



(1) An Er, Cr:YSGG laser with a 400 micron tapered tip is used to contour excess gingival tissue around orthodontic brackets. **(2)** The cervico-incisal height of tooth No. 8 is measured with a caliper and the disparity in length between teeth Nos. 8 and 9 is noted. For a patient who displays gingiva when smiling, this can be very unattractive. Lasers can be used in a minimally invasive fashion to equalize the cervico-incisal heights and make the patients' smile more attractive when the new restorations are completed. **(3)** A diode laser (EZ Lase: Biolase Technologies) is used to equalize gingival heights over teeth Nos. 8 and 9 immediately prior to marginal refinement of the preparation and final impressions for porcelain laminate veneers. A diode laser is used in a controlled sweeping motion to contour the gingival crest.

LASERS

in restorative practice

PART 1

Robert A. Lowe, D.D.S., F.A.G.D., F.I.C.D., F.A.D.I., F.A.C.D., F.I.A.D.F.E.

Esthetic and cosmetic dentistry delivered at its optimal level often requires correcting both hard tissue (teeth and alveolar bone) and soft tissue abnormalities. Re-creation of a harmonic balance between tooth contour, position, and color is often not complete without also addressing soft tissue discrepancies and gingival asymmetries. It has been reported that the use of lasers to perform dental procedures often minimizes surgical trauma, which in turn reduces postoperative discomfort and speeds recovery and healing times. Various types of lasers have been used for some time to perform soft tissue procedures in the dental practice. Today,

diode lasers can be used to perform various surgical (soft tissue) procedures such as esthetic gingival recontouring, sulcular curettage in periodontal pockets, excisional biopsy, gingival troughing to aid in final impression making, and frenectomy, just to name a few. The zone of necrosis is so minimal from a laser incision that healing is very predictable—much more so than electrosurgery—which is critical in the aesthetic zone.

Lasers are also available that combine water with laser energy, allowing them to be used on hard tissues – enamel, dentin, and bone. One manufacturer, Biolase Technologies, of the Waterlase Er, Cr:YSGG laser describes a phenomenon called “hydrophotonics” whereby water particles, energized by laser energy, perform the cutting on hard tissues. Unlike most laser systems that remove tissue through direct laser energy, the Er,Cr:YSGG laser transfers most of the energy to the water droplets in the spray; therefore, there is no tissue melt-

ing or vaporization. Such lasers can now be used effectively to remove decay and prepare a cavity for restoration with resin restorative materials. A nice feature about performing operative dentistry on enamel and dentin with an Er,Cr: YSGG laser is that the laser energy causes an interruption of the sodium/potassium pump at the neuron level, making it possible to use the laser in many cases, without local anesthesia. For some patients, this is a major breakthrough. Using the Er,Cr:YSGG laser to remove alveolar bone can be much less traumatic than conventional surgical techniques. The laser

Laser technology is profoundly impacting the day-to-day practice of esthetic and restorative dentistry. Its uses expand daily. This article will discuss some of the latest applications for lasers in clinical esthetic dentistry and show how this amazing technology allows us to better treat our patients.

cuts only out of the tip, so that when placed parallel to the tooth/root surface, only bone is removed. The side of the tooth/root is not affected by the cutting action of the instrument. Among the operations that can be performed are Class I, II, III, IV, V cavity preparations, dentin desensitization, enamel etching, osseous recontouring during gingival surgery, endodontic therapy, including pulpal vaporization, and osseotomy during tooth/root extraction or ridge recontouring, to name a few. When these procedures are performed, the laser wound yields a sterile surface that promotes healing with less postoperative discomfort.

Here, several soft-tissue laser techniques will be described. In Parts 2 and 3 (February and March issues of DPR), several more soft- and hard-tissue procedures will be spotlighted.

Tissue recontouring

When adequate amounts of free gingiva are present, laser contouring (gingivectomy) can predictably increase cervico-incisal heights of clinical crowns to create esthetic symmetry. In the maxillary anterior

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region, gingival symmetry is aesthetically pleasing, particularly when patients display gingival tissue when smiling. As long as biologic width is not violated (2 mm for connective tissue and epithelial attachments and 1 mm for minimal sulcus depth), amounts

of free gingiva in excess of the 1 mm minimal sulcus depth can be excised for aesthetic reasons.

Removal of gingival tissue can be accomplished using a diode laser or by using the Er,Cr:YSGG laser with or without anesthesia.



(4) This is a 2-week postoperative view of the surgerized area shown in Figure 3. Notice how well the area is healed. The margins for the porcelain veneer restorations are located at the crest of the free gingiva, precisely where the tissue was lasered. Unlike when using electrosurgery where tissue necrosis can be unpredictable, the negligible zone of necrosis from the laser wound is only a few cell layers thick. Therefore, final impressions can be taken at the time of surgery with predictable margin placement after healing.

The diode laser cuts soft tissue effortlessly and bloodlessly when the fiber is directed with a light “paint stroke” motion. The Er,Cr:YSGG cuts soft tissue with a “sewing machine stitch-like cut.” Hemostasis can be achieved using low power with no air or water, but on some types of tissue (in the presence of inflammation) is not as complete as when using a diode laser.

Gingival hyperplasia

Patients with gingival hyperplasia, such as the patient in **Figure 1** with orthodontic appliances, can be effectively treated using a Er, Cr:YSGG laser without anesthesia around the metallic appliances to remove the excessive gingival tissue and improve the patient’s aesthetics. Direct tissue contact with the tip of the Er,Cr:YSGG laser is recommended. If bleeding is not controlled, defocus the laser by moving the tip back a few millimeters from the tissue surface. The laser will produce a fine white surface on the epithelium as the bleeding is coagulated.

