A Systematic Approach to Predictable Esthetics
Using Porcelain Laminate Veneers

Tal Morr, DMD, MSD*
Harald Heindl, MDT**

With the continual advancement in all aspects of dentistry, esthetics remains at the forefront for the patient. More than in the past, today's patients are much more educated about the treatment options available. This improved dental knowledge has developed as a result of the availability of information via the Internet, publications, and television. Because of this increase in knowledge, patients are now demanding the highest level of esthetics possible.

Although esthetics is certainly crucial, the ultimate objective for any dental treatment should be to restore health, function, and beauty using the most conservative method of treatment available to achieve the desired result. Bonded ceramic veneers are often the restoration of choice from a biologic, functional, mechanical, and aesthetic standpoint when the objective is to modify tooth position and/or tooth form, close diastemata and/or cervical embrasures, or change the color of teeth. All of these options are approached with the assumption that enough enamel substrate is available and that the patient does not wish to undergo orthodontic treatment.

The natural tooth is uniquely made up of two materials: enamel and dentin. The rigidity of enamel and the flexibility of dentin create the unique complex of the tooth crown. Studies have shown that from a mechanical and functional standpoint, feldspathic porcelain veneers adequately restore the rigidity of the crown when used as an enamel substitute. From a biologic standpoint, we know that, because of their esthetic qualities, bonded veneers do not require penetration into the gingival sulcus in every clinical situation. This may prevent potential damage to the periodontal tissues.

Because plaque and bacterial vitality have been found to be significantly reduced around porcelain veneers, these restorations may be biologically beneficial to patients with poor oral hygiene. Porcelain has been found to be less susceptible to accumulation of bacterial plaque than mineralized tooth structure, gold, and composite resin. Because porcelain veneers have no metal substructure, they allow light to be absorbed, deflected, and reflected in a manner similar to natural tooth structure. By contrast, in a restoration with a metal substructure, light traverses the ceramic but is blocked by the metal core, all too often with a resultant graying effect of the definitive restoration.
As with all restorative procedures, a thorough diagnosis and treatment plan must be implemented with communication occurring between all members of the treatment team. The initial evaluation should encompass visualization of the final esthetic alterations within the mechanical and functional parameters. An esthetic interpretation of the final result will help to shape the treatment plan in relation to proposed changes in tissue level, contour, tooth form and arrangement, and preparation design and will enable the team to achieve the final result.

CASE 1

Esthetic Evaluation

A 28-year-old female, who was a model, presented for esthetic improvement of her smile. Her chief complaint was that her teeth were too round and she was told that they did not reflect light appropriately; hence, she was asked to pose with her lips closed during photo shoots. The patient was emphatic about having a long-term esthetic result that would not stain and discolor as did her composite resin restorations. Before a determination could be made about the treatment modality to be used and the number of teeth to be restored, a thorough esthetic evaluation was performed.

The patient was asked to say “M” letting her lips relax naturally (Fig 1a). With the patient’s lips at rest, the incisal edge position of the central incisors was evaluated; the position of the maxillary right central incisor appeared to be appropriate for the patient in terms of age and gender. Some problems became evident when the patient smiled, however (Fig 1b). The left central incisor was slightly shorter than the right central incisor. Both canines were slightly worn and were too short in relation to the occlusal plane drawn from the right central incisor to the molars. Lengthening of the canines would level the occlusal plane.

The rotation of the maxillary left canine created severe disharmony in the smile, its distal aspect being more prominent than the mesial. A key element of esthetics is that, from a facial point of view, it is preferable to see the mesial aspect of the canine only. This helps to create the transition from the anterior of the mouth to the posterior. The canine is the tooth that defines the arch form, whether square, u-shaped, or v-shaped.

Also noted in the examination was the axial inclination of the maxillary left lateral incisor. Rather than appearing to be tipped toward the mesial from a cervicoincisal direction, it was tipped distally. This in turn created imbalance in the smile line. There was also an obvious discrepancy in the balance of the gingival levels (Fig 1c). Ideally, dental professionals prefer the gingival margins of the central incisors and canines to be at the same level while the lateral incisor tissue heights should be somewhat more coronal. Although the soft tissue on both centrals was even, it was more coronal than that of both canines. The gingival tissue around the maxillary left lateral incisor accentuated the problem by being more cervical to that of the centrals, and the soft tissue around the left canine was more cervical than that of the right canine.

Another key element that the patient wanted to address was the diastema (Fig 1d). An attempt had been made at some point to close the diastema with composite resin, but at the initial presentation, the composites were discolored and worn. In addition, the central incisors appeared to be too narrow relative to the lateral incisors and canines.

From the esthetics evaluation, it was determined that soft tissue correction would be necessary to create a more harmonious result. As part of the evaluation, a local anesthetic was administered and the facial aspects of the two central incisors were probed to determine the location of the cementoenamel junction. Approximately 1.5 mm of the crowns (enamel) of the central incisors and the right lateral incisor were covered by the gingiva. The bone was sounded, and the biologic width for this patient was found to be about 2.5 mm. This determination would be helpful for bone recon-touring. From a mechanical and functional point of view, all other findings were within normal limits.
Esthetic Treatment Plan

The problems were discussed with the patient, and the objectives for restorative treatment were laid out as follows: (1) to surgically level the soft tissue to create a balanced and harmonious gingival plane and accompanying tooth length and shape, while maintaining the cervical aspect of the preparation in enamel; (2) to close the diastema between the central incisors so that these teeth would appear more dominant; (3) to correct the axial inclination of the teeth so that from a cervico-incisal direction they would appear to be tipped toward the mesial; and (4) to bring the maxillary right canine more buccal, lengthen both canines slightly, and rotate the maxillary left canine so that it would transition from anterior to posterior and create a more harmonious arch form. It is important to note that when severe manipulation of the position of the teeth is necessary, some dentin exposure will result during the preparation.

Porcelain veneers are an ideal restoration for this type of treatment if the objective is to change the size, contour, arrangement, and color of the teeth. Not only are they the least invasive type of restoration, other than composite bonding, but they can fulfill all of the objectives of treatment. Composite restorations were not an option because of their inherent problems with staining and degradation over time. If the objective had been only to correct tooth alignment and the diastema, orthodontics would have been the treatment of choice.

Diagnostic Waxup

Alginate impressions of the maxilla and mandible were made, and models were mounted using a facebow leveled with the eyes. A diagnostic waxup of all the proposed changes was made on the cast (Fig 2). The diagnostic waxup is the most critical step for predictability in any type of restorative procedure. Not only does it allow visualization of the final proposed changes, it also reveals whether the desired changes are reasonable and able to be achieved. In this case, the facial surfaces of the central incisors were ground down slightly on the diagnostic cast to make them less rounded, and the distal of the left canine was modified to allow correction of the rotation prior to the waxup. Knowing how much was ground off helps tremendously in the preparation step.

The incisal edges were waxed first, followed by the facial contour, and then the tissue heights were corrected by waxing over the gingival margins where necessary to level the gingival plane. The waxup enabled the future tooth preparation design and soft tissue leveling to be visualized.

Soft Tissue Leveling and Contouring

The patient returned for surgical crown lengthening. A modified approach to the technique, as described by Eriks,* was used. A papilla-preservation flap was elevated, and the bone was contoured to be at the same level on both the canines and the centrals, taking into consideration the incisal edge positions. The bone on the maxillary right lateral incisor was leveled with that of the maxillary left lateral. As mentioned earlier, a biologic width of 2.5 mm was found when sounding to bone. This measurement was used to position the bone according to the final position of the marginal tissue as determined by the waxup. Care was taken not to create a situation in which the dentin would be exposed. Because of this, the centrals were left somewhat shorter than the canines, and the laterals were not leveled perfectly. More aggressive crown lengthening would have exposed dentin.

After 3 months of healing, the smile already revealed a harmonious improvement (Fig 3a). The biologic width was evaluated again for maturation by sounding to bone. When the measurement equaled 2.5 mm, it was deemed ready for preparation. It was noted at this time that the tissue heights of the central incisors were not level even though the bone had been carefully placed in the correct position (Fig 3b). It is possible that some remodeling of the bone around the left central incisor occurred.
Second Diagnostic Waxup

Because the soft tissue was surgically corrected, a second diagnostic waxup was necessary. A new alginate impression of the maxilla was made, and the cast was mounted against the mandibular model.

Using silicone indices, the tooth contours of the original waxup were duplicated on the postoperative maxillary cast with the corrected gingival levels and contour. Now that the central incisors were longer, they could be made wider and more dominant. A full-coverage silicone index of the waxup was made, extending beyond the facial and palatal margins and from second premolar to second premolar (see Fig 6a). This would be used for fabrication of the provisional restorations. A facial index was also fabricated to be used for verification of precise reduction of the preparations in the facial plane (Fig 4).

Tooth Preparation

The patient was given local anesthetic, and the preparations were begun. Current techniques suggest using a depth-defining bur to ensure proper reduction, which is 0.3 to 0.7 mm for porcelain veneers. If the teeth to be veneered are properly aligned and no major changes in tooth form are required, this type of technique is useful. On the other hand, when changes in tooth form and alignment are required, a more precise technique is needed, one that will take into consideration the final shape and contour of the veneers. In this case, a facial silicone index was beneficial in guiding the preparation depth and design (see Fig 4). Knowing how much stone was removed from the cast to create the tooth contours was also beneficial. All waxups were prepared by the restorative dentist since he was responsible for evaluating and determining the final changes. Preparations were begun by removing the existing bonding and then opening the proximal surfaces using diamond disks. The latter technique facilitates preparation of the proximal surfaces, impression making, and laboratory procedures. Because one of the objectives was to close the diastema and the cervical embrasures, the preparations needed to be continued to the palatal aspects of the teeth interproximally as well as subgingivally to allow for a smooth emergence profile of the veneers. Interproximal preparation is also necessary for alteration of the position and rotation of a tooth.

Once the teeth were disked, Ultrapak 000 cord (Ultradent, South Jordan, Utah) was placed interproximally within the sulcus. The teeth were prepared again so that they finished at the level of the tissue facially and at the level of the cord interproximally (Fig 5). The facial matrix was used to ensure proper reduction of the facial and interproximal aspects of the teeth. Cervically, the preparations were left in enamel. Under normal circumstances, the preparations would be cut to the tissue level when little or no alterations in color are needed. In this case, the soft tissue of the left central incisor was more cervical than that of the right central incisor following surgical correction, even though bony placement during surgery was carefully measured with a caliper. If the bone was placed in the correct position, then the tissue should eventually move down to the desired position. Because of this, the cervical extent of the preparation on the left central incisor was made by carefully measuring the preparation on the right central incisor so that the teeth would be the same length, even though tooth structure remained cervical to the preparation. Once the preparations were finished, a laser was used interproximally to modify the cervical contour of the tissue (see Fig 5).

Provisionalization

Once the preparations were finished, the full-coverage matrix of the waxup was filled with Alike temporary resin (GC America, Alsip, IL) and placed in the mouth (Fig 6a). The matrix with the resin inside was gently pumped up and down until the resin set (Fig 6b). The provisional restorations were then finished with burs and disks after evaluation in the mouth, and any necessary contour
CASE 1 (Figs 1 to 11)

Fig 1a Initial presentation of lips at rest.

Fig 1b Initial smile.

Fig 1c Initial intraoral frontal view.

Fig 1d Closeup of maxillary anterior teeth showing diastema and discolored composite resin restorations.

Fig 2 Diagnostic waxup of proposed changes.

Fig 3a Smile after esthetic crown lengthening.

Fig 3b Intraoral view of soft tissue after esthetic crown lengthening.

Fig 4 Facial matrix made from the waxup model.

