling root canal systems. Going forward, the question that must be scientifically answered is, how restrictive can any given access cavity or root canal be prepared, and—most importantly—still enable the root canal system to be both 3-D cleaned and filled? Until this question is universally answered in collaborative research, it would be wise to continue to practice utilizing the best evidence, coupled with the most proven treatment concepts and techniques. There is an old expression, “Model success. Success leaves clues.” Long-term endodontic treatment success should integrate respect for the concept of MIE, while concomitantly fulfilling the mechanical and biological treatment objectives.

References


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Disclosure: Dr. Ruddle has a financial interest in products on which he collaborates, which includes the ProTaper System (DENTSPLY Tulsa Dental Specialties).
There Is More to Front Teeth Than Looks Alone: Diagnosis and Treatment Planning

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Background

Age at Initial Presentation: 26

Initial Presentation: December 8, 2008

Active Treatment Completed: May 12, 2009

Medical History

The female patient had a history of an anxiety disorder and gastrointestinal symptoms.

She was taking Lexapro® daily for anxiety symptoms and Levsin® prn to control stomach pain.

Dental History

The patient presented seeking a cosmetic solution to her smile. Her last dental examination was 2 years earlier, and she had a history of trauma to her right central incisor. She reported intermittent pain and a sense of "tiredness" on the left side of her face. She was embarrassed to smile due to her "dark front tooth" and had noticed the edges were "chipping and thinning" (Figure 1 and Figure 2).
Diagnostic Findings

**Extraoral:** Normal.

**Intraoral:** Normal. Findings from the cancer screening were negative.

**Temporomandibular Joints:** Within normal limits. Maximum interincisal opening was 55 mm. No deviation or pathologic joint sounds were noted. Findings from the load and immobilization tests were negative.

Occlusal Notes

The patient had a Class 1 dental relationship.

Radiographic Assessment

The right central incisor had a questionable periapical lesion.

Diagnosis

**Periodontal:** Mild, chronic periodontitis, AAP Type I. There was no bleeding on probing, and the depths were within normal limits. Bone support was within 2 mm of the cementoenamel junction without infrabony defects. The gingival architecture was symmetrical. No pathologic mobility was present.

**Biomechanical:** Caries and minimal erosion were present on the occlusal surfaces of teeth Nos. 18 and 19. The central incisors exhibited combination lesions of erosion and abrasion at the incisal edges. The right central incisor had possible periapical pathology.

**Functional:** The patient presented with minimal attrition on the surfaces of teeth Nos. 5, 13, 20, 21, and 28. Moderate attrition with an erosive component appeared on the palatal/incisal surfaces of teeth Nos. 8 and 9. This cupping indicated that the chemical aspect was outpacing the frictional damage (Figure 3). The frictional issue was the causal agent of the diastema between the central incisors. Teeth Nos. 6, 7, 10 to 12, and 22 to 27 exhibited moderate attrition (Figure 4). Parafunctional activity was evident, and the patient experienced pain in the left masseter.

**Dentofacial:** Gingival tissue levels on the lateral incisors were not harmonious. The patient exhibited a high smile line, and the right central incisor appeared dark. There was a diastema between the central incisors.

**Medical:** Within normal limits.

Risk Assessment

An individual risk assessment is critical for determining the most appropriate treatment plan. There can be multiple treatment plans but only one diagnosis. The goal is to decrease the risk and increase the prognosis with the proposed treatment plan.
Periodontal: Low risk because there was no evidence or risk factors for bone loss.

Biomechanical: Moderate risk because of the amount of active attrition, erosion, caries, and the need for endodontic intervention on the central incisor.

Functional: High risk because of the combination of occlusal dysfunction and parafunction.

Dentofacial: High risk because the patient exhibited high lip dynamics, high gingival scallop, thin biotype, and excessive tooth and gingival architecture display. Restoration margin placement and shade matching of the dark tooth would be more challenging. Exceeding the patient’s expectation can be complicated when all aspects of the show.

Prognosis
Periodontal: Good
Biomechanical: Fair
Functional: Poor
Dentofacial: Poor

Concerns
1. How can the occlusion be managed to reduce the functional risk?
2. How can the parafunctional habits be handled in order to provide longevity to the final porcelain restorations?
3. How can esthetics be achieved without increasing the biomechanical risks?
4. Can the posterior dentition be equilibrated to allow the patient to feel posterior bilateral contacts simultaneously, thus attaining a "home position"?
5. Can the dark tooth be masked with porcelain and match the adjacent veneer?
6. Can the dark stump under the gingival margin of the right central incisor be masked, or will it show through the patient’s thin biotype?

Treatment Goals
1. Maintain provisional and final restorations that do not break, chip, or debond.
2. Perform predictable minimally invasive preparation design of the anterior dentition.
3. Meet the patient’s esthetics goals.
4. Increase the functional prognosis by equilibrating the dysfunction and making the patient aware of her parafunctional habits.
5. Determine the appropriate length, angle of guidance, overjet, and overbite.

**Treatment Plan**

The proposed treatment plan began with a periodontal referral for crown lengthening so the zenith on both lateral incisors would be equal, an orthodontic referral to correct the mandibular teeth the right central incisor.

The patient refused to see the periodontist and orthodontist but agreed to have did not want internal bleaching.

**Phase I**

1. Kois deprogrammer  
2. Functional analysis  
3. Equilibration

**Phase II**

1. Zoom power bleaching would be performed on all teeth not receiving porcelain restorations.  
2. Records would be taken for a diagnostic wax-up.  
3. Teeth Nos. 6, 7, and 9 to 11 would receive veneers. A crown would be placed on tooth No. 8, and incisal composites would be put on teeth Nos. 12 and 22 to 27. Teeth Nos. 18 and 19 would receive occlusal composites, and teeth Nos. 13, 14, 20, and 21 would be recontoured.

**Phase III**

The bruxism appliance would be fabricated.

**Functional Analysis**

The patient exhibited generalized wear facets on the incisal edges of many teeth necessary to see if these clinical findings correlated with the mechanics of occlusion. A Kois deprogrammer was fabricated to erase the engrams, break the feedback loop, halter muscle activity location (centric relation [CR]). The patient was instructed to wear this appliance of eating and lifestyle interruptions.

This appliance has one anterior point of contact and separates the posterior teeth removes the appliance, he or she should put teeth together and note the first tv when this point of contact is duplicated consistently in the same location with repeat reprogrammed and ready for a CR bite record. This appointment occurs 1 week wear the deprogrammer. The CR record is taken with the deprogrammer in the
and the feasibility of occlusal correction is determined.

In this patient, centric occlusion, which is the first point of contact in CR, was posterior to the maximum intercuspal position (MIP). This constituted occlusal dysfunction. The treatment was to correct the position of the posterior teeth by performing an occlusal equilibration using the deprogrammer 4 weeks later.

**Restorative**

New records were taken, and a diagnostic wax-up with preparation and provisional matrixes were fabricated. To assure appropriate but minimal reduction, the provisional matrix was loaded with a bis-acrylic composite. Composite prototypes were added to the facial surface of the maxillary anterior dentition. This allowed guide modifications in shape, fullness, and length. This facilitated appropriate preparation with minimum reduction. The patient evaluated the length and fullness; modifications were made until the patient approved this (Figure 7). Depth cut guides were then used across the facial prototype with the definitive patient-approved incisal edge was performed (Figure 8). The probe was removed, and the marks left by the depth cutter guided the definitive restoration. The color of the restoration and the underlying stump shade were the determining factors in the amount and depth of axial reduction.

A minimal preparation of 0.3 mm of facial reduction is necessary for a one-shade shift. A deep preparation of 1 mm can provide a two- to three-shade shift. A deep preparation of 1 mm is necessary for three shades or more (Figure 9). In general, a depth of 0.2-mm space is needed for a shade shift.

It was necessary to remove 1 mm of facial dentin in the preparation design on the upper left central incisor to create space for restorative material with a four-shade shift stump. On evaluation of the endodontic access preparation, and a full cohesively designed crown preparation was performed.

Probing of the labial gingival sulcus revealed a space of less than 3 mm before, reflected a high risk of biologic width violation, dictating that the preparation margin be placed at the free gingival margin. The probe could be visualized when being used because a thin biotype was present. Expasyl hemostatic atraumatic cord-free retraction was placed and rinsed. Impressions, facebows, and bites were recorded. A bis-acrylic composite (Venus® Temp C&B, Heraeus, loaded into the provisional matrix. Composite prototypes were fabricated and loaded with veneer cement (RelyX™, 3M ESPE, http://www.3mespe.com) clear cement was employed at the periphery of the restorations and light-cured but returned 20 mins later with the anterior prototypes fractured at both lateral incisors. The clicking and protrusive bruxism habits of abnormal posturing and protrusive bruxism were occurring at a frequency that was appreciated until the provisionals were placed. A key concern was identifying the destructive pattern.

An acrylic was placed on the anterior ramp of the patient’s deprogrammer 4 mm high to prevent contact of the lower teeth against the maxillary provisionals (Figure 13). The patient was instructed to wear the deprogrammer during the day as a reminder to keep her lower incisors away from the incisal edges of her maxillary dentition. During this time, her occlusal diagnosis and treatment plan were reviewed. In occlusal dysfunction, the
guidance and increase the interincisal angle. This was performed as part of her treatment to flatten the angle of guidance, eliminate excursive interferences in the cuspid guidance. Modifications to the composite prototypes were made until these parameters were accomplished. The patient began weaning herself from the device. No breakage or loosening of the provisionals, a record and photographs were taken, and a template for fabricating the final prosthesis. The delivery appointment entailed cementation of the six porcelain-bonded restorations. The patient wore a nighttime appliance as instructed. Two years after treatment, no pulpal pathology, delaminations, or chipping was clinically appreciated. On periodontal recall, she was directed to bring her appliance, which displayed occlusal streaks and grooves (Figure 14).

Summary

When treating high-risk parafunctional cases, patient compliance and understanding of the disease are paramount in the success and longevity of the restorations. Controlling the patient’s expectations for augmenting the length and blocking out the dark color was accomplished (Figure 15, Figure 16, Figure 17, and Figure 18).

Acknowledgments

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Posterior Composite Resin Restorations

Overcoming traditional challenges with new materials.