Esthetic gingival-level correction

Many patients may exhibit maxillary central incisors that have disparate gingival heights (**Figure 2**). A diode laser or Er,Cr:YSGG laser can be used to correct the tissue levels above the affected area prior to making final impressions if a sufficient amount of free gingival tissue exists. First, the periodontal sulcular environment needs to be evaluated. The depth of the gingival sulcus is measured using a periodontal probe. If the biologic width is to be altered due to the esthetic requirements of the case, the distance from the base of the sulcus to the crest of the alveolar bone

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must also be measured by sounding. For the average 3-mm sulcus, leaving a minimum sulcus depth of 1 mm is required, which means that there is 2 mm of free gingival tissue that can be altered for aesthetic needs. In general, it is aesthetically desirable to have

the gingival tissue over the maxillary central incisors slightly higher (apically) than the tissue over the maxillary lateral incisors. The tissue over the maxillary cuspids should be slightly higher than the tissue over both the lateral and central incisors. The height

of contour of the gingival tissue (gingival zenith) should be located toward the distolabial line angles. According to Kois¹, this gingival architecture is a reflection of the underlying alveolar crest. The distance from the alveolar crest to the restorative margin (free gingival margin) for anterior teeth should be 3 mm facially and 4 mm interproximally. Taking these parameters into consideration, a diode laser, or Er,Cr:YSGG laser can be used effectively to artistically create these changes. Because of the minimal zone of necrosis as a result of the laser wound, healed tissue levels will be very predictable and impressions can be taken immediately after laser surgery. When using a diode laser, anesthesia is usually recommended, although with EZ Lase diode (Biolase Technologies), using a comfort pulse setting, the instrument can be used without local anesthesia. The author uses hydrogen peroxide to debride the surgical site following diode laser surgery (**Figure 3**). In general, the lowest power to adequately remove the tissue is

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THE USE OF A LASER...IS SAFE AROUND METALLIC SURFACES

recommended. A two-week postoperative view of the surgical area is shown in **Figure 4** prior to placing porcelain veneer restorations.

Soft-tissue removal around implants

Another valuable use for laser technology is the removal of excess gingival tissue around healing abutments and fixture platforms of dental implants (**Figure 5**). Being able to perform this procedure bloodlessly without a scalpel is very convenient for the restorative dentist during the impression and restoration phase of implant reconstruction. The use of a laser, unlike electrosurgery, is safe around metallic surfaces such as titanium or metal restorative materials. When removable "flippers" (temporaries) are used as interim restorations for implants, it is not uncommon to encounter gingival hypertrophy around the healing abutment due to the contact of the restoration during function. This phenomenon can even happen when the restorations are adjusted to avoid implant contact. The Er,Cr:YSGG laser, or diode laser can be used in these instances to remove redundant tissue around implant components

without danger of altering the titanium surfaces or interfering with the osseointegration process. Also, when healing abutments become loose, the gingival tissues can migrate into the space between the abutment and the implant platform. When this occurs, it is impossible to properly

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(5) The Er, Cr: YSGG laser is used around this titanium healing abutment to remove excess gingival tissue prior to removal for a fixture level impression. This simplifies placement of impression copings and esthetic tissue contours around the final abutment and restoration.

place implant components on an external hex platform. On radiographic examination, the space between the platform and abutment is apparent. It is essential to clear this tissue from the platform of the implant so that the restorative components will fit properly. Once the implant platform is cleared, the restorative components are more easily placed.

Summary

Some techniques have been described using both diode and the Er,Cr: YSGG lasers in the esthetic/restorative dental practice. As time goes on, more uses will be discovered for this wonderful adjunctive technology to aid the dentist in creating beautiful and functional smiles for patients in a more comfortable manner.² In February and March, Parts 2 and 3 of this article, several more laser technique will be outlined, including gingival troughing, frenectomy, root desensitization, osseous recontouring, cavity preparation, and alveoectomy. **DPR**

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LASERS in restorative practice

PART 2

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

Laser technology is profoundly impacting the day-to-day practice of esthetic and restorative dentistry. Its uses expand daily. This article will discuss some of the latest applications for lasers in clinical esthetic dentistry and show how this amazing technology allows us to better treat our patients.

Delivered at its optimal level, cosmetic dentistry often requires correcting both hard-tissue (teeth and alveolar bone) and soft-tissue abnormalities. Re-creation of a harmonic balance between tooth contour, position, and color is often not complete without also addressing soft-tissue discrepancies and gingival asymmetries. Using lasers to perform dental procedures often minimizes surgical trauma, which in turn reduces postoperative discomfort and speeds recovery and healing times. Various types of lasers have been used for some time to perform soft-tissue procedures. The zone of necrosis is so minimal from a laser incision that healing is very predictable—much more so than from electrosurgery—which is critical in the esthetic zone.

Last month, in Part 1 of this article, I described several soft-tissue procedures using a diode laser. Here, and in the concluding Part 3, I discuss additional soft- and hard-tissue applications using both a diode laser and the Waterlase Er,Cr:YSGG laser from Biolase Technologies.

Inflammatory-tissue control and troughing

When replacing failing restorations, it is not uncommon to find unhealthy marginal gingival tissues, even when the patients' homecare is adequate. Localized chronic inflammatory tissue can be removed and hemorrhage controlled by using a laser prior to the impression-making process. The laser allows the dentist to control the tissues and take impressions at the same appointment. The resultant healing will be predictable, and a margin placed at the time of surgery will remain in the same relation to the gingival crest after healing occurs. This can be especially critical when using PFMs in the esthetic zone. Troughing is a procedure by which a laser is used to create a space between the preparation margin and the tissue to aid in the proper registration of master impressions. Many laser users claim to forego

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(1) The Er,Cr:YSGG laser is used to trough around tooth No. 10. This will simplify placement of retraction cord and enhance access to the restorative margins and root surface beyond to the impression materials. **(2)** A labial frenectomy is being performed between teeth Nos. 8 and 9 to correct a low attachment, which could in turn lead to gingival recession. Because of the ease of completion and unremarkable healing when performed with a laser, this can be done as a preventive measure when low frenum attachments exist. **(3)** The Er,Cr:YSGG laser is shown cutting enamel and dentin on a maxillary premolar that has occlusal and distal decay. Outline and convenience forms are established. Caries can be excavated with hand instrumentation and slow speed round burs without local anesthesia. **(4)** Attrition that exposes dentin on incisal edges of anteriors is easily treated with the Er,Cr:YSGG laser. This slows wear and helps maintain disclusive patterns, further slowing posterior wear as well.

