CLINICAL USE OF THE ER,CR: YSGG LASER FOR OSSEOUS CROWN LENGTHENING: REDEFINING THE STANDARD OF CARE

Robert A. Lowe, DDS, FAGD, FICD, FADI, FACD*

To design the optimal outcome for a patient during aesthetic enhancement, the restorative dentist must seek to create a symmetrical and harmonious relationship between the lips, gingival architecture, and the positions of the natural dentate forms. In the author's experience, the Er,Cr: YSGG laser has been a useful adjunct for performing aesthetic surgical crown lengthening procedures. This article will highlight the associated biological principles and demonstrate techniques for the application of this laser in closed and open crown lengthening procedures.

Learning Objectives:

This article demonstrates the use of the Er,Cr: YSGG laser for osseous crown lengthening . Upon reading this article, the reader should have:

- Enhanced awareness of criteria for developing a biologically stable free gingival margin.
- Greater familiarity with the open and closed crown lengthening procedures, including case selection and surgical approaches.

Key Words: crown lengthening, biologic width, FGM, laser, Er,Cr: YSGG

**Private practice, Charlotte, NC; and Diplomat, American Board of Aesthetic Dentistry.*

Robert A. Lowe, DDS, Charlotte Center for Cosmetic Dentistry at South Park, 2809 Coltsgate Road, Suite 200, Charlotte, NC 28211
Tel: 704-364-4711 • E-mail: boblowedds@aol.com

When designing the optimal aesthetic outcome for a patient during the smile rejuvenation process, the clinician must create a symmetrical and harmonious relationship between the lips, gingival architecture, and the positions of the natural dentate forms. Spear, et al[1] have referred to this diagnostic methodology as facially generated treatment planning, where the maxillary central incisal edges determine where the soft tissue (ie, gingiva) and bone should be positioned.

The versatility of the Er,Cr: YSGG laser and its ability to recontour both hard and soft tissues creates the opportunity for a minimally invasive approach in many clinical situations that require repositioning of the periodontal structures for both aesthetic or restorative reasons. The laser can also decrease the need for suturing, reduce postoperative discomfort, and shorten healing times. This article will demonstrate and discuss techniques for the use of the Er,Cr: YSGG laser for osseous crown lengthening procedures, specifically highlighting the associated biologic principles as well as the "open" and "closed" techniques.

The Dentogingival Complex

The dentogingival complex consists of connective tissue attachment, epithelial attachment (or junctional epithelium), and the gingival sulcus. As described by Kois,[2] the most critical relationship for biologic health when the clinician is placing a restoration at or below the free gingival margin (FGM) is the margin location relative to the crest of bone. Kois states that the distance from the FGM to the osseous crest on the facial aspect is 3 mm. Interproximally, on anterior teeth, this distance is 4 mm due to the curvature of the cementoenamel junction; posteriorly it is 3 mm. The height of the interdental papilla can also be predicted to be maintainable 4 mm incisal to the osseous crest between anterior teeth with normal root proximity, approximately 2 mm at the osseous crest (Figures 1 through 4). With these parameters in mind, the clinician must first decide where the restorative margin will be placed. For all-ceramic restorations that do not need to block out undesirable dentin colors or core materials, it may be desirable to place the restorative margin at the free gingival crest or slightly supragingival.[3]

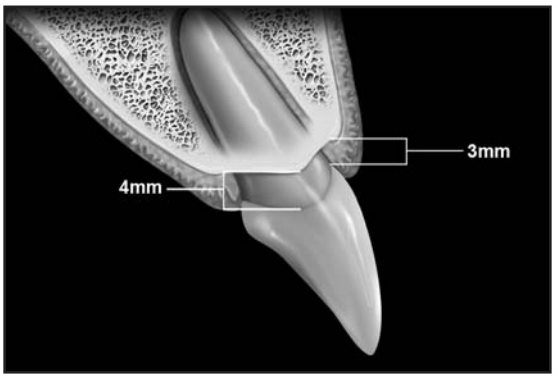

Figure 1. Illustration of the relationship of the FGM to the alveolar crest. When these parameters are followed, restorative margins can be placed in harmony with the biologic health of the surrounding tissues.

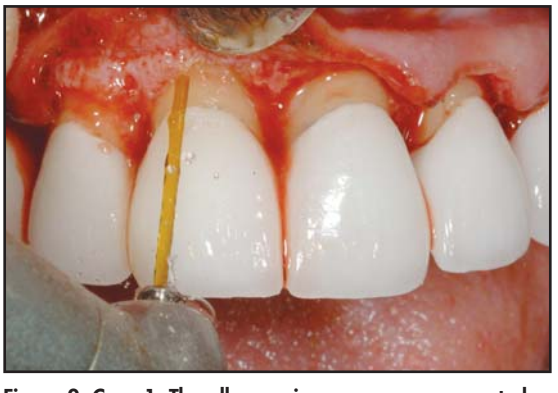

Figure 2. Case 1. The all ceramic crowns were cemented and a full-thickness mucoperiosteal flap was raised immediately following delivery. The Er,Cr: YSGG laser is shown performing an ostectomy on the alveolar crest.

Figure 3. After 2 weeks, the restorative margin of the maxillary left lateral incisor is measured 4 mm from the crest of bone interproximally and 3 mm facially.

Figure 4. Three-year postoperative photo of the patient. The interdental papillae between all teeth have filled the gingival embrasures. It took one-year postsurgery for the papillae to completely fill the embrasure space.

Figure 5. Case 2. The surgical plan is mapped using a fine, black tissue marker. A caliper is used to measure the planned correction in the cervico-incisal direction to ensure aesthetic width-to-length ratios are followed.