Joyce Bassett, DDS

Recently introduced to help clinicians overcome the operative challenges traditionally faced when placing composite resin restorations in the posterior region, a new light-curing, radiopaque nanohybrid composite (Venus® Bulk Fill, Heraeus, www.heraeus-dental-us.com) offers the physical characteristics of conventional materials with the esthetics of composite resins.¹

For use as a base in Class I restorations, in conjunction with a universal composite in Class II and Class V restorations, and for deep lesions, Venus Bulk Fill enables clinicians to complete fills up to depths of 4 mm. Highly conducive to light transmission, the material demonstrates unmatched translucency. Reducing the risk of shrinkage stress, Venus Bulk Fill also allows for highly predictable esthetic and functional results. Further promoting fast and efficient application, the bulk fill material adapts quickly to the preparation with little if any manipulation required. Additionally, Venus Bulk Fill is radiopaque.

Overcoming Traditional Challenges

Based on its chemical composition and physical characteristics, Venus Bulk Fill resolves many of the issues clinicians typically faced when using previous generations of posterior composite resins. For example, early composite resins demonstrated polymerization shrinkage rates that increased with the size of fill.²,³ The stress caused by shrinkage often led to marginal leakage, sensitivity, secondary caries, and,...
consequently, restoration failure.\textsuperscript{2,3} A more elastic material, Venus Bulk Fill demonstrates increased marginal adaptation in the gingival area and reduces microleakage and minimizes polymerization shrinkage.\textsuperscript{4-7}

Additionally, due to previously encountered shrinkage problems, composite restorations required time-consuming and tedious placement processes that attempted to prevent voids that could lead to restoration failure.\textsuperscript{8,9} Saving the patient and dentist time and added stress, Venus Bulk Fill allows for fills of up to 4 mm, with the added benefits of quick adaptation and self-leveling characteristics.\textsuperscript{8,9}

Eliminating the need for manipulation, the material is ideal when fast and efficient restorations are required.\textsuperscript{8,9} With a compressive strength of 331 MPa and a high flexural strength of 120 MPa, Venus Bulk Fill demonstrates a higher resistance to wear, providing stable restorations for the long term.\textsuperscript{2}

Additionally, traditional direct posterior composites demonstrated poor translucency and radiopacity.\textsuperscript{4} Venus Bulk Fill, however, was developed to be easily detectable on radiographs, with radiopacity of 300%-Al. Based on its high translucency and excellent optical properties, much of the guesswork of shade selection for creating esthetic posterior restorations is removed when using bulk-fill techniques and materials. As a result, Venus Bulk Fill represents a new alternative in restorative products that enable dentists to achieve faster, easier, and more predictable direct posterior composite restorations.

**Clinical Protocol**

To demonstrate the use of Venus Bulk Fill composite, a case is described involving the restoration of an upper left first bicuspid that presented with interproximal decay, as seen on the radiograph (Figure 1).

The patient was anesthetized and a carbide bur was used to prepare the tooth. A caries-detecting agent was applied (Figure 2), and complete caries removal was achieved, in addition to placement of retention grooves on the facial and lingual line angles (Figure 3).

The tooth was acid-etched (Figure 4), with the etchant extending beyond the preparation margin. Once the etchant was removed by rinsing the preparation, an adhesive bonding agent (iBond\textsuperscript{®} Total Etch, Heraeus) was applied and rubbed thoroughly around the preparation. Excess solvent was evaporated and the adhesive was cured for 20 seconds.

Then, the matrix was placed (Figure 5) and molded with a composite placement instrument to ensure a tight contact. It was held against the contact during placement of a nanohybrid composite (Venus\textsuperscript{®} Diamond, Heraeus) and remained at this juncture while the curing light was used to activate and cure the composite for 20 seconds.
the distal and the mesial to create the interproximal wall (Figure 6). A second increment of nanohybrid composite (Venus Diamond) was placed on the mesial and distal marginal ridge adaption and cured for 20 seconds (Figure 7 and Figure 8).

Venus Bulk Fill composite then was placed into the depth of the preparation (Figure 9) up to 4 mm, leaving 2 mm of space for placement of the final nanohybrid composite layer. The bulk fill composite was light-cured for 20 seconds (Figure 10). After the self-leveling composite was placed, the final nanohybrid composite layer (Venus Diamond) was applied to the occlusal surface, then cured (Figure 11). To finalize the restoration, polishing points (Venus® Supra Polishers, Heraeus) were used to enhance the restoration’s finish (Figure 12).

Conclusion

Traditionally, predictably placing composite materials in the posterior region presented challenges for clinicians. However, Venus Bulk Fill changes the way dentists deliver restorative care that can withstand years of clinical function by enabling fast placement of bulk fills up to 4 mm (Figure 13).¹

Disclosure

Dr. Bassett has received honorarium from Heraeus for writing this article.

References


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INTRODUCTION
Have you ever walked into a hygiene exam check to find your orthodontically banded patient anxiously waiting for an answer? “When?” the patient demands; “How many more minutes?” A letter from the orthodontist asks if spacing is appropriate between the canines and the centrals. The letter requests explicit direction on tooth movement or permission to deband.

Your immediate reaction is, “I don’t know!” The patient’s teeth do not fill the existing space, they are contralaterally dissimilar, and you are responsible for setting up the case so the restorative phase is both functionally and aesthetically predictable. The patient wants the brackets off yesterday. What do you do?

Many restorative dentists have worked on patients who were debanded but whose existing dentition had not been orthodontically structured to allow for contralateral symmetry in the final reconstruction. Usually the restoring dentist does not recognize this until he or she bonds the spaces closed, filling in whatever space remains after orthodontic treatment. It then becomes clear that the spaces were not equalized, leading to asymmetry of the contralateral teeth, an unattractive and unequalized smile, and a dissatisfied dentist and patient.

Today, however, we have the ability to preplan these complex situations and better satisfy our patients. The composite bonding technique I describe in the following article will serve as a predictable, functional, and aesthetic solution to these complex situations. The article will review the parameters for anterior tooth positioning, proportions, contours, and techniques to predictably manage space management dilemmas.

CASE REPORT
Diagnosis and Treatment Planning
A 14.5-year-old female patient presented with fully banded upper and lower arches as part of orthodontic treatment to align and straighten her teeth and bite (Figures 1a to 1c). Her gingival zenith and tissue appeared healthy and symmetrical. Her dentition was caries free with no wear. She was healthy and had no significant medical history.

Transitional orthodontic bonding was prescribed as part of a multidisciplinary approach to improve aesthetics. She demonstrated diastemas in the smile zone, with teeth Nos. 6 to 8 and 9 to 11 being separated by gaps. The lateral incisors were irregularly shaped, asymmetrical, and narrow (Figure 2). The patient presented to the orthodontist as a 13-year-old female 18 months prior with a Class II division II malocclusion and a significant tooth size discrepancy, primarily between the upper lateral incisors. The orthodontist, in the past 18 months, had reduced the overbite and overjet and had obtained an ideal posterior occlusion. The central incisors were aligned so the roots were parallel, and the centrals were at the midline of the face and perpendicular to the interpupillary line.1
The dental midline runs vertically from the nasion subnasal point, interincisal point, to the pogonion. Ideally the papilla between the maxillary central incisors coincides with the midline of the face. In research conducted by Miller et al., it was shown that 70% of the time, the maxillary midline coincided with the facial midline when the lip’s philtrum was used as a reference point. It is more important to have the dental midline perpendicular to the interpupillary line and straight; this allows for symmetry. The occlusal line should conform to the commissural line. In this case, the orthodontist placed the centrals’ incisal edges in close relationship following the curvature of the lower lip, which has also been called the smile-line. The upper lip contour and movement can vary considerably. The lateral incisors’ edges were placed at a distance of 0.5 to 1.5 mm from the lower lip. A space was created mesial and distal to the lateral incisors, ensuring that adequate spacing was provided to allow for functionally strong and visually appealing composite placement.

With the above parameters accomplished, the brackets were removed from Nos. 6 to 11, and we were ready to restore.

In consultation with the patient and her parents, we developed a treatment plan that would utilize transitional bonding and attempt to close the diastemas and correct the contralateral asymmetry found in the upper arch. The goal was to create 2 lateral incisors with ideal size and shape following the golden rule of proportion. Once this was accomplished, the brackets would be replaced; any residual spaces would be closed orthodontically.

The most influential factors in a harmonious, balanced anterior dentition are the size, shape, and position of the maxillary incisors; it is therefore paramount that they are contralaterally identical to each other. The width of a central incisor should measure approximately 70% to 80% of its length. Evaluation of the central incisors’ mesiodistal widths, incisal architecture, and embrasures revealed asymmetry.

Measurements with a Dentagauge digital caliper (Erskine Dental International) revealed that the right central (8.5 mm wide) was thinner by 0.5 mm than the left central incisor (9.0 mm wide) (Figure 3). The distal incisal corner was also curvier and its embrasure more open, with the incisal edge slanted apically toward the distal. The right central incisor would require composite bonding on the distal to equalize the width and provide symmetry.

Preparation and Composite Placement
A universal nanocomposite resin (Filtek Supreme Ultra [3M ESPE]) composite resin was selected for the transitional bonding due to its strength, sculptability, and shade-matching capabilities. A microfilled composite resin (Durafil [Heraeus Kulzer]) was chosen as the thinnest final facial layer; its silica particles are .04 µm in size, with the filler being 35% of the weight. This microfilled composite is translucent and provides excellent polishability and long-term color retention to the final restoration. The treatment plan was to deband, perform transitional bonding, and reband within 3 days. Fortunately, the patient was satisfied with the present color of her dentition, as time did not allow for whitening procedures.

Extrinsic stain was removed from debanded tooth surfaces using plain pumice on a soft prophy cup. Shade selection should be performed immediately, as the tooth will have otherwise desiccated and lightened after the bonding protocol, leading to an incorrect match. The center body portion of the tooth was examined and matched to the VITA Vitapan (Vident) tooth shade guide, and a composite body shade was selected that
matches this portion.