Featured laser applications

PART 1 (January)

- Tissue recontouring
- Gingival hyperplasia
- Esthetic gingival-level correction
- Soft-tissue removal around implants

PART 3 (March)

- Surgical crown lengthening—open and closed techniques
- Alveoectomy prior to tooth extraction
- Laser pulpectomy and root canal therapy

>> PART 2

- Inflammatory tissue control and troughing
- Frenectomy
- Class II cavity preparation
- Incisal edge restoration
- Class V cervical erosion and root desensitization
- Osseous recontouring and surgical removal
- Eliminating excessive gingival display

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- All of the above
- Aphthous ulcer treatment
- Laser pocket debridement
- Cavity preparation
- Preventive resin restorations

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retraction cord. Troughing alone is reliable only when there is enough horizontal thickness of tissue that troughing around the preparation does not result in loss of vertical tissue height. That

said, when gingival troughing is indicated to aid in gingival displacement, use of either the diode laser or the Er,Cr:YSGG laser is much more predictable than electrosurgery. When troughing with electrosurgery, the unpredictable zone of necrosis—particularly in

a thin sulcular environment—can lead to excessive recession and gingival sloughing following healing. Because it is reported that the necrosis resulting from a laser wound is only a few cell layers thick, this is much less likely to happen when troughing with a laser. It is still a good practice to use mechanical tissue retraction when possible, particularly in the esthetic zone, and use gingival troughing when localized gingival excess or chronic inflammation is present, and in areas outside the esthetic zone. In general, a diode laser will provide more consistent coagulation. In the case illustrated in Figure 1, troughing is being performed interproximally; then

NECROSIS RESULTING FROM A LASER WOUND IS ONLY A FEW CELL LAYERS THICK

retraction cord was placed to create 360° of totally patent sulcus for placement of light-bodied impression material. This virtually assures a perfect impression every time. The goal is not only to capture the margins, but also 0.5 mm of root surface apical to the margin so that the laboratory can create the proper emergence angle for the restoration.¹

Frenectomy

Maxillary labial frenum position can affect the periodontal stability and position of the central incisors. However, many low frenum attachments go uncorrected because of the need for a surgical referral. With a diode or Er,Cr:YSGG laser, a labial frenectomy (Figure 2) can be performed easily, with very little postoperative discomfort and without the use of anesthesia. For patients with a diastema between the maxillary central incisors, having the space closed with esthetic restorations may have a better, more stable result when a frenectomy is performed. The tip of the laser is held parallel to the alveolar bone at the point where the frenum intersects the attached gingiva. The instrument is moved back and forth as the fibrous attachment is severed. There is little bleeding from the laser wound and sutures are not required. The patient can expect minimal discomfort and rapid healing.

If the lingual frenum is attached too close to the tip of the tongue, a patient's speech may be affected. A lingual frenectomy can often help a patient who is "tongue-tied,"

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but when performed with a scalpel or surgical scissors, requires local anesthesia and sutures. For some patients, especially children, this may dissuade them from having the procedure done. Now

with the Er,Cr:YSGG laser, this procedure can be easily performed without anesthesia or sutures and with no discomfort or postoperative difficulty. The tip of the laser is oriented toward the dorsum of the tongue along the fibrous attachment of the frenum. Make

sure to begin the laser incision distal to the salivary gland ducts (Wharton's duct). Pull the tongue upward toward the palate as the laser cuts the attachment fibers. Stop when the ventral surface of the tongue is reached, or when sufficient mobility of the tongue is realized. When the Er,Cr:YSGG laser is used at a setting of 2 watts or less, no local anesthesia is usually required (topical only!). No sutures are needed. Mild postoperative discomfort is often handled with over-the-counter NSAIDs, such as ibuprofen.

Class II cavity preparation

For conservative Class II interproximal carious lesions without occlusal involvement, a "tunnel preparation" can be made angling from the nearest pit (mesial or distal) toward the carious lesion that is usually located just apical to the contact. Through this approach, the marginal ridge can be preserved while gaining access to the caries lesion. Air abrasion or a small round bur can be used to remove the decay. The laser is used to disinfect and etch the enamel and dentin, and the restorative procedure is completed.

For larger lesions, the Er,Cr:YSGG laser is used to complete the outline and convenience form (Figure 3). Slow speed round burs can be used to remove caries, then the preparation is sterilized and etched using a dentin setting in the laser's defocused mode.

Incisal edge restoration

When anterior teeth show signs of incisal attrition, the dentin "cups out" leaving the unsupported enamel susceptible to further fracture and shortening of the clinical crown. Eventually, anterior guidance and cuspid disclusion is lost, leading to premature posterior tooth wear. Intervention using hybrid composites has never been easier than when using the Er,Cr:YSGG laser without anesthesia. The exposed dentin and enamel is prepared with the laser (Figure 4). The enamel is beveled by angling the 600-micron tip at 45° to the cavosurface margins. Hybrid composite restores the lost enamel on the incisal edge and can add years of life to the posterior dentition by maintaining proper guidance and disclusion.

Class V cervical erosions/root desensitization

Exposed dentin in the cervical third of the clinical crown can cause hypersensitivity, particularly when dentinal tubules are open. Many topical remedies can give temporary relief, but the sensitivity usually returns with time. The Er,Cr:YSGG laser can be used to permanently occlude the tubuli, even in hard-to-treat interproximal

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areas. The 600-micron tip is used for the desensitizing procedure. Start with the tip 5 to 10 mm from the affected surface. Move the tip in a circular motion toward the tooth surface for a total treatment time of about 30 seconds (Figure 5). If no erosion or abfraction is present, covering the surface with composite resin may not be necessary. If needed, bonding adhesive and composite resin can be applied directly to the lased surface.

Osseous recontouring and surgical removal

The use of Er,Cr:YSGG laser for bony recontouring is going to revolutionize traditional osseous surgery. Because the



(5) The cervical area of a maxillary first premolar has been treated for dentin hypersensitivity using the Er, Cr: YSGG laser. The obliteration of open tubules by the laser energy will decrease sensitivity almost immediately. If restoration is required, the surface is already prepared (laser etched) to receive an adhesive resin and composite restoration.

laser cuts only at the end of the tip, control of osseous removal is maximized. With diamonds, the rotation of the instrument could damage adjacent root surfaces. Also, because 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 water-cooling. This translates into less postoperative discomfort and quicker healing times. Once the bone immediately adjacent to the tooth is safely removed using the laser, an osteoplasty bur on a slow speed handpiece with water spray can be lightly and sporadically used to smooth and contour the lased bony interface with the adjacent untreated bone. The diode laser or Er,Cr:YSGG laser can be used to recontour the gingival crest prior to flap reflection and the Er,Cr:YSGG laser can be used to incise the flap and perform osseous recontouring during crown lengthening. Surgical provisionals are placed after the laser surgery.