If an intracrevicular margin is required for aesthetic reasons, however, it should be placed no farther than 0.5 mm into the gingival sulcus to avoid adverse biologic responses due to encroachment upon the attachment apparatus.

Kois,[4] Coslet, et al[5] also describe a variation in biologic width that compares the distance from the alveolar crest to the FGM and divide this into three categories: 1) normal crest, 2) high crest, and 3) low crest. In simplified terms, normal crest patients (about 70%) have approximately a 2-mm combined epithelial and connective tissue attachment and 1-mm sulcus depth (a total dentogingival complex of 3 mm). If the sulcus depth is greater than 1 mm, the free gingival excess can be safely resected and, upon healing, will result in a dentogingival complex measuring 3 mm on the facial aspect. Patients with a high crest often have a shallower sulcus depth and a combined dentogingival complex measurement of less than 3 mm. These patients have relatively stable FGM positions and are not prone to recession upon manipulation of the tissues. Low-crest patients often have normal sulcus depth (1 mm to 3 mm) and a combined epithelial and connective dentogingival complex measurement that is greater than 3 mm. These patients can be prone to recession and must be treatment-planned accordingly. The FGM of low-crest patients will tend to apically reposition and turn into a normal crest situation after gingival retraction or surgery. Therefore, the most

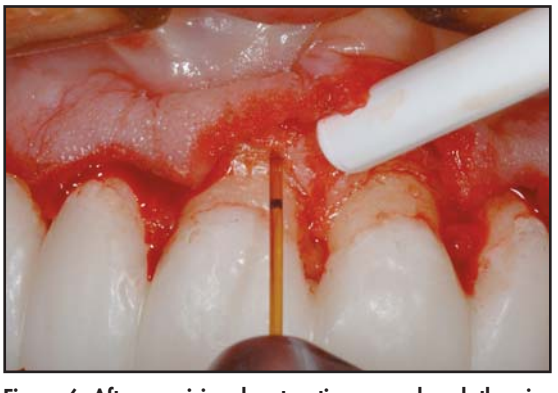

Figure 6. After provisional restorations are placed, the gingival tissues are reflected and open correction of the osseous crest position is completed using the Er,Cr: YSGG laser. The tip of the laser is marked at 3 mm.

Figure 7. View of patient after completion of tooth preparation, final impressions, gingival crest and bony crest correction, and cementation of provisional restorations.

Figure 8. Closed crown lengthening is used to correct the maxillary central incisor zeniths apically. New provisional restorations are placed on teeth #8(11) and #9(21) while the ceramics are fabricated at the laboratory.

Figure 11. Case 3. Preoperative view of a patient whose complaint was the short appearance of teeth #20(35) and #21(40). This was an ideal case for the closed crown lengthening technique.

Figure 9. A 3-year postoperative follow-up is shown. Note the correction of cervico-incisal tooth dimensions, gingival zenith corrections, gingival symmetry, and lessening of the excessive gingival display.

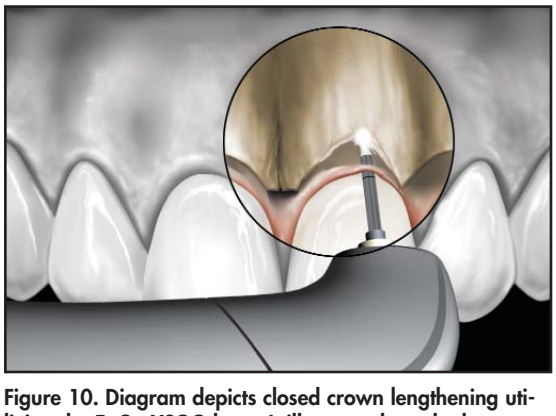

Figure 10. Diagram depicts closed crown lengthening utilizing the Er,Cr: YSGG laser. It illustrates how the laser can reposition the alveolar crest through the gingival sulcus in a minimally invasive, controlled fashion.

important factor in postrestorative gingival health and stability is the position of the restorative margin relative to the bony crest, ***not*** the preoperative health and/or position of the gingival tissues.

Smile Design and Tooth Dimension

Several parameters must be considered when designing an aesthetic smile, including: 1) Width-to-length ratio of the maxillary central incisors, 2) Mesiodistal proportional width of the maxillary anterior teeth, 3) Position of the maxillary central incisors in the face (ie, the "e" position), and 4) Relative gingival zenith positions and height of contour.

The width of the average maxillary central incisor has been measured at approximately 10 mm.[6] Using the "Golden Proportions" as guidelines, one can arrive at an appropriate measurement for the width and the length of the central incisor. The next consideration is that the width-to-length ratio of an aesthetic maxillary central incisor is 75% to 80%. Thus, the 10-mm central incisor should measure 7.5 mm to 8 mm mesiodistally if it is proportionally correct. The "e" position (ie, when a patient says "e") shows the relative amount of maxillary tooth display. In the "e" position, it is aesthetically desirable for a patient to show 50% to 70% of the maxillary incisor teeth. Finally, the heights of the gingival tissues over the maxillary central incisors should be slightly higher (1 mm apically) than the heights of the tissue over the maxillary

Figure 12. Teeth #20 and #21 are shown 3 weeks after closed crown lengthening. Note the health of the gingival tissue on the facial aspect.

Figure 13. Postcementation view of the crowns fabricated for teeth #20 and #21. The aesthetics of the entire area is improved due to the gingival and bony correction of the zeniths on the facial aspects of the teeth.