**Figure 2.** Preoperative frontal view of teeth Nos. 6 to 11. Note irregularly shaped and narrow lateral incisors.

**Figure 3.** The right central was thinner by 0.5 mm than the left central incisor.

**Figure 4.** Composite bonding on the distal of the right central to equalize the width and provide symmetry.

**Figure 5.** Measuring the mesiodistal widths of teeth Nos. 7 and 10; note that they are different.

**Figure 6.** Etching of tooth No. 7 showing where composite will be applied.

**Figure 7.** A diamond bur (No. 8889-009 [Brasseler USA]) was used to contour the mesial facial embrasure of No. 7.

**Figure 8.** Removing the aprismatic enamel on the mesial of tooth No. 10 (left lateral) with the 8889-009 bur.

**Figure 9.** Microetching (Micro Etcher II [Danville Materials]) the mesial of tooth No. 10 using with a 60º-rounded
It is important to discuss the level of aesthetics the patient requires in the final restoration. If the patient has low expectations and a monochromatic tooth, the case can be completed using one body shade. In this case, the depth of color and vitality needed to mimic the adjacent tooth was simple and required Filtek Supreme Ultra shade A1B on the body of the tooth and WE on the incisal corner. When applied as a thin, final facial layer, Durafil VS in shade A1 will modulate the color and allow color depth to come from within the restoration. Experimenting with these different shades and thickness of composite by placing them in the planned area of the tooth and curing them allows the dentist a preview. This is a technique that provides predictability in color mapping and can aid in designing an imperceptible restoration.

The patient was fully retracted during the bonding procedure, and the protocol for teeth Nos. 7 to 9 was unchanged: Aprismatic enamel was removed using Brasseler USA diamond 8889-009 and by roughening the tooth lightly with a pendulumlike movement. The distal incisal surface of tooth No. 8 was microetched (Micro Etcher II [Danville Materials]) with a 60° rounded 0.032 µm nozzle aluminum oxide 27 µm white, and rinsed 5 seconds. Total-etch techniques have been shown to provide predictable shear bond strength to enamel of 18 to 30 MPa. The patient was then acid-etched with 35% phosphoric acid (Heraeus Kulzer) for 15 seconds with agitation, rinsed for 5 seconds, and blotted dry. We then applied 2 to 3 coats of a one-step bonding agent (Adper Single Bond Plus Adhesive [3M ESPE]); lightly air-drying, and then light-curing for 10 seconds. Composite
resin was sculpted using an 8A composite placement instrument (Cosmedent) and a contouring gold instrument (Almore International). The composite was contoured, and when visual symmetry was attained, the composite was light-cured for 20 seconds (Figure 4). The 2 centrals were grossly finished and measured to ensure that identical, contralateral shapes existed.

Beauty is connected to numerical values, and Pythagoras’ Theory of Golden Proportion is considered a mathematical tool for determining dominance and proportion in arranging the maxillary teeth from the frontal view. Ideal width-to-length ratios for central incisors, referred to as the Golden Rule of Proportions, should be used a guide when reconstructing the lateral incisors. These rules were applied to the apparent size, as viewed directly from the anterior. Lombardi states that the Golden Proportion has proven too rigid for dentistry. Excessive narrowness of the maxillary arch can be observed in situations of strict adherence to the Golden Rule. Aesthetic display has been driven to include widened buccal corridors, which would drive the anterior teeth in a wider direction. The ratios between the widths of the incisors should be 1.618 for the centrals to one for the laterals and 0.618 for the canines.

The mesiodistal widths of tooth teeth Nos. 7 and 10 (Figure 5) were different and required augmentation with composite. Using the Golden Rule of Proportion as a guide, the laterals should be 5.4 mm wide (5.4 x 1.68 = 9 mm, the widths of teeth Nos. 8 and 9). Magne et al3 has shown the widest crowns were those of central (9.0 mm) and lateral incisors (7.0 mm). The central incisors in this case were 9 mm wide. If we use the Golden Rule of Proportion to create 5.4-mm wide lateral incisors, they would appear thin and disproportionate. The relative dimensions of teeth seem to be the most objective dental criteria within the aesthetic checklist; they can be controlled using line angles and special effects of tooth form to influence perceptions of symmetry, dominance, and proportion.

The anatomy of a lateral incisor shows a distinct contrast between facial-palatal surfaces. The perceived tooth width is highly influenced by shape and especially interincisal angles, which are opened to create a perception of narrowness. The width-to-height ratio is 75% to 80% for a lateral incisor. Tooth shape and form range from square to oval to triangular. Due to these variations, the incisor shape to be restored must blend in harmoniously with existing dentition. A lateral incisor generally has a more rounded mesial incisal angle; however, laterals show the greatest variation in form when compared to all other teeth in the mouth. The incisal effects and surface texture should mimic the existing dentition. The incisal edge configuration influences the negative space during laughter and mouth opening. Rounded incisal edges will compensate for teeth that are too large, and straight edges are indicated for incisors that are too narrow. These parameters are very subjective.

The identical bonding protocol that was described earlier on tooth No. 8 was performed on No. 7. The mesial and distal incisal spaces of No. 7 were etched (Figure 6) and adhesive was applied. A1B was positioned on both sides of the tooth in order to equalize the space, and a thin facial layer of Durafil was placed as a final facial layer over the A1B. After light-curing for 15 seconds, the Brasseler USA diamond was used to contour the facial and incisal embrasures (Figure 7). The width that was aesthetically pleasing was 7.0 mm; the incisal embrasures are a youthful V shape.

The bonding protocol that was described on teeth Nos. 7 and 8 was again performed on No. 10. Aprismatic enamel was removed using the Brasseler USA diamond (Figure 8), and the mesiodistal incisal surface of No. 10 was microetched (Figure 9) and rinsed for 5 seconds. The tooth was acid-etched for 15 seconds with agitation, rinsed for 5 seconds, and blotted dry. The adhesive bonding agent was applied in 2 to 3 coats, lightly air-dried, and light-cured for 10 seconds. Composite A1B was sculpted mesially and distally to equalize the tooth width and ensure symmetry to No. 7 by using the aforementioned composite placement instrument and contouring gold instrument. Durafil A1 was placed as the thinnest final facial layer over 7 and 10. Measurements of Nos. 7 and 10 verified that our composite placement had balanced the widths of these 2 teeth, brought them into proportion, and ensured contralateral symmetry (Figure 10).

Finishing and contouring was performed to ensure that proper anatomical contour and imperceptibility between the composite and the tooth interface was attained. Primary anatomy, which consists of the facial
Postoperative Check
The patient and her parents returned for a postoperative visit one day after placement of her composite restorations. The size and contour of each tooth was verified for contralateral symmetry using a digital caliper (Dentagauge [Erskine Dental]). Refinement, finalization, and margination of the composite was performed; followed by a final polish with Enamelize (Cosmedent) aluminum oxide polishing paste on a FlexiBuff (Cosmedent) (Figure 11). Our clinical check confirmed contralateral symmetry, shade matching, and flawless margins between the patient’s natural tooth and composite reconstruction. The teeth gave off a luminescent, lifelike appearance, and demonstrated indistinguishable restorations.

The transitional bonding, accomplished with a combination of a universal nanocomposite resin and a microfilled composite resin, will provide this patient a fully functional, aesthetically pleasing smile for years to come. With the patient’s and her parents’ final approval, she returned to the orthodontist’s office for banding and closing of the remaining spaces distal to the lateral incisors by moving the canines mesially.

CONCLUSION
When treating space management situations, parameters for anterior tooth positioning, proportions, contours, and techniques must be applied. The final restorative result (Figure 12) demonstrated symmetry, balance, and harmony, as well as seamless, undetectable restorations. The advantages of using this technique are predictability in shape and form of the final results. Immediate fabrication of an Essex retainer can be accomplished at debanding, and the patient is happy with the final results.

Acknowledgement
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References

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INTRODUCTION

Have you ever walked into a hygiene exam check to find your orthodontically banded patient anxiously waiting for an answer? “When?” the patient demands; “How many more minutes?” A letter from the orthodontist asks if spacing is appropriate between the canines and the centrals. The letter requests explicit direction on tooth movement or permission to deband.

Your immediate reaction is, “I don’t know!” The patient’s teeth do not fill the existing space, they are contralaterally dissimilar, and you are responsible for setting up the case so the restorative phase is both functionally and aesthetically predictable. The patient wants the brackets off yesterday. What do you do?

Many restorative dentists have worked on patients who were debanded but whose existing dentition had not been orthodontically structured to allow for contralateral symmetry in the final reconstruction. Usually the restoring dentist does not recognize this until he or she bonds the spaces closed, filling in whatever space remains after orthodontic treatment. It then becomes clear that the spaces were not equalized, leading to asymmetry of the contralateral teeth, an unattractive and unequalized smile, and a dissatisfied dentist and patient.

Today, however, we have the ability to preplan these complex situations and better satisfy our patients. The composite bonding technique I describe in the following article will serve as a predictable, functional, and aesthetic solution to these complex situations. The article will review the parameters for anterior tooth positioning, proportions, contours, and techniques to predictably manage space management dilemmas.

CASE REPORT

Diagnosis and Treatment Planning

A 14.5-year-old female patient presented with fully banded upper and lower arches as part of orthodontic treatment to align and straighten her teeth and bite (Figures 1a to 1c). Her gingival zenith and tissue appeared healthy and symmetrical. Her dentition was caries free with no wear. She was healthy and had no significant medical history.

Transitional orthodontic bonding was prescribed as part of a multidisciplinary approach to improve aesthetics. She demonstrated diastemas in the smile zone, with teeth Nos. 6 to 8 and 9 to 11 being separated by gaps. The lateral incisors were irregularly shaped, asymmetrical, and narrow (Figure 2). The patient presented to the orthodontist as a 13-year-old female 18 months prior with a Class II division II malocclusion and a significant tooth size discrepancy, primarily between the upper lateral incisors. The orthodontist, in the past 18 months, had reduced the overbite and overjet and had obtained an ideal posterior occlusion. The central incisors were aligned so the roots were parallel, and the centrals were at the midline of the face and perpendicular to the interpupillary line.1

![Image a](image1.png) ![Image b](image2.png)
The dental midline runs vertically from the nasion subnasal point, interincisal point, to the pogonion. Ideally the papilla between the maxillary central incisors coincides with the midline of the face. In research conducted by Miller et al., it was shown that 70% of the time, the maxillary midline coincided with the facial midline when the lip’s philtrum was used as a reference point. It is more important to have the dental midline perpendicular to the interpupillary line and straight; this allows for symmetry. The occlusal line should conform to the commissural line. In this case, the orthodontist placed the centrals’ incisal edges in close relationship following the curvature of the lower lip, which has also been called the smile-line.3 The upper lip contour and movement can vary considerably. The lateral incisors’ edges were placed at a distance of 0.5 to 1.5 mm from the lower lip. A space was created mesial and distal to the lateral incisors, ensuring that adequate spacing was provided to allow for functionally strong and visually appealing composite placement.