Eliminating excessive gingival display

It is generally perceived that the esthetic smile shows 3 to 5 mm of gingival display. Ideally, the height of the gingival

tissue over the maxillary central incisors is slightly higher than the tissue over the lateral incisors—and the tissue over the canines is higher than both. Also, gin-

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gival display should be symmetrical on both sides of the midline. Many patients exhibit asymmetrical gingival levels, have

“gummy smiles” (greater than 3 mm of maxillary gingival display), or both. For these patients, surgical correction prior to the placement of restorations will lead to

a greatly improved esthetic result. If adequate amounts of free gingiva exist, minor asymmetries can be corrected with gingivoplasty alone. To give the appearance of

bodily moving teeth in space to alleviate excessive gingival display, osseous correction (facial osteotomy) must often be done

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(6) This patient has a surgical plan “drawn” on the attached gingiva to correct cervicoincisal height and create a more esthetic balance of the hard and soft tissue display. **(7)** Surgical correction of the gingival zeniths over teeth Nos. 8 and 10 has been accomplished with the Er,Cr:YSGG laser. **(8)** This patient required removal of osseous crest corresponding to the amount of free gingiva removed to create esthetic harmony and re-establish proper biologic dimension. The Er,Cr:YSGG laser allows crestal bone to be shaped accurately following the restorative margin of the provisional restorations approximately 3 mm apically. **(9)** A 7-week post-op view. The porcelain veneers were bonded three weeks after laser correction. The healing is remarkable as the gingiva seeks out and re-established the 3-mm biologic zone, creeping incisally back to the restorative margins.

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in conjunction with soft tissue resection.

When planning the surgery, the finished maxillary central incisors should be 10 to 12 mm in length. The incisal edges can be shortened when adequate free way space exists, however 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 6). Following the "rules" for esthetic tissue levels previously stated, the perceived final gingival level is traced creating heights of contour at the distolabial line angles. The Er,Cr:YSGG or diode

laser can be used to remove the gingival tissue and create symmetry following the proposed surgical plan (Figure 7). Next, the preparation margins are adjusted to the new heights of the tissue. Biologic width will be encroached upon, so it is important to subsequently remove the same amount of bone to recreate normal biologic parameters. An intrasulcular internal bevel incision is made and a full-thickness mucoperiosteal flap is elevated using a periosteal elevator. According to Kois², the soft tissue architecture (gingival crest) will follow the alveolar crest below 3 mm apical to the free gingival margin. The bony correction is made using the Er,Cr:YSGG laser and a 600-micron tip. Since the laser only cuts at the tip, it is set against the side of the root parallel with the long axis (Figure 8). This prevents damage to the dentin surface. 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 now mimic the restorative margin 3 mm apically, allowing for biologic width restoration. The interproximal bone on facial esthetic correction cases is not altered, the flap is sutured back using 3-0 silk and interrupted suture technique. If a section of the flap needs to be evened or adjusted after suturing to blend gingival levels, it can be done with the Er,Cr:YSGG or diode laser. The definitive restorations on tooth Nos. 7 through 10 are shown in Figure 9 seven weeks after bony surgery with the Er,Cr:YSGG laser.

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Summary

As time goes on, more uses will be discovered for this wonderful adjunctive technology to aid the dentist in creating beautiful and functional smiles for patients in a more comfortable manner.⁶ Stay tuned for more applications next month. **DPR**

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(1) A 14 millimeter 600 micron periodontal tip is used on the Er, Cr: YSGG laser to remove the soft and hard tissue during a localized closed crown lengthening procedure to correct a biologic width violation caused by previous preparation design. **(2)** An incisal view of the maxillary lateral incisor shown in Figure 15 shows the surgical site after osseous correction. Final impressions can now be taken, as the area will heal by secondary intention. **(3)** The maxillary lateral incisor shown in Figure 15 three weeks after corrective laser surgery, prior to the delivery of the restoration. Note the complete epithelialization of the surgical area. This area now probes a 1-millimeter gingival sulcus without bleeding.

LASERS

in restorative practice

PART 3

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

Laser technology is profoundly impacting the day-to-day practice of esthetic and restorative dentistry. Its uses expand daily. This final installment covers surgical crown lengthening, aveoectomy, and pulpectomy.

In Parts 1 and 2 of this article, I described several soft- and hard-tissue procedures (see index on facing page). This final installment spotlights four procedures using the Waterlase Er, Cr:YSGG laser from Biolase Technologies. *Editor's note: In addition to the procedures described here, four additional applications—aphthous ulcer treatment, laser pocket debridement, cavity preparation, and preventive resin restorations—are described by Dr. Lowe in the unabridged version of this article that appears on our Web site, www.DPRWorld.com.*

Esthetic and cosmetic dentistry delivered at its optimal level often requires correcting both hard-tissue (teeth and alveolar bone) and soft-tissue abnormalities. Re-creation of a harmonic balance between tooth contour, position, and color is often not complete without also addressing soft-tissue discrepancies and gingival asymmetries. It has been reported that the use of lasers to perform dental procedures often minimizes surgical trauma, which in turn reduces postoperative discomfort and speeds recovery and healing times. Various types of lasers have been used for some time to perform soft-tissue procedures in the dental practice. Today, diode lasers can be used to perform various surgical (soft-tissue) procedures, such as esthetic gingival recontouring, sulcular curettage in periodontal pockets, excisional biopsy, gingival troughing to aid in final impression making, and frenectomy, just to name a few. The zone of necrosis is so minimal from a laser incision that healing is very predictable—much more so than from electrosurgery—which is critical in the esthetic zone.

Lasers also are available that combine water with laser energy, allowing them to be used on hard tissues – enamel, dentin, and bone.

Surgical crown lengthening—Open technique

Open surgical circumferential crown lengthening can be performed using the same technique described last month for the cosmetic recontouring of gingival tissue and alveolar bone. It is important to keep “Ferrule Effect”⁵ in mind when crown lengthening teeth broken at the gingival line. At least 2 millimeters of tooth structure needs to be present incisally or occlusally to the restorative margin after the surgery has healed.

