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Dent Clin N Am 51 (2007) 525–545

THE DENTAL CLINICS OF NORTH AMERICA

Laser Use for Esthetic Soft Tissue Modification

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In endeavoring to improve a patient's smile, various means of altering tooth morphology, position, and color have been used. These include orthodontics, bleaching, bonding, full porcelain jackets, and porcelain veneers. These techniques involve only tooth structure and do not address the equally important relationship of the soft tissues to the teeth or the relationship of the teeth and soft tissues to the patient's face. If disharmonies between these elements are not corrected, the resulting smile enhancement will not achieve the full desired effect.

Lasers for soft tissue and osseous recontouring

Of the means at our disposal for esthetic alteration of the soft tissues, the availability of lasers of different wavelengths provides us with the greatest range of options. Using lasers we can alter the mucosa and gingival tissues without causing bleeding, which provides better visualization, and recontour the osseous crest in a "flapless" procedure. Laser wounds exhibit histologic features that confer significant advantages over those created by scalpel or radiosurge. Most significantly, laser wounds have been found to contain significantly lower numbers of myofibroblasts, resulting in a minimal degree of wound contraction and scarring, and allowing for improved postoperative

Dr. Magid and Dr. Strauss receive compensation from Lumenis Inc. for lectures presented on the subject of laser dentistry.

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0011-8532/07/$ - see front matter © 2007 Published by Elsevier Inc.
doi:10.1016/j.cden.2006.12.005

contours were evaluated for gingival zenith, height, and papilla shape (Fig. 23). The patient was dismissed and examined in 2 weeks. At that time, healing was excellent, and the teeth were prepared for the porcelain veneers to the new free gingival margin. Two weeks later, the veneers were inserted with no evidence of untoward gingival recession (Fig. 24).

CO_2 correction of gingival hyperplasia

A 35-year-old man presented with hyperplastic gingival tissue secondary to cyclosporin therapy (Fig. 25A). The use of the CO_2 laser is ideal for this procedure due to its excellent hemostasis, lack of scarring, and the ability to ablate large areas by defocusing the laser. After local anesthesia, the new gingival margin was established by incising with the laser at 6 W CW in focused mode. Protection of the teeth in this technique is crucial and is achieved with a thin Freer elevator or a metal matrix band. When working in interproximal areas, an intermittent mode (50-millisecond pulses at two pulses per second) is recommended. After the excess coronal tissue was excised, the hypertrophic tissue overlying the alveolus was sculpted. This process was performed in defocused mode at 6 to 8 W using a defocused technique. This entails traversing the laser beam in a series of connecting and paralleling "U"s. This method ensures even lasing of the

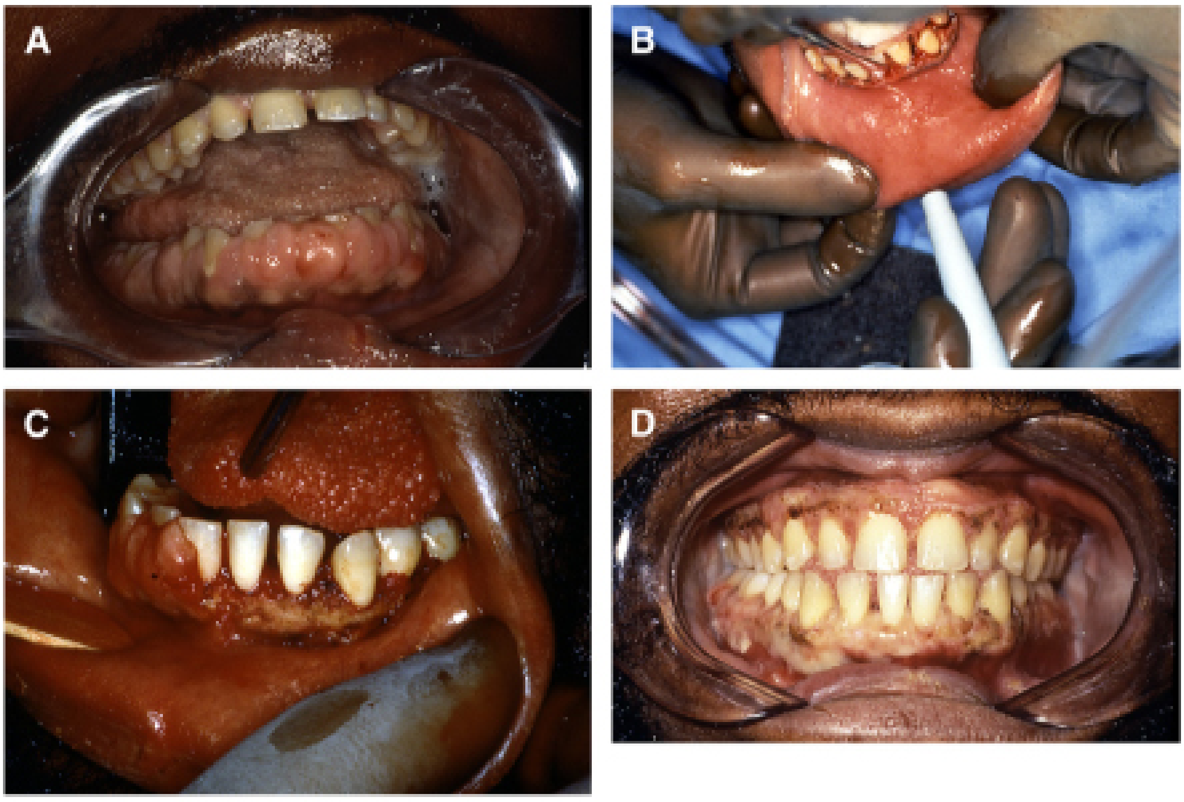

Fig. 25. (*A*) Preoperative view of a patient who has severe drug-induced gingival hyperplasia. (*B*) Using a periosteal elevator to protect the tooth from the laser beam. The red beam is from a coaxial red light aiming laser. The CO_2 laser beam is invisible. (*C*) Midway through the procedure, the hemostasis and clear surgical field are evident. (*D*) Two weeks postoperatively, the healing is excellent.