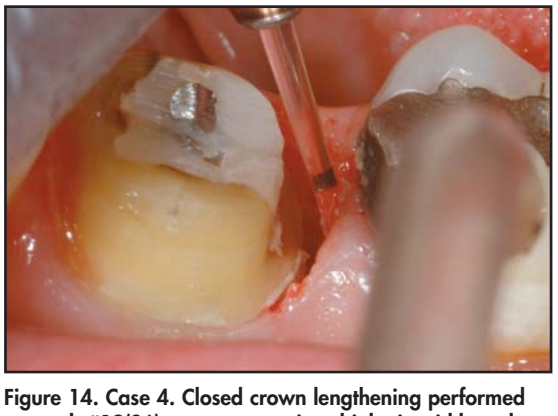

Figure 14. Case 4. Closed crown lengthening performed on tooth #19(36) to correct a minor biologic width problem. Interproximal crestal bone was removed 3 mm apical to the restorative margin.

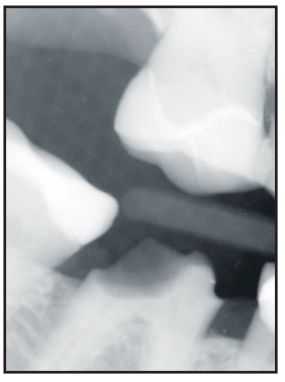

Figure 15. Preoperative radiograph shows the initial measurement from the restorative margin to the bony crest is approximately 1 mm.

lateral incisors. The heights of the maxillary canines should be at the same level apically as the central incisors, or slightly more apical. The gingival zeniths should be located at the distolabial line angles, thus creating a "raised eyebrow" over the central incisors.[7]

Laser-Assisted Crown Lengthening

Use of the Er,Cr: YSGG laser for gingival and bony recontouring has a tremendous impact on the way periodontal surgery is performed. Since the laser cuts only at the end of the tip, the user has effective control of soft and hard tissue resection. Using the Er,Cr: YSGG with a tapered tip allows the operator to make scalloped gingivectomies with surgical precision and no bleeding. When using traditional rotary instruments to perform osseous resection, there is always a risk that their rotation will damage adjacent root surfaces. Additionally, since the surgical laser wound is less traumatic, there is less chance of bony damage due to frictional heat, which is always possible when using rotary instrumentation without proper irrigation. This minimally invasive technology translates into less postoperative discomfort and quicker healing of the patient.[8]

The Open Technique

For an aesthetic gingival display, it is critical that symmetry (right and left) exists as far as cervico-incisal tooth height and gingival zenith positions are concerned.

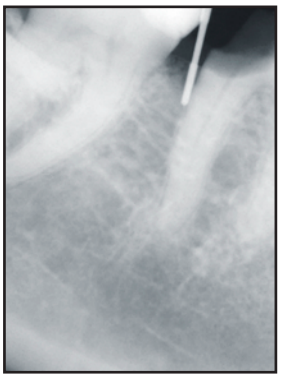

Figure 16. Postoperative radiograph demonstrates that, after closed crown lengthening, the measurement can be corrected to 3 mm.

Figure 17. Two-year follow-up after final impressions were made at the surgical appointment so that the crown could be delivered and the gingival tissues could mature around the definitive rather than the provisional restoration.

Patients that exhibit asymmetrical gingival levels, those with greater than 3 mm to 5 mm of maxillary gingival display, or both may be candidates for surgical gingival and/or alveolar bone repositioning to improve their aesthetics. Typically, these patient types have adequate amounts of attached gingiva so that after the resective procedure the mucogingival junction will not be encroached. If adequate amounts of free gingiva exist, minor asymmetries can be corrected with gingivectomy or gingivoplasty alone. A minimum sulcus depth of 1 mm must always remain after any tissue resection unless the alveolar bony crest is also repositioned in the apical direction, as well. To give the appearance of spatially moving teeth in the cervical direction to alleviate excessive gingival display or asymmetry, oftentimes osseous correction must be performed in conjunction with soft tissue resection because of sulcus depth violation.

As previously stated, the finished maxillary central incisors should be 10 mm to 12 mm in length. While the incisal edges can be shortened when adequate freeway space exists posteriorly, the amount depends on the disclusive pattern of the patient. The shortened incisal edges must still disclude the posterior teeth in all eccentric movements to maintain occlusal harmony. A tissue marker can be used to plan the soft tissue surgery (Figure 5). Following the guidelines for aesthetic tissue levels, the perceived final gingival level is traced,

Figure 18. Case 5. Preoperative view of a minor biologic width violation on the distal aspect of tooth #7(12). The distal proximal margin of this crown preparation is too close to the epithelial-connective tissue apparatus.

Figure 19. Three-week postoperative view after closed crown lengthening. Note the health of the interdental gingival tissues and the corrected placement of the restorative margin relative to the FGM.

creating heights of contour at the distolabial line angles. The Er,Cr: YSGG laser is used to remove the gingival tissue and create symmetry according to the proposed surgical plan. The preparation margins are then adjusted to the corrected FGM. As the biologic width will be encroached upon, it is important that the same amount of bone be removed to recreate normal biologic parameters. An intrasulcular internal bevel incision is made, and a full-thickness mucoperiosteal flap is elevated. The alveolar crest correction is made using the Er,Cr: YSGG laser and either a 9-mm or 14-mm 600-μm tip. Since the laser only cuts at the tip, it is set against the side of the root parallel with the long axis of the tooth (Figure 6). This ensures that the dentin/cementum surface is never damaged. A black marker can be used to place a line at a point 3 mm from end of the tip. This is used as a guide to apically position the bone 3 mm from the restorative margin. Only the alveolar bone will be ablated by the laser-energized water. The root surface is then planed using a back-action chisel. The alveolar architecture should thus mimic the restorative margin 3 mm apically, allowing for biologic width restoration to a normal crest position.

The interproximal bone on facial aesthetic correction cases is not altered; the flap is sutured back using 3-0 silk and an interrupted suture technique (Figure 7). For this particular case, at the delivery appointment, the heights of the gingival zeniths above the maxillary central incisors were adjusted apically using a closed crown lengthening technique to slightly modify the final FGM position (Figure 8). The definitive restorations are shown 3 years after corrective gingival and bony surgery with the Er Cr, YSGG laser (Figure 9).