It is sometimes necessary to use a 12 or 14 millimeter 600-micron periodontal tip on the Er, Cr: YSGG laser to gain access interproximally and maintain the proper orientation of the tip to remove the bone adjacent to the root. If an osteoplasty diamond is used to festoon interproximal bone (not next to the root) and blend adjacent bony surfaces, the laser is subsequently used to create a laser wound, which will promote healing.

When smoothing the osseous crest interproximally, a Wedlestadt chisel and Sugarman file can be used at right angles to the long axis of the tooth to cleave and smooth

the bone adjacent to the root surfaces prior to suturing the flap back to place.

Surgical crown lengthening—Closed technique

For minor localized biologic width and esthetic corrections, a “closed flap” procedure utilizing the Er, Cr: YSGG laser can sometimes be used in lieu of an “open” flap procedure to make the soft tissue and bony correction. It allows the restorative process to be completed without the extended healing time required for open type surgeries.

The soft tissue (gingiva) is removed using a 600-micron tip (Figure 15). The osseous crest is sounded using a periodontal probe to determine the distance from the restorative margin. 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” (up and down movement) to a 3-millimeter depth (Figure 16). Afterwards, a periodontal probe is used to verify depth by sounding to 3 millimeters. The tip of the laser can be angled away from the tooth slightly to blend adjacent bone and avoid digging a trench around the tooth. Expa-Syl (Kerr Corporation) in conjunction with retraction cord is used in the surgical area to aid in hemostasis while taking the master impression.

A provisional restoration is then fabricated and cemented. The definitive restoration can be placed in 2 to 3 weeks and the periodontal structures can heal adjacent to the actual restoration with precise margins and contour, rather than a “temporary” restoration. The surgical area will heal by secondary intention. Figure 17 shows a three year post-operative view of the surgical site after a “closed” crown lengthening procedure followed by the placement of an all ceramic crown on tooth number 7.

Alveoectomy prior to tooth extraction

When a tooth needs to be extracted, particularly one in the esthetic zone, it is extremely important that it be done as atraumatically as possible. Preservation of the buccal plate and interproximal bony crest—whether an implant is to be placed, or a conventional fixed bridge—will have a profound effect on the final esthetic outcome of the case. When an extraction is treatment planned for a fixed



(4) The Er, Cr: YSGG laser is shown removing palatal crestal bone prior to surgical extraction of a fractured maxillary lateral incisor. By removing this tooth from the palatal aspect as atraumatically as possible with the help of the hard tissue laser, the buccal and interproximal bone is preserved allowing for placement of an esthetic ovate pontic. (5) A digital radiograph of the provisional three-unit bridge with ovate pontic in place after socket grafting. Note the preservation of the interproximal bone so critical to papillary regeneration. The ovate pontic extends approximately 2 to 3 millimeters into the socket site.

bridge case, consideration for preservation of alveolar bone height is of primary importance. Grafting the socket with some type of bone substitute and development of an ovate pontic in the provisional restoration can create a very natural looking environment where the facial and interproximal bone is preserved, and the soft tissue is supported (papillary and marginal gingiva). Therefore, careful extraction of the tooth is critical.

One way to accomplish this is to use the Er, Cr: YSGG laser to carefully remove bone from the lingual aspect (non-esthetic side) and use periostomes and small elevators to atraumatically remove the tooth (Figure 18). Once the site is grafted and the soft tissues are sutured to place, a provisional restoration with an ovate pontic that extends 2-3 millimeters into the extraction site is fabricated and cemented to place (Figure 19). The bottom of the ovate pontic should be shaped like the large side of an egg. This design will support the surrounding gingival tissues and put horizontal pressure against the interproximal periodontium creating a natural bioesthetic papillary zone.

After the soft tissues have healed (4-6 weeks), master impressions can be made for the laboratory-processed restoration. In the case of immediate implant placement, an implant is selected by the surgeon and placed in the appropriate position. Depending on the extracted tooth diameter and the diameter of the implant chosen, placement of osseous graft material and/or a resorbable membrane may also be done at the time of placement prior to soft tissue closure.

Laser pulpectomy and root canal therapy

Tips have been designed to be used with the Er, Cr: YSGG laser that can negotiate the length of the root canal system and have the flexibility for curved canals. The cutting action at the tip is different than for most YSGG tips, as there is a small amount of lateral cutting that takes place. This allows enlargement of the root canal space and subsequent obturation. Many times in general practice, we have to deal with pulpal exposures during the course of tooth preparation, either due to caries or mechanically induced. For some patients, intrapulpal injections and pulp extirpation can be difficult to tolerate from a comfort standpoint. Using the Er, Cr: YSGG laser

Continued on page 3

Featured laser applications

PART 1 (January)

- Tissue recontouring
- Gingival hyperplasia
- Esthetic gingival-level correction
- Soft-tissue removal around implants

PART 2 (February)

- Inflammatory tissue control and troughing
- Frenectomy
- Class II cavity preparation
- Incisal edge restoration
- Class V cervical erosion and root desensitization
- Osseous recontouring and surgical removal
- Eliminating excessive gingival display

>> PART 3 (March)

- Surgical crown lengthening—open and closed techniques
- Alveoectomy prior to tooth extraction
- Laser pulpectomy and root canal therapy

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- All of the above
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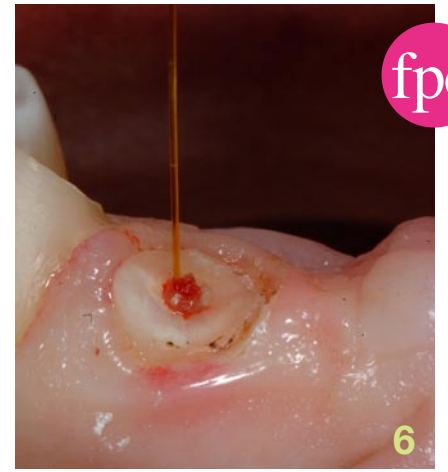
Continued from page 2

and a specially designed endodontic tip, the offending pulp can now be removed comfortably and effortlessly (Figure 20).

A radiograph is taken to determine the approximate canal

length. Digital radiography is convenient because many systems have tools that can measure distances on radiographs with a fair degree of accuracy. The pulpal tissue can then be easily ablated to the proposed working length.

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(6) A laser pulpectomy is performed using an Er, Cr: YSGG laser after this patient's bridge was broken along with the maxillary lateral incisor abutment from a traumatic blow to the face. The ablation of the pulp tissue relieves the distress from the vital pulp exposure and allows for comfortable provisionalization for the patient and allowing the completion of root canal therapy to be done at a later time.