With the above parameters accomplished, the brackets were removed from Nos. 6 to 11, and we were ready to restore.

In consultation with the patient and her parents, we developed a treatment plan that would utilize transitional bonding and attempt to close the diastemas and correct the contralateral asymmetry found in the upper arch. The goal was to create 2 lateral incisors with ideal size and shape following the golden rule of proportion. Once this was accomplished, the brackets would be replaced; any residual spaces would be closed orthodontically.

The most influential factors in a harmonious, balanced anterior dentition are the size, shape, and position of the maxillary incisors; it is therefore paramount that they are contralaterally identical to each other. The width of a central incisor should measure approximately 70% to 80% of its length. Evaluation of the central incisors’ mesiodistal widths, incisal architecture, and embrasures revealed asymmetry.

Measurements with a Dentagauge digital caliper (Erskine Dental International) revealed that the right central (8.5 mm wide) was thinner by 0.5 mm than the left central incisor (9.0 mm wide) (Figure 3). The distal incisal corner was also curvier and its embrasure more open, with the incisal edge slanted apically toward the distal. The right central incisor would require composite bonding on the distal to equalize the width and provide symmetry.

**Preparation and Composite Placement**

A universal nanocomposite resin (Filtek Supreme Ultra [3M ESPE]) composite resin was selected for the transitional bonding due to its strength, sculptability, and shade-matching capabilities. A microfilled composite resin (Durafill [Heraeus Kulzer]) was chosen as the thinnest final facial layer; its silica particles are .04 µm in size, with the filler being 35% of the weight. This microfilled composite is translucent and provides excellent polishability and long-term color retention to the final restoration.4 The treatment plan was to deband, perform transitional bonding, and reband within 3 days. Fortunately, the patient was satisfied with the present color of her dentition, as time did not allow for whitening procedures.

Extrinsic stain was removed from debanded tooth surfaces using plain pumice on a soft prophy cup. Shade selection should be performed immediately, as the tooth will have otherwise desiccated and lightened after the bonding protocol, leading to an incorrect match. The center body portion of the tooth was examined and matched to the VITA Vitapan (Vident) tooth shade guide, and a composite body shade was selected that
matches this portion.

**Figure 2.** Preoperative frontal view of teeth Nos. 6 to 11. Note irregularly shaped and narrow lateral incisors.

**Figure 3.** The right central was thinner by 0.5 mm than the left central incisor.

**Figure 4.** Composite bonding on the distal of the right central to equalize the width and provide symmetry.

**Figure 5.** Measuring the mesiodistal widths of teeth Nos. 7 and 10; note that they are different.

**Figure 6.** Etching of tooth No. 7 showing where composite will be applied.

**Figure 7.** A diamond bur (No. 8889-009 [Brasseler USA]) was used to contour the mesial facial embrasure of No. 7.

**Figure 8.** Removing the aprismatic enamel on the mesial of tooth No. 10 (left lateral) with the 8889-009 bur.

**Figure 9.** Microetching (Micro Etcher II [Danville Materials]) the mesial of tooth No. 10 using with a 60º-rounded
0.032-µm nozzle aluminum oxide 27-µm white.

Figure 10. Finalizing width and verifying contralateral symmetry.

Figure 11. One day postoperative: finalizing shapes and shade matching before brackets are reapplied and canines are moved anteriorly to close remaining spaces.

Figure 12. Final postoperative view after debanding of orthodontic brackets. Note the symmetry, balance, and harmony, and seamless undetectable composite restorations.

It is important to discuss the level of aesthetics the patient requires in the final restoration. If the patient has low expectations and a monochromatic tooth, the case can be completed using one body shade. In this case, the depth of color and vitality needed to mimic the adjacent tooth was simple and required Filtek Supreme Ultra shade A1B on the body of the tooth and WE on the incisal corner. When applied as a thin, final facial layer, Durafil VS in shade A1 will modulate the color and allow color depth to come from within the restoration. Experimenting with these different shades and thickness of composite by placing them in the planned area of the tooth and curing them allows the dentist a preview. This is a technique that provides predictability in color mapping and can aid in designing an imperceptible restoration.

The patient was fully retracted during the bonding procedure, and the protocol for teeth Nos. 7 to 9 was unchanged: Aprismatic enamel was removed using Brasseler USA diamond 8889-009 and by roughening the tooth lightly with a pendulumlike movement. The distal incisal surface of tooth No. 8 was microetched (Micro Etcher II [Danville Materials]) with a 60° rounded 0.032 µm nozzle aluminum oxide 27 µm white, and rinsed 5 seconds. Total-etch techniques have been shown to provide predictable shear bond strength to enamel of 18 to 30 MPa. The patient was then acid-etched with 35% phosphoric acid (Heraeus Kulzer) for 15 seconds with agitation, rinsed for 5 seconds, and blotted dry. We then applied 2 to 3 coats of a one-step bonding agent (Adper Single Bond Plus Adhesive [3M ESPE]); lightly air-drying, and then light-curing for 10 seconds. Composite
resin was sculpted using an 8A composite placement instrument (Cosmedent) and a contouring gold instrument (Almore International). The composite was contoured, and when visual symmetry was attained, the composite was light-cured for 20 seconds (Figure 4). The 2 centrals were grossly finished and measured to ensure that identical, contralateral shapes existed.

Beauty is connected to numerical values, and Pythagoras’ Theory of Golden Proportion is considered a mathematical tool for determining dominance and proportion in arranging the maxillary teeth from the frontal view. Ideal width-to-length ratios for central incisors, referred to as the Golden Rule of Proportions, should be used as a guide when reconstructing the lateral incisors. These rules were applied to the apparent size, as viewed directly from the anterior. Lombardi states that the Golden Proportion has proven too rigid for dentistry. Excessive narrowness of the maxillary arch can be observed in situations of strict adherence to the Golden Rule. Aesthetic display has been driven to include widened buccal corridors, which would drive the anterior teeth in a wider direction. The ratios between the widths of the incisors should be 1.618 for the centrals to one for the laterals and 0.618 for the canines.

The mesiodistal widths of tooth teeth Nos. 7 and 10 (Figure 5) were different and required augmentation with composite. Using the Golden Rule of Proportion as a guide, the laterals should be 5.4 mm wide (5.4 x 1.68 = 9 mm, the widths of teeth Nos. 8 and 9). Magne et al has shown the widest crowns were those of central (9.0 mm) and lateral incisors (7.0 mm). The central incisors in this case were 9 mm wide. If we use the Golden Rule of Proportion to create 5.4-mm wide lateral incisors, they would appear thin and disproportionate. The relative dimensions of teeth seem to be the most objective dental criteria within the aesthetic checklist; they can be controlled using line angles and special effects of tooth form to influence perceptions of symmetry, dominance, and proportion.

The anatomy of a lateral incisor shows a distinct contrast between facial-palatal surfaces. The perceived tooth width is highly influenced by shape and especially interincisal angles, which are opened to create a perception of narrowness. The width-to-height ratio is 75% to 80% for a lateral incisor. Tooth shape and form range from square to ovoid to triangular. Due to these variations, the incisor shape to be restored must blend in harmoniously with existing dentition. A lateral incisor generally has a more rounded mesial incisal angle; however, laterals show the greatest variation in form when compared to all other teeth in the mouth. The transition line angle is prominent on the mesial and much softer on the distal. The incisal effects and surface texture should mimic the existing dentition. The incisel edge configuration influences the negative space during laughter and mouth opening. Rounded incisal edges will compensate for teeth that are too large, and straight edges are indicated for incisors that are too narrow. These parameters are very subjective.

The identical bonding protocol that was described earlier on tooth No. 8 was performed on No. 7. The mesial and distal incisal spaces of No. 7 were etched (Figure 6) and adhesive was applied. A1B was positioned on both sides of the tooth in order to equalize the space, and a thin facial layer of Durafil was placed as a final facial layer over the A1B. After light-curing for 15 seconds, the Brasseler USA diamond was used to contour the facial and incisal embrasures (Figure 7). The width that was aesthetically pleasing was 7.0 mm; the incisal embrasures are a youthful V shape.

The bonding protocol that was described on teeth Nos. 7 and 8 was again performed on No. 10. Aprismatic enamel was removed using the Brasseler USA diamond (Figure 8), and the mesiodistal incisal surface of No. 10 was microetched (Figure 9) and rinsed for 5 seconds. The tooth was acid-etched for 15 seconds with agitation, rinsed for 5 seconds, and blotted dry. The adhesive bonding agent was applied in 2 to 3 coats, lightly air-dried, and light-cured for 10 seconds. Composite A1B was sculpted mesially and distally to equalize the tooth width and ensure symmetry to No. 7 by using the aforementioned composite placement instrument and contouring gold instrument. Durafil A1 was placed as the thinnest final facial layer over 7 and 10. Measurements of Nos. 7 and 10 verified that our composite placement had balanced the widths of these 2 teeth, brought them into proportion, and ensured contralateral symmetry (Figure 10).

Finishing and contouring was performed to ensure that proper anatomical contour and imperceptibility between the composite and the tooth interface was attained. Primary anatomy, which consists of the facial...
profile, outline form, and incisal embrasures, was refined by using a Sof-Lex Finishing and Polishing disc (3M ESPE) to give a final polish to bring about a lustrous, lifelike finish.

Postoperative Check
The patient and her parents returned for a postoperative visit one day after placement of her composite restorations. The size and contour of each tooth was verified for contralateral symmetry using a digital caliper (Dentagauge [Erskine Dental]). Refinement, finalization, and margination of the composite was performed; followed by a final polish with Enamelize (Cosmedent) aluminum oxide polishing paste on a FlexiBuff (Cosmedent) (Figure 11). Our clinical check confirmed contralateral symmetry, shade matching, and flawless margins between the patient’s natural tooth and composite reconstruction. The teeth gave off a luminescent, lifelike appearance, and demonstrated indistinguishable restorations.