Fig 5 Final tooth preparations.
changes were made by either addition or subtraction of acrylic resin. At this point, interproximal shape was modified to close the cervical embrasures and to shape the cervical contour of the tissue. Once the final contours were achieved, the provisionals were removed and measured individually from the cervical extent to the incisal edge to verify correct reduction. Any areas that were not reduced enough were corrected by modifying the preparation.

With every provisional fabricated from a waxup, some modification is always needed in the mouth. The waxup is prepared without the face to provide context. The final contours must be corrected in the mouth to obtain a true visualization. Only after the provisionals are properly contoured can it be determined if the preparations were made correctly (Figs 7a and 7b).

Once the preparations were deemed completed, a second cord, Ultrapak 00 soaked in a 20% aluminum chloride gel (Styptin, Van R Dental, Oxnard, CA), was packed into the sulcus to retract the tissue for final impressions. Small cords are generally used for veneers because, if there are no alterations in the tooth color, a supragingival margin, or one made to the tissue level, is adequate. As always, the final objective is to have gingival health at the periodontal-restorative interface. Final impressions were made using a polyvinyl siloxane material (Affinis, Coltene Whaledent, Mahway, NJ).

Photographs

Color photographs of a shade guide with the original teeth and the tooth preparations were taken to allow the technician to see the underlying tooth color. This is essential to inform the technician if any blockout is needed to achieve the desired shade (Figs 8a and 8c). A black-and-white photograph was also taken to allow evaluation of the desired value versus the shade tab (Fig 8b).

Provisional Cementation

The provisional veneers were cemented with resin and no bonding agent. There is generally enough friction to hold them in place because of the interproximal preparation. If friction is limited, spot etching and bonding with a resin can be used to aid in the retention. The initial cord used for preparation was left in the sulcus until after the provisionals were cemented.

Alginate Impressions

Once the provisionals were cleaned, alginate impressions were made of the provisionals and the opposing arch. Because the lingual aspects of the anterior teeth were not altered, no occlusal record was needed.

Laboratory Considerations

Three casts were made from the final impression with type IV dental stone. The first pour was kept as a solid cast, the second was used for fabrication of a saw-cut working model, and the third was used for final control dies. The DVA (Dental Ventures of America, Corona, CA) model system was used for the working model. This system provides duplicate molds for single teeth and exchangeable, heat-resistant, aluminum oxide pins for the refractory dies. The dies were sealed with a thin-bodied cyanoacrylate, and one layer of die spacer was applied to the surface. The prepared dies were then duplicated using a polyvinyl siloxane material (Doubletake, Ivoclar Williams, Amherst, NY). Refractory dies were fabricated from this impression.

Once all the casts were ready, the working model and the solid cast were cross-mounted with the provisional model for reference. From the cross-mounted provisional model, four types of indices were made. The first was a full-coverage index (Fig 9a) cut into vertical segments. This was
used to verify the available space for porcelain layering, the labial curvature of the provisionals, and the length of the planned restoration. The next index fabricated was the labial index (Fig 9b) cut into horizontal segments. This index showed the labial separations between the teeth, the position of the line angles, and most importantly, the width of the desired final tooth form. A third index was made from the palatal (Fig 9c) aspect. This index was used to establish the correct length of the dentin body, the placement and position of the internal effects, and the final length of the restoration. The fourth index was made by imprinting the incisal edge (Fig 9d). This index was used as a precautionary measure to ensure proper incisal edge position during the buildup process. By opening the pin 1 mm and building up the ceramic to the incisal index, the restorations should be either slightly long or perfect in length after porcelain shrinkage occurs.

After all of the indexes were made, the veneers were built up on the refractory dies, checked on the master dies, and adjusted on the solid cast. The internal aspect of the veneers were then etched with 9.5% hydrofluoric acid for 5 minutes and delivered to the restorative dentist.

**Final Cementation**

At delivery, the health and beauty of the soft tissue form was evident. This was developed by the preparation design, the precise fit of the provisionals, and meticulous oral hygiene by the patient (Fig 10). These elements are essential for final cementation of the veneers. The only way to achieve a healthy soft tissue is by atraumatic manipulation of the gingival tissues throughout the restorative phase of treatment (preparation, retraction, provisionalization, and final cementation).

A local anesthetic was administered followed by removal of the provisionals and scaling of the resin from the teeth. The sulcus was packed with Ultrapak 000 cord soaked with the same hemostatic agent used previously. The cord serves many purposes: it allows retraction of the tissue from the preparation margin, aids in moisture control, provides hemostasis, and helps in the final cleanup of excess cement.

The veneers were tried in first to evaluate the interproximal contacts. Articulating paper was used to verify the contacts, and adjustments were made with a diamond-impregnated wheel where needed. The esthetics were then evaluated with the patient by placing water in the veneers and seating them in the mouth. After the patient approved them, the veneers were re-etched with a 9.5% buffered hydrofluoric acid (Ultraetch, Ultradent) for 3 minutes and placed in the ultrasonic cleaner for 5 minutes to remove any residue. They were then silanated with ScotchBond ceramic primer (3M Dental Products, St Paul, MN), and a layer of bonding agent was applied to the surface and the excess blown off. The preparations were cleaned with pumice, rinsed, and etched with 32% phosphoric acid (3M). Bonding agent was applied to the moist tooth surface (Single Bond adhesive, 3M), and the veneers were cemented with RelyX veneer luting cement (color B0.5/white, 3M). Excess cement was removed initially with a brush and the contacts cleaned with floss after 3 seconds of light curing. Removal of the cord and final cement cleanup were performed after the veneer margins were covered with Deox, an oxygen-barrier solution (Ultradent) and light cured adequately.

After 2 weeks of healing, the patient presented for final photographs. It was evident that all of the desired objectives were achieved (Figs 11a to 11f). The soft tissue was leveled to create a balanced and harmonious gingival plane; tooth arrangement and contour were improved, as was the occlusal plane; the diastema was closed; the axial inclinations of the teeth were improved to provide harmony; and the maxillary left canine was derotated to create a smooth transition between the anterior and the posterior aspects of the arch.

The veneers are biologically, mechanically, functionally, and esthetically sound.
Fig 6a  Full-coverage silicone matrix with acrylic resin prior to placement in the mouth.

Fig 6b  Full-coverage silicone matrix after acrylic resin has set.

Figs 7a and 7b  Smile and intraoral view of provisional veneers on the tooth preparations. Note the exposure of dentin beyond the margin of the provisional of the left central incisor.

Fig 8a  Color photograph of the teeth at initial presentation with B1 shade tab.

Fig 8b  Black-and-white photograph used for evaluation of the value of the teeth relative to the shade tab.

Fig 8c  Photograph of the tooth preparations with B1 shade tab.

Fig 9a  Full-coverage index used to evaluate facial reduction.

Fig 9b  Labial index used to evaluate both the labial separation between the teeth and the width of the proposed veneers.

Fig 9c  Palatal index used to establish correct length and internal effects of the porcelain.

Fig 9d  Incisal index used to ensure proper incisal edge position during the porcelain buildup.
Predictable Esthetics Using Porcelain Laminate Veneers

Fig 10 Tissue health at delivery of the final restorations, after removal of provisionals.

Fig 11a Final incisal edge position with lips at rest.

Fig 11b Final smile.

Fig 11c and 11d Final intraoral views. Note that the tissue level around the left central incisor is almost level relative to that of the right central incisor.

Fig 11e Right lateral view of veneers.

Fig 11f Left lateral view of veneers.
CASE 2

Esthetic Evaluation and Treatment Plan

A 34-year-old man presented with two existing veneers. His chief complaint at the time of treatment was the difference in the color of the two veneers. He was also unhappy with the embrasure that was developing between the teeth and the darkness at the junction of the maxillary right veneer and tooth (Figs 12a to 12c).

A thorough esthetic evaluation was performed as described for case 1. The soft tissue profile was deemed acceptable. The necessary correction was localized to the central incisors. As with case 1, predictability even with only two teeth is achieved by determining the objectives for treatment. In this case, the objectives were (1) to reshape the maxillary central incisors to mimic natural contours and optical qualities; (2) to close the cervical embrasure between the central incisors to create balance in the soft tissue; and (3) to make the junction between the tooth and veneer invisible.

Veneers were clearly the restoration of choice for improvement of the patient’s esthetic concerns.

Waxup

As with case 1, a waxup was prepared to obtain the desired corrections in contour, size, and tissue form (Fig 13). When waxing to close a cervical embrasure, facial line angles help define the final contour of the teeth. The line angles give the illusion that the teeth are tapering even though the actual tooth form may be more square as a result of the lengthened contact. Embrasure closure is obtained from the palatal aspect of the restoration. Indexes were made from the waxup as in case 1.

Preparations

Ultrapak 000 cord was packed into the sulcus after locally anesthetizing the area. The teeth were prepared based on the changes made on the model and the waxup and with the use of the facial index. Preparations were extended to the palatal aspect and intrasucularly to allow room for a smooth emergence and embrasure closure (Fig 14). As in case 1, a full silicone index was used to fabricate the provisionals. The provisionals were removed and contoured using acrylic burs and a variety of disks. Once the desired contours were achieved, the smile was evaluated for harmony and balance by the clinician and the patient (Fig 15a). The cervical contact point was carried just above the papillary level. When soft tissue is manipulated from an intrasucular position, a small interproximal space must remain for coronal movement of the papilla, which occurs with lateral pressure from the provisional.

The provisionals were measured for adequate preparation depth (Fig 16), and any needed adjustments were made. Preparation was aimed at finishing in enamel; however, not only does removal of old veneers make this difficult, but in this case, the preparations were already partly in dentin. An explorer was used to determine when the existing porcelain and composite had been removed.

Final Impressions and Photographs

Once the provisionals were made and the preparations were acceptable, a second cord (0) was placed into the sulcus. Final impressions were made using a polyvinyl siloxane impression material. Photographs were taken of the preparations and the adjacent teeth with shade tabs. These were done both in color (for color comparison) and black and white (to compare value).

Provisional Cementation

As in case 1, the first cord was left in the sulcus. The provisional veneers were cemented with resin cement with no bonding agent. Because the preparations were parallel, there was enough fric-
CASE 2 (Figs 12 to 22)

Fig 12a Initial smile.

Fig 12b Initial intraoral view.

Fig 12c Closeup of existing veneers on the central incisors. Note the exposed margin on the distal aspect of the right central incisor and the cervical embrasure.

Fig 13 Waxup of the proposed changes.

Fig 14 Final preparations for veneers with retraction cords in place, ready for impression.

Fig 15a Smile with provisionals.

Fig 15b Closeup of provisionals. Note the closure of the cervical embrasure and tissue recontouring.

Fig 16 Measuring the thickness of acrylic resin to ensure proper reduction of the preparations.
tion to hold the provisionals in place. As an added precaution, alginate impressions of the provisionals were made, and a vacuum-formed appliance that the patient would wear was fabricated to help hold the provisionals in place. The cords were removed after the composite was light cured.

Alginate Impressions and Laboratory Considerations

Alginate impressions of the provisional model and the opposing arch were made for cross mounting. No occlusal records were made. The impression was treated as in case 1 and was cross-mounted with the provisional model. All the same indices were fabricated to maintain predictability.

Ceramic Buildup

Porcelain layering was carried out using d.SIGN (IPS d.SIGN, Ivoclar Vivadent, Amherst, NY). The first layer was made using d.SIGN margin material applied in a thin layer up to the margin. This layer seals the refractory die and provides a secure bond between the porcelain and refractory material. The initial ceramic layer was a modified deep dentin placed on the incisal and interproximal areas to prevent excessive light absorption into these areas and to help smooth the transition from the incisal edge of the prepared tooth to the porcelain (Fig 17).