entire lesion, precluding the repetition of laser strikes at the top and bottom of the typical "V" pattern, which would double the time on tissue in those locations and increase the depth and lateral thermal damage. Once tissue has been ablated, the poor water content of the remaining carbonized surface substantially increases lateral thermal damage if lased again. Therefore, after an initial pass is performed, the surface carbonization should be gently wiped with moist gauze. If deeper ablation is desired, the next pass should be made perpendicular to the preceding one, ensuring even and complete coverage of the tissue. This ablation is continued until the desired contours are achieved [18]. After the surgery, the patient is released with no dressing or medications. The appearance of the tissues 2 weeks after the surgery is a testament to the advantages of the CO_2 laser for this procedure.

Laser punctation of perioral vascular lesions

A good cosmetic dentist realizes that esthetic results do not rest solely on the teeth or the gingival architecture. The cosmetic appearance of surrounding oral, perioral, and facial structures can have a distinct positive or negative effect on the esthetics of the anterior dentition, and the best efforts of the dentist can be enhanced or diminished by these structures.

Although alteration of facial and perioral structures is best left to a qualified oral and maxillofacial surgeon or another cosmetic facial surgeon, many cosmetic issues of the oral cavity can easily be ameliorated by the general dentist. Due to their many advantages, including the increased visibility afforded by hemostatic surgery, the use of lasers can be of great benefit in this situation. Many cosmetic issues that would be difficult to treat with other modalities are simple and safe to treat effectively with a laser.

A prime example of this is management of vascular lesions of the lips. Venous lakes, a generally harmless condition, are a common finding on physical examination of the oral cavity. Venous lakes are a collection of enlarged veins, most commonly seen in the lower lip. These nongrowing, blue, flat lesions, especially if large or multiple in nature, can be obvious and unaesthetic. An obvious vascular lesion the lip can overshadow even the most beautiful dental reconstructive effort of the anterior region.

In general, it is the goal of the laser surgeon to minimize collateral tissue damage. Lateral thermal conduction also causes vascular collagen contraction and hemostasis. Therefore, in this situation, it is desirable to maximize thermal conduction. This is accomplished by using the CO_2 laser with long pulse durations, usually in the range of 500 to 1000 milliseconds.

Fig. 26 demonstrates the use of a CO_2 laser to eradicate a typical venous lake in a 52-year-old woman. The lesions had been present for many years and had not changed in that time. When pressed upon by a clear glass slide, the lesions disappeared, confirming their vascular nature. The patient expressed dissatisfaction with the cosmetic appearance function [1]. For esthetic dentistry, this is particularly important in dynamic soft tissues, such as those of the labial mucosa and frenum.

Frequently, the cause of a diastema and abnormal tissue architecture is a maxillary or mandibular frenum attached too close to the free gingival margin. This fibrous attachment of the lip to the alveolar mucosa may pull on the interdental papilla during lip movement, resulting in forces that separate the teeth, change the shape of the interdental papilla, and, in extreme cases, cause a malformation of the lip. In our esthetic evaluation, these tissues must be included in the overall planning to insure that the final result is not compromised. Fig. 1 shows an example of an extremely wide frenum that was attached so low it altered the contour of the lip to an unnatural, everted appearance. The frenum was excised with a CO_2 laser (Opus Duo; Lumenis, Santa Clara, CA) set on 6 W in continuous wave and attached to a focusing handpiece. The labial mucous membrane was then recontoured to eliminate the bulge of hyperplastic tissue by defocusing the laser beam and removing the tissue layer by layer in a vaporization procedure. The abnormal angle of the papilla between the central incisors was narrowed, and the gingival zenith was corrected using an Nd:YAG laser (Pulsemaster 6; American Dental Technologies, Corpus Christi, TX) set at 150 mj and 20 Hz with an initiated tip (Fig. 2).

Lasers also result in a sterile cut due to the destruction of all bacteria by the laser energy, even at low energy levels [2]. In addition, postsurgical bacteremia is greatly reduced with laser use, as a result of sealing of blood vessels and lymphatics, compared with other methods of incision [3].

When accomplishing surgical alteration of oral tissues using lasers, a thorough understanding of the physics involved and the differences between laser wavelengths is essential if a predictable outcome is to be expected. With all lasers, it is important that the operator has a thorough knowledge of laser safety and that all requisite safety measures are used for the protection of the patient and treating personnel.

Fig. 1. Before photograph showing extremely wide and low frenum attachment resulting in the diastema between 8 and 9, everted labial mucosa, and the need for gingival recontouring.