The transitional bonding, accomplished with a combination of a universal nanocomposite resin and a microfilled composite resin, will provide this patient a fully functional, aesthetically pleasing smile for years to come. With the patient’s and her parents’ final approval, she returned to the orthodontist’s office for banding and closing of the remaining spaces distal to the lateral incisors by moving the canines mesially.

CONCLUSION
When treating space management situations, parameters for anterior tooth positioning, proportions, contours, and techniques must be applied. The final restorative result (Figure 12) demonstrated symmetry, balance, and harmony, as well as seamless, undetectable restorations. The advantages of using this technique are predictability in shape and form of the final results. Immediate fabrication of an Essex retainer can be accomplished at debanding, and the patient is happy with the final results.

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References


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Conservative Restoration of a Traumatically Involved Central Incisor

Joyce Bassett, DDS

Abstract

The use of a direct composite material known for excellent polishability, polish retention, and wear resistance is described in this case of a fractured central incisor restoration. The method used enabled the clinician to conserve tooth structure and maintain full control of the outcome while creating an esthetically imperceptible, reliable, and durable restoration for a young male patient. Emphasized in this case are the techniques of layering, contouring, and polishing of a nanocomposite used to maximize esthetics and meet patient expectations. To further ensure imperceptibility, the author recommends first facilitating color shade selection for both body and dentin—especially in two-shade or multiple-shade restorations—by placing the composite in its planned area of the restoration and curing it in its proper thickness to allow a preview and recipe map.

Composite restorations provide a number of advantages when selected as the to restore a dentition. Direct composite treatments are more conservative than full coverage crowns or facial veneers and can be performed without having to wait for a ceramist to fabricate a porcelain restoration. For dentists, skilled use of composite help deliver an outstanding level of esthetics. Composite treatments also can ai
clinician in maintaining control over the esthetics, which is paramount in the anterior region. This case demonstrates the use of composite to create an esthetically imperceptible restoration for a fractured central incisor.

**Case Report**

The patient, a 25-year-old man, presented to the office after fracturing his maxillary right central incisor while intoxicated. The patient, who expressed feeling humiliated by his condition, also had abrasions to his lips, and reported diffuse, intense pain in the area (Figure 1).

An assessment of the damage beyond the tooth structure was conducted. Zygoma and root fracture were ruled out, and the pulpal status was evaluated. Microfractures in adjacent teeth were noted, and an assessment for cracked-tooth syndrome on remaining dentition, which still had intact enamel, was performed.

Radiographs were taken, and clinical testing revealed a fracture-free root and zygoma. An endodontic assessment was performed, and a diagnosis of reversible pulpitis was determined. The patient was informed that testing of the pulpal status should be repeated 2 weeks after the site had healed from the trauma.

**Treatment Plan and Phases**

The patient was informed of his restorative options, which included a full-coverage crown, ceramic veneer, or composite bonding. In order to conserve tooth structure and for the clinician to maintain full control of the outcome of the rehabilitation, a direct composite restoration was chosen as the restorative solution.

Local anesthesia was administered, and the extrinsic stain was removed from the surface of the fractured and adjacent teeth by using pumice on a soft prophy cup. Shade selection and a mock-up were performed immediately. (Note: If the clinician chooses the shade after the bonding protocol, there is a risk that the tooth will desiccate and become lighter, resulting in an incorrect match.) The body shade restorative composite (Filtek™ Supreme Ultra Universal Restorative, 3M ESPE, www.3MESPE.com) was selected by using the Vitapan® tooth shade guide (Vident, www.vident.com) and choosing a color that matched the center portion of the tooth (Figure 2).

In cases such as this, it is important to discuss the patient’s expectations for the esthetics in the final restoration. If the patient has low expectations and a monochromatic tooth, the case can be completed using one body shade. However, in this case, the depth of color, vitality, and translucency needed to mimic the adjacent tooth were complex and required a multiple-shade mock-up.

The dentin composite shade was also selected by using the Vitapan tooth shade guide to match the visually exposed dentin of the fractured tooth. This layer provides opacity and color intensity. The enamel shade was selected by using the Vitapan tooth shade guide to match the proximal and/or incisal area of the adjacent tooth.
this step, the 3M ESPE Shade Selection Wheel was used to assist by providing shade restorations. A dentin color was chosen that was one chroma higher than color can be modulated by placing enamels and translucent composite shades perception allows the depth of color to come from within the restoration.

A translucent shade was also selected for internal use in order to create translucent shade can also be used as the final facial layer over the top of the restoration to the restoration. Experimenting with these colors by placing the composite in its curing it in its proper thickness allows a preview and a recipe map. This step is restoration. A putty lingual and incisal matrix of the mock-up was fabricated.

**Preparation**

In order to produce a seamless, undetectable transition from tooth to restoration aspect with a fine, tapered diamond bur. An infinity bevel, as described by Fahl, dentin and carried 2 mm to 2.5 mm past the fracture line, rounding the finish line be used on the facial in cases like this; the bevel varies in length, depth, and voids. In this case, the lingual preparation required a chamfer preparation of 0.8 mm to 1 mm bulk of composite will sustain tooth flexure (Figure 4).

The tooth was microetched and rinsed, and a 37% phosphoric etch was applied microbrush past the margins of the infinity bevel onto unprepared tooth structure and lightly air-dried, leaving a moist dentin surface.

Adhesive (Scotchbond™ Universal Adhesive, 3M ESPE) was applied and agitated seconds in order to remove the ethanol water solvent. The area was then light-cured for 10 seconds.

The lingual increment of the composite—including the incisal facial line angles and the proximal contacts—was created by placing the white enamel (WE) composite inside the putty matrix, seating the matrix against the tooth, and light-curing for 20 seconds. The lingual matrix was removed, and while comparing it to the adjacent tooth, it was decided that some additional opacity was needed. Therefore, an additional thin layer of WE was placed on the incisal edge and cured (Figure 5).

The dentin shade A2D was applied in two separate increments. A small amount was feathered over the bevel. The second increment was used to form the lobes. Note from an incisal, occlusal view and not to build this layer too thick. This will allow enamel (Figure 6).

A combination of blue and clear translucent shades was then applied in between characterization and an internal diffusion of light. When creating this layer, the color and the effects were mimicked. To create the translucency of the enamel, B1E composite was placed as a final seconds. This final layer created an illusion of depth.

**Finishing and Contouring**
Finishing and contouring were performed to ensure proper anatomical contour: composite and fractured tooth segment and the contralateral central incisor. Primary anatomy, which consists of the facial profile, outline form, and incisal embrasures, was refined by using a large, Sof-Lex™ (3M ESPE). A central incisor exhibits three planes when viewed from a profile; the middle plane is flat and the incisal plane tips back towards the lingual. When viewed from the incisal, the facial incisal line angle must remain as close as possible to a 90-degree angle and not be rounded. When performing these adjustments, it is important to evaluate and mimic the contralateral tooth in all views.

Secondary anatomy, which consists of line angles and reflective surfaces, was contoured by using fine diamond burs. Line angles of a central incisor typically converge 10 mm to 12 mm from the cemento-enamel junction. The anatomy consists of major facial grooves, and in this case perikymata, which are striae of Retzius. These were created by using a coarse diamond bur, turning down the revolutions per minute (rpm) on the electric handpiece and dragging it over the facial surface in a pendulum-like motion. A final polish over the facial surface (Figure 9) was carried out using a Sof-Lex™ disc.

The contrast between the preoperative condition and the final restoration is depicted in Figure 7.

Conclusion

A myriad of options are available for restoring a fractured anterior tooth. The restorative used in this case is a nanocomposite material that is known for excellent polishability, polish retention, and wear resistance; therefore, it can be expected to serve well for years.

The conservative nature of the technique used allows the dentist to re-establish exceptional esthetics to the fractured tooth while having complete control over the procedure. Mastering the techniques of layering, contouring, and polishing of composite is paramount to the imperceptibility of the restoration.

References


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INTRODUCTION
“Responsible aesthetics” and “minimally invasive dentistry” are buzzwords that reflect the current trends in dentistry. We all strive to perform conservative treatment, but how do we differentiate between the cases that lend themselves to successful outcomes via minimally invasive dentistry and those cases involving porcelain restorations that may require more aggressive preparations? The dentist’s obligation is to evaluate each situation, gaining a thorough understanding of the patient’s history, condition, and expectations; then, to assess the risk, longevity, and predictability of each proposed treatment modality. When a patient presents with discolored teeth and a high smile-line on both maxillary and mandibular arches, bleaching is my treatment of choice. If the result is satisfactory, a minimally invasive solution (such as bonded composite resin augmentation, or minimal to no-prep feldspathic veneers) can be proposed.

Historically, whitening is more predictable and dramatic with yellow teeth and not as effective with gray teeth. Also, monochromatic (even-toned) teeth have a more predictable bleaching outcome than striated, tetracycline-stained, or white-spotted teeth.

White Spot Lesions
White spot lesions are caused by the demineralization of the subsurface enamel, by the malformation of the enamel during tooth development, acid breakdown of the enamel, and/or poor oral hygiene. During bleaching procedures, the teeth desiccate and the white spots appear more prominent. During the next few days, as the tooth rehydrates, the white spot color may blend in with the new whiter surrounding enamel or the white spot color may become visually intensified, requiring an additional procedure of either composite resin or microabrasive techniques.

Microabrasion uses a slurry of pumice with 15% hydrochloric acid (HCl) applied to the tooth for 15 to 30 seconds. Next, the slurry is rinsed away, and then visually observed. The procedure is repeated again until the desired color correction is noted.

The enamel “microreduction” technique utilizes a fine-grit diamond, which is applied to the affected enamel for 5 to 10 seconds. This removal of a small amount of the affected enamel decreases overall treatment time for the microabrasion as the microabrasion eliminates superficial intrinsic stain and the bleach lightens the deeper stain.\(^1,2\)

If the color does not match after microabrasion or microreduction, then a composite protocol can be implemented.

Bleaching Choices and Techniques Differ
Time, convenience, and efficacy are the variables to be evaluated when comparing in-office systems and take-home systems. It takes 14 days of continuous use of take-home bleach to gain the same effects of one in-office procedure.