The Closed Technique

For minor, localized biologic width and/or aesthetic gingival zenith corrections, the Er,Cr: YSGG laser can be used in lieu of a flap procedure to make the correction and complete the restorative process without the necessary healing time required for open crown lengthening surgeries.[9] Patients with normal or thick biotypes (ie, normal to thick keratinization) are good candidates for this procedure.

Figure 20. The surgical area on the distal of tooth #7 has a probable gingival sulcus with the absence of bleeding prior to cementation of the ceramic restoration.

Figure 21. Three-year follow-up on tooth #7 reveals the interdental papillae are completely filled in the gingival embrasure and the tissue is clinically healthy.

The soft tissue is resected using a 400-μm tapered tip on facial areas or a 600-μm tip in proximal areas, creating the new apical position and scallop of the FGM. The osseous crest is sounded using a periodontal probe to determine the distance from the free gingival crest. Using a 9-mm 600-μm tip, the laser is then used to remove bone, holding the tip adjacent to the tooth and "walking" the tip across the affected area using a "sewing machine" (ie, up and down) movement to a 3-mm depth (Figure 10). After establishing the corrected crestal level, the bone is "smoothed" by setting the laser at 50 pulses per second and moving the tip in a horizontal direction over the crestal bone. It is important to note that with both of these movements, the tip of the

Figure 22. Case 6. A preoperative view of a patient with excessive gingival display. Diastemata exist in these areas, as well. Porcelain veneers and apical repositioning of the gingival tissues will correct these abnormalities.

Figure 23. Five-year view of the patient. Preparation, impression making, open crown lengthening, and provisionalization were achieved in one visit. The definitive restorations were placed three weeks postsurgery.

laser is in contact with the bony crest. Next, a periodontal probe is used to verify depth by sounding to 3 mm (Figures 11 through 13). For interproximal biologic width corrections, the tip of the laser can be angled away from the tooth, slightly toward the adjacent root to blend adjacent bone and avoid digging a trench around the tooth (Figures 14 through 16). A final impression can then be made and provisional restoration fabricated and cemented to place. The definitive restoration can be seated 2 to 3 weeks after the closed crown lengthening procedure. The surgical area will heal by secondary intention around the finished restoration with ideal tooth contours, rather than an ill-fitted temporary restoration (Figure 17). The criteria for clinical health of the dentogingival complex are 1) pink color (ie, absence of inflammation), 2) reestablishment of a probable gingival sulcus, and 3) absence of bleeding upon probing (Figures 18 through 21).

Conclusion

Techniques have been described using the Er,Cr: YSGG laser for periodontal crown lengthening procedures. Using the biologic parameters discussed in this article, it is now possible to perform open periodontal procedures both facially and interdentally ***and*** predict the level that tissues will heal to based on the position of the restorative margin. It is important for the clinician to use a periodontal probe and sound from the FGM to the alveolar crest to determine the biologic parameters of the patient ***prior to*** preparing teeth for restorative materials. This makes it possible to make final impressions on the day of preparation and surgery, deliver the definitive restorations several weeks later, and be confident that the gingival tissues will heal to the appropriate aesthetic levels (Figures 22 and 23). Patients and dentists can enjoy a shortened treatment time by avoiding extended time in provisional restorations while the tissues mature around their new ceramic restorations.

Acknowledgment

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CONTINUING EDUCATION (CE) EXERCISE NO. 1

To submit your CE Exercise answers, please use the answer sheet found within the CE Editorial Section of this issue and complete as follows: 1) Identify the article; 2) Place an X in the appropriate box for each question of each exercise; 3) Clip answer sheet from the page and mail it to the CE Department at Montage Media Corporation. For further instructions, please refer to the CE Editorial Section.

The 10 multiple-choice questions for this Continuing Education (CE) exercise are based on the article "Clinical use of the Er, CR: YSGG laster for osseous crown lengthening: Redefining the standard of care," by Robert A. Lowe, DDS. This article is on Pages S2-S9.

1. In the "e" position, what percentage of the maxillary incisor teeth is aesthetically desirable for a patient to show?
a. 60% to 80%.
b. 50% to 70%.
c. 25% to 45%.
d. 40% to 60%.

2. What of the following are NOT criteria for clinical health of the dentogingival complex?
a. Pink color.
b. Reestablishment of a probable gingival sulcus.
c. Presence of inflammation.
d. Absence of bleeding upon probing.

4. What is the most important factor in postrestorative gingival health and stability?
a. Preoperative health.
b. Position of the gingival tissues.
c. Position of the restorative margin relative to the bony crest.
d. None of the above.

5. What is the minimum sulcus depth that must remain after any tissue resection?
a. 0.25 mm.
b. 0.5 mm.
c. 1 mm.
d. 1.5 mm.

6. Using the biologic parameters discussed in the article, it is now possible to:
a. Perform open periodontal procedures interdentally.
b. Predict the level that tissues will heal to.
c. Perform open periodontal procedures facially.
d. All of the above.

3. The Er,Cr: YSGG laser can:
a. Decrease the need for suturing.
b. Reduce postoperative discomfort.
c. Shorten healing times.
d. All of the above.

7. The dentogingival complex does NOT consist of:
a. Cementoenamel junction.
b. Connective tissue attachment.
c. Epithelial attachment.
d. Gingival sulcus.

8. The Er,Cr: YSGG laser with a tapered tip allows the operator to:
a. Create a symmetrical relationship between the nose and lips.
b. Eliminate the need for suturing.
c. Make scalloped gingivectomies with surgical precision and no bleeding.
d. None of the above.