Three different types of dentin were used (Fig 18). Incisally, a modified dentin was used to enhance the brightness and value. Regular dentin was used in the center of the tooth. A blend of dentin and transparent was used on all areas where the preparation ended to allow the color of the underlying tooth to influence the color of the restoration. The length of the ceramic buildup was checked with a palatal index prior to cutback for enamel/translucent layering. In contrast to other ceramic materials, the dentin of the d.Sign system is so translucent that it is possible to apply internal effects directly onto the dentin. It is not necessary to apply those effects on the enamel wall.

The final form was developed in alternating increments of various enamels and transluents (Fig 19). A second bake is usually necessary to optimize form and contours. Quite frequently, interdental deficiencies, such as blunted interdental papillae, unfavorable tooth morphology, or diastemata, require an artificial closure of the interproximal spaces. In these cases, the interproximal contacts are overcontoured in the second bake. Once baked, the contact point is modified so it begins just above the position of the retracted papilla and ends near the incisal edge. Creating such a long contact area can cause an unnatural appearance to the tooth form. It is necessary to maintain the natural tooth form by emphasizing the triangular line angles and making the proximal contacts more toward the palatal aspect to give the illusion of reality.

Final Contouring and Finishing

The final contouring and surface texturing were carried out using a variety of diamond burs and green stones. Final tooth surface contour must be achieved prior to elaborating the surface texture. Use of silver powder applied directly to the surface helped to visualize the final contours and surface texture (Fig 20). Final surface treatment was completed with a quartz-infiltrated nylon wheel (Upofix Austenal, York, PA) and an oven glazing cycle without a vacuum. Mechanical polishing with pumice and a felt wheel is optional.

The dies were removed from the veneers, and the veneers were cleaned with 30-μm glass beads. The definitive restoration margins were checked on the master dies. Contours and interproximal contacts were confirmed and adjusted on a solid cast, both with and without the soft tissue model material in place (Fig 21).
Fig 17 Modified deep dentin layer to smooth the transition between the incisal edge of the preparation and the porcelain.

Fig 18 Dentin buildup.

Fig 19 Enamel and translucent buildup.

Fig 20 Silver powder to help visualize the final contours and surface texture.

Fig 21 Definitive restorations on the solid cast.
Final Smile Showing Improved Esthetics

The black-and-white photograph shows the value of the veneers relative to the adjacent teeth.

Frontal Views of the Final Restorations

Closeup of the Veneers on the Central Incisors

Note the undetectable margins and closure of the cervical embrasure.

Final Cementation

The teeth and the veneers were treated and cemented as in case 1. One week after final cementation, tissue health and soft tissue embrasure closure from the papillae were evident, and the restoration margins were clinically undetectable (Figs 22a to 22e).
CONCLUSION

Following a step-by-step protocol is crucial to achieve predictability in any restorative case. Only through a meticulous process can success be consistently insured. The clinician's initial evaluation is imperative for success. Clinical cases must be evaluated from structural, biologic, functional, and esthetic standpoints. Not only does the initial evaluation enable the clinician to identify what alterations must be made, but it also helps in the formulation of the treatment plan needed to achieve the desired result. Treatment planning can only be verified by using the diagnostic contours cast, and only through this procedure can one truly tell if the proposed changes are possible. From the development of the proposed contours, reduction templates can be made to aid incorrect preparation depth and design, to guide the surgeon as to the required soft tissue contours, and to directly fabricate the provisional restorations.

The provisional restorations are the only way for the clinician and patient to visualize the outcome within the natural frame of the face and mouth. When the provisional is correctly contoured, the soft tissue can be manipulated and shaped appropriately. A final esthetic tooth form and arrangement of the veneers is more consistently achieved by correctly cross-mounting a cast of the provisional restorations with the casts of the actual tooth preparations and using the information gathered from the various templates and indices. The final shade of the restorations can be predictable when the clinician supplies photographs of teeth and preparations for both shade and characterization and when the laboratory technician has a thorough understanding of ceramic layering. Throughout the treatment process, traumatic manipulation of the soft tissue during tooth preparation, adequate provisionallization of the teeth, and careful cementation are essential if a healthy gingival response is to be achieved.

REFERENCES

Integration of a single-tooth implant in the esthetic zone can be one of the most difficult treatment options because of the numerous biologic and esthetic requirements. Of critical importance is the soft tissue integration of the implant-supported restoration relative to the rest of the anterior teeth. Failure to mimic the natural gingival form from both the cervical contour and the papillary form can create an esthetic dilemma. The need to preserve the gingival form has led to the trend of immediate implant placement. After anterior tooth loss, the normal course of wound healing will cause the facial bone and soft tissue to recede both facially and palatally. Without support, this recession may be compounded by the loss of the interdental papilla. This creates a narrower residual ridge that may impede placement of an implant in an ideal, restoratively driven position without additional surgical procedures, even if the soft tissue form looks acceptable. Although surgical procedures to rebuild the residual ridge can be performed with generally good results, rebuilding the papilla to its proper form can be much more of a challenge. Forced eruption via orthodontics can be a critical adjunct to regenerating papillae adjacent to an implant, especially when papillary regeneration via a surgical procedure may not achieve the desired result.

CASE 1

A 40-year-old woman was referred to the office by an orthodontist who questioned the integrity of an existing anterior restoration made 18 years earlier. At age 18, the patient had had an accident in which she lost tooth 6(13) and fractured the remaining incisors, with a resultant need for endodontic treatment. The patient was rehabilitated with a fixed partial denture from teeth 3(16) through 8(11) (tooth 5[14] was extracted for or-
CASE 1

Fig 1 Initial radiographs at presentation.

Fig 2 Lips at rest during initial evaluation.

Fig 3 Smile during initial evaluation. Note the papillary levels from right to left; the papillae on the right side are shorter.

Fig 4 Intraoral frontal at presentation. Note the discrepancy in the level of the gingiva, which is higher on the right side.

Fig 5 Initial preparations. Note the short preparations and form of the pontic area.

Thodontic purposes, 6(13) because of trauma), with single units (full-coverage crowns) on teeth 9(21) and 10(22).

Implants were not readily available at the time of the injury, so the patient opted for a fixed partial denture to replace the missing canine. Radiographic evaluation revealed fairly short roots on the anterior teeth, with good residual height of bone in the area of tooth 6(13), although there had been both vertical and horizontal bone loss (Fig 1).

Clinical evaluation of the incisal edge at rest position revealed approximately 5 mm of tooth exposure (Fig 2). Assessment during smiling showed more papilla on the left side than the right (Fig 3).

At the time of examination the patient was already in mandibular orthodontic appliances for the correction of crowding (Figs 4 and 5). After intraoral evaluation, it was determined that the marginal integrity of the restorations was compromised by washout of the cement and the resultant decay.

Evaluation of the pontic area 6(13) revealed fair to good remaining soft tissue form, although deficient in the horizontal aspect and the papillae (Figs 4 and 5). The soft tissue margin was posi-
tioned more cervically around tooth 7(12) and more coronally around tooth 11(23) than around the other remaining anterior teeth. The marginal tissue contours on the central incisors were not symmetrical or level. The papillary heights were not level; the papillae on the left side were more coronal than on the right (see Figs 3 and 4).

**Treatment Plan**

The patient wanted to have single-tooth prostheses rather than bridgework. To determine if this was possible, the teeth would be evaluated periodontally at the time of provisionalization to determine whether they could be maintained as single units. Once the determination was made that the teeth could be made into single units from the standpoints of function, mechanics, and biology, the marginal heights of the soft tissue would be corrected with crown lengthening along with an implant placed in the area of tooth 6(13). The soft tissue around tooth 7(12) would be coronally positioned to cover the exposed root and help to level the soft tissue. Shortening of the incisal edges and cervical positioning of the soft tissue would maintain the proportions of the teeth.

The final restorations would be fabricated with Procera crowns (Nobel Biocare, Göteborg, Sweden) to replace teeth 3(16), 5(14), 7(12), 8(11), 9(21), and 10(22), with a porcelain-fused-to-metal crown and a gold custom abutment replacing tooth 6(13) and a feldspathic veneer tooth replacing tooth 11(23).

The patient began treatment as described. At the time of provisionalization, it became evident that the patient needed crown lengthening, not only for esthetic reasons but also for form retention and resistance of the preparations because of the inadequate height (see Fig 5). The mobility of the teeth was negligible; therefore, an implant was deemed appropriate for replacement of tooth 6(13). Once the functional and esthetic requirements were fulfilled in the provisional phase (Fig 6), the patient was sent to a periodontist for esthetic crown lengthening and an implant to replace the missing maxillary right canine. The patient was anesthetized with Xylocaine (AstraZeneca, London, United Kingdom) 1:100,000 epinephrine. A sulcular incision was made around tooth 7(12) and continued into an inverse bevel incision at the new marginal levels of the remaining maxillary anterior teeth, sparing the papilla from the mesial of tooth 7(12) to the distal of tooth 12(24). In the area of teeth 3(16) through 5(14), facial and palatal palatal flaps were reflected to enable circumferential ostectomy for resistance and retention form of the preparations. Vertical incisions were made on the mesial of tooth 5(14) and the distal of tooth 7(12) internal to the papilla on either side to enable coronal positioning of the soft tissue over the implant site 6(13). In the area of the residual ridge, the flap was extended slightly palatal of the center of the ridge to obtain extra tissue. Upon reflection of the flap, the bone was reshaped on all teeth slightly coronal to the bony level of tooth 7(12), as it was the limiting factor because of its bony dehiscence, short root, and minimal bony support. No bone was removed around tooth 7(12) at all. A narrow-diameter standard neck dental implant (Straumann, Waldenburg, Switzerland) was placed in the area of tooth 6(13) with the head of the implant 3.0 mm cervical to the desired gingival margin of the future implant crown as dictated by the surgical stent (Figs 7 and 8). The soft tissue was sutured in place with the flap over the implant coronally positioned to gain vertical height (Fig 9). The soft tissue around tooth 7(12) was also coronally positioned to level the gingival margins (Fig 10).

At 5.5 months, the biologic width had re-established itself, and the patient was ready to begin re-lining of the provisionals and soft tissue manipulation in the area of the implant. Verification of maturation was made by sounding to bone and comparing the biologic width in the implant area to areas that were not surgically modified. The mass of the papilla on the mesial of the implant (distal of 7[12]) was almost negligible, with only the palatal aspect remaining (Figs 11 and 12). The marginal ridge remained very flat, with an angular transition from the marginal ridge to the papilla rather than a nice scallop (Fig 12). The gingival margin around
tooth 7(12) ended up in a more cervical position than the remaining anterior teeth (Fig 11). The teeth were prepared again to the gingival level, except for tooth 7(12), which was left slightly coronal to the margin (Fig 11). An octa-abutment was torqued into the implant, followed by modification of a titanium temporary abutment with addition of acrylic resin to create a root form to support and mold the soft tissue (Figs 13 and 14). The provisionals were relined, and the patient was told to return in 3 months.

After 3 months, the soft tissue form around the implant was still unacceptable. Not only was the facial half of the papilla almost nonexistent, with only the palatal aspect remaining, but the marginal ridge form around the implant was too flat and an-
MORR

regular, creating a defect on the mesial of the canine (Fig 15). The marginal ridge height of tooth 7(12) remained more cervical than the remaining teeth.

At the time of the initial evaluation it seemed that there was adequate soft tissue and bony topography to adequately restore tooth 6(13) with an implant without bone augmentation prior to placement. In hindsight, it may have been appropriate in this case to augment at least the soft tissue component in this area. The patient had fairly thin soft tis-

Fig 11 Soft tissue form after full healing and reformation of the biologic width. Note the defect around the implant at site 6(13).

Fig 12 Lateral view of the soft tissue around the implant at site 6(13).

Fig 13 Placement of an octa-abutment prior to fabrication of a temporary abutment.

Fig 14 Temporary abutment in place after being modified with a bur and acrylic resin. Note the flat gingival form and deficient papilla on the mesial of the implant.

