the impression, facilitating stacked technique results in a tapering more accurate die trimming.

and assist in controlling crevicular seepsecond. Its purpose is to hold the base of form to the sulcus, facilitating easy injec­
tion of the impression material. When the impression is taken, the second, larg­
er cord is removed while the thinner first cord remains in place.

There are a number of precautions to take when using cord (double or single). Although the author has used both cord techniques, postoperative discomfort when the double-cord technique was used was a more consistent finding.

In instances of tight, healthy gingiva, if heavy pressure and/or a thick cord are used, tissue blanching indicates a reduc­tion in blood flow to the area. This re­duction in flood flow can strangulate the free gingiva, with subsequent sloughing and resultant recession. Heavy place­ment pressure can tear the connective tis­sue fibers, also resulting in permanent gingival recession.

In addition, when two teeth are extremely close together, it is virtually im­possible to place retraction cords around both teeth without the danger of strangula­tion or even tearing the papillae. This torn tissue can result in irreversible loss of the interdental tissue and produce the dreaded black triangle, the tissue embra­ture void of a papillae that appears as a black triangle in the smile.

The potential for permanent gingival recession is increased when retraction cord is left in a thin crevice for more than 15 minutes. It has been recommended that the cord be left in place 8–10 min­utes prior to the impression for adequate tissue displacement. If the cords are left in place for 8 minutes and an impression is inserted and left in the mouth for another 5 minutes with the first, thinner cord still in place, the total time would be 13 minutes. If a second impression is re­quired, the recommended 15-minute limit would be exceeded, with the danger of permanent gingival recession. This is not a problem when the erbium laser is used, as there is no cord in place.

Discomfort related to cord placement became evident in the author’s practice after a dental laser was used instead of the traditional double-cord technique to trough around crown preparations. Prior to laser use, the 24-hour follow-up phone call often would elicit a response of sore gingiva. As laser troughing re­placed the cord technique, gingival sore­ness was no longer a complaint.

An erbium laser is used to produce a trough extending slightly below the finish line of the preparation to facilitate a consistently readable margin. The depth of the cut is easy to control.

Biologic width
Invasion of the biologic width can result in a less-than-favorable tissue response to restorations. These changes may manifest as gingival recession, pocket formation, periodontal disease, and bone resorption. Definition of the biologic width varies. Some authors de­fine it as the combination of the epithe­lial attachment (also referred to as the junctional epithelium) and the connective tissue attachment. Together, these two attachments are approximately 2.0 mm wide; the gingival sulcus is not in­cluded. Another definition of the bio­logic width is the entire gingival com­plex from the crest of the gingival margin to the crest of the alveolar bone; this definition includes the gingival sul­cus and is described as being 3.0 mm wide.
Regardless of the definition of choice, the biologic width can vary not only from tooth to tooth but also from surface to surface.29

Location of the subgingival margin
Some authors believe that the margin should not extend more than 0.5–0.7 mm into the crevice.29 Others approach the margin location from the bottom of the sulcus, rather than approaching it in terms of how deep it should be. These authors recommend placing the margin at least 0.40 mm from the epithelial attachment.29

Surprisingly, other authors have reported seeing crown margins adjacent to the bone with acceptable tissue appearance.30 Waerhaug examined autopsy studies and found when plaque was situated closer than 0.5 mm to the bone, resorption completely dominated.31 He reported no evidence of bone destruction when the apical border of the subgingival plaque front was more than 2.7 mm coronal to the bone; in addition, gingival inflammation rarely led to a loss of attachment when the plaque was more than 1.2 mm from the junctional epithelium.32 Waerhaug’s article was limited to evaluating the distance from plaque to the junctional epithelium as well as to the nearest point of the alveolar crest. The presence or absence of a crown was not a consideration. In the author’s experience, a margin placed 2.7 mm above the crestal bone or more than 1.2 mm from the junctional epithelium very likely would result in a supragingival margin.

The potential for a less-than-ideal finished margin to harbor bacteria, the physical proximity of the margin to the attachment (and resultant procedural trauma), and the emergence profile of the final restoration are three of the main considerations when placing a subgingival margin.

Determining the actual depth of the gingival pocket is a challenge, as one must determine if the probe is short of the epithelial attachment, is exactly at the level of the attachment, or has penetrated into the attachment.

In 1961, Gargulio et al reported that the average finding for the epithelial attachment was 0.97 mm while the connective tissue attachment was 1.07 mm, a total of 2.04 mm.33 That same article reported a mean sulcular depth of 0.69 mm in the anterior facial aspect of the maxilla. On average, the biologic width of anterior teeth from the crest of the bone to the crest of the free gingival margin was 2.73 mm. The key phrase is “on average.” It should be noted that the same article also reported sulcular depth of 0.00–5.36 mm, epithelial attachment of 0.08–3.72 mm, and connective tissue attachments that ranged from 0.00–6.25 mm.33 Evidently, there are no absolutes when dealing with the actual measurements of the biologic width.

Case report and analysis
A 23-year-old woman with excellent home care required full coverage for tooth No. 14 (maxillary left first molar). The sulcular depth was 1.0 mm on the facial while the distance from the crest of the gingiva to the alveolar bone was only 1.75 mm. Assuming the sulcus was probed accurately, the total tissue attachment width would be 0.75 mm. The margin was visible on smiling and was placed very slightly (<0.50 mm) into the sulcus. Tissue response to the provisional crown and the finished restoration placed three weeks later was excellent (Fig. 1 and 2). This shallow placement makes it possible to adequately reach the margin with a toothbrush (facially and lingually) while using floss to clean the interproximal areas.