Both light-activated and non-light-activated systems produce whitening of between 6 to 9 shade differences. However, the light-activated systems will provide one to 2 shade guide improvements over the non-light-activated in-office systems.\(^3,4\)

The current whitening lamp (Zoom WhiteSpeed [Philips Oral Healthcare]) has a narrow light spectrum that produces very little heat. The LED blue light technology makes the hydrogen peroxide more effective at
breaking down stains (double carbon bonds) that are held within the carbon portion of the tooth. The blue light from the lamp is absorbed by the yellow stains in the dentin.\textsuperscript{5}

Greater tooth sensitivity has been reported when using the light; therefore, pre-existing sensitivity must be identified and recorded. Patients must be informed prior to treatment that a temporary increase in sensitivity may be experienced, and a strategy for managing this sensitivity should be implemented.

If a patient has a history of sensitivity to hot and cold temperatures, a desensitizing toothpaste that does not contain sodium laurel sulfate should be used for 2 weeks before the procedure (Sensodyne Pro Enamel). For the patient who reports extreme sensitivity, desensitizing gels (Relief ACP Gel [Philips Oral Healthcare]) can be placed inside the custom whitening trays and worn for one hour daily for a week before the in-office procedure and for one hour immediately following the whitening session.\textsuperscript{6}

Sensitivity during the bleaching procedure is likely caused by the penetration of the hydrogen peroxide through the enamel and dentin into the pulp, creating a reversible pulpitis.\textsuperscript{7} Any sensitivity is transient and an analgesic (such as Ibuprofen 600 mg) should be administered at the onset of the procedure.\textsuperscript{8}

\textbf{CASE REPORT}

\textbf{Diagnosis and Treatment Planning}

A 16-year-old male presented with multicolored teeth. His mother confidentially warned me of his extreme emotional sensitivity, and asked me to choose my words carefully when evaluating her son’s photos and explaining his treatment options.

\textbf{Figure 1.} Initial consultation of our patient, showing yellowed, multicolored teeth.

\textbf{Figure 2.} Pre-op shade photos of a case
similar to our patient shown in Figure 1. Photos in Figures 2 to 4 were used for a before-and-after comparison in the process of explaining treatment options.

Figure 3. Preoperative photo before bleaching and bonding (same patient shown in Figure 2).

Figure 4. Postoperative photo after bleaching and bonding showing similar potential results (same patient shown in Figure 2).

It was difficult to get him to smile during the photographic series, and when the photos were displayed, he was uncomfortable looking at himself on the screen. As a result, I immediately changed the facial images to pictures that showed only his teeth with the adjacent shade tabs (Vitapan Classic [Vident]) (Figure 1). He was then shown pretreatment images with visual color matching followed by pre- and post-treatment images of a completed bleaching and bonding case (Figures 2 to 4). Visual verification occurred when he saw another patient’s teeth that appeared similar to his and that had been transformed to an amazing, whiter result. This visual evidence of success was crucial in gaining his confidence. After he saw the photos, he relaxed and became open to learning about the risks and benefits of his treatment options. Once I gained his confidence, it was crucial to make sure that I managed his expectations properly.

Further examination and evaluation revealed a stained composite and some white spots on his left maxillary incisor. His initial shade of A3.5 on the lowers and a range of A1.5 to A3 on the uppers was noted.

Whitening options were then presented. He was a teenager with a history of noncompliance, so he declined the at-home tray protocol (such as KöR Whitening [KöR Whitening], Venus White Pro [Heraeus Kulzer], Opalescence PF [Ultradent Products], and Philips Day White). He desired the quickest solution to attain the
whitest smile possible, so in-office power bleaching (Zoom WhiteSpeed) was chosen as the treatment of choice in this case.

**Clinical Protocol**
The 25% hydrogen peroxide bleaching gel (Zoom 2 kit) was applied and repeated for three 15-minute cycles, for a total exposure time of 45 minutes. At-home trays were filled with desensitizing gel (Relief ACP Gel) that also contains remineralization agents to increase the enamel microhardness.\(^\text{10}\)

![Figure 5. Etchant placed on affected teeth.](image)

![Figure 6. Pre-op photo showing the aesthetic challenge.](image)

![Figure 7. A whiter, brighter and aesthetic outcome can be seen here in this post-op photo.](image)
The peroxide from the whitening decreases the bond strength to the tooth, and it takes 14 days for the bond strength to return to normal. Therefore, the patient was appointed 2 weeks later for an evaluation of the initial bleaching results, and also to discuss the treatment options to complete his overall treatment. We planned microabrasion on the lower incisors and replacement of the unattractive composite with a new, imperceptible composite on tooth No. 10. A composite protocol for the lower incisors was selected instead of microabrasion, because he was leaving for college in a few days and he desired predictability and imperceptibility on all discolored areas.

All extrinsic stain on the teeth was removed with pumice on a soft prophy brush. The tooth was monochromatic on the facial areas being restored so only one body shade was necessary. Shade selection was accomplished by curing small increments of enamel shades (A1E and B1E Filtek Supreme Ultra [3M ESPE], Premise A1 [Kerr], Venus Diamond A1 [Heraeus Kulzer]). All 4 of these materials/shades were previewed and visual color matching occurred. The B1E (Filtek Supreme Ultra) demonstrated the best match for the surrounding tooth structure. A coarse diamond bur (No. 850.31.016 [Brasseler USA]) was used to remove the previously placed stained composite resin, and then a football diamond (No. 8379.31.021 [Brasseler USA]) was used to remove a small portion of the affected enamel white spot. In order to produce a seamless and undetectable transition from tooth to restoration, an infinity bevel (as described and taught by Dr. Newton Fahl) was prepared on the facial with a medium-grit diamond bur (No. M862-009 [Brasseler USA]). Next, the tooth was microetched.
(MicroEtcher II [Danville Materials]) and then rinsed. Since all the bonded surfaces were in enamel, a total-etch technique was done using a 37% phosphoric acid etching gel. The gel was placed to extend beyond the margins of the infinity bevel and onto unprepared tooth enamel, then agitated with a microbrush for 15 seconds (Figure 5). The etchant gel was rinsed off the tooth for 5 seconds, then lightly air-dried in order to leave the preparation visibly moist. Next, a coat of universal (MDP-containing) adhesive (Scotchbond Universal [3M ESPE]) was scrubbed with a microbrush on the preparation for 15 seconds. A second coat was scrubbed for 15 seconds, then the excess solvent was evaporated away by thoroughly air-drying with an air syringe for 10 seconds. Once the tooth had a glossy appearance, it was ready to be light-cured for 10 seconds.

This total-etch and adhesive technique was also used on all the surfaces that were selected for augmentation with composite resin (teeth Nos. 8, 9, 23, and 26). A gold waxing instrument (Titanium 8A Instrument [Cosmedent]) was used to anatomically sculpt the composite resin. Shade B1E (Filtek Supreme Ultra) was placed in a very thin increment on the body (middle) of the teeth. A microfill composite resin (Durafill VS SL [Heraeus Kulzer]) was selected as the thinnest final facial layer for these restorations and was carried across the restoration surfaces. The silica particles are 0.04 µm in size, with the fillers comprising 35% of the weight. It is translucent, providing an illusion of depth along with excellent polishability and long-term color retention. It should be noted that the incisal edges were augmented using shade XWB (Filtek Supreme Ultra).

The primary anatomy was refined using finishing and polishing discs (Sof-Lex [3M ESPE]). Finally, the polishing sequence consisted of using spiral-finishing wheels (Sof-Lex Spiral Finishing and Polishing Wheels [3M ESPE]), and then achieving the final desired luster with a polishing paste (Enamelize [Cosmedent]) on a felt wheel (Figures 6 to 9).

CLOSING COMMENTS

In a society where instant gratification reins and patient compliance is often lacking, in-office power bleaching is a quick, safe, and predictable way to discern whether a simple solution to an aesthetic situation can be accomplished. In order to optimize success, the cosmetic practice depends upon the clinician’s ability to offer a fast and predictable solution to the patient’s presenting concern, to know when simply changing the shade and brightening up the patient’s smile will satisfy their aesthetic desires, or whether a more invasive procedure might be required, such as the preparation of the teeth for porcelain restorations. This initial consultation must provide clarity regarding both the possible treatment options and the results that can be expected with each option proposed.

References


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*Disclosure: Dr. Bassett has lectured on behalf of Philips Oral Healthcare.*
To bulk fill or not to bulk fill ... that is the question

Joyce Bassett, DDS, FAACD, FAGD

Direct composite restorations are the most requested and performed dental procedures. Class II posterior composites are the number one restoration dentists place. Bicuspids and molar treatments account for more than 70% of all direct restorations placed, but they generate only minimal revenue for practices. The average fee accepted by insurance companies for a Class II composite is $195. It takes substantial time to isolate, prepare, remove old resin and decay, bond, matrix, incrementally place the composite, cure, finish, and polish. If done properly, these restorations are the most demanding restorations we create. Where can we save time without compromising long-term predictability?

The incremental placement technique has been the gold standard for posterior universal composite placement. This technique carefully places and cures multiple layers of composite in 2 mm increments to minimize shrinkage stress and ensure adequate depth of cure. This technique, if done properly, is arduous, time-consuming, and despite our efforts—we may still see shrinkage, gap formation, craze lines, and microleakage. How many of us are performing this technique in 2 mm increments?

Figure 1: Pre-op amalgam with marginal leakage
Decreasing the insertion and polymerization time can simplify this procedure, improve chairside efficiency, and increase profits. Manufacturers have realized these problems and developed a more advanced dental composite designed specifically for posterior use. This composite allows a dentist to place larger increments of composites in a single application, rather than placing tedious layers and curing in small 2 mm increments. So what is the hesitation in making the switch? Many dentists are worried that the composite is not fully cured, especially in the deeper part of the proximal box. Can we believe the manufacturers?

Let's go to the independent researchers-Clinicians Report (Christensen), Dental Advisor, Reality, and the ADA. Hardness has been shown to correlate with polymerization. Researchers measure the hardness at the bottom of the box, then they measure the hardness at the top of the box. If it is at 80% (bottom to top depth to cure ratio), it is cured. Christensen's Clinicians Report confirmed hardness results at 6 mm for Kerr SonicFill to 4 mm for Tetric EvoCeram (Ivoclar) and Venus Bulk Fill (Heraeus Kulzer).