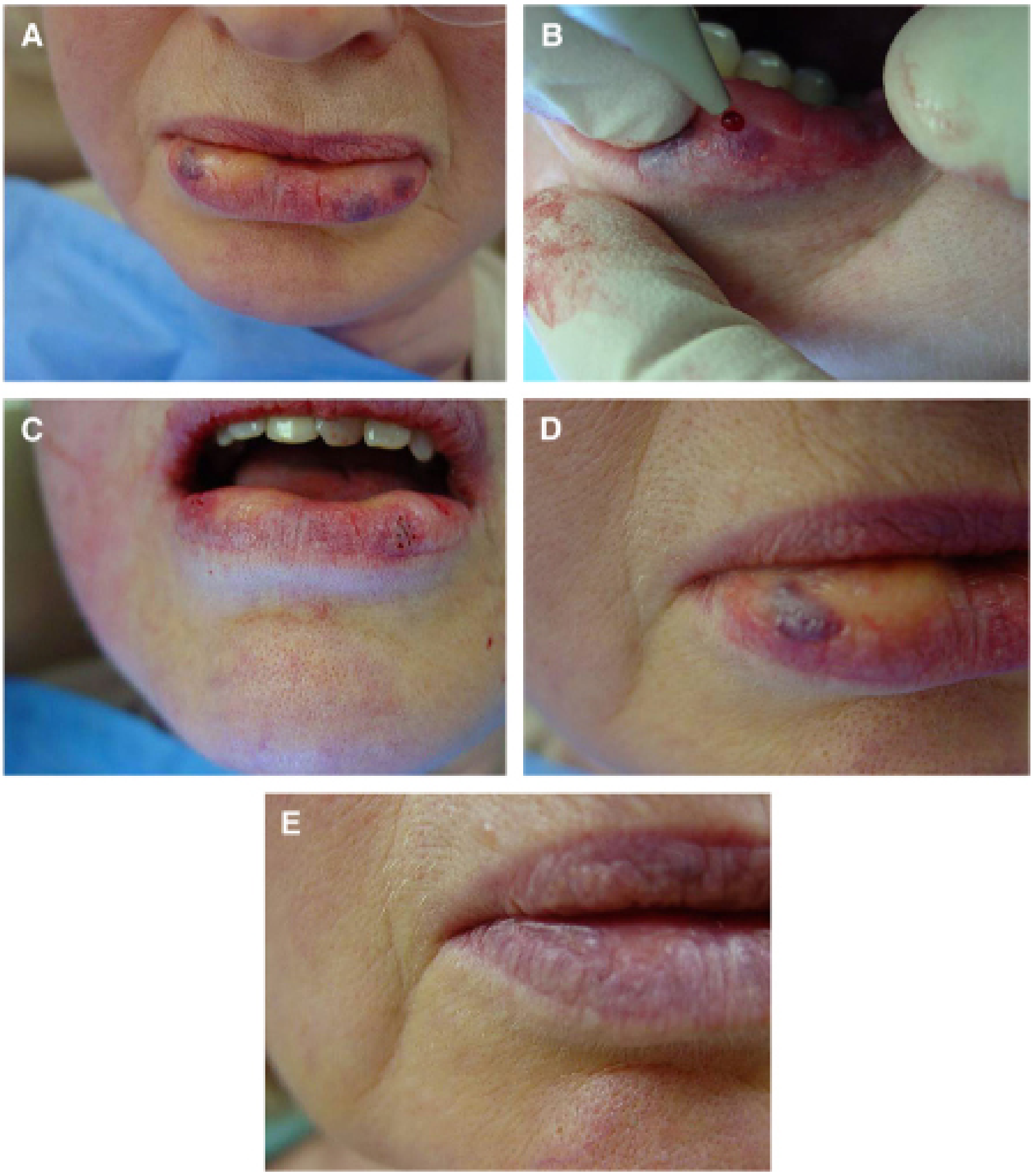

Fig. 26. (*A*) A 52-year-old woman who has bilateral vascular lakes of the lower lip. (*B*) CO_2 laser applied using 6 W, CW in 500-millisecond single pulses. (*C*) The lesion is eradicated with pulses placed across the lesion at 2-mm intervals. The initial bleeding is stopped after several pulses. (*D*) Preoperative close-up view of the right lesion. (*E*) Postoperative close-up view of the right lesion.

of the lesions and requested removal. After local anesthesia was administered, a CO_2 laser (Novapulse; Lumenis Inc., Santa Clara, CA) was used at 6 W CW on a setting to provide single 500-millisecond pulses. The laser pulses were distributed, one at a time, across the entire lesion at 2-mm intervals. It is not uncommon to see some bleeding associated with the initial pulses (due to the presence of any vessels with a diameter that exceeds the lateral thermal effects of the laser pulse), but this typically diminishes with each succeeding pulse. Immediate disappearance of the lesion should be seen, and any residual bleeding is easily controlled with local pressure. The patient is discharged with antibiotic ointment on the lip and with no special dietary or hygiene instructions.

Although this is a simple technique and the results are immediate and usually impressive, a proper diagnosis is critical. Lesions with a similar appearance, such as melanoma, hemangioma, or oral melanotic macule, should not be treated with this technique.

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Fig. 2. After treatment with laser soft-tissue recontouring and a combination of porcelain full-coverage and labial veneers.

Laser wavelengths

Although other laser wavelengths have been used in dentistry, the following lasers are commonly used today.

Diode and neodymium:YAG lasers

Although different in their wavelengths and output, diode and neodymium:YAG (Nd:YAG) lasers are used for esthetic dentistry in a similar fashion. Both lasers penetrate deeply into soft tissue when used in a noncontact mode. When the end of the quartz fiber used to deliver the laser energy is first "activated" or "initiated" by turning on the laser and running the tip on a dark medium, such as articulating paper, the laser tip becomes carbonized. The energy of the laser beam is then absorbed by the carbonized tip, vibrating the molecules in the tip. The vibrations are converted to heat energy. As the tip heats up, it emits first red, and then orange, visible light. This can be seen as the tip reaches 900°C to 1200°C [4,5]. This "hot tip" is the mechanism by which tissue is removed without causing bleeding or substantial collateral tissue damage. The diode and Nd:YAG lasers are used in a contact mode to reshape gingival tissue. Neither laser affects tooth enamel, so they can be used in direct contact with the teeth for optimum control. Because these lasers have been shown to cause little postoperative gingival recession, cosmetic gingivoplasty can be done at the same visit as veneer preparation and impression to the new free gingival margin.