Fig 15 Provisional relined over the temporary abutment. Note the short papilla on the mesial of the canine compared to the other teeth.
Improving Soft Tissue Form Around Implants via Forced Eruption

sue, especially in the papillary area distal to tooth 7(12) (see Fig 5). Evaluation of the preoperative photographs reveals that the papillary heights on the right side of the maxilla were at least 1.5 mm shorter than those on the left side (see Figs 4 and 5). Without augmentation, the two sides would never be at the same levels.

At the time of surgery, a vertical incision was made through the distal papilla of tooth 7(12) to allow coronal repositioning of the flap over the healing abutment so that the soft tissue could gain vertical height. Close observation of the surgical procedure shows that the incision was placed very close to tooth 7(12), leaving very little bulk or mass of papilla (see Figs 8 and 9). As a result, the blood flow to the area was compromised, and the facial aspect of the papilla sloughed over time, leaving only the palatal aspect. Both a loss in vertical and horizontal mass of the papilla was evident (see Figs 11 and 12). A better approach may have been to include the papilla in the flap by making the vertical incision at the distal line angle of the central incisor rather than through the papilla. This would have allowed even greater freedom to coronally position the flap and possibly get root coverage over the lateral incisor.

Options for Redevelopment of the Papilla and Marginal Tissue

One option for regeneration of the papilla and mesial marginal ridge of the implant was to wait for the biologic width to regenerate. The dentogingival complex was described in 1961 by Garguilo et al in a study in which they measured the distance from the free gingival margin to the underlying bone. This complex comprises the connective tissue attachment, the epithelial attachment (junctional epithelium), and the gingival sulcus. They reported measurements of 2.04 mm for the depth of the connective tissue and epithelial attachments and 0.69 mm for the depth of the sulcus. Kois described a similar biologic width of 3 to 4 mm on the facial aspect of central incisors, with 85% of the subjects within the 3-mm range. Interproximally, a measurement of 4.5 mm was observed. This coincides with the study done by Tarnow and associates in which they measured the distance from the cervical contact to the underlying bone and evaluated the presence or absence of a papilla. There was complete presence of a papilla when the distance was less than 5 mm. Both of these studies evaluated the papilla between two adjacent intact teeth. Between two teeth, the papillary height is actually controlled by the shape and volume of the gingival embrasure, which is determined by the contours of the adjacent roots and teeth and the level of interseptal bone. When one of the contacts is eliminated via tooth loss, as was the case with the missing canine, the papilla will generally collapse to a normal biologic dimension of 3 mm. The connective tissue attachment and junctional epithelium in the papillary area still compose only 2 mm of the total length of the papilla, as they do at the free gingival margin. Between a tooth and an implant, bony support of the soft tissue papilla comes from the attachment level at the tooth side, not the bone level of the implant. Waiting for the regeneration of the papilla could take up to 1 year, and there would still remain a vertical and horizontal deficiency in comparison with the adjacent papilla. This would also not address the marginal discrepancy of tooth 7(12). The second option for redeveloping the papilla was to surgically rebuild the papilla. Several techniques have been proposed for rebuilding the papilla around single-tooth implants, although they are difficult to perform, predictability has not been documented, and there are no data regarding long-term stability. These surgical techniques also rely solely on thickening of the overlying soft tissue without augmentation of the underlying supporting bone. The most biologically sound and predictable method for altering gingival levels and papillary levels was to forcibly erupt tooth 7(12).

Forced Eruption

Forced eruption is defined as an orthodontic process whereby a tooth is intentionally moved in a coronal direction through the application of gen-
tle, continuous force in order to effect changes in the soft tissue and bone.\textsuperscript{13,14} Because forced eruption modifies the gingival and alveolar crest, it has been used to alter gingival discrepancies and osseous defects of periodontally involved teeth.\textsuperscript{15-19} The fibers of the periodontal ligament are attached to the bone by fibers, with formation of new bone around the ends of the fibers.\textsuperscript{20,21} Bone is dynamic in nature and hence is constantly being resorbed and rebuilt. When tension is applied to the periodontal ligament, periodontal fibers are elongated, and osteoblasts are induced to deposit new bone in the alveolus, where the attachment is.\textsuperscript{22,23} When a tooth is erupted, the bone comes with it and the height of the fiber attachment remains constant.\textsuperscript{24} If a tooth is forcibly erupted and, following the movement, held in its new position for 4 to 6 months, the bone and soft tissue should re-establish themselves in this new 3-dimensional position.

**Technique**

The provisional restorations were sectioned, leaving the restoration at 7(12) as a single unit. This unit was cemented with a final cement (RelyX ARC, 3M ESPE, St Paul, MN) to prevent loosening during the forced eruption. Only three brackets were used for the eruptive process (Fig 16): one on the maxillary right canine, one on the maxillary right lateral incisor, and one on the maxillary right central incisor. Because the canine was an implant and the right central incisor was splinted to the other central incisor and the left lateral incisor medially, there was no mobility and hence no reason to add more brackets posteriorly. The bracket on the lateral incisor was placed more cervical in relation to the brackets on the canine and central incisor to create a coronal force on the lateral incisor for eruptive purposes (Fig 16). Once the brackets were placed and the acrylic resin was set, nickel titanium wire was placed in the brackets and held with ties. A small-diameter 0.016-mm wire was used to create a slow force during eruption to bring down the bone and soft tissue with the maxillary right lateral incisor. The forced eruption process in this case took only 2 weeks (Fig 17). This was most likely because of the limited bony support around the root of the lateral incisor (Fig 19). Once the lateral incisor was erupted to its correct position, it was luted back together with the remaining provisionals and the brackets were removed. The incisal edge was shortened to compensate for the eruption. Generally, a 4- to 6-month stabilization period is advocated to allow for proper reorganization of the soft tissue and bone and for prevention of relapse (intrusion).\textsuperscript{25} In this case, a 4-month stabilization period was chosen to allow redevelopment of the papilla and the gingival margin around the implant. Not only was the gingival margin around the lateral incisor brought more coronal, but the papillary height was increased by approximately 1.5 mm (Figs 18 and 20). Although there was good improvement in the papillary form and the gingival margin of both the canine and lateral incisor, the thickness and bulk of the papilla prevented achievement of an ideal form on the mesial aspect of the marginal ridge of the canine (Figs 20 and 21). Once the tissue was healthy, final impressions were taken (Fig 22).

All of the restorations other than the implant crown and the veneer were fabricated from all-ceramic Procera crowns (Nobel Biocare). For the implant crown, a castable custom gold abutment was fabricated (Fig 23). It was decided to use gold rather than a ceramic abutment because the crown for the implant was going to be made of porcelain fused to metal, allowing the same type of porcelain to be used for the porcelain veneers for the purpose of color matching. If a Procera crown had been made for the implant, the porcelain used for the veneer would have to have been made of a different type of porcelain than the overlay porcelain for the Procera. This in turn would have been difficult to match.

The final results were good considering the original soft tissue defect following surgery (Figs 24 through 26). Radiographs showed that the implant was well integrated, and the new bone apical to the root of tooth 7(12) filled in nicely (Figs 19 and 27).
Improving Soft Tissue Form Around Implants via Forced Eruption

**FORCED EROUPTION—CASE 1**

**Fig 16** Beginning of the eruptive process on tooth 7(12) to coronally position the margin and grow the papilla.

**Fig 17** Tooth 7(12) erupted into place after 2 weeks of orthodontics.

**Fig 18** Soft tissue form around the mesial of the implant improved tremendously, including the marginal configuration and the papillary form and height.

**Fig 19** Radiograph after eruption of the lateral incisor. Note the space at the apex of the root.

**Fig 20** New provisionals relined over the teeth and the temporary implant abutment.

**Fig 21** Facial view of the provisionals after orthodontics, prior to making the final impression. The papilla and soft tissue on the mesial of the canine are still not ideal.
Fig 22  Final preparations with chord and implant transfer coping on implant 6(13). Note the improved clinical crown length on the teeth.

Fig 23  Final gold abutment on implant 6(13).

Fig 24  Intraoral frontal view of the final case.

Fig 25  Final smile.

Fig 26  Lateral view of final crowns.

Fig 27  Final radiograph of implant 6(13).
CASE 2

A 55-year-old man presented with a porcelain-fused-to-metal crown on tooth 7(12) in his hand. The crown had come loose the previous day (Fig 28); the post had remained within the crown. This is a classic example of the failure associated with a lack of ferrule in which the cement seal breaks, the cement washes out, and the post comes out with the crown, leaving decay in the canal and a broken-down tooth. There was approximately 0.5 mm of remaining tooth structure above the gingival line with decay into the canal space (Fig 28). For long-term predictability, there needs to be at least 1.5 mm of tooth structure beyond the core to create a "ferrule effect." Evaluation of the gingival levels revealed an ideal gingival margin location, and the patient desired an ideal esthetic result. The patient was given three options, although there were only two options (options 1 and 2) for treatment that would maintain the same gingival levels:

- Option 1: Forced eruption of tooth 7(12) along with supracrestal fiberotomy
- Option 2: Extraction of the tooth and immediate implant placement
- Option 3: Crown lengthening, which would create a "long tooth" relative to the adjacent teeth and disturb the esthetic balance

The patient refused to wear braces due to vanity reasons and therefore chose option 2. Alginates were taken, and a removable provisional was fabricated to replace tooth 7(12). The patient was referred to an oral surgeon for extraction of the tooth and immediate implant placement. Periotomes were used to extract tooth 7(12) with no trauma to the surrounding bone and soft tissue. A 4.1 × 3.8-mm implant (Straumann) was placed in the extraction socket with the head of the implant placed 3 mm apical to the desired marginal ridge (Fig 29). An implant design that decreases in diameter apically (ie, a tapered implant) is ideal to prevent perforation or stress to the thin labial plate. The surgeon modified a plastic healing abutment to create the proper anatomical emergence form (Figs 30 and 31). The healing abutment was left above the gingival margin to allow full support for the papilla. The removable provisional was inserted as a temporary prosthesis (Fig 31).

After 6 months of healing, the patient was ready for restoration. A titanium temporary abutment was modified with acrylic resin to create the proper emergence profile (Fig 32). The acrylic resin was applied with a salt-and-pepper technique directly into the sulcus form created by the healing abutment. Once set, the temporary abutment was prepared directly in the mouth. The provisional was relined over the abutment, and the tissue was allowed to heal for 1 month prior to the final impression (Fig 33). Even with meticulous surgical technique, there was slight recession on the distal aspect of the central incisor papilla.

At the time of the final impression, acrylic resin was added to the transfer coping to register the emergence profile to the final model. A polyvinyl siloxane impression was taken and poured in stone. A custom abutment was fabricated using a castable abutment. Porcelain was baked on the abutment to create the emergence form and to cover the metal of the abutment so that an all-ceramic crown could be used (Fig 34). An Inceram crown (Vita, Bad Sackingen, Germany) was fabricated to match the existing porcelain Dicor crowns (Dentsply, York, PA) (Fig 35). After torquing the abutment and cementing the final crown, the patient was told to return in 1 week for photographs.

Emergency Visit

Six days after delivery of the implant crown, tooth 8(11) had fractured down to the gingival line. The patient again presented to the office with a crown in his hand, although this time, the preparation was broken within the crown (Fig 36).

Intraoral evaluation revealed that the gingival margin of tooth 8(11) was in the ideal position. The tooth had fractured to the gum line with no remaining ferrule effect, but radiographically, there was enough root length to restore the tooth if the
**CASE 2**

Fig 28 Tooth fracture down to the gum line.

Fig 29 Implant placed immediately at the site of tooth 7(12).

Fig 30 Healing abutment supporting the soft tissue around the implant.

Fig 31 Flipper in place with soft tissue, supported by the healing abutment.

Fig 32 Temporary abutment prepped and modified with acrylic resin to create the proper emergence form.