Restorative procedures, such as provisionalization can be completed and the patient will be comfortable until the root canal therapy can be completed.

Summary

Some techniques have been described using both diode and the Er,Cr: YSGG lasers in the aesthetic/restorative dental practice. As time goes on, more uses will be discovered for this wonderful adjunctive technology to aid the dentist in creating beautiful and functional smiles for patients in a more comfortable manner.⁶

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LEARNING OBJECTIVES

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

- describe the dentogingival complex.
- discuss the closed-flap technique.
- compare laser-assisted crown lengthening with laser-assisted open-flap crown lengthening.
- explain remodeling of the bony crest.

Use of the Er,Cr:YSGG Laser for Osseous Crown Lengthening: Clinical Update

Robert A. Lowe, DDS

ABSTRACT

Surgical techniques using the laser have been shown to decrease the need for suturing, reduce postoperative discomfort, and shorten healing times. This article demonstrates and discusses 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-flap and closed-flap techniques.

When designing the optimal esthetic 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. Spear¹ has referred to this diagnostic methodology as facially generated treatment planning, where the maxillary central incisal edges determine where the soft tissue (ie, gingiva) and bony crest should be positioned.

The versatility of the erbium, chromium: yttrium, scandium, gallium, garnet (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 esthetic or restorative reasons. Surgical techniques using the laser also have been shown to decrease the need for suturing, reduce postoperative discomfort, and shorten healing times.^{2,3} This article demonstrates and discusses 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-flap and closed-flap techniques.

THE ESTHETICS OF GINGIVAL DISPLAY—THE DENTOGINGIVAL COMPLEX

The dentogingival complex consists of connective-tissue attachment, epithelial attachment (or junctional epithelium), and the gingival sulcus. As described by Kois,⁴ 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 bony crest. Kois stated that “the distance from the free gingival margin to the osseous crest on the facial aspect should be 3 mm.” Interproximally, on anterior teeth, this distance should be 4 mm because of the curvature of the cemento-enamel junction and the position of the bony crest relative to it. The height of the interdental papilla also can be predicted to be maintainable 4-mm incisal

to the osseous crest between anterior teeth with normal root proximity, which is approximately 2 mm to 3 mm at the osseous crest. 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 (preparation) colors or core materials, it may be desirable to place the restorative margin at the free gingival crest or slightly supragingival. If an intracrevicular margin is required for esthetic reasons, however, it should be placed no farther than 0.5 mm into the gingival sulcus to avoid adverse biologic responses caused by encroachment upon the attachment apparatus.

Coslet et al⁵ and Kois⁶ also have described a variation in biologic width that compares the distance from the alveolar crest to the FGM and divides this distance 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 an average 1-mm to 3-mm sulcus depth. If the sulcus depth is > 1 mm, the free gingival excess can be resected safely and, on 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 epithelial and connective-tissue attachment < 2 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-tissue attachment that is > 2 mm. These patients are highly prone to recession and must be treatment planned accordingly. The FGM of low-crest patients will tend to reposition apically and turn into a normal crest situation after gingival retraction or surgery. Therefore, the most 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.

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. Because 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 gingivectomy incisions 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, because the surgical laser wound is less traumatic, there is less chance of bony damage from frictional heat, which is always possible when using rotary instrumentation without proper irrigation. This minimally invasive technology translates into



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THE MOST IMPORTANT FACTOR IN POST-RESTORATIVE GINGIVAL HEALTH AND STABILITY IS THE POSITION OF THE RESTORATIVE MARGIN RELATIVE TO THE BONY CREST...

less postoperative discomfort and quicker healing of the patient.⁷

LASER-ASSISTED OPEN-FLAP CROWN LENGTHENING

For an esthetic gingival display, it is critical that symmetry (right and left) exists as far as cervicoincisal tooth height and gingival zenith positions are concerned. Patients who exhibit asymmetrical gingival levels may be candidates for surgical gingival and/or alveolar bone reposition-

ing to improve their esthetics (Figure 1). Typically, these patients have adequate amounts of attached gingiva so that, after the resective procedure, the mucogingival junction will not be encroached upon. 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, osseous correction must often be performed in conjunction with soft-tissue resection because of sulcus depth violation.

A tissue marker can be used to plan the soft-tissue surgery (Figure 2). Following the guidelines for esthetic tissue levels, the perceived final gingival level is traced, creating heights of contour at the distolabial line angles. The Er,Cr:YSGG laser was used to remove the gingival tissue and create symmetry according to the proposed surgical plan (Figure 3). Then, the teeth were prepared to the respective corrected free gingival margins. As the biologic width would be encroached upon, it is important that the same amount of bone be removed to recreate normal

biologic parameters.⁷ After the teeth were prepared, the Er,Cr:YSGG laser was used to “trough” around areas where the gingivectomies had been performed to allow for retraction needed for master impressions to be made (Figure 4). A hemostatic agent and tissue deflector was used to aid in tissue management during the impression process (Figure 5). A two-cord retraction technique was used as the tissue was prepared for the impression process (Figure 6). The completed master impression is shown in Figure 7. Note that the entire restorative margin and 0.5 mm of tooth or root surface apical to the margin needed to be captured in the master impression. A plastic matrix was filled with a bis-Acrylic provisional material and placed on the preparations to fabricate the provisional restorations.



Figure 1 Preoperatively, the patient's smile showed a full gingival display and asymmetrical gingival levels in the maxillary anterior region. Although the “gummy smile” may not be able to be eliminated completely, better symmetry of the tissue levels was one of the goals of treatment.



Figure 2 A black marker was used to delineate the surgical plan. The patient had chosen to treat only tooth Nos. 7 through 10. The tissue level over tooth No. 8 needed to be positioned more apically to be symmetrical with tooth No. 9. The gingival level above tooth No. 10 also needed to be raised slightly to better match the tissue level of tooth No. 7.



Figure 3 A gingivectomy was performed using an Er,Cr:YSGG laser to harmonize the soft-tissue levels. Biologic width was encroached upon and, therefore, a repositioning of the bony crest was also needed to prevent a relapse of the preoperative tissue position.



Figure 4 Troughing was performed before tissue displacement to allow access to the submarginal area for the impression medium.