Although the diode and Nd:YAG lasers are occasionally used for frenectomy, they are limited in this function. These laser wavelengths are capable of cutting the mucosal tissue of the frenum, but the fibers that make up the true attachment are too dense for "hot tip" vaporization, and, therefore, the operator typically uses the glass fiberoptic delivery tip to cut the fibers. This does not remove the reticular fibers that insert between the teeth to permit orthodontic closure and results in substantial reattachment of a low frenum.

Carbon dioxide lasers

Carbon dioxide (CO_2) lasers have several characteristics that make them ideal for intraoral soft tissue surgery, particularly where large amounts of tissue or larger areas must be modified, such as with frenectomy or removal of hyperplasic tissue. Of great significance in the decision to use the CO_2 laser is the high degree of absorption of this wavelength by oral mucosal tissues, which are 90% water. Absorption of the laser energy by intracellular water results in a photothermal effect that is manifested by cellular rupture and vaporization. During this process, heat is generated and conducted into surrounding tissues, creating a zone of lateral thermal damage that has been found to be 500 μm or less. This lateral thermal damage also results in contraction of blood vessel walls of up to 500 μm in diameter, which is responsible for the excellent hemostasis provided by this wavelength.

When a reduction in the amount of lateral thermal damage is important, such as in gingivoplasty, modifying the output of the laser may be desirable. Control of the extent of lateral thermal damage is based primarily on the speed of the laser application. One method of reducing this "time on tissue" is to "pulse" the laser, which is possible with flashlamp or optically pumped lasers, such as erbium:YAG (Er:YAG), Er,Cr:YSGG, and Nd:YAG lasers. The faster the pulse, the less time there is available for conduction into adjacent tissues. Continuous-wave CO_2 lasers cannot be optically pumped but can be superpulsed, which is a means of obtaining high power for short periods by briefly overpumping the laser tube [6]. With a decrease in the amount of lateral thermal damage comes a concomitant decrease in the hemostatic effect of the laser. The clinician must arrive at a balance based upon the size of the blood vessels in the area and the need for hemostasis compared with the need to reduce lateral thermal damage and postoperative tissue changes.

Although CO_2 laser energy is primarily absorbed by water, it is also well absorbed by hydroxyapatite, a major structural component of tooth enamel. A significant delivery of laser energy may result in temperature changes great enough to compromise the dental pulp [7]. Commonly, errant laser energy can result in etching or pitting of the enamel [8]. It is essential that the enamel be protected while using the CO_2 laser by placing a barrier between the laser energy and the tooth or by carefully aiming the laser beam.

Erbium:YAG and Er,Cr:YSGG

Er:YAG and Er,Cr:YSGG lasers are pulsed erbium lasers whose target or "chromophore" is the interstitial water in the tissues on which they are used. Although these lasers can be used for soft tissue modification, including gingivoplasty or frenectomy, cutting is much slower than with CO_2 lasers, and the amount of laser-induced collateral thermal energy is so low that little hemostasis is provided. Although they are normally used with air/water coolant spray, these lasers can be used with little or no water, which increases the hemostatic properties to some extent but far less than