Fig 33 Placement of the provisional.

Fig 34 Final porcelain-fused-to-metal abutment. Porcelain was baked on the abutment to cover the metal and create a tooth-colored margin and post.

Fig 35 Final crown at try-in.
Improving Soft Tissue Form Around Implants via Forced Eruption

Fig 36 Tooth 8(11) fractured to the gumline 1 week after delivery of an implant-supported crown at site 7(12).

Fig 37 Radiograph of the fractured tooth. Note the angular peaks of bone around the root.

crown was lengthened or the tooth erupted (Fig 37). The root taper was fairly significant, so a narrower marginal diameter would be created if the tooth was crown lengthened or erupted. The interproximal bone surrounding the root of tooth 8(11) was angular, not horizontal, with the peaks more coronal than the adjacent bone. The root was actually supporting the two peaks of interseptal bone.

Taking the aforementioned into consideration, the patient was given two options for treatment. Only option 1 would ensure an ideal gingival marginal relationship; however, option 2 was more sound biomechanically:

- Option 1: Forced eruption with supracrestal fiberotomy and restoration with a crown
- Option 2: Implant placement immediately post-extraction and restoration with a single crown

Even though it would take much longer to forcibly erupt tooth 8(11), and even with the biomechanical compromise of maintaining the tooth versus placing an implant, the patient chose to maintain his tooth for esthetic reasons and felt he could always have an implant placed if the tooth failed over time.

There were many reasons why forcibly erupting the central would create a more esthetic result. Radiographically, it was evident that the root of tooth 8(11) was supporting the angular interproximal peaks of bone surrounding the root (Fig 36). Extraction of the root, even with immediate implant placement, would inevitably have resulted in the loss of the interseptal bony peaks. After extraction and immediate implant placement, there is generally up to 1 mm of apical migration of the free gingival margin.\(^{27,28}\) Interproximally, the ideal bone width is approximately 1.5 mm at the crest to minimize lateral resorption of the osseous crest and biologic width violation after implant placement with resultant bone loss.\(^{29}\) The bone on the distal of the root of tooth 8(11) adjacent to the implant was thin (less than 1.5 mm), especially in the coronal portion (Fig 37). Because the interproximal bone was angular, in order to maintain the peaks of bone, the implant would need to have been placed more coro-
nal than the adjacent implant and tooth 9(21). This would have created a very short distance from the implant head to the free gingival margin, which would have made creating a smooth emergence profile very difficult. Placement of the implant in the correct depth for creation of a smooth emergence profile would have necessitated obliteration of the angular peaks of interseptal bone. The last disadvantage of placing an implant adjacent to another implant is that when 2 adjacent implants are placed, the biologic width around flat implants does not support the papilla interproximally. In fact, only 3 to 4 mm of interproximal soft tissue height is routinely possible, even with a 3-mm distance between implants, as advocated by Tarnow et al. Because the biologic width is apical to the crest of interproximal bone between implants, the connective tissue attachment and the epithelial attachment will not support the papilla. Findings by Tarnow et al indicated that the height of the soft tissue covering the inter-implant bony crest is 2 to 4 mm as compared to the 5 mm found around teeth. Kois and Kan also found comparable measurements of 3 to 4 mm of peri-implant mucosa for anterior single implants.

Taking the aforementioned into consideration, placement of an implant in the area of tooth 8(11) would most likely have created an esthetic nightmare due to loss of papilla, especially between the two implants, as compared to forced eruption with a supracrestal fiberotomy of the remaining root of tooth 8(11). Again, the patient chose to maintain his natural root.

**Forced Eruption with Supracrestal Fiberotomy**

It is advantageous to erupt a tooth for the purpose of crown lengthening when there is need for sound tooth structure and the gingival height and contour is ideal. Given that surgery would create an imbalance in the marginal levels and increase the crown-to-root ratio, orthodontic eruption with a fiberotomy is the treatment of choice. Kozlovsky et al used forced eruption combined with an incision of the supracrestal gingival attachment. The intrasulcular incisions were performed in conjunction with root-surface curettage at 2-week intervals. This technique prevented coronal displacement of the attachment apparatus, eliminating the need for surgery. Pontoriero et al indicated that the fiberotomy eliminated tensile stress on the alveolar bone and allowed more rapid tooth movement. Bone and soft tissue were left behind, although they recommended weekly fiberotomies.

**Technique**

The patient was sent to an endodontist for root canal treatment of the maxillary right central incisor. Once week later, a GC post pattern (GC Dental, Tokyo, Japan) was fabricated and cast in type III gold alloy. After cementation with zinc phosphate cement, the preparation was refined with a diamond bur, and an acrylic resin provisional was fabricated. The provisional was cemented with RelyX ARC cement to ensure retention during the eruption process.

Five brackets were placed; one on the implant crown at site 7(12), one on the provisional, and three on the contralateral central incisor, lateral incisor, and canine for anchorage (Fig 38). The bracket on tooth 8(11) was placed 2.5 mm cervical to the remaining brackets to create a coronal force after wire placement. Prior to placing the wire, the patient was anesthetized on both the facial and palatal aspects of the soft tissue surrounding tooth 8(11). A no. 15C blade was placed directly into the sulcus until contact with bone occurred. The blade was pulled against the root surface and moved around the full circumference of the root to ensure severing of the supracrestal gingival fibers. The root was planed to the level of the bony crest as described by Kozlovsky et al. A 0.018 nickel titanium round wire was used to rapidly extrude the right central incisor. Even though the tooth reached its final position after only 2 weeks, the patient returned for a fiberotomy every week for 5 weeks to ensure that the fibers would not reattach. The brackets remained
Improving Soft Tissue Form Around Implants via Forced Eruption

**FORCED ERUPTION—CASE 2**

**Fig 38** Orthodontic forced eruption of tooth 8(11) after a supracrestal fiberotomy.

**Fig 39** Final positioning of tooth 8(11) after forced eruption.

**Fig 40** Radiographic view of tooth 8(11) in its final position following forced eruption.

in place for 4 months to allow reformation of the biologic width and for bone deposition apical to the root (Figs 39 and 40). At this point, there was no movement of the gingival margin.

**Choosing Orthodontic Brackets**

There are two main types of orthodontic techniques, the standard edgewise technique and the straight-wire technique. The standard edgewise incorporates a brace with no torque and no angulation. The clinician must introduce torque and angulation by means of bending a stainless steel wire. For the general practitioner who does not understand angulation and torque, this can be confusing. A more popular technique is the easier-to-use straight wire system. This involves using a brace that has a predetermined angulation and torque. The brace itself controls the root torque and angulation of the tooth. The torque and angulation are determined by a prescription, depending on which method is used. The most popular prescription is the Roth technique. This was the technique used by the author.
Choosing a Wire

There are round and rectangular wires. When a round wire is used, only angulation can be altered; the torque of the brace is not expressed. The torque and angulation of the root can only be controlled using a rectangular wire. Torque control becomes very important when the premaxilla is thin, and it is imperative to avoid moving the root facially and possibly creating a dehiscence. Most of the time, a round wire is appropriate. The type of wire used by the author was a round, heat-sensitive, superelastic nickel titanium wire. For a slow, controlled eruption aimed at bringing the bone and soft tissue down with the tooth, a 0.014- or 0.016-size wire can be used. For fast eruption, one can use 0.018-size wire or a rectangular wire.

Provisional and Final Restoration

During the healing process, redoing the restoration on tooth 9(21) was discussed with the patient. The objective was to modify the papillary form between the centrals to close the cervical embrasure. The only way to do this was to restore both of the centrals and change the interproximal shape of the crowns. Redoing the maxillary left central crown would make matching to the maxillary right central much more predictable. Once the bone filled in apical to the root, as verified by a periapical radiograph (see Fig 40), the provisional was removed along with the old crown on the maxillary left central incisor (Fig 41). There was very little remaining tooth structure on the preparation (Fig 41); this may be why tooth 8(11) fractured. Care was taken not to touch the existing preparation. Provisionals were fabricated from a waxup of the proposed new restorations (Fig 42). Because the preparations were narrow at the margin, especially the right central incisor, a more horizontal emergence form on the interproximal had to be developed to mold and shape the papilla as well as to close the cervical embrasure (Fig 43). After 2 weeks, the papillary form was developed and final impressions were taken (Fig 44). Individual porcelain-fused-to-metal crowns were fabricated to help mask the color of the gold post of the maxillary right central incisor (Fig 45). The final crowns were cemented with RelyX ARC cement. A harmonious gingival balance and a healthy soft tissue response was achieved via forced eruption (Figs 45 and 46).

DISCUSSION

Soft tissue integration of a single-tooth implant is the most difficult and the most important esthetic aspect in creating an implant prosthesis that appears natural. Not only is the marginal level important, but the papillary form and height are critical. When the soft tissue outcome following implant placement is not as desired, a procedure such as orthodontic eruption can be a tremendous tool in your armamentarium to assist the manipulation of the soft tissue form around an implant or on a tooth adjacent to an implant. Surgically rebuilding the soft tissue can be quite unpredictable and very technique-sensitive, and no long-term data are available on the stability of rebuilt soft tissue. With orthodontics, not only can the marginal tissue of an adjacent tooth be coronally moved, but the papilla can be brought down as well. What makes this even more valuable as a procedure is the long-term predictability of moving the biologic complex 3-dimensionally to a new position rather than rebuilding one aspect of the biologic component (the soft tissue) without support by the other (the bone). Orthodontics may make it possible to save and restore teeth that previously may have been deemed hopeless because of lack of tooth structure, especially adjacent to an implant restoration. This can be critical when the soft tissue form is ideal and a soft tissue defect will be assured following extraction and placement of one implant adjacent to another.
Fig 41 Preparations after removing old crown 9(21) and temporary crown 8(11). Note the excess soft tissue on the mesial of tooth 8(11) from the orthodontic procedure. Also note the previous overpreparation of tooth 9(21).

Fig 42 Provisionals 8(11) and 9(21)—manipulating the papillary form to close the embrasure.

Fig 43 Cervical view of provisionals. Note the cervical contour of the provisional compared to the margin of the preparation. A mesial cantilever was made to manipulate the soft tissue.

Fig 44 Soft tissue after manipulation of the soft tissue with provisionals.

Fig 45 Final crowns 7(12) through 9(21).

Fig 46 Lateral view of final crowns 7(12) through 9(21).
ACKNOWLEDGMENTS

Special thanks to Dr Isaac Garazi for his surgical work in case 1 and to Dr Stephen Rimer for his surgical work in case 2. Special thanks also to Mr Harald Heindl for the beautiful porcelain in case 1 and to Emanuele di Piazzera for the beautiful porcelain in case 2.

REFERENCES

TRANSFER OF INFORMATION FOR ESTHETIC AND FUNCTIONAL PREDICTABILITY IN SEVERE WEAR CASES

Tal Morr, DMD, MSD¹

Prosthodontists are often called upon to reconstruct the occlusion in patients with severe wear. There may be a multitude of issues to address in such cases, including attrition, abrasion, and erosion, all of which contribute to uneven wear and compensatory eruption throughout the arches. There may also be incisal wear and/or interproximal wear, and as a result, the occlusal plane may need leveling and lengthening for enhanced esthetics and to allow correction and control of the occlusal relationship.

Treating the edentulous patient requires the fabrication of occlusion rims to allow evaluation of critical esthetic and functional information, mounting of the final casts, and fabrication of esthetic and functional complete dentures.¹⁻⁸ The esthetic and functional information includes determination of the incisal edge position at rest, the occlusal plane, midline and angulation of the midline, lip support, facial plane of the incisors, arch form, and buccal corridors. In addition, the clinician can evaluate the vertical dimension of occlusion, check phonetics, and take a centric record.