Figure 5 A combination “tissue deflector” and hemostatic agent (Expasyl, Kerr Corporation) was used after troughing and before the registration of master impressions.



Figure 6 A two-cord technique was used to complete final tissue retraction. A No. 00 cord was placed around each preparation to the base of the sulcus, followed by a No. 1 cord placed adjacent to each margin circumferentially around each preparation.

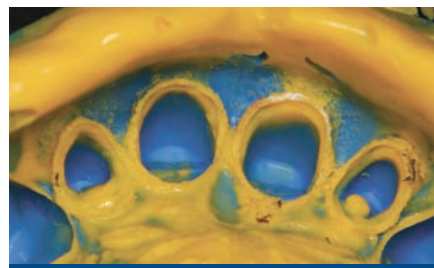


Figure 7 The completed master impression. Note that a 360° margin was present as well as 0.5 mm of tooth or root surface apical to the restorative margin.



Figure 8 After initial closed-flap bony correction, a full-thickness mucoperiosteal flap was raised to visualize the accuracy of the osseous correction and observe the tooth surface and condition of the bony crest as a result of the procedure. It can be seen that the surface of the root is unscathed. The osseous crest was accurately repositioned 3 mm apically from the restorative margin, following its exact contour.



Figure 9 Facial view of tooth Nos. 7 through 10 after completion of the surgical phase of treatment.



Figure 10 Facial view of the gingival tissues 9 weeks after open-flap surgery and at the time of placement of the ceramic restorations (original magnification 2x). Note the symmetrical positioning of the gingival zeniths of tooth Nos. 8 and 9. The level of tissue health 9 weeks after surgery is excellent.



Figure 11 The all-ceramic restorations (Venus™ porcelain, Heraeus Kulzer, Inc, Armonk, NY) in place at the delivery appointment. (Ceramic artistry performed by Mr. Vincent Devaud, CFC, MDT, Pasadena, CA.)



Figure 12 Six months after surgery, the patient's full smile showed improvement in gingival symmetry and the gingival papilla between tooth Nos. 8 and 9 had completely reoccupied the gingival embrasure space.



Figure 13 Preoperative view of a fixed partial denture that spanned anteriorly from tooth No. 18 to tooth No. 21. There was a minor biologic width encroachment on the distal aspect of the anterior abutment, tooth No. 21. The anterior abutment also had recurrent facial decay apical to the restorative margin and a lack of attached gingiva on the facial aspect.



Figure 14 The preoperative radiograph showed an overhanging margin that was in close proximity to the bony crest.

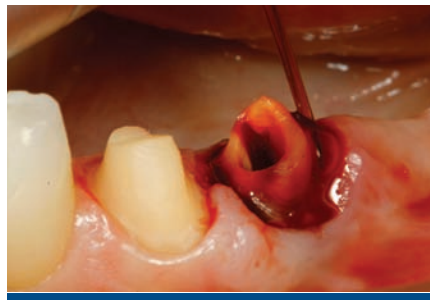


Figure 15 After removal of the defective restoration, it can be seen clinically that the margin of the preparation on the distal of tooth No. 21 was extremely subgingival. The surrounding periodontium was inflamed and hemorrhagic. The laser was used to perform apical repositioning of the bony crest using a closed-flap technique.

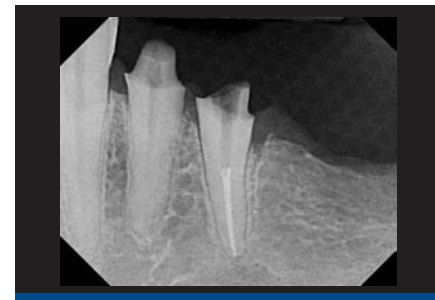


Figure 16 After initial positioning of the bone, keeping the tip of the laser in intimate contact with the root surface, a slight troughing of the bone was seen on radiographic examination.



Figure 17 The tip of the laser was angled slightly to the distal and moved away from the root surface to smooth and blend the adjacent bony surfaces.



Figure 18 Radiographic examination after smoothing and blending of the bony surfaces confirmed that the bone was smooth and the ledge was eliminated.

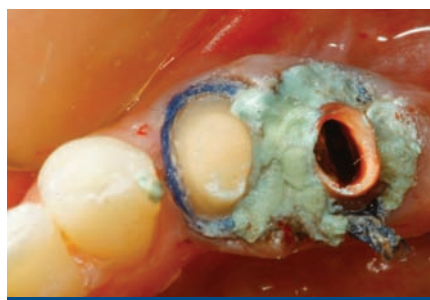


Figure 19 A combination of retraction cord and hemostatic agent (Expasyl, Kerr Corporation) was used to control the periodontal environment for a master impression that would be taken immediately after resective surgery.



Figure 20 Buccal view of tooth No. 21, 8 weeks after resective surgery and master impression taking. A connective-tissue graft was also placed on the facial aspect to increase the amount of attached tissue. The post and core was cemented to place, but the provisional restoration would remain in place until the graft healed sufficiently, in case the periodontal specialist wanted to add more connective tissue.

**THE VERSATILITY OF THE ER,CR:YSGG LASER AND ITS
ABILITY TO RECONTOUR BOTH HARD AND SOFT TISSUES
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After the provisional shell was fabricated, the osseous portion of the surgical procedure was completed. An intrasulcular internal bevel incision was made, and a full-thickness mucoperiosteal flap was elevated (Figure 8). The alveolar crest correction could be made using the Er,Cr:YSGG laser and either a 14-mm 600- μ m or a 9-mm 600- μ m tip. Because the laser only cuts at the tip, it is set against the side of the root parallel with the long axis of the tooth. This placement 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 the end of the tip. This line is used as a guide to position the bone apically, 3 mm from the restorative margin. Only the alveolar bone would be ablated (resected). The root surface was then planed using a back-action chisel. The alveolar architecture, thus, should mimic the restorative margin, 3 mm apically, allowing for biologic width restoration to a normal crest position. The interproximal bone on facial esthetic correction cases is not altered; the flap is sutured back using 3-0 silk and an interrupted suture technique (Figure 9). At the delivery appointment, the tissue is shown before cementation in Figure 10. Figure 11 shows the restorations of tooth Nos. 7 through 10 with all-ceramic restorations at delivery. Note the position of the gingival papilla between

stead of an open-flap procedure, to make the correction and complete the restorative process without the necessary healing time required for open-flap crown-lengthening surgeries. The patient depicted in Figure 13 had a long-span bridge on the mandibular left side that was in need of replacement. From the radiograph (Figure 14), it was noted that there was a biologic width violation on the distal surface of the second premolar abutment. After removal of the bridge, there was an area on the distal of the abutment where the soft tissue was extremely inflamed and edematous and the bony crest was approximately 1-mm apical to the previous restorative margin.