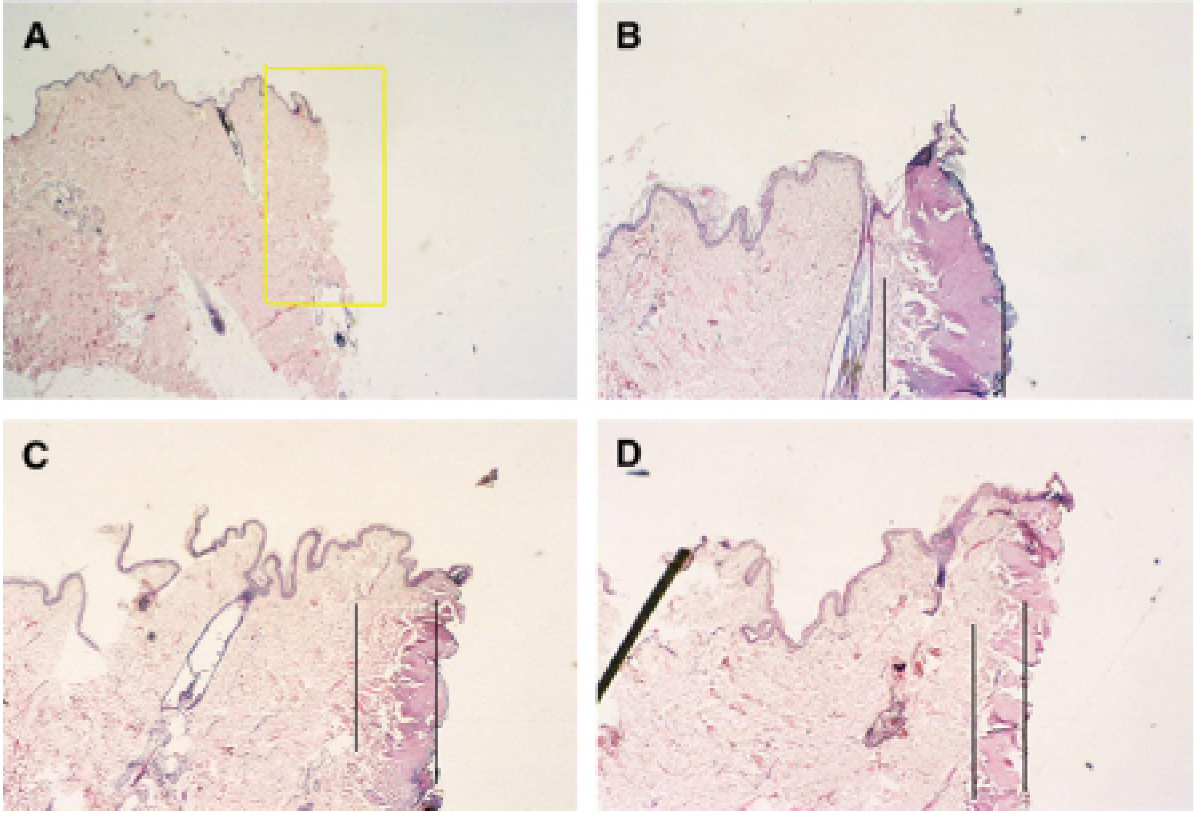

Fig. 7. (*A*) Scalpel incision on the right with no collateral tissue effect. (*B*) Radiosurgery incision using at 2.5 power intensity, fully filtered output, showing 0.5 mm of collateral tissue damage. (*C*) CO_2 incision at 8 W continuous wave with 0.3 mm of collateral tissue damage. (*Courtesy of* John Rice, PhD, Bristol, TN.) (*D*) CO_2 incision at 8 W continuous wave in superpulsed mode with 0.25 mm of collateral tissue damage.

a comparison of incisions made by scalpel, radiosurgery, and CO_2 laser, histologic evaluation shows that the scalpel incision had no collateral tissue damage, the radiosurge produced tissue damage of 0.5 mm, and the CO_2 laser had a zone of collateral thermal damage of 0.3 mm in continuous wave and 0.25 mm superpulsed wave (Fig. 7A–D). In a study that compared tissue recession after troughing (or sulcular development) before impression taking, the radiosurgery resulted in significant gingival recession in 14 out of 110 cases, whereas the Nd:YAG laser resulted in three cases of recession and the 940-nm diode laser resulted in two cases of recession [17]. If radiosurgery is used for tissue modification before veneers or other cosmetic alteration of the teeth, it is advisable to delay final preparation and impression until gingival recession has stabilized.

Case studies

Diode gingivoplasty

A patient presented with the desire to reduce her "gummy" smile, close a diastema between the central incisors, and reshape and whiten the teeth (Fig. 8). Examination showed gingival depths of greater than 3 mm, with the free gingival margin located incisal to the cemento-enamel junction,

Fig. 8. Delayed passive eruption resulting in short clinical crowns and a "gummy" smile.

resulting in a diagnosis of delayed passive eruption. A discussion of gingival versus osseous recontouring resulted in the patient choosing gingival recontouring followed by porcelain veneers. During the evaluation for the gingivoplasty, the patient's anterior teeth were analyzed for angulation, gingival zenith, and the shape of the interdental papillae, especially between teeth #8 and #9 (Fig. 9).

The patient was anesthetized with one carpule of 2% lidocaine with epinephrine. An 830-nm diode laser (Diolase; Biolase, Irvine, CA) set on 3 W in continuous wave (CW) was first initiated on blue articulating paper. The laser was then used in a contact mode to resculpt the gingival tissues, reducing the periodontal pocket to no less than 1 mm. During this phase of treatment, it is essential that the practitioner keep in mind the correction of tooth position and angulation to be accomplished with the veneers so the appropriate gingival zenith and contours are established. For example, in this case, because the diastema between the central incisors was to be closed without further widening of the crown by reducing the distal enamel and adding to the mesial, effectively "moving" the crown mesially, the gingival zenith had to be moved mesially to provide an esthetic result. The angulation of the left lateral incisor would be corrected in the veneers, which would require repositioning the gingival zenith of that tooth. The gingivoplasty

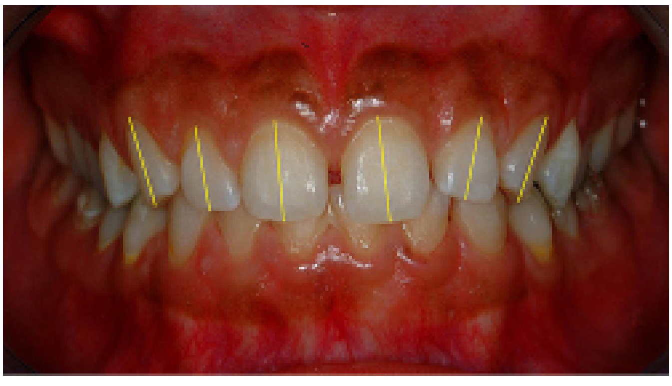

Fig. 9. Evaluation of the smile for angulation and position of the teeth indicating the necessary changes in the gingival zenith.

Fig. 10. After gingivoplasty using the diode laser.

was completed with no bleeding and no postoperative pain or need for medication (Fig. 10). The teeth were prepared for veneers to the new free gingival margin, impressions with vinyl polysiloxane material were taken, and the teeth were temporized. When the veneers were inserted 2 weeks later, the tissue was completely healed and the margins of the veneers were still at the free gingival margin, showing no obvious recession of the tissues after the surgery (Figs. 11 and 12).

Fig. 11. Close-up of finished case with veneers. Note healing and lack of recession beyond margins. (*Courtesy of* Saiesha Mistry, DDS, and Steven Chu, DDS, MDT, New York, NY.)

Fig. 12. Reduction of "gummy" smile, improvement of crown length/width ratio, and proper placement of gingival zenith.

Erbium:YAG osseous crown lengthening and diode gingivoplasty

A patient presented requesting an improvement in her smile. Of particular importance to this article was the discrepancy in the tissue height of the right cuspid (Fig. 13). Radiographic examination showed this to be a deciduous cuspid with a congenitally missing permanent tooth. The tooth had a substantial root structure, and the decision was made to retain the tooth rather than to perform extraction and replacement. After periodontal probing, it was decided that osseous crown lengthening would be necessary to avoid invading the biologic width. The various means of accomplishing these ends were discussed with the patient, and the decision was made to use laser osseous crown lengthening and laser gingivoplasty.