**Figure 2:** Post-op photo courtesy of Ron Jackson displaying five years of clinical success
All composites shrink; the material and placement technique must account for the polymerization shrinkage stress on the bonded interface. If it is excessive, then debonding or cuspal flexure will occur. It has been reported that avoiding bonding to opposing walls of the restorations all at once can mitigate shrinkage stress (the incremental technique). The most current literature shows that bulk filling with these revolutionary bulk-fill composites does produce lower shrinkage stress than the traditional universal composites placed in oblique layers.\(^6\)

There are two categories of bulk fills. Low viscosity flowables (e.g., Surefil SDR Flow, Dentsply Caulk; 3M ESPE Filtek Bulk Fill Flowable Restorative, Voco X-tra Base, Heraeus Kulzer Venus Bulk Fill), and high viscosity restorative (e.g., Ivoclar Vivadent Tetric EvoCeram Bulk Fill and Voco X-tra Fil and Kerr SonicFill).

A low-viscosity flowable is placed in the bottom of the preparation as a dentin replacement base and then a second increment of composite is placed as enamel on the top layer. Two layers are placed and cured.

The high-viscosity restoratives are strong, but they do not adapt to the cavity walls, so it may be wise to place a low-viscosity composite or a resin ionomer liner to achieve intimate adaptation to the gingival and pulpal floors.\(^7\) Again, two layers are placed and cured.

One exception is Kerr's SonicFill. It is the only sonic-activated, single-step, bulk-fill composite that starts out as a low-viscosity composite. The handpiece is activated, liquefaction occurs, the viscosity drops, and optimal cavity adaption occurs, much like a true flowable. The cavity is filled in seconds; the composite goes through a phase change and it is transformed to a high-viscosity
composite.

The *Journal of the American Dental Association* reports that 37% of our restorations are not fully cured.\(^8\) Undercured composites will display cracks, fractures, poor crosslinking, and color instability. Christensen reports that most curing lights are inadequate and delivered around 512mW/cm\(^2\).

A high-output LED light (1000mW/cm\(^2\)) with a powerful collimated (directed, not scattered) beam is a requirement when curing these bulk-fill composites. The lights should be regularly checked for consistent output. There is an enormous difference between the clinical outcomes associated with a 500-watt light versus a 1000-watt light.

Increasing the curing time increases the bond strength. Since there is a distance between the light tip and the deeper placed composite, it is recommended to final cure the composite 10 seconds from the occlusal, 10 seconds from the buccal, and 10 seconds from the lingual.

Are dentists hesitant, since we have not seen long-term clinical performance? Split-mouth studies, where one quadrant is restored with universal composite (Kerr Premise) using the layering technique and the contralateral quadrant is restored with bulk fill (Kerr SonicFill) were evaluated. There were no clinical differences between the two materials and techniques at the two-year postoperative evaluations.\(^9\) Clinical cases have been documented showing five-year postoperative outcomes with Kerr SonicFill (figures 1-2).

Dentists are conscientious, work really hard, and take a lot of time to perform first-rate, predictable restorations. At the end of the month, we evaluate our profits and losses, and the overhead can be strangulating. Make the change with these innovative materials and technology, and you will save time and money. I predict that the incremental technique will be antiquated and invalid in two years. Bulk fill is the answer.

**References**


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Treatment Solutions for a Complex High-Risk Caries Patient

Planning for long-term success in a case of poor compliance

Joyce Bassett, DDS, FAACD, FAGD

Offering high quality dentistry is the goal of every dentist. Our responsibility is to evaluate the condition and gain a thorough understanding of the patient’s history, circumstances, and expectations, while assessing the risk, longevity, and liability of the proposed treatment modality. It may be difficult for the dentist to determine if an identified condition is progressing, regressing, or stable. Uncertainty is problematic because appropriate treatment often depends on an accurate understanding of oral conditions.

Case Presentation

A 14-year-old male patient presented for a structural and esthetic assessment of his dental condition (Figure 1). He reported that his orthodontist decided that early debanding was required, leaving the buccal corridor undeveloped. He had been noncompliant with wearing elastics and had missed many appointments. The enamel exhibited many decalcified areas and plaque control was poor. The patient's mother sought a conservative approach to his current situation. He was displeased with his appearance and stated that he detested all visits to the dentist.

The patient received a comprehensive exam, full-mouth series of radiographs, a panoramic x-ray, diagnostic photos, records, and a periodontal evaluation.
sulcus depths of 2 to 3 mm were noted. Plaque was rampant and his hypertrophied gingiva exhibited bleeding on probing. The panoramic x-ray revealed bone support within 2 mm of the cementoenamel junction. A clinical evaluation revealed white lesions and carious lesions on multiple surfaces of his dentition.

The patient exhibited a dental Class I malocclusion. The musculature and joints were not painful to loading or palpation. On a full smile, he demonstrated high lip dynamics on the maxillary arch and low lip dynamics on the mandibular arch (Figure 2).

The patient’s esthetic vision could not be addressed until caries control, caries removal, and hygiene compliance was attained.

**Periodontal Re-Evaluation**

Topical anesthetic was placed, and scaling and curettage was performed. The patient was given plaque management and oral hygiene instructions, along with reinforcing future monitoring of home care. The re-evaluation of the hyperplastic tissue 60 days after the initial periodontal therapy revealed the necessity to perform a gingivectomy and gingivoplasty on the maxillary incisors.

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To ensure that the biologic width was respected, sounding to bone was performed after anesthetizing and before any tissue was removed to safeguard the health of the dentogingival complex. The NV® microlaser 810 Nm diode (DenMat, www.denmat.com) was used because the zone of necrosis is 3 to 5 cells thick and healing was quick and painless.

**Caries Assessment**

Caries is a disease of susceptibility. Bacterial plaque accumulation called biofilm creates an acid environment that allows caries disease to spread. Risk factors for developing caries include active orthodontics, a cariogenic diet, presence of biofilm, poor oral hygiene, and acquired enamel defects.

White spot lesions are caused by the demineralization of the subsurface enamel by the malformation of the enamel during tooth development or breakdown of the enamel due to acids and poor oral hygiene. Since the surface of the enamel is porous, phosphates can move out of the tooth.

To offer the most conservative treatment, the Icon system was considered (DMG America, www.dmg-america.com), as MI Paste™ (GC America, www.gcamerica.com) and Icon have been successfully used in the early stages of white spot lesions. The Icon system involves microabrasion with hydrochloric acid, simultaneously eroding and abrading the enamel while saturating the enamel with hydrochloric acid and infusing...
with liquid resin. The challenge for the dentist is diagnosing the lesion stage and degree of activity. Visual assessment cannot determine the depth or activity of the lesion. It must be determined if anterior lesions are progressing, regressing, or remaining the same. After this HCl-infused microabrasion, the remaining enamel is dense aprismatic and more resistant to acid challenges and plaque retention.4

A multifaceted intervention approach combining fluoride, xylitol, remineralization infiltration, MI Paste, and antimicrobials was investigated.

A pediatric dental specialist expert and an initial tester for the Icon resin infusion system was employed to perform a diagnostic evaluation to see if the Icon product would be a possible solution to this situation in a conservative manner. He reported that the penetration and destruction was so advanced, the minimally invasive resin infiltration was not a possible solution. Therefore, the treatment with the best long-term predictable outcome was removal of the damaged enamel and affected dentin. The carious lesions were so widely distributed that full-mouth reconstruction was necessary.

A 5000-ppm toothpaste, a fluoride rinse, and MI Paste were prescribed in the interim.

**Bleaching and Caries Removal**

Since this patient was only 14 years old at the initial visit and nervous about dental treatment, it was important to arrest the disease while gaining his confidence and keeping appointments as short and pain free as possible. At-home bleaching trays had been fabricated during initial periodontal therapy, but he was not satisfied with the tray protocol and admitted he was noncompliant. He desired the quickest solution to attain the whitest smile, so in-office power bleaching (Philips Zoom WhiteSpeed, Philips Oral Healthcare, www.philipsoralhealthcare.com) was chosen (Figure 3 and Figure 4).
Do you ever wonder where to take off tooth structure when preparing a difficult case? Is your laboratory team frustrated at times with the preparation design of your case? Is it difficult to obtain the final esthetics because you took off too much tooth structure here, and not enough there? Do you realize your preparations are the guide for the final esthetics?

There are techniques to assure predictable and repeatable results, guaranteeing conservative tooth preparation and still meeting current esthetic standards. The use of these techniques will simplify space-management cases and systemize routine procedures. Designs, such as those for porcelain laminate veneers, are much less invasive than complete preparations. The goal is to restore function and esthetics at a minimal biologic cost. However, tooth preparation requires the execution of a combination of meticulously planned techniques. In the past, the dentist would visualize the final outcome and prepare the teeth within these boundaries, leaving large margins of error. Depth guides were used to ensure proper facial reduction, but the to be in the proper arch form and not be deficient facially in order for the depth cutters accuracy.

Smile design principles—midline, canting, arch form, and buccal corridor expansion—are parameters to consider when preparing teeth. Evaluating these principles leads to working from the final outcome and tracing the steps backward to the preoperative state. Today, diagnostic wax-ups based on these smile design principles are fabricated and indices are used to guide the dentist in tooth removal. This has led to another technique that involves the prefabrication of provisionals (made from the diagnostic wax-up) bonded over the original technique, employing depth guides on the facials of these porcelain veneer preparation. This article presents three different case complex, in which tooth preparation design principles and indices a
CASE ONE
A patient presented with rotated, malpositioned maxillary and mandibular teeth (Figure 1). She was happy with her dominant centrals, but was looking for a more symmetrical smile. The primary clinical recommendation was orthodontic treatment, but she requested a treatment plan that could be executed more expeditiously. She had been using an at-home bleaching system and claimed that the color was as white as it was going to get. She was happy with the shade and did not want to attempt a Zoom!® power bleaching (Discus Dental, Culver City, CA). A comprehensive history and physical was performed. No temporomandibular joint (TMJ) disorders, periodontal, or periapical problems were noted. The patient had no occlusal wear and demonstrated acceptable occlusal function (Figure 2). The cosmetic analysis revealed a low smile line as a result of Gortex implants placed in her lips 10 years earlier. This created an asymmetrical backdrop that had to be addressed. The right lateral was rotated, the canines were protruding, and the bicuspids were lingualized. Bonding on the facials of the centrals. Ten maxillary units were prescribed to correct all of these parameters. Because the patient felt that her lip covered most of these issues, she chose a more conservative treatment plan, calling for only four maxillary bonded-porcelain restorations, recontouring of the canines, and future lip fillers in the Cupid’s bow area of the lip. The patient’s time constraints required immediate tooth preparation; therefore, a pretreatment wax-up was not performed and the case was prepared.