CRITICAL ESTHETIC DETERMINANTS

All comprehensive treatment planning should begin with an esthetic evaluation. Evaluation of the face is essential in determining the ideal esthetic orientation of the teeth from a horizontal perspective. The horizontal reference planes will help the clinician align the occlusal plane and the soft tissue levels along with other related esthetic determinants. The horizontal reference planes should be evaluated from two perspectives: the frontal and the sagittal. The frontal perspective is assessed by having the patient look out into the horizon and choosing the ideally leveled plane. The most commonly used horizontal reference

¹Private practice, Aventura, Florida, USA.

Correspondence to: Dr Tal Morr, 20760 West Dixie Hwy, Aventura, FL 33019, USA. E-mail: tmprostho@yahoo.com

QDT 2007
planes include the ophriac line, interpupillary line, and commissural line (Fig 1). Most people are slightly asymmetric in these planes, and in these cases, the floor is used as the horizontal reference plane. From a lateral (sagittal) perspective, the patient holds his or her head erect, again looking out to the horizon. From the sagittal perspective, the horizontal reference plane should again be leveled with the floor. Once the horizontal reference plane is established, the critical esthetic determinants are established in relationship to the horizontal reference plane.

The incisal edge position, incisal plane, and occlusal plane are the three most important esthetic determinants in the development of the treatment plan. These determinants enable the clinician to transfer information throughout the treatment, and are related in specific ways to other esthetic criteria. The first step in determining the position of the teeth is evaluation of the incisal edge position at rest (Fig 2). Tooth exposure is considered to be esthetic in the 1- to 5-mm range. To achieve this range, tooth proportions can be adjusted by either shortening or lengthening the anterior teeth. For example, if crown lengthening is indicated on teeth that were previously ideally proportioned, the incisal edge length can be reduced. Maintaining a minimum of 1 mm of tooth exposure at rest should be the goal. Once the final incisal edge position is determined, the incisal plane (a line from canine to canine in the anterior portion of the occlusal plane) is evaluated (Fig 3). The incisal plane should be leveled to the chosen horizontal reference plane (the floor, interpupillary line, etc), and evaluated from the frontal perspective while the patient is smiling. The Incisal plane should be flat from the incisal edge of the central incisor back to approximately the mesial of the first molar (Fig 4). The illusion of a radial relationship of the smile line to the lower lip derives from the cant of the maxilla in the frontal perspective (see Fig 3).
Transfer of Information for Esthetic and Functional Predictability in Severe Wear Cases

The original occlusal plane guide technique

As with the edentulous patient, a method of transferring critical esthetic and functional information is needed to allow the technician to predictably achieve the ideal esthetic orientation and occlusal relationship of the teeth in the waxup. The original occlusal plane guide technique\(^2\) employed a vacuform machine and acrylic resin to evaluate the ideal esthetic determinants in the patient’s mouth. The maxillary cast was mounted to the articulator with the occlusal plane guide using a facebow, an earbow, or a dentofacial analyzer. The mandibular cast was mounted at the evaluated vertical dimension using the occlusal plane guide (Fig 5). The mandibular cast was removed, and a flat mounting plate was placed against the acrylic resin and mounted to the lower member of the articulator (Fig 6). When the occlusal plane guide was removed, the space between the original cast and the flat plane indicated the exact amount the teeth needed to be lengthened. Unfortunately, there were problems with delamination of the acrylic resin from the vacuform material, and the acrylic resin was difficult to trim and shape. Wax is a more suitable material for this technique due to its ease of trimming and shaping, and its ability to take a centric record at the appropriate vertical dimension (Figs 7 and 8). The centric record should be taken at the appropriate vertical dimension with both the ideal overjet and overbite relationship. This will minimize the negative effect of the arc of closure if the casts are not mounted in a direct relationship to the hinge axis of the articulator and the vertical dimension is modified.

Diagnostic waxup fabrication

Step 1: Develop the occlusal plane
Mount the casts on the articulator at the correct vertical dimension and relative to the mounting plate, and remove the maxillary wax occlusal plane guide. The resulting space indicates the amount of wax to be added to reach the ideal occlusal plane (Fig 9). First, add wax to the incisal edges of the anterior teeth and the buccal cusp
tips of the posterior teeth (Fig 10). If wax is added to fill the space from the mounting plate distal to the mesial cusp of the first molar, it will be impossible to close the casts together in the posterior area due to the axis of closure of the hinge. Therefore, the length of the wax distal to the first molar should be short of the mounting plate, but equal in distance from the flat plane on both sides.

**Step 2: Alter the vertical dimension of occlusion (if needed)**

Ideally, the casts should be mounted at or close to the correct vertical dimension of occlusion based on the restorative space needed to develop the ideal anterior relationship, including the anterior guidance and room for the envelope of function. If the casts are mounted at the ideal vertical dimension of occlusion, the effect of the arc of rotation will be insignificant. If the casts are not mounted at the ideal vertical dimension, open or close the articulator pin to develop the ideal space needed for the restorative material (Fig 11). If the casts do not close to the ideal position, either shorten the maxillary posterior teeth, move the maxillary buccal cusps facially, or move the mandibular buccal cusps lingually. This is a purely subjective process and can be refined during the next step.

**Step 3: Develop the anterior guidance**

If the mandibular anterior incisal plane is irregular and the treatment plan calls for restoration of the mandibular anterior teeth, level the mandibular incisal plane with wax, followed by the lingual aspect of the maxillary anterior teeth, to develop the correct anterior guidance relationship. If only one arch will be restored, add wax to the appropriate teeth (Fig 12).

**Step 4: Level the mandibular posterior plane**

If the mandibular occlusal plane requires leveling, add wax to the mandibular occlusal surfaces to level the mandibular arch (Fig 13). It may not be possible to level the mandibular posterior plane with the mandibular anterior plane because this may require opening the vertical dimension too much. If this is the case, level as much as possible.
The level of the lower posterior plane can be evaluated by opening the pin slightly and assessing the space between the maxillary and mandibular posterior cusp tips. There should be equal space on either side of the arch.

Step 5: Add wax to the maxillary occlusal surfaces to develop the occlusal contacts
Once the mandibular teeth are ideal, add wax to the maxillary posterior occlusal surfaces to fit into the mandibular occlusal surfaces in the correct relationship (Fig 14).

Step 6: Refine the occlusion and perfect the contours
Add to or modify the occlusal surfaces to perfect the occlusal relationship and to idealize the esthetic contours (Fig 15). The final contours of the central incisors should be determined first, followed by the lateral incisors and canines, since the symmetry of these teeth is not as critical as the central incisors.

Relationships to the critical esthetic determinants
There are certain relationships that can be developed regarding the critical esthetic determinants. It has been established that the midline position is not as critical as the midline verticality. If the incisal plane has been idealized in the waxup, the midline should be perfectly perpendicular to the incisal plane. Ideally, the facial plane of the incisors should be perpendicular or slightly acute relative to the occlusal plane from a sagittal perspective. The gingival plane should be parallel to the incisal plane.

CASE PRESENTATION
An 82-year-old man presented to the office in need of a complex rehabilitation. He had noticed rapid wear on his anterior mandibular teeth in the last couple of years, and that his maxillary and mandibular anterior teeth were “on top of each other.” Considering the severe occlusal wear and Class III malocclusion, a thorough esthetic evaluation was done to formulate a treatment plan. The incisal edge position at rest was evaluated first. The patient showed approximately 2 to 3 mm of tooth structure with the lips in repose (Fig 16). According to esthetic principles, this fell within the desired range. When the patient smiled, the incisal plane also seemed adequate; however, a distinct step between the anterior and posterior planes existed, indicating an esthetic need to lengthen the maxillary posterior teeth (Fig 17). Opening the vertical dimension of occlusion would be beneficial in this case because this patient was in need of a dramatic leveling of the maxillary occlusal plane and the mandibular incisal and occlusal planes to create room for development of a better functional relationship of the anterior teeth (Figs 18 to 20).
Modified occlusal plane guide technique

In this case, the anterior occlusal plane was deemed adequate at the esthetic evaluation, so the wax was added to the posterior occlusal plane. This occlusal plane guide was tried in the mouth and shaped to the correct length corresponding to the ideal esthetic plane. A centric record was taken at the anticipated vertical dimension to aid in creating a better relationship in the anterior region, as well as room to level both the maxillary and mandibular occlusal planes.

Mounting the casts

Once the wax of the occlusal plane guide was idealized, the maxillary cast with the occlusal plane guide was mounted on the Kois dentofacial analyzer mounting plate (Panadent, Grand Terrace, CA, USA) by aligning the facial aspect of the incisors with the line drawn on the platform (Fig 21). The midline on the maxillary diagnostic cast was aligned with the midline drawn on the platform. The Panadent system mounting platform was developed using scientific data (unpublished research, 2006), so there is no need to use the dentofacial analyzer or an earbow leveled to the horizontal plane with this technique (Figs 22 and 23). The incisal edge position on the mounting platform that was used to align the cast is based on a 100-mm measurement from the hinge axis of the articulator (Fig 24). According to Kois and Kois and others, this measurement is the average in the population from the hinge axis to the incisal edge position, with 80% of the population falling within 1 standard deviation of the mean. The maxillary cast was mounted relative to the hinge axis using the mounting plate. By using the wax to mount the cast, there was an ideal esthetic relationship of the cast to the mounting plate. Once
the maxillary cast was mounted, the mounting plate was removed and the mandibular cast was mounted using the occlusal plane guide at the appropriate vertical dimension. The wax occlusal plane guide was removed and the diagnostic waxup was fabricated as previously described, although the maxillary cast was waxed against the dentofacial analyzer mounting plate rather than a standard mounting plate (Fig 25). Both arches were leveled and aligned to the horizontal reference plane, and other relationships, such as the interincisal angle and the facial plane of the incisors, were also incorporated in the waxup (Figs 26 and 27).
Making the provisional prostheses

Once the waxup was complete, a provisional shell was made by fabricating a matrix and painting in both incisal- and dentin-colored cold-cure acrylic resin. These prostheses were filled with acrylic resin, relined in the mouth, trimmed, and equilibrated slightly. It was difficult to visualize the esthetic aspect of the provisional prostheses while the patient was anesthetized, so he was allowed to leave and return 1 week later for further refinement. There will almost always be a need to slightly recontour the provisional prostheses to achieve the desired esthetic outcome, but modification of the incisal edge position and occlusal plane is rarely needed when this technique is used (Figs 28 and 29).

Crown lengthening

This patient refused crown lengthening, but after preparation there was enough tooth structure for retention of the final restorations (Figs 30 and 31). In a complex wear case, a surgical procedure is often needed to level the soft tissue for esthetic and/or structural reasons. Because the ideal incisal edge position and incisal plane are developed in the provisional stage based on the horizontal reference plane, it is easy to develop ideal soft tissue levels. If the clinician has determined the proper esthetic and structural length for the teeth, he or she can ask the surgeon to measure from the incisal edge up to the desired soft tissue height and add 2.5 to 3.0 mm of length for the biologic width to achieve the new bone level (Fig 32). Once the
bone level is idealized, the soft tissue is positioned and sutured 2 to 3 mm more coronal than the bone. If the ideal tooth width has been developed in the provisional prosthesis, the surgeon also has the information necessary to scallop the bone so the gingival zenith will be in the correct position (the height of the contour of the soft tissue, distal to the center of the tooth) (Fig 33).

**Centric record and cross-mounting**

Once the biologic width is redeveloped and the provisional prostheses are relined, a final impression is taken of at least one arch. This is then mounted on the articulator using the dentofacial analyzer to develop the correct relationship with the face. The various centric records allow the technician to mount the casts of the provisional prostheses and the preparations in identical 3-dimensional positions. Four critical relationships (centric records) need to be taken if both arches are to be fabricated at the same time. The first is a provisional prosthesis-to-provisional prosthesis relationship (see Fig 29). There is no need to take an occlusion rim for this relationship if there is an ideally generated occlusal relationship that shows bilateral simultaneous contacts in centric occlusion. The second and third centric records are those of the preparations against the opposing provisional prostheses in both arches (Figs 34 and 35). The final relationship needed is the centric record of the preparations to preparations (Fig 36).