To obtain and show the excellent healing after flapless osseous surgery, it was decided to perform the crown lengthening in two distinct procedures. The first procedure was lowering the osseous crest with an Er:YAG laser (Opus 20; Lumenis, Santa Clara, CA). Because the free gingival margin was to be raised 1.5 to 2 mm, in the next procedure the osseous crest was raised to 5 mm beyond the present free gingival margin as measured by sounding the bone with a periodontal probe (Fig. 14). After 1 week of healing, which showed excellent tissue response (Fig. 15), the gingivoplasty was accomplished with an 830-nm diode laser (Diolase) set at 3 W in continuous mode with an initiated tip (Fig. 16). The veneers were prepared and temporized to the new free gingival margin. The final veneers were placed 2 weeks after surgery, with the tissue around the deciduous cuspid having healed completely and with no evidence of gingival recession. Comparing the gingival position in the initial photograph to the final position, it is easy to see the successful raising of the gingival margin to the new height (Fig. 17).

Fig. 13. Evaluation of gingival tissue showing poor height and contours of deciduous right cuspid.

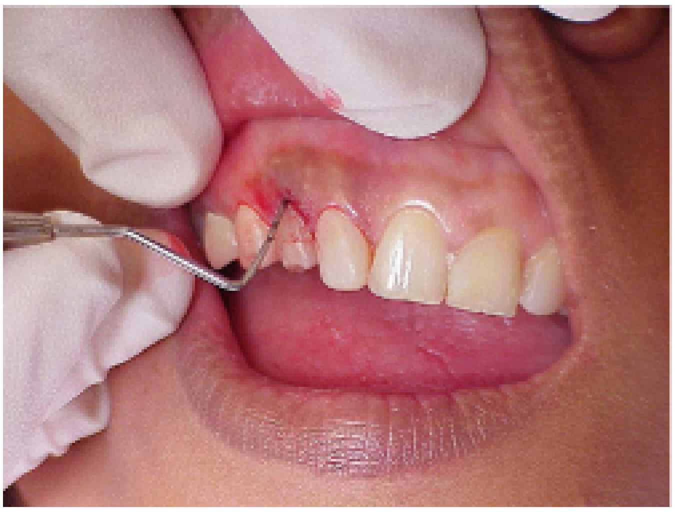

Fig. 14. Flapless osseous contouring was done, and the 5-mm height of bone required is confirmed by sounding with a periodontal probe.

Fig. 15. One week postosseous surgery with excellent healing.

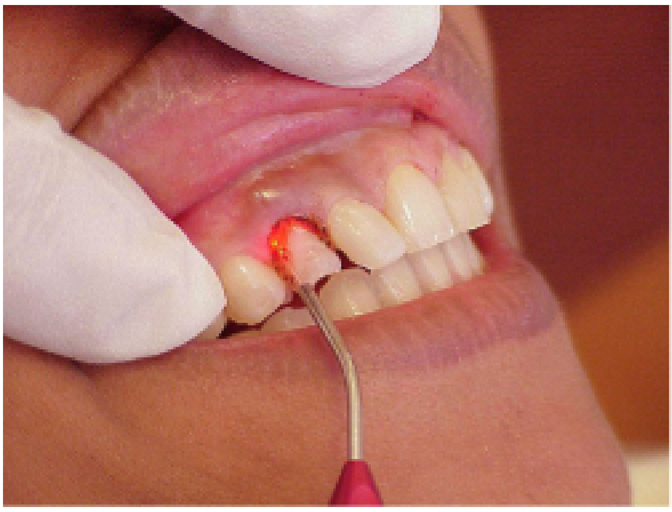

Fig. 16. Diode gingivoplasty to create desired contours.

Fig. 17. Proper tissue contours achieved and veneers placed.

CO_2 gingivoplasty and erbium:YAG osseous crown lengthening

Evaluation of this patient showed a large diastema between the central incisors, malpositioning of the teeth, a high lip line, and short crown length (Fig. 18). The various options for treatment were discussed with the patient, and laser gingivoplasty and osseous crown lengthening followed by porcelain veneers was the final treatment plan.

The patient was anesthetized with 2% lidocaine with epinephrine. A CO_2 laser (Opus 20) was used at 3 W with a nonfocusing handpiece to reshape the gingival tissues. Because the energy from the CO_2 laser scars enamel, it is essential in this technique that the laser be directed at the tissue axially along the long axis of the tooth and away from the enamel (Fig. 19). The gingival zenith on the central incisors and cuspids was raised and moved mesially, as indicated by the final wax up of the veneers (Fig. 20). The shape of the interdental papilla between the central incisors was narrowed commensurately with reducing the diastema to 1 mm at the patient's request. After the CO_2 gingivoplasty, a periodontal probe was used to sound the crest of bone and determine the necessity for osseous recontouring (Fig. 21). An Er:YAG laser (Opus 20) was then used in a flapless osseous crown-lengthening procedure as described previously to reestablish the biologic width wherever it had been invaded by the gingivoplasty (Fig. 22). The periodontal probe was used repeatedly during the procedure to insure that sufficient reduction of the osseous crest had been accomplished. After surgery, all tissue

Fig. 18. Malpositioned central and gingival height discrepancies and a large diastema with wide papilla combine to create a difficult esthetic challenge.

Fig. 19. CO_2 laser in a collimating handpiece aimed axially to avoid hitting the tooth as it recontours the gingival.

Fig. 20. Evaluation of the gingival height of #8 now higher than #7.

Fig. 21. Sounding the bone indicates the need for osseous recontouring.

Fig. 22. Erbium laser raises the osseous crest in a flapless procedure.