As with many aspects of dentistry, sound clinical judgment and common sense enables clinicians to make decisions in situations that may be outside of the normal parameters cited in the literature.

Armamentarium
An erbium, chromium:YSGG (Er:Cr: YSGG) pulsed laser (Waterlase, Biolase, San Clemente, CA; 888.424.6527), operating at 20 Hz with a pulse energy range of 0–300 mJ and a pulse duration of 145 μsec, was utilized to accomplish the described technique. The operational wavelength was 2,780 nm, delivered through a zirconium/fluoride trunk fiber at up to 6.0 W of power in 0.25 W increments.

The operator determines the desired wattage; adjustable air and water settings make it possible to facilitate cutting hard and soft tissues. Because soft tissue and bone have a higher water content than tooth structure, a lower percentage of water is used to cut them; in addition, the power setting is lower than that used for enamel and dentin.

Laser energy provided at the 2,780 nm wavelength is absorbed by an applied water spray and is reported by the manufacturer to produce a hydrokinetic effect which will ablate hard oral tissue effectively.34 This unique effect, along with the vaporization of any water that is present in the tissue, enables the Waterlase to cut enamel, dentin, decayed tooth structure, bone, and soft tissue effectively. Interchangeable fiber tips are used to deliver the photonic energy to the target tissue. A 6.0 mm T-4/400 μ tapered sapphire tip (Biolase) was used for the troughing described in this article.

When additional length is needed, either a longer tip or a straight handpiece can be used. The 14 mm Z-6, 600 μ zirconium tip (Biolase) may be used. A wider trough will result due to the larger diameter of the tip. In addition, a higher power setting will be necessary, which could present a problem in the presence of very thin facial tissue. A straight handpiece utilizing the 6.0 mm T-4 tip also will be effective.

Fig. 1. A 23-year-old woman with a trough completed immediately prior to impression.

Fig. 2. The patient in Figure 1, with a crown bonded three weeks after preparation.
The T-4 is the preferred tip because it offers a more precise and conservative cut, making it more desirable when preparing the gingival crevice for an impression. This precision is especially valuable when the free gingiva is thin.

When adjacent anterior teeth are very close and a thin interdental papillae is present, the laser trough technique is an excellent method for minimizing the potential of tearing through the papillae during the retraction cord phase. The laser can provide access to a subgingival margin with minimal trauma to the adjacent sides of the papillae, in addition to excellent healing.

Method for troughing with an erbium laser

If a subgingival margin is desired, the margin should be placed at the gingival crest and the trough should be prepared. After the troughing procedure is accomplished, the margin may be extended into the sulcus (Fig. 3 and 4).

If a high-speed handpiece is used, a Zekrya gingival protector (Zenith/DMG, Englewood, NJ; 800.662.6383) may be used to protect the gingiva from the bur during this procedure; however, a protector is not necessary if the direction of spin of the bur is taken into consideration. The resultant centrifugal force will keep the gingiva blown away from the tooth. When the occlusal surface of the preparation is viewed as a clock face and the handpiece proceeds around the preparation in a counterclockwise direction, the centrifugal force produced by the rotating bur will keep the soft tissue slightly away from the bur. This effect can be seen when the rotating bur is placed just below the surface of a container of water and the handpiece is moved in a counterclockwise direction.

A small wave of water will move slightly in front of the advancing bur. The Er,Cr:YSGG laser also may be used instead of the bur to extend the shoulder of the preparation subgingivally, minimizing trauma to the tissue.

The epithelial lining (along with some of the underlying connective tissue) is removed from the tooth side of the sulcus to a depth just below the finish margin of the preparation. The height of the free gingiva is not altered. Regeneration of the sulcular lining occurs without a clinically observable reduction in gingival height and with minimal or no discomfort to the patient.

The minimal power setting required to accomplish the desired result is used. A T-4 sapphire tip is set initially at 0.50 W with 7% water and 11% air. The air/water spray is delivered from the hub of the tip. Short, brushing strokes with the tip touching the tissue will gently remove the lining of the sulcus. The tip is angled to avoid lasing the root surface. Minimal or no bleeding will result if the wattage is kept to a minimum and the air and water are limited to the above settings. The chance for bleeding increases when the wattage and/or percentages of air or water are increased.

A trench is prepared around the entire tooth to reveal the margin. If the laser is cutting too slowly, the power should be increased in increments of 0.25 W. Exceeding 0.75 W seldom is required, although patients with thick, dense gingiva will require a slightly higher wattage. For the occasional bleeding in the interproximal area of molars, a hemostatic agent of choice should be used after the troughing procedure has been completed.

Immediately after the margins are exposed, the preparation is finished, hemostasis (if necessary) is achieved, and the impression is taken (Fig. 5 and 6). Figures 7-9 show healing after the removal of provisional crown(s), prior to placement of the indirect restoration.

Summary

Troughing for impressions to complete indirect restorations can be accomplished easily with the Er,Cr:YSGG laser. This technique eliminates the necessity for packing cord and will minimize or eliminate any postoperative discomfort the patient may experience as a direct result of retraction cord placement. It also
avoids possible recession that would result from excessive placement pressure by using a cord that was too thick and leaving it in place for an extended period. In addition, the laser makes it simpler to provide an impression trough when teeth are extremely close while reducing the potential for tissue tears in these close areas.

Placing the margin above the epithelial attachment but at a depth shallow enough for the toothbrush bristles to access will result in a healthy, normal gingival appearance (Fig. 10-14).

Disclaimer
The author has no relationship with any manufacturer cited in this article, with the exception of Biolase, for whom he gives lectures on laser technique to owners of the Waterlase Er,Cr:YSGG laser.

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References

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