If only one arch is undergoing restoration, the provisional-to-provisional and provisional-to-preparation relationships need to be taken only for that arch. These 3-dimensional relationships of the preparation casts to the provisional casts are essential in allowing the technician to duplicate both the esthetic and functional relationships that were developed in the provisional prostheses.

**Transferring information in the laboratory**

Once the casts are mounted and have become interchangeable, the technician must use the information from the provisional prostheses. One such transfer of information is the incisal guide table (Fig 37). This is fabricated by placing acrylic resin (GC America, Alsip, IL, USA) within the table that houses the pin. When the acrylic resin is in the doughy stage, the upper member of the articulator with the provisional cast is moved against the opposing cast in all directions to replicate the guidance. This movement creates a trough through the acrylic resin. After the acrylic resin
The next transfer of critical information in the laboratory is the fabrication of matrices. The main matrices used in the laboratory are the facial matrix, the lingual matrix, and the incisal matrix. The first two allow verification or reduction of either the waxup or framework, as well as comparison of the final prosthesis to the provisional prosthesis from a facial and lingual contour perspective. This saves time because the technician does not have to remake the waxup. Because the provisional prosthesis is the pattern for the final prosthesis, all the esthetic and functional information is present. The next step is to open the pin by 1 mm and fabricate a matrix against the incisal edges and cusp tips of the maxillary provisional cast (Fig 38). When the provisional cast is replaced with the preparation cast, the laboratory technician knows exactly how much material to add incisally in the frame to support the ceramics and for the final length of the ceramics. This matrix can be used to fabricate the ideal porcelain buildup. If the technician knows how much shrinkage will result, the pin can be opened by that amount, and after the first bake, the incisal edge will be nearly in the perfect position (Figs 39 and 40). The final prostheses should fit intimately to the incisal matrix.

**CONCLUSION**

It is evident that the transfer of information throughout the rehabilitation process is critical. Although it may take a bit more time in the diagnostic phase of treatment, accurate means of transferring information throughout the rehabilitation process is paramount to predictability. In severe wear cases where the teeth are too short and need to be lengthened, the incisal plane guide is an indispensable tool. By transferring the critical esthetic determinants to the articulator, the process of waxing becomes easier and more predictable. If the patient needs crown lengthening, all the information necessary for esthetic success is already incorporated in the provisional prosthesis because the critical esthetic determinants were used for fabrication. Once the provisional prosthesis is idealized and the correct occlusal relationships are taken to allow cross-mounting the casts, fabrica-
tion of the incisal guide table and matrices from these casts will guide the laboratory technician to ensure esthetic and functional predictability in the final restorations (Figs 41 to 43).

ACKNOWLEDGMENTS

A special thanks to Drs John Kois and Dean Kois for the use of their diagrams and research findings. Also, a special thanks to Harald Heindle (Aesthetic Dental Creations, Mill Creek, Washington) for the beautiful ceramic work.

REFERENCES

18. Monson GS. Occlusion as applied to crown and bridge work. JADA 1920;7:399-413.
ZIRCONIUM OXIDE CAD/CAM-GENERATED RESTORATIONS: AN ESSENTIAL OPTION IN CONTEMPORARY RESTORATIVE DENTISTRY

Ricardo Mitrani, DDS, MSD
Roberto Duran, DDS
Eduardo Nicolayevsky, DDS
Joel Lopez, MDT

Two of the most important characteristics of modern restorative dentistry are:

1. The ability to integrate an interdisciplinary treatment plan
2. A full understanding of current restorative materials and technology

The treatment planning phase unquestionably represents the foundation of contemporary dentistry. Whether dealing with the restoration of a single tooth, an implant, or a full-mouth reconstruction, it is through this planning phase that the dental team must set the road map for therapy. While the final outcome may be reached through a variety of pathways, close communication between specialists is essential to choose the ultimate route of treatment.

Indeed, there is no better investment than the time spent during treatment planning. The interdisciplinary team should not overlook even the slightest detail regarding the treatment options.

The starting point for any therapy should be a full understanding of the patient's needs, desires, and complaints. Clinicians should explore the patient's mind before diagnosing his or her mouth, and devote as much time as necessary during...
Understanding the Esthetic Evaluation for Success

Tal Morr, DMD, MSD

ABSTRACT

With any restorative procedure, a thorough evaluation, diagnosis, and treatment plan is essential for a positive outcome. When dealing with esthetic dilemmas, the same holds true. Without a sequential esthetic evaluation, diagnosis, treatment plan, and execution, an acceptable outcome is difficult to predict. The treating clinician should be able to visualize the esthetic problem, visualize the proposed changes, and devise a way to achieve the result while still maintaining mechanically, functionally, and biologically sound principles.

Esthetic Evaluation

The following method of evaluation for esthetics is the author's expressed opinion. Esthetics is subjective and hence there are many concepts that work well.

Incisal Edge Position of the Centrals

The first objective for evaluation is to envision the future positions of the final restorations. In order to facilitate this, the clinician should find a starting point in the evaluation process. A good starting point is the incisal edge position of the upper central incisors at rest. The patient is seated and asked to say the letter "m" followed by relaxation of the lips (Figure 1). The amount of central incisor showing is evaluated and measured. According to Vig et al.,¹ the average amount of tooth exposure with the lips at rest in men was less than women. As the age of the patients increased, the amount of incisal edge display decreased, and short upper lips generally displayed more maxillary tooth structure than long lips. The future incisal edge position may be related to the sex, lip length and age although more importantly, how youthful the patient wants to appear, and the patients overall self image, and personality. The less tooth exposure, the older appearing is the smile. Generally, the author's objective is to make his patients look more youthful. If this is the case, there should be some tooth exposure evident at rest, the more, the more youthful appearing.

Occlusal Plane

The next step in this evaluation process is the occlusal plane. This is done by having the patient smile (Figure 2). The occlusal plane allows evaluation of the whole arch relative to the chosen incisal edge position. The occlusal plane is actually a flat plane derived from the incisal edges of the centrals, bisecting the cusp tips of the canines and continuing posteriorly (Figure 4). What gives the illusion that it is radial in relationship to the lower lip (follows the curvature of the lower lip) is the cant of the maxilla in a sagittal plane (anterior to posterior) (Figure 2).

Generally, the occlusal plane is obtained by paralleling (canine to canine) to the interpupillary line assuming no asymmetries in the eyes (Figure 3). This reference plane is used even if there are inherent irregularities of the lips. The only time the interpupillary plane is not used as a reference is if the eyes are not level. If this is the case, the occlusal plane should be paralleled to the floor by mounting the diagnostic models using an earbow leveled with the floor.

Author / Tal Morr, DMD, MSD, is in private practice limited to prosthodontics in Miami, Fla.
Another reference for the occlusal plane is the curvature of the lower lip. The incisal edge positions of the upper teeth should follow the curvature of the lower lip if the objective is to make the patient appear more youthful, assuming no irregularities in the smile. If the objective is to make the teeth appear more age appropriate, it is not uncommon due to wear of teeth for the occlusal plane to be flattened out relative to the lower lip. If this is the case, the plane should parallel the interpupillary line with the incisal edges and cusps equidistant from the lower lip (if the lip is symmetrical).

Facial Plane of the Incisors
A line drawn on the midfacial plane of the incisors should bisect a line drawn on the occlusal plane perpendicularly (Figure 4). Evaluating the facial plane gives an idea if the facial contours of the proposed restorations need to be modified to create the appearance of being perpendicular to the occlusal plane. This can be done by making the cervical contour slightly more pronounced or by tapering the incisal edges lingually (if the teeth are proclined) or by bringing the incisal edges outward (if the teeth are retroclined). Any modifications to the incisal edges of the centrals in a facial-palatal direction should be evaluated functionally and phonetically as well as esthetically (whether the lip support will be adversely affected).

Midline
In an ideal esthetic setting, the maxillary midline should coincide with the midline of the face. In reality, the verticality of the midline appears to be much more critical than the mediolateral position. As long as the midline is perpendicular to the occlusal plane and hence the interpupillary plane, the smile can appear balanced (Figure 5). If the midline deviates in verticality from being perpendicular, this can create lack of flow and symmetry to the smile. Generally, the midline is made to line up with the middle of the face and the philtrum of the lip. If a severe mediolateral abnormality exists, orthodontic or orthognathic treatment may be necessary.

Gingival Health and Balance
Successful treatment of the anterior dentition requires both a harmonious integration of hard and soft tis-
sue. When evaluating the soft tissue, health and harmonious gingival contours are essential for esthetics. In a healthy situation, the gingival tissue follows the cervical contours of the teeth with the apical extent of the free gingival margin (gingival zenith) lying distal to the center of the tooth (Figure 6). On the mesial and distal aspects of the teeth (interproximally) the cervical embrasures between the teeth are filled by the scalloping of the tissue forming the papillae. For the appearance of health and beauty, the papillae should fill the cervical embrasures. Balance is achieved with the tissue heights of the centrals and canines at the same level and the tissue heights of the lateral incisor slightly more coronal.

There are subtle variations of this pattern that are acceptable as long as the cervical margin of the contralateral centrals are at the same level, the contralateral canines on either side are close to being at the same level, and the lateral incisors are not cervical to the centrals and canines.

In the esthetic evaluation, final position of the soft tissue will be dictated by the incisal edge position chosen for the occlusal plane. By using the average measurements of 10.4-11.2 mm for the central incisors and measuring cervicaly, the new soft tissue levels can be visualized. If they differ from the present soft tissue levels, the possibility of performing either orthodontics, soft tissue grafting, gingival reshaping, or esthetic crown lengthening for the purposes of leveling the tissues becomes evident. This decision process is based on whether there is a need for root coverage or tooth exposure.

If veneers are being considered, and the tissue needs to be raised cervically to create a harmonious gingival contour, exposure of dentin may indicate the need for a different type of restoration. Ideally for long-term predictability of ceramic veneers, the preparation should remain in enamel due to the documented strong bond to enamel vs. the variability of bonding to dentin.

Arrangement

From clinical experience, when patients present for esthetic changes, they are usually seeking correction of irregularities or mal-alignments. In nature, there is no such thing as perfect symmetry. Although more patients are seeking correction of mal-alignments of their teeth by doing orthodontics, there is still no such thing as perfectly aligned teeth. If our goal is to please our patients yet still make our restorations appear life-like, creating symmetry of the central incisors and making any slight rotations or irregularities in alignment on the laterals or canines can create a pleasing and natural esthetic appearance to our restorations.

Any obvious irregularities in alignment or rotation that create imbalance should be noted by the clinician in the evaluation. If there exists any crowding or mal-alignment that will create a lack of space after alignment of the teeth, the patient should be informed of the limitations of veneers or crowns to align the teeth or that overlapping may be necessary. If overlapping is not an option, orthodontics may be the best option. Again, only in the diagnostic wax-up phase can the overall arrangement to be assessed as to whether it will create the esthetic goal that the patient and the dentist are trying to achieve.

Another important criteria for esthetic success in arrangement are the position of canines. The canines are important in transitioning the anterior aspect of the arch to the posterior. The more visible the distal aspect of the canine, the wider the anterior segment of the arch will appear, creating a squarer shape to the arch with a loss of a smooth transition from anterior to posterior. Only the mesial half of the canine should be visualized from an anterior perspective (Figure 6). Although the golden proportion is a mathematical concept that does not take into consideration dominance, symmetry, and overall subjective creativity, it does emphasize the fact that the canine, viewed from a facial perspective can be seen only from the mesial aspect. The facial aspect of the canine ideally should be made to flow with the posterior facial aspects to create a smooth transition from anterior to posterior (Figure 7).