Preparation Design
Current preparation techniques recommend the use of depth guides to ensure proper enamel reduction. This technique is only beneficial when the teeth are in proper arch form with no facial enamel deficit. In an improper alignment case where the teeth are rotated lingually or labially, it is necessary to remove the protruding portion of the misaligned tooth. Occlusally, the dentist must visualize, then align the arch form before the definitive preparation begins (Figure 3). In this case, the protruding portions of the misaligned tooth were removed with a diamond bur (Figure 4).

A rotated tooth will not occupy the same mesial-distal diameter as its contralateral counterpart. The difference must be measured and equalized by removing the adjacent tooth without causing a discrepancy in the ultimate width of the central incisors. In this case, the distal surfaces of both centrals were recontoured to accommodate the added space necessary to make the two laterals the same width (Figure 5 and Figure 6).

The midline was evaluated for canting and proper mesial-distal placement. The midline is extremely important when focusing on the symmetry and balance of the smile. Because it was acceptable in this case, there was no reason to alter this contact. When these steps were achieved, the case was in appropriate arch form with the correct amount of incisal translucency and incisal effects. The original length of the patient’s centrals was just shy of the wet-dry line of the lower lip (Figure 2). Lengthening these teeth would interfere with her phonetics; therefore, the original incisal-edge position could not be altered. Calipers were used to measure 2 mm from the incisal and terminate on the lingual surface. This would add strength to the ceramics, provide a vertical stop during cementation, and give the ceramist room to use the depth of incisal translucency and incisal effects. Provisional restorations were fabricated using direct-composite freehand bonding. Calipers were used to measure the widths to assure symmetry of the contralatera...
Nos. 8 and 9 and teeth Nos. 7 and 10, respectively) (Figure 8).

Once the patient’s expectations of the provisional esthetics were established, a record of the provisionals and photographs were sent to the ceramist to serve as the final prosthesis. The most important provisional photograph for image with retractors. The ceramist evaluated the incisal-edge position and the angle of the dental midline (Figure 9). The delivery appointment entailed try-in, cementation of teeth Nos. evaluation of the canines. The canines were recontoured after final esthetics. This helped in the management of patient expectations a opportunity to maximize the esthetics of teeth Nos. 7 through 10 us position and morphology of teeth Nos. 6 and 11. A medium-grit diameter to contour the bulges of the native canines so that the facial contours patient was pleased with the final esthetics (Figure 11).

**CASE TWO**

A patient presented with a smile that met all of the criteria of smile teeth Nos. 7 and 10 appeared dark and were lingualized (Figure 12) case for "prepless veneers" (feldspathic porcelain). It is important if performed, the emergence profile will appear bulbous, and there will ceramist to determine where to place the porcelain margin. Therefore, reduction at the gingival margin is necessary. Most dentists believe preparation must be completed, ideally in enamel, with a chamfer preparation demanding case because the adjacent dentition was perfect, as we patient’s expectations were set and she was willing to invest the time and necessary financial resources to attain these goals. Therefore, an additive wax-up and a Heraeus Kulzer, Inc, Armonk, NY) over the wax-up was fabricated (F clinician to develop the tooth form, contour, and emergence profile. allows esthetic modifications before the final restoration is fabricat the restoration determines the tooth preparation. Inadequate reduce delivery of an esthetic result.

To assure appropriate but minimal reduction, Luxatemp® Fluorescence Englewood, NJ) were added to the facial surface of the lingually positioned lateral incisors using Grel technique (Figure 14). In this technique the tooth is buccally volume of the final porcelain restoration. This facilitates appropriate maximum esthetics with minimal reduction. The depth-cutter was used across the facial of the provisional (Figure removed and the marks left by the depth-cutter were smoothed with a bur. There was no need for any incisal reduction because of the shown Discs were then used on the mesial and the distal to assure a facial laminate (Figure 16). The completed preparation will often require more facial reduction so because the middle and the cervical thirds must be adequately re emergence profile and room for the porcelain. If the principles of G under-preparation of the tooth would have occurred and the final est compromised (Figure 17 and Figure 18).

**CASE THREE**

A patient presented with a provisional restoration over a stock abut
because of the color and shape. The patient’s chief complaint was that of the color and shape. The patient’s chief complaint was that of esthetics. The initial goal was to attain a natural, beautiful appearance. Full record photographs, models, a facebow, and a centric relation bite registration were taken. An occlusal analysis was performed and she exhibited a high-risk esthetic category. Therefore, a satisfactory result in gingival esthetics was challenging. From a frontal perspective, the more gingiva than the left bicuspid distracted the appearance of a crooked smile (Figure 19). Her maxillary restorative treatment plan called for seven bonded-porcelain custom abutment and crown on the implant, gingival recontouring on the right Zoom! power bleaching on the mandibular teeth. A corresponding sectioned silicone facial and incisal index, which was produced. The sectioned silicone matrix was necessary to control the space available at three different planes, from cervical to incisal (Figure 20).

**Preparation Design**

The patient was anesthetized. Upon removal of the implant’s provisional restoration, significant hemorrhagic tissue was noted. The tissue was managed by placing a hemostatic agent in the sulcus of the implant site until the fixture-level impression phase To determine the level of the final margin relative to the hard and soft tissue, a periodontal probe was used to sound to bone to determine if 3 mm of tooth structure was available from the free gingival margin to the osseous crest for biologic width. A laser was used for gingival recontouring in the area of the right bicuspid following Tarnow’s principles. Before any facial preparation began, the facial index was placed. The areas of the tooth required minimal preparation because of augmentation. The desired final color of the restoration and the underlying stump shade factors in the amount of facial reduction. A minimal preparation of 0.3 mm is necessary for a one-shade shift. The medium preparation of 0.5 mm can provide for two shade shifts depending on the underlying preparation color. A deeper preparation of 1 mm is necessary to provide a difference in color of three shades or more. 4

Because the patient desired natural esthetics, a two-shift change was planned and 0.5 mm in facial reduction was performed. At this point in treatment this parameter was revisited with the patient. When this patient was questioned again to clarify her desires and align her results, she changed her mind and requested the "whitest teeth possible." For teaching purposes, images of the right side being facially prepared for feldspathic porcelain and the left side being prepared for pressed porcelain were taken (Figure 22). The facial preparations were completed in three planes using the three-sectioned labial matrix as the guide. The middle third is flat and the incisal third must be rolled toward the lingual space for both tooth form and light transmission. The gingival chamfer margin was placed in enamel following the contour of the free gingiva. This completed the interproximal composite that was placed to close the diastemas was placed (Figure 23).
The incisal matrix was used to ensure 2 mm of reduction from the definitive incisal edge. Any tooth structure in this zone was removed. The porcelain would overlap the lingual surface.

Attention to proper preparation design for diastema closure between the left canine required a maximum wrap and a full-slice preparation. It was critical that the preparation continued to the lingual to allow the porcelain from the lingual and reduce the possibility of black gingival triangles (Figure 24). The incisal matrix was again placed over the prepared teeth. It was used to assure that the interproximal preparations aligned within the outline form of the matrix. Any portion of the tooth that fell outside the form of the matrix was removed (Figure 25). This would give the ceramist the ability to change the final restorations. At this point the use of the matrices was complete.

Impressions and records were then sent to the ceramist. Once the provisional esthetics were established, a record of the provisionals was used. The delivery appointment entailed try-in, evaluation of the esthetics, evaluation of the abutment, and cementation of the 10 porcelain-bonded restorations. The patient was pleased with the final result because her expectations were understood and met.

CONCLUSION

When treating smile design cases ranging from simple additive types to difficult space-management types, it is necessary to understand and apply preparation design principles. Indices and the prefabrication of provisionals will allow for conservative removal of tooth while simultaneously assuring the best esthetic outcome.

ACKNOWLEDGMENT

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References


Figure 1 Preoperative view. Note the rotated malpositioned teeth.

Figure 2 Note the low smile line because of the Gortex implants and long central incisors just shy of the lower lip.

Figure 3 Preoperative occlusal view. Note the protruding portion of the lateral incisor.

Figure 4 Aligning the arch form removing the protruding portion of the misaligned tooth.
Figure 5 and Figure 6 The lateral spaces were measured and equalized by the removal of tooth structure on the distal of the centrals.

Figure 7 Depth-cutters were employed to ensure the proper amount of enamel reduction.

Figure 8 All contralateral width were measured to ensure symmetry.

Figure 9 The ceramist uses this photo to evaluate that the midline of the centrals is perpendicular to the interpupillary line.

Figure 10 Recontouring of the protruding portion of the canine after final cementation of the ceramics on teeth Nos. 7 through 10.

Figure 11 Final occlusal view. Note the symmetry and arch-form correction.

Figure 12 Case 2: Preoperative ideal smile design principles with lingualized lateral incisors.
Figure 13 The additive wax-up.

Figure 14 The provisional was added to the tooth and the photograph taken with shade tabs before dehydration of the dentition occurred.

Figure 15 The depth-cutting instrument establishes the amount of facial reduction. Note that the patient's facial enamel was removed during this stage.

Figure 16 A disc was used to ensure the path of insertion from a labial perspective.

Figure 17 Postoperative view; note the invisible prosthetics.

Figure 18 Postoperative smile view. Note the uncompromised esthetics.
Figure 19 Case 3: Preoperative note: Triangular-shaped teeth, stained interproximal composite bonding, a dark canine provisional, and greater gingival display on the right bicuspsids compared to the left, making the smile appear crooked.

Figure 20 A sectioned silicon matrix threeplane visualization.

Figure 21 Sounding to bone to determine the amount of gingiva to be removed.

Figure 22 Medium preparation on the left: 0.5 mm (feldspathic); deep preparation on the right: 1 mm (pressed ceramic).

Figure 23 An incisal matrix was used to guide the reduction of interproximal and incisal tooth structure. Note the overlap of the mesial of tooth No. 10 and the

Figure 24 After removal of the direct composite, a subgingiva slice preparation is necessary to create room for the ceramist to close the diastema.
distal of tooth No. 9.

Figure 25 Centering the preparation in the matrix and assuring that the preparation aligns within the outline form of the matrix.

Figure 26 The final esthetics. Note the gingival symmetry, healthy papilla, and tooth form.

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