Fig. 23. All tissue contours are evaluated showing correction of gingival height and zenith and narrowing of the interdental papilla between the centrals.

Fig. 24. Veneers in place with proper gingival contours and healing without recession (*Courtesy of* Ashish Shetty, BDS, MDS, Bangalor, India.)

that achieved with the CO_2, Nd:YAG, or diode lasers. In addition, the erbium lasers are true pulsed lasers, varying from 7 to 50 pulses per second (pps). This pulsing results in a more ragged cut than continuous-wave or "hot tip" lasers, which is a significant detriment in esthetic gingivoplasty, although the higher pulse rates have ameliorated this problem to some extent.

A significant advantage of the erbium lasers is their ability to cut bone without carbonization or scarring. Fourier transformed infrared spectroscopy has shown that the chemical composition of the bone surface after Er:YAG laser ablation is much the same as that after bur drilling, suggesting that the use of Er:YAG laser ablation may be an acceptable alternative method for oral and periodontal osseous surgery [9].

Determination of gingival versus combined osseous and gingival treatment

With each patient for whom we consider treatment with lasers, we must first determine the extent of such treatment. If the cosmetic evaluation of the patient's smile indicates the need to move the incisal edges apically, the treatment often requires the gingival architecture to move apically to provide for an esthetic length-to-width relationship, depending upon other factors, such as the patient's "high lip line" and willingness to undergo the treatment. Even when the incisal edge is determined to be in an esthetic position, evaluation of the smile includes the length-to-width ratio of the incisors and the amount of gingival and mucosal tissue displayed by the patient during smiling. Often this "gummy" smile is the main concern of the patient and must be addressed as part of the esthetic evaluation and treatment. Factors such as a hypermobile lip that exposes an inordinate amount of mucosa must be considered in the evaluation and treatment of the "gummy" smile.

Once the decision has been made to raise the free gingival margin, it is necessary to determine if this requires osseous modification and, if so, by what means. It is accepted that the normal "biologic width" (the distance from the base of the periodontal pocket to the osseous crest, incorporating the connective tissue attachment and junctional epithelium) averages 2 mm. Violating the biologic width in patients whose gingiva is "thick tissue type" results in a continuous inflammatory process, and doing so in patients who have "thin tissue type" gingiva results in uncontrolled gingival recession [10]. If raising the free gingival margin to the required esthetic height results in invading the biologic width, then osseous modification is necessary. Because lasers are "end cutting" and "side safe," a laser may be used in a novel approach to osseous crown lengthening. This "flapless" osseous crown–lengthening procedure can be used to move the osseous crest apically and change the osseous morphology such that proper contours are achieved. The healing rate after Er:YAG bur drilling has been reported to be equivalent or faster than that after bur drilling [11], and the healing rate observed

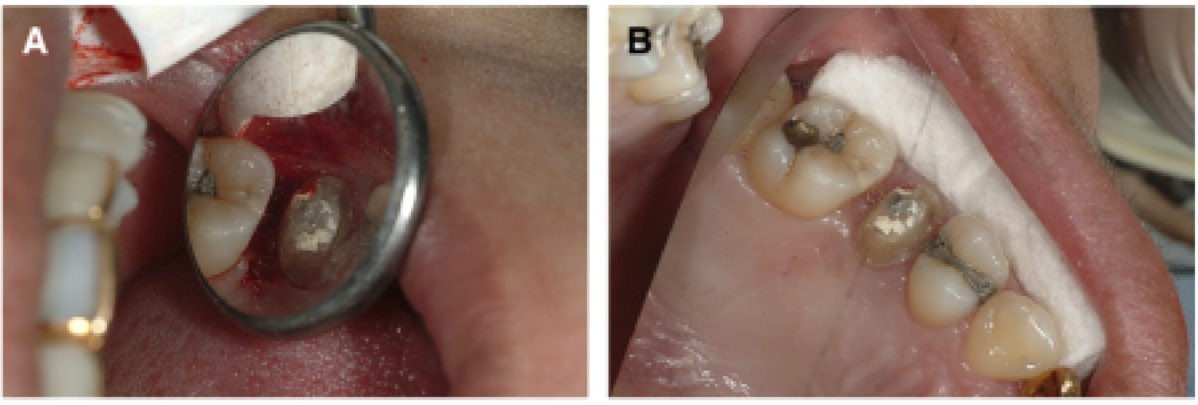

Fig. 3. (*A*) Flapless osseous crown lengthening. Osseous contours are reshaped interproximally and carried facially and lingually to achieve a periodontally stable architecture. (*B*) After 2 weeks, excellent healing and contours at the new gingival height are established.

after “flapless” crown lengthening is equally fast, usually with no evidence of the surgery after 2 weeks (Fig. 3A, B).

Procedure for flapless osseous crown lengthening

The following steps are used for flapless osseous crown lengthening:

1. Raise the gingival height and contours to the desired level using the laser wavelength of choice. The superpulsed CO_2 laser or the “hot tip” of the diode or Nd:YAG laser are excellent choices.
2. Raise the crest of bone approximately 3 mm beyond the new free gingival margin to reestablish the biologic width and normal pocket depth. Using the erbium laser, place the tip subgingivally along the long axis of the tooth until the remaining junctional epithelium and connective tissue attachment are encountered. Using approximately 200 mj and 20 pps, ablate the tissue until the crest of bone has been reached, insuring that there is sufficient water flow directed down the surgical pocket for adequate cooling of the tissues (Fig. 4). Although higher pulse rates can be provided by Erbium lasers, this increases the “time on tissue,” which promotes lateral thermal damage.
3. Reduce the pulse rate to 10 pps to decrease heat buildup, and ablate the crestal bone to reestablish the desired architecture of the osseous crest at the new level (Fig. 5). It is essential that the reshaping of the bone be carried out to the outer cortical layer to avoid creating a trough in the bone. Because the side of the laser tip is not a cutting element, the tip can be used to push the soft tissue away and create the smooth desired shape (Fig. 6). The procedure is done with minimal visualization, so frequent pauses to evaluate the depth and shape of the contouring are required. A curette may be used once the bone is recontoured to smooth any irregularities and to insure proper architecture for optimal results.