To perform the closed-flap technique, the soft tissues (epithelial and connective-tissue attachments) were resected using a 9-mm 600- μ m tip in the proximal area. The osseous crest was sounded using a periodontal probe to determine its position and topography. Using a 9-mm 600- μ m tip, the laser was then used to remove bone, holding the tip adjacent to the tooth and “walking” the tip across the affected area using a “sewing machine” (up-and-down movement) to a 3-mm depth (Figure 15). After establishing the corrected crestal level, the bone was “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 laser is in contact with the bony crest. A radiograph was taken to confirm that a slight “trough” was made in the bone, correcting the crest position 3-mm apical to the restorative margin (Figure 16). To blend, or “ramp,” the bony crest distally, the tip of the laser was angled away from the tooth, eliminating the slight “trench” and creating a smooth transition from the distal tooth surface to the adjacent bony edentulous area (Figure 17). A radiograph was taken to verify that the correction was made (Figure 18). The correction could be verified by sounding with a periodontal probe as well. Then, the master impression was made (Figure 19), and provisional restoration fabricated and cemented to place. The definitive restoration could be seated 2 to 3 weeks after the closed-flap crown-lengthening procedure. The surgical area would heal by secondary intention around the finished restoration with ideal tooth contours, rather than around an ill-fitting temporary restoration (Figure 20 and Figure 21). The criteria for clinical health of the dentogingival complex are: (1) pink color (absence of inflammation); (2) reestablishment of a probable gingival sulcus; and (3) absence of bleeding on probing.^{8,9}

REMODELING OF THE BONY CREST

There has been much discussion about the condition of the bony crest after the closed-flap laser correction and whether

this procedure is not better performed using an open-flap technique. After treating and observing the healing of hundreds of closed-flap crown-lengthening procedures over the past several years, the author has no doubts that closed-flap crown lengthening is an excellent way to handle minor bony corrections in a minimally invasive fashion (Figure 22 and Figure 23).

Many teeth have been extracted without flap reflection, leaving less than ideal

contours of the resulting osseous crest peripheral to the extraction site. The author has observed that as the extraction site heals and the bone fills in, the crest remodels and becomes smooth. The same clinical observations have been noted when minor closed-flap crown lengthening has been carefully performed. Critics have noted that the technique does not leave the bony crest as smooth as when performing surgery with an open flap and smoothing the bone with hand instru-

mentation. The author has found this to be true. However, the real question is one of clinical relevance. If after healing, a minor closed-flap site exhibits pink, healthy gingival reattachment and a sulcus that does not bleed when probed, the author believes that this result satisfies the criteria for clinical success. It should be emphasized that the closed-flap procedure is indicated for minor biologic width corrections and gingival zenith esthetic corrections. When faced with involved cuspal

fractures where clinical crowns are lost and the remaining tooth structure is located below the gingival tissue at the bony crest, an open-flap crown-lengthening procedure may be preferred for access, adequate instrumentation, and predictable healing.

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-flap periodontal procedures both facially and interdentially and predict to what level the tissues will heal based on the position of the restorative margin. It is important for the clinician to use a periodontal probe and sound from the free gingival margin to the alveolar crest to determine the biologic parameters of the patient before preparing teeth for restorative materials. This step enables the clinician 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 esthetic levels. 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.

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Use of the Er,Cr:YSGG Laser for Osseous Crown Lengthening: Clinical Update

Robert A. Lowe, DDS

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1. Surgical techniques using the laser also have been shown to:
 - a. decrease the need for suturing
 - b. reduce postoperative discomfort
 - c. shorten healing times
 - d. all of the above
2. If an intracrevicular margin is required for esthetic reasons it should be placed no farther than how far into the gingival sulcus to avoid adverse biologic responses caused by encroachment upon the attachment apparatus?
 - a. 0.5 mm
 - b. 1.0 mm
 - c. 2.0 mm
 - d. 3.0 mm
3. Low-crest patients often have normal sulcus depth (1 mm to 3 mm) and a combined epithelial and connective-tissue attachment that is:
 - a. > 1 mm.
 - b. > 2 mm.
 - c. < 1 mm.
 - d. < 2 mm.
4. Using the Er,Cr:YSGG with what allows the operator to make scalloped gingivectomy incisions with surgical precision and no bleeding?
 - a. a football shaped tip
 - b. a tapered tip
 - c. a flat tip
 - d. b and c
5. A minimum sulcus depth of how many millimeters must always remain after any tissue resection unless the alveolar bony crest is also repositioned in the apical direction as well?
 - a. 1 mm
 - b. 2 mm
 - c. 3 mm
 - d. 4 mm
6. Conventional treatment modalities would probably have the patient in provisional restorations at:
 - a. for shade and contour purposes only.
 - b. 1 week.
 - c. 1 month.
 - d. the 6-month follow-up visit.
7. The criteria for clinical health of the dentogingival complex are:
 - a. pink color (absence of inflammation).
 - b. reestablishment of a probable gingival sulcus.
 - c. absence of bleeding on probing.
 - d. all of the above
8. Critics have noted that the technique does not leave the bony crest as smooth as when performing surgery with an open flap and smoothing the bone with hand instrumentation. However, the real question is one of:
 - a. biologic width.
 - b. biologic height.
 - c. clinical relevance.
 - d. it is in a critical esthetic zone.
9. Using the biologic parameters discussed in this article, it is now possible to perform open-flap periodontal procedures both facially and interdentially and predict to what level the tissues will heal based on:
 - a. periodontal biotype.
 - b. the position of the restorative margin.
 - c. patient history of smoking and diabetes.
 - d. use of laser surgical procedure.
10. It is important for the clinician to use what to determine the biologic parameters of the patient before preparing teeth for restorative materials?
 - a. digital radiograph
 - b. panoramic radiograph
 - c. a periodontal probe and sound from the free gingival margin to the alveolar crest
 - d. cone beam CT imaging

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