9. As the biologic width is encroached upon, it is important that _____ bone be removed to recreate normal biologic parameters.
a. Less.
b. The same amount of.
c. More.
d. No.

10. According to Kois, what is the distance from the FGM to the osseous crest on the facial aspect?
a. 1 mm.
b. 2 mm.
c. 3 mm.
d. 4 mm.

[Intro for Dr. Lowe to come from Dr. Radz]

Gary M. Radz, DDS
Editor-in-Chief

Perspectives:

Prosthetic Tooth Repositioning Is a Viable Treatment Option for Select Cases

By Robert A. Lowe, DDS

For many years, patients with esthetic and functional problems resulting from tooth malposition have had few treatment options. Orthodontics is the first option to correct tooth malposition; however, not all patients are willing to follow through because of the length of time it takes to complete treatment. In a certain percentage of these cases, orthognathic surgery is also suggested to correct maxillary and mandibular jaw position before orthodontic therapy. Often, the patient is still faced with the prospect of restorative dentistry to gain a full esthetic and functional correction when these therapies are completed. Therefore, many patients never have the opportunity to receive the treatment they seek unless they agree to this lengthy regimen.

With the advent of dentin bonding and the advancements in dental

Figure 1—Preoperative view of the patient's smile shows the facial prominence of the maxillary central incisors. Because of their labial position, the smile line was concave and lip support was excessive.

Figure 2—Occlusal view of the maxillary arch shows that out of the maxillary 6 anterior teeth, the left lateral incisor and cuspid were in the most favorable position as far as the proposed final arch form was concerned. The right cuspid was rotated mesiofacially, the right lateral incisor was crowded out of the arch form toward the lingual aspect, and both central incisors were flared labially.

Figure 3—Enameloplasty was performed on the maxillary right cuspid and central incisor to bring these teeth back into arch form. Because the lateral incisor was palatally positioned, very little facial reduction was needed on this tooth.

Figure 4—Depth cuts were made to prepare the teeth to make room for the restorative material. Note the minimal preparation on the facial surface of the maxillary right lateral incisor.

Figure 5—Approximately 2 mm of free gingiva were removed from the facial aspect of the maxillary right lateral incisor to correct the cervicoincisal height of the tooth. A 1-mm gingival sulcus remained after laser surgery to preserve the biologic dimension.

Figure 6—The definitive restorations, including facial veneers on the maxillary first and second premolars, were tried on and approved by the patient.

Figure 7—Postcementation view of the maxillary arch.

porcelains, elective esthetic dentistry has never before been in such high demand. For a select group of these patients with minor tooth malposition—such as spacing (diastemas), crowding (mesial and/or distal overlapping), and facial-lingual arch form displacement—esthetic and functional correction may be accomplished purely by restorative means. However, the patient must understand that correction of these malpositions will require a more aggressive preparation of the teeth involved to align the arch form. A diagnostic wax-up is absolutely necessary to help determine the amount of tooth preparation that will be required. A preparation guide (silicone or plastic stent) is fabricated from the diagnostic wax-up and approved by the patient. In some cases, intentional endodontics is required to gain the proper space for the correction of tooth position. It is imperative that the patient be aware of this possibility before any treatment is started. However, as long as the patient is fully informed of all treatment options, they should have the opportunity to pursue this type of elective treatment if that is what they desire.

Case Preparation

To determine whether a patient is a candidate for prosthetic tooth repositioning, mounted study casts are required. It is recommended that the models be duplicated so that a preoperative model can be kept as part of the permanent record. The duplicate model is prepared to assess how much tooth reduction is required to gain an optimal result. Depth cuts and preparation dimensions can be recorded for use during the operative phase of treatment. Once the teeth are prepared, a wax-up is done to correct tooth contour and position. Keep in mind the proper tooth length and width when designing the esthetics (the "Golden Proportion") of the case. When preparing a crowded dentition, the first step is to perform an enameloplasty on teeth that are outside the proposed arch form to bring them into better alignment. Next, the proximal contacts between are broken. Crowded or overlapped teeth will require "wrap around" veneers or full-coverage crowns. It is recommended that a very thin diamond instrument, such as a 30-µm interproximal composite finishing diamond, be used to shape opposing proximal surfaces and vertically break the contact between the roots.

Figure 8—The patient's postoperative smile.

Figure 9—Preoperative full-arch retracted view shows the amount of crowding present in this class II, division 1 case.

Figure 10—Maxillary arch preoperative incisal view shows the rotation and crowding of the maxillary anterior segment.

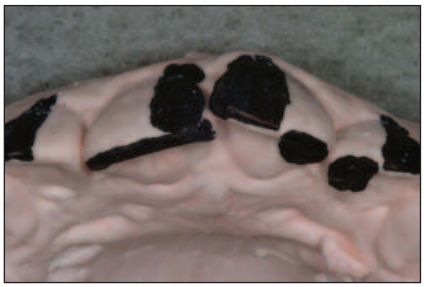

Figure 11—Incisal view of the preoperative cast shows the areas in black that need to be reduced to bring the teeth into proper arch form before reducing for the restorative material.

Figure 12—The completed maxillary and mandibular composite mock-up.

Figure 13—Areas of the teeth that needed reshaping as determined on the preoperative cast were marked on the patient's teeth before preparation.

These surfaces can later be highly polished with fine curets. One key to good results is having adequate interradicular space for development of a healthy gingival papilla that is easily cleansable by the patient. Teeth that are out of line in the buccolingual dimension must be corrected by overpreparing the side of the tooth that is out of alignment. The opposite side of the tooth, in most cases, will only need slight preparation in the marginal area. It is important to mention that so-called "no prep techniques" cannot possibly correct misalignment of functional surfaces without adding thickness to the tooth form, resulting in overcontoured teeth.

Case Report 1

A 23-year-old man presented with a class II, division 1 malocclusion with excessive overjet and labial flaring of the maxillary central incisors (Figures 1 and 2). His desire was to have an esthetic correction in the smile zone to improve his overall appearance and self-esteem. After initial consultation, he was advised to seek an orthodontic consultation to help meet his esthetic objectives. At a follow-up reconsultation visit, the patient related that the orthodontist wanted an orthognathic consult to correct the deficiency in maxillary and mandibular jaw position before starting orthodontic treatment. The patient was adamant about not wanting to undergo jaw surgery, but he was interested in pursuing an esthetic restorative solution. It was explained that the tooth position could be addressed; however, the jaw relationship, which was manifested in a deep overbite, could not be totally corrected. Diagnostic models were taken and a wax-up was done. The patient reviewed the wax-up and was satisfied with the correction. He was advised of the possibility of root canal therapy, particularly on the maxillary central incisors because of the excessive labial flare. It was also decided to place porcelain veneers on the maxillary premolar teeth to build out the buccal corridor because of the constricted arch form and the prominence of the maxillary cuspids.

The first step in the preparation phase was to align the teeth to the desired preoperative position (with enameloplasty and dentinoplasty) (Figure 3). Next, 1.5-mm depth cuts were made to make room for the restorative material (Figure 4). Tooth preparation was then completed using conventional high-speed diamond instrumentation. A diode laser (Twilight by Biolase Technology, Inc) was used to make

Figure 14—Provisional stents were used as preparation guides to evaluate for proper tooth reduction.

Figure 15—Maxillary arch incisal view of the completed case.

Figure 16—Retracted facial view of the completed case.

a correction of the tissue level above the maxillary right lateral incisor (Figure 5) to match the cervicoincisal height of the contralateral lateral incisor. There was an adequate amount of free gingiva present to avoid correction of the alveolar bone level.

Once the tooth preparations were complete, a preparation guide made from the diagnostic wax-up was placed to verify adequate tooth reduction. This stent was also used to fabricate the provisional restorations to give the patient and the dentist a good idea of what to expect in the definitive restorations. Arch form, tooth position, smile line, incisal edge position, anterior guidance, overbite-overjet relationships, and tooth color were some of the parameters that were evaluated while the patient was wearing the provisional restorations. The maxillary bicuspids were very conservatively prepared for facial veneers at the time of the final impressions.

After a period of evaluation of 4 to 6 weeks, the final impressions were taken for this case. Although the patient was informed of the possibility of intentional endodontics, no pulpal exposures or near exposures were encountered. The ceramic restorations were tried on the preparations, and the patient was asked to approve the result. The definitive restorations were then bonded in place using resin cement. Figures 6 through 8 show various views of the completed rehabilitation. Compare these to the preoperative views in Figures 1 and 2. Esthetic and functional parameters have been considerably improved. The facial inclination of the maxillary central incisors and the lingual inclination of the lateral incisors have been improved as well. As a result, in 2 appointments 6 weeks apart, the patient underwent an esthetic and functional rehabilitation that he was completely pleased with. The treatment met all of the patient's preoperative expectations without lengthy orthodontic treatment or maxillofacial surgery. It should be emphasized that all cases of these types cannot be treated without surgery and/or orthodontics. However, patients should be aware that, in some select cases, they can acquire a beautiful result via esthetic restorative dentistry only—and they should be given the option to do so.

Case Report 2

A 41-year-old woman presented with a class II, division 1 malocclusion with normal overjet and crowding of the maxillary and mandibular anterior segments (Figures 9 and 10). The areas of tooth structure outside the proposed arch form were marked on the preoperative study model (Figure 11). For labiolingual malpositions, the proposed arch form is positioned halfway between the most facially positioned tooth and the most lingually positioned tooth. This allows for more conservation of tooth structure by not making a full correction on any one malpositioned tooth. It is important to inform the patient that cases of this type will often require correction of both arches because with normal overjet, the mandibular malpositioned teeth will get in the way of correcting the

Prosthetic tooth repositioning is a viable treatment option for select malocclusions that require esthetic and functional correction. The stability of these cases has been shown clinically when proper guidelines have been followed.

Figure 17—A 3-year postoperative view of the completed case.

Figure 18—Full-arch retracted preoperative view of a patient in centric relation with no posterior tooth contact and no temporomandibular joint symptoms at the time.

Figure 19—As the incisal edges of teeth nos. 7 through 10 were reduced out of contact, the posterior teeth began to come into contact.

Figure 20—Maxillary arch view showing contacts of posterior maxillary teeth with the incisal reduction of teeth nos. 7 through 10.

Figure 21—Tooth preparation of the maxillary incisors completed for all-ceramic restorations.

Figure 22—After placement of the ceramic restorations, contacts in the posterior region can now be seen back to the first molar region, giving this patient a more stable intercuspation in centric occlusion.

maxillary teeth in the lingual direction if only a maxillary arch alignment correction is attempted. Again, this must be verified by a preoperative cast preparation and a composite mock-up first (Figure 12). If the case is determined to be reasonable to perform, the mock-up must then be approved by the patient to see if the proposed correction will meet their expectations. If desired, the actual teeth can be marked in the same fashion as the study models with a sterile marker to show where the teeth need to be reshaped before depth-cut placement and tooth preparation for the restorative material (Figure 13). Clear provisional stents made from the composite mock-ups can also serve as three-dimensional preparation guides to verify proper tooth reduction (Figure 14). A completed incisal view and maxillary arch postoperative facial view are shown in Figures 15 and 16. Compare these to the preoperative views (Figures 9 and 10) to visualize the prosthetic corrections. A 3-year postoperative full-arch retracted facial view is shown in Figure 17. This case has been esthetically and functionally stable during this period of time.

Case Report 3

A 58-year-old man presented with occlusion on the anterior teeth only and had no posterior tooth contact (a preoperative retracted view of the patient positioned in centric relation is shown in Figure 18). He had been told that his only option was to have jaw surgery. After mounting the preoperative study models in centric relation on a semiadjustable articulator, it was determined that if the maxillary anterior arch form can be expanded slightly facially, it may allow the mandible to close and the posterior teeth to contact. When the maxillary teeth nos. 7 through 10 were reduced incisally (Figures 19 and 20), the posterior teeth came into contact. Therefore, the operative plan was to prepare teeth nos. 7 through 10 and place 360-degree ceramic restorations (Figure 21) to correct the arch form in the facial direction and tilt the long axis of the crowns slightly toward the facial aspect. As the incisal edges were shortened, the posterior teeth came into contact. Once this occurred, the teeth were then depth-cut on the facial and palatal aspects to allow for the thickness of the ceramic material. Figure 22 shows the completed case after the 4 maxillary incisor restorations were delivered. Note the functional contact that now exists in centric occlusion for the patient. Although the crossbite cannot be addressed without restoring the posterior teeth (ie, a full-mouth reconstruction), the patient has gained a stable occlusal situation by the restoration of 4 teeth without invasive orthognathic surgery.

Conclusion

Prosthetic tooth repositioning is a viable treatment option for select malocclusions that require esthetic and functional correction. The stability of these cases has been shown clinically when proper guidelines have been followed. In this author's opinion, it has been editorialized by some specialists that this type of treatment is "a quick-fix cop-out" and that patients should be talked into the ortho/surgical approach for all of these types of cases. But just ask the patients presented in this article if the sacrifice of a little more tooth structure vs the more "conservative" surgical approach has been worth it for them. It is always best to present the options and let the patient help decide the course of treatment that best suits their needs.

Robert A. Lowe, DDS, FAGD, FICD, FADI, FACD, maintains a private practice in Charlotte, N.C. A Diplomate of the American Board of Esthetic Dentistry, Dr. Lowe lectures internationally and is co-chair of Advanstar Dental Media's continuing education advisory board. He can be reached at 704-364-4711 or at boblowedds@aol.com.

PART 1

Minor movement, **major change**

Minor orthodontic tooth repositioning is an important component of overall esthetic treatment.

Dr. Robert A. Lowe, DDS, FAGD, FICD, FADI, FACD

Public awareness of the esthetic component of restorative dentistry continues to elevate the demand for cosmetic dental treatments in many practices today. Elective cosmetic procedures, such as the placement of porcelain laminate veneers and tooth whitening are performed today as a routine part of general dental practice.

Form and function

Many clinicians consider orthodontics as the first "cosmetic" dental procedure ever offered to patients……long before adhesive dentistry and tooth whitening catapulted the practice of dentistry into the "esthetic or cosmetic" era. Many patients got their teeth straightened to "look better", not fully understanding the true functional benefits that orthodontics provided for them. Having teeth aligned in their correct positions not only gives a person a pleasing smile, but also creates a healthy occlusal and periodontal environment that will allow their smile to be enjoyed for years to come.

Dr. Harold M. Shavell once said in regards to the dentition "If it looks good, it functions well…..and if it functions well it looks good." There indeed are many clinical situations where malocclusion and misalignment of teeth require full mouth orthodontic correction by the dentist or dental specialist. On the other hand, there are also many situations where limited orthodontic treatment of a few misaligned teeth can improve the esthetic and functional result. Minor tooth movement or esthetic tooth repositioning, is a simple technique to treat minor tooth misalignment involving four teeth or less, moving them over a total distance of up to three millimeters. The corrective movements of the misaligned teeth are accomplished using clear plastic aligners to tip, torque, and bodily move teeth into a

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(1) This pre-operative facial view shows slight rotations of the maxillary left central and lateral incisors that can be corrected using Essix Aligners. **(2)** A thin, needle shaped 30 micron interproximal finishing diamond (Anterior ARS Diamond Bur: Dentsply Raintree Essix) is used in a high speed handpiece to creatively "slenderize" and cosmetically reshape the proximal surfaces to create the space in which to make the rotational correction. **(3)** Interproximal thickness gauges verify the amount of proximal tooth surface removed. **(4)**The pre-operative model is blocked out in the appropriate areas prior to fabrication of the Essix Aligner so that the tooth (teeth) will have space to move into. **(5)** The Thermoforming machine (The Essix Machine: Dentsply Raintree Essix) is used to heat the plastic and vacuum form the appliance. **(6)** Freeze spray stops the thermal expansion of the plastic and helps to ensure a good tight fit of the appliance.

(7) A mayo scissors is used to cut out around the model and remove excess plastic.

(8) After cutting off the ends of the plastic with an Essix lab knife, the appliance removal tool helps to pry the aligner from the model without breaking it.

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more desirable position. Applications of this technique include minor esthetic tooth alignment of the maxillary and/or mandibular incisor segments; tooth positioning for more ideal placement of porcelain laminate veneers, crowns, or implants; closing small diastemas or spaces; and positioning abutment teeth prior to bridge or implant placement.

This month, Part 1 of this two-part article outlines the basic steps for fabricating the Essix aligner. Next month, two actual case studies will be presented.

Fabrication steps

The maxillary left central and lateral incisors of the patient in Figure 1 has some minor crowding and rotational issues that can be easily corrected via minor tooth movement technique utilizing Essix Aligners (Dentsply Raintree Essix).

A technique known as Air Rotor Stripping (ARS) will be used to "slenderize" the proximal surfaces up to .5 millimeters to create the space to move the misaligned teeth back into the arch form (Figure 2). Incremental

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Mechanics of minor tooth movement

Movement of a tooth in the arch requires three things:

Space–there must be room for a tooth to move and a space for it to move into. The most common ways to create space are extraction and expansion. For minor tooth movement, however, less radical alternatives are just as effective, including:

Interproximal Reduction (IPR), shaving enamel with stainless steel strips in a movement not unlike flossing, or cutting away enamel with slow-speed discs or burs.

Air Rotor Stripping (ARS), high-speed stripping of the proximal surface of a tooth.

Protocol for both IPR and ARS call for enameloplasty of up to 1 mm from each tooth (1/2mm per proximal tooth surface). Several adjacent teeth are stripped to gain up to 3 mm. Dentists generally adopt ARS and IPR readily, since these procedures are similar to others performed in practice everyday with a handpiece, like preparing a tooth for a crown (of course, on a much more limited scale).

Force–Pressure must be applied in the direction desired to move the tooth.

Brackets are rarely needed for minor tooth movement. In fact, the best starting point for moving teeth up to 3mm is basically an Essix plastic retainer appliance created from a conventional pre-operative stone model using a thermoforming machine.

The force is provided simply by placing a bump (dimple) on the Essix appliance using one of eleven Hilliard Thermoplier Pliers (Dentsply Raintree Essix), each designed to make exactly the right size and shape of bump to create rotation, bodily movement, tipping, or torquing movement. Thermopliers position each bump with complete precision. These tools are heated to the correct temperature to indent the appliance perfectly, so the plastic retains its shape and the bump maintains its force. The same plier can then increase the bump, applying additional force over time without taking a new impression and beginning the process over to fabricate a new appliance.

Time–Movement must be incremental over a number of weeks,

The Essix approach simply increases the force by increasing the depth of the bump as the tooth moves incrementally over time.

Every few weeks, the patient returns and the bump is made larger (deeper), again using Hilliard thermopliers. The desired tooth movement is usually achieved after three adjustments, about 3 to 6 months of wearing the appliance (depending upon patient compliance). One millimeter of movement per month is expected when the appliance is worn full-time except while eating. After the tooth (teeth) are moved to the desired position, the can be retained by making an Essix retainer from a model of the post operative position.

(9) A dental burner is used to heat the Hilliard Thermopliers, which will be used to create the "bumps" on the inside of the appliance. **(10)** The Hakko Digital Thermometer ensures that the Thermopliers are not too hot or too cool, but at the appropriate temperature for making the "ideal" bump. **(11)** The Maxillary Hilliard Thermopliers is shown making the bump in the appliance. It is recommended to start with a .5 mm bump, and then increase the depth of the bump by .5mm increments until the desired movement is achieved. **(12)** A ScotchBrite wheel is used to polish the rough edges of the

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Thickness Gauges (Dentsply Raintree Essix) can be used to measure the amount of tooth structure removed from the proximal surfaces (Figure 3).

An impression of the arch to be treated is taken and poured up in quick stone. A block out material, such as flowable resin, or Triad Light Cured Gel (Dentsply Raintree Essix) (pictured in Figure 15) is used to create space for the tooth to "move into." Interproximal embrasures and incisal edges need to be covered with block-out so the tooth will move in the desired direction and not be encumbered by the plastic. Teeth encased in plastic do not move!!

A piece of Essix ACE .035 plastic is heated in a thermoforming machine and vacuum-formed over the correct plaster model (Figure 16). For bruxers or grinders, Essix C+ .040 plastic is recommended. An Accentuator tool (Dentsply Raintree Essix) is used in the embrasure spaces to push the hot plastic into these retentive areas making the appliance fit tighter. A freeze spray (Essix Freeze Spray Coolant: Dentsply Raintree Essix) is used to stop the thermal action and prevent malformation of the plastic upon removal from the plaster model (Figure 17).

A curved mayo scissors is used to cut the aligner away from the excess plastic (Figure 18). Once the excess plastic is trimmed away, the cast removing instrument (Dentsply Raintrss Essix) can be used to lift the aligner off the heal of the model and remove it entirely from the model (Figure 19).

To create the force to move teeth, dimples, or bumps are made inside the aligner (1 mm at a time) in preselected locations depending on the direction the tooth is required to move. Only two teeth can be moved at a time so that the aligner will fit correctly in the mouth.

Hilliard Thermopliers are used to create these bumps. The thermoplier is heated in the flame of a Bunsen burner (Figure 20). A Hakko digital Thermometer (Dentsply Raintree Essix) is used to make sure the thermoplier is at the correct temperature to make the perfect bump into the plastic aligner (Figure 21). For ACE plastic, this temperature is about 240°. Once this temperature is reached, the thermoplier is used to create the bump inside the aligner in the appropriate position (Figure 22). A ScotchBrite (3M ESPE) wheel is used on the aligner to polish all edges prior to delivery to the patient (Figure 23).

Figure 24 shows the completed Essix Cosmetic aligner in place. The patient will be recalled on a weekly basis to assess progress and deepen the bumps as the tooth (teeth) move. The same appliance can often be used to complete the entire minor tooth movement process.

Conclusion

Minor tooth repositioning is easily accomplished by the restorative dentist for very little cost that will enable him or her to manage minor tooth misalignment in conjunction with routine restorative therapy. Next month in Part 2, cases will be presented that show the use of Essix Aligners to make prosthetic tooth position corrections long after the case has been delivered saving the dentist and patient the cost and time of prosthetic remakes. Minor tooth movement is demystified by the Essix system and would be a tremendous benefit to any restorative/cosmetic practice. DPR

(13) The completed Essix Aligner in place. The patient can keep the appliance clean and fresh by soaking it in Retainer Brite (Dentsply Raintree Essix) when not in use.