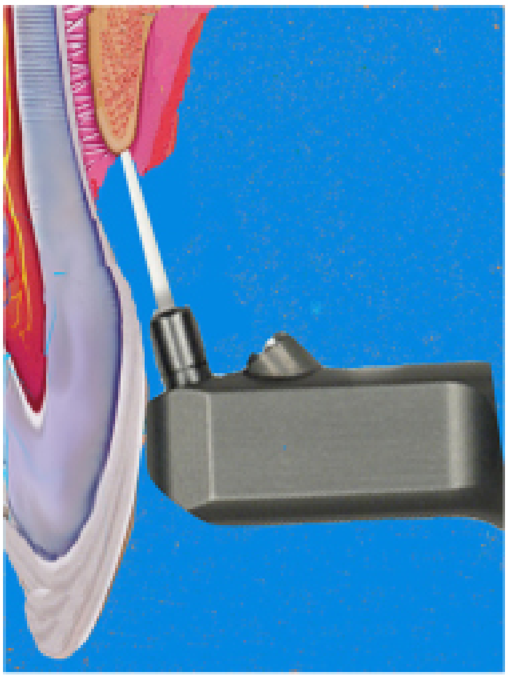

Fig. 4. Graphic showing a cross-section of the dental architecture after soft-tissue gingivoplasty and access to the crestal bone.

Although the tip is kept parallel to the long axis of the root, there is still the issue of the effect of laser energy inadvertently shining on the root surface. An experiment to determine the effect on root surfaces during calculus removal with Er:YAG laser found that root surfaces treated in vivo showed homogeneous and smooth surface morphology at settings of 120 to 160 mj [12]. When evaluated as an alternative to classic scaling and root planing,

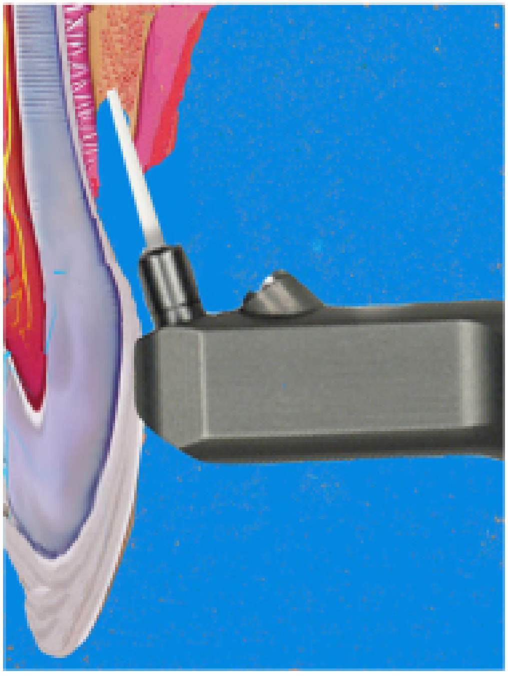

Fig. 5. The osseous crest is lowered by the erbium laser to a height necessary to reestablish biologic width at the new level.

Fig. 6. Using the "safe side" of the laser tip, the soft tissues can be moved while the "end cutting" erbium laser carries the osseous recontouring out to the cortical plate.

Er:YAG lasers at 120 to 160 mj did not remove the cementum layer as would be the case with hand instrumentation [13]. In addition, Schoop and colleagues [14] found that the root surface structure of laser-irradiated roots offers better conditions for the adherence of fibroblasts than a root surface after mechanical scaling only.

Control of the tooth–gingiva interface

The visual interface of the teeth and the surrounding gingival tissues is the final element in designing soft tissue esthetics. The ideal gingival outline of the anterior sextant should be bilaterally symmetrical, with the maximal height of the gingival contours of the cuspids and central incisors on the same horizontal plane [15]. The gingival contours of the lateral incisors and bicuspids should fall slightly below this level. It is essential in anterior esthetic modifications that any discrepancy in these heights be corrected.

In correcting the position of the gingival scallop, we must also control its shape. Under normal anatomic conditions, the gingival zenith (ie, the most apical point of the clinical crown of a tooth at the gingival level) is at the junction of the middle and the distal third of the facial aspect of a tooth. This point is influenced by tooth angulation and the position of the contact point [15,16]. For optimal esthetics, the gingival scallop should not be a smooth curve but rather should peak at the gingival zenith.

The position and shape of the interdental papilla must also be taken into consideration. This is particularly important in cases where diastemas are to be closed. The interdental papilla in these areas is usually wide and blunted.

If cosmetic alteration of the teeth is done without correcting this tissue, the result will be an unnatural appearance and proximal contours that are hard to clean and do not promote gingival health.

Other modalities for tissue modification

Although this article focuses on the use of lasers in esthetics, there are other means of achieving the esthetic modifications discussed. A brief overview of the other choices in armamentarium is instructive for comparison.

Scalpel gingival recontouring

Scalpel gingival recontouring method uses small scalpel blades or periodontal surgical instruments to create the contours necessary for a pleasing esthetic result. The difficulty with this method is the resultant bleeding that obscures the operative field and the inability to use this technique at the time of preparation or impression due to the inability to achieve hemostasis. In addition, the ability of the scalpel to thin and recontour the tissues is limited. The advantage of mechanical recontouring is the lack