Ideally, the heights of contour of all the upper anterior teeth should follow the gingival zenith (distal to the middle of the tooth) with the axial inclination (Figure 7) from a cervical-incisal direction toward the mesial.

Tooth Dimension and Proportion

Dominance and relative symmetry of the centrals are two of the fundamental parameters for esthetic success (Figure 8). The centrals are the focal
length of the teeth as dictated by the width of the teeth. Any changes in the clusal relationship will dictate the cause in reality, the arch form and occlusal wax-up phase of treatment be-

point of the smile and should appear appropriate in size and relatively symmetric. In terms of the overall size and proportion of the teeth, there are studies of average measurements that tend to be useful as guidelines for the dimension of the future restorations. Not only are there many studies that show the average length and width of teeth, but Sterret et al., found that the width/length ratios of unworn incisors and canines both fall within 77-85 percent. Centrals and canines have similar crown length with an average of 1-1.5 mm longer than lateral incisors.

Evaluation should include a subjective evaluation of the existing dimension and proportion of the existing teeth and any planned changes. Any severe discrepancies should be noted in the clinical examination. Alteration of the length of the teeth via esthetic crown lengthening or soft tissue grafting will alter overall dimensions and proportions of the final tooth form. Future tooth proportion and dimension can only be determined during the diagnostic wax-up phase of treatment because in reality, the arch form and occlusal relationship will dictate the width of the teeth. Any changes in the length of the teeth as dictated by the evaluation should be incorporated into the diagnostic wax up. Waxing over the tissue on the diagnostic model to change the crowns length is necessary to visualized if the proposed changes in tooth dimension and contour will be acceptable with a change in the soft tissue contours.

Tooth Contour and Incisal Embrasures

There are three basic shapes of teeth: square, ovoid, and triangular. Although there are three natural tooth forms, all anterior teeth are formed by three facial lobes and one palatal lobe. The conjunction of the three facial lobes create the mamelons. As a result, all incisal edges are rounded in youth. As we age, the teeth wear at varying degrees. This in turn creates a squarer appearance to the incisal edges of the centrals, and flattening of the cusps on the canines. If the objective is to create a more youthful smile and delicate smile, rounder incisal edges and more pointed cusp tips on the canines are necessary and vice-versa.

The incisal embrasures (Figure 8) are formed by the interrelationships of the incisal edges of the anterior teeth and the cusp tips of the canines and posteriors. They are important in creating a life-like appearance to any restoration. The interaction of the incisal embrasures with the space between the lower teeth or lower lip and the incisal edges of the upper teeth when laughing (negative space) helps to outline and give individuality to the teeth. In youth, with less wear, the incisal embrasures are quite large with the smallest between the central incisors and progressively getting larger as you move in the arch posteriorly (Figure 8). If there has been some wear due to function or parafunction, not only do the teeth wear but the incisal embrasures get smaller. If a youthful appearance is the objective, larger incisal embrasures are essential.

Color and Character

In the evaluation step, it is important to determine what types of color changes are necessary for the final restorations. If the color of the final restorations is not going to be changed relative to the existing color of the teeth or only slight modifications in color are required, veneers may be the ideal type of restoration due to their inherent translucency. If a moderate color change is required, it may still be possible with veneers although the technician should be given slides of the preparations and of shade tabs to be able to visualize the areas to be blocked out in the porcelain. If severe color changes are required, either bleaching prior to preparation or choosing a different type of final restoration may be indicated.

Characterization of the teeth such as translucencies, crack lines, etc. on remaining natural teeth should be noted if the veneers are to match them (Figure 8).

Diagnostic Wax up

The diagnostic wax-up phase of treatment is one of the most essential aspects in all of the treatment. It is only through the wax up that all of the alterations that were planned as a result of the esthetic evaluation can be tested. All of the criteria for esthetic success should be implemented in the wax up. If any of the changes are not possible, this is where it will be discovered, and not after preparing the teeth.

Tissue Recontouring

Once the wax up is complete, visualization of the proposed soft tissue alterations are possible. The soft tissue levels may be waxed up on the model so that
Provisionalization and Final Impressions

Using a facial matrix made off of the diagnostic wax-up model to check preparation depth both facially and interproximally, proper reduction of the preparations can be ensured (Figure 9). A palatal matrix helps to achieve proper incisal edge preparation (Figure 10), and a full contour matrix of the diagnostic wax up helps to fabricate the provisionals. By loading the matrix with acrylic and seating the matrix on the preparations, the contours of the wax up will be formed in acrylic (Figure 11). Only by virtue of the provisionals can the esthetic alterations be visualized and checked. The wax up may look great on the model but only by visualizing the provisionals in the mouth can a true evaluation be made.

Any final contour changes should be made to the provisionals intraorally so that they are as close as possible to the desired width, length, contour, and arrangement of the final restorations. Once the contours are idealized, the provisionals should be measured to verify adequate preparation and only once ideal, the final impression is taken. Once the provisionals are cemented, alginate impressions are taken to produce stone casts of the provisionals in the mouth.

Laboratory Considerations

All of the models are cross mounted so that the provisional model is transferable with the preparation model. Indexes made off of the provisional model help transfer the information from the provisionals to the final restorations.

The final color, character, and texture are all defined in the final restorations. Photos are made of the preparations and shade tabs so the laboratory technician can determine if any block out any necessary areas to achieve the desired color. Internal characterization is paramount to success of any restoration. Teeth have varying amounts of translucency and internal characterization. In the older patient, crack lines are a very common occurrence. All of these minor characterizations help to lend a natural appearance to the final restorations. Surface texture is also important.

Teeth erupt into the mouth with a very complex surface morphology of horizontal lines (lines of retzius) and vertical grooves (between the lobes). This surface texture reflects and deflects light and hence makes the teeth appear brighter. Due to erosion and abrasion over time, the surfaces of older teeth tend to display less surface texture. This allows more light to be absorbed and hence lower value to the teeth. Surface characterization is based on matching adjacent teeth or the by overall objective of youthfulness or aging.

Case Presentation

A 45-year-old patient presented to the office for a consult regarding her oral condition (Figure 12). She had a history of numerous restorative procedures (crowns and large composite fillings) in all of the teeth except the upper central incisors. She expressed unhappiness with the way her mouth looked and wanted a long-term, natural appearing esthetic solution that would make her appear more youthful. Upon evaluation, it was determined she had decay on almost all of her teeth and under her old restorations, necessitating a full-mouth rehabilitation. The patient was examined thoroughly from an extraoral, intraoral, and radiographic aspect. The objectives of treatment were to create a functionally, mechanically, and biologi-
cally sound rehabilitation while making the patient look better and more youthful. All ceramic Procera crowns were planned for the posterior teeth and porcelain veneers for the incisors.

Theesthetic evaluation revealed the following:

**Incisal edge position**

At rest, the patient showed approximately 5mm of tooth structure with wear on the distals of the centrals (Figure 13). This created a V-shaped incisal edge relationship between the central incisors that the patient did not like. The distal aspects of the centrals were subjectively determined to be the correct length for the future incisal edge position because the centrals were actually a bit long relative to the width.

**Occlusal Plane**

When the patient was asked to smile, the occlusal plane was evaluated (Figure 14). Although the posterior aspect of the occlusal plane was fairly adequate, both canines were short relative to the occlusal plane (Figure 15).

**Facial Plane of the Incisors**

The facial plane was nearly perpendicular relative to the occlusal plane.

**Midline**

The upper midline was vertical and hence adequate in positioning (Figure 12).

**Gingival Health and Balance**

From an intraoral view, it was evident that the patient had generalized moderate amounts of gingival recession (Figure 15). Because the teeth were long already and because the canines needed to be lengthened to level the occlusal plane, the need for a root coverage procedure was indicated to create proportional width/length ratios.

Another indication for root coverage was that the centrals and laterals were going to be restored with veneers. In order to create a finish line in enamel, root coverage was essential.

**Arrangement**

The arch form in the cuspid area did not flow with the posteriors aspect of the arch because both canines were tipped palatally on both sides while the first bicuspids were slightly buccal (Figure 15). This gave the illusion of a V-shaped arch rather than the desired U-shaped arch.

**Tooth Dimension and Proportion**

The distance from the distal aspect of the incisal edge of the central incisors up to the CEJ’s created a proportionate dimension and dominance to the central incisors. Both lateral incisors were worn and although the upper left lateral was an appropriate length it was not appropriately shaped. The upper right lateral incisor was too short relative to the left. The canines needed to be lengthened to correct the occlusal plane (Figure 16).
Tooth Contour and Incisal Embasures

Because the teeth were worn, the incisal edges were flat, creating an older appearance to the teeth. (Figure 16). As a result of wear, the embrasures were small as well. The objective was to create a more youthful smile and therefore, rounder incisal edges and larger incisal embrasures would be appropriate.

Color and Character

All of the teeth other than the two centrals were dark in color due to previous restorations and decay (Figure 15). Due to the severity of the decay, the posterior teeth needed crowns. The lateral incisors and the centrals were restorable via the use of porcelain veneers.

From the esthetic evaluation, a wax up with all of the proposed changes was made. The patient went to see the periodontist for connective tissue grafting of the upper and lower arches (wherever needed) along with a coronally positioned flap to cover the exposed root surfaces. After three months of healing, a wax up was completed on a new diagnostic model reflecting the improved tissue relationship. The provisionals were made using the matrix made from the diagnostic model and evaluated functionally and esthetically (Figures 17 and 18). With the patient’s approval, the final impressions were taken and the case was finished.

From the final photographs, one can see the esthetic objectives were achieved to create a harmonious and balanced smile:

- At rest, the patient showed an adequate amount of tooth structure creating a youthful look (Figure 19).
- When smiling, the occlusal plane was made level to the eyes with a radial relationship to the lower lip (Figures 20 and 21).
- The facial plane of the incisors was maintained perpendicular to the occlusal plane (Figure 22).
- The arch form was widened in the anterior segment. The canines were brought out facially and the bicuspids lingually to create a smooth transition from the anterior segment to the posterior segment of the upper arch (Figure 21).
- The teeth were made proportional with a pleasing symmetry (Figure 21).
- The incisal edges of the centrals
Figure 23. A facial view of the soft tissue revealed a healthy, balanced, and harmonious gingival contours along with a pleasing symmetry in arrangement. The teeth were made brighter while still maintaining a realistic appearance by incorporating internal effects and translucency in the porcelain.

and lateral incisors were made rounder, hence more youthful and delicate (Figures 23 and 24).

- The Incisal embrasures were opened to create individuality and a sense of reality to the restorations (Figure 22).
- The teeth were made whiter, brighter and hence more youthful (Figure 23).
- Translucency and crack lines were incorporated into the restorations to create an illusion of reality (Figure 23).

Conclusion

Esthetic predictability in any restorative procedure can make our dental careers much more enjoyable and rewarding. It would be nice to be able to predictably fabricate beautiful restorations. By consistently following a step-by-step protocol, the chances of success are greatly enhanced. Skipping an important step such as the wax up and provisionalization will ultimately lead to failure. Of critical importance is that knowledge, ability, and artistic flair of the laboratory technician. Not only should he or she know how to transfer all of the vital information obtained from the mouth (provisionals) via indexes, but be able to create a life-like replica in the ceramics. It goes without saying that long-term success demands that the esthetic alterations should fall within the function, mechanical, and biologic principles.

Acknowledgment / Many thanks for the laboratory aspect of treatment to Mr. Harald Heindl. Without his exquisite artistic abilities and understanding of functional and mechanical principles, the case presented would never be the same.


To request a printed copy of this article, please contact / Tal Morr, DMD, MSD, 20760 West Dixie Highway, Aventura, Fla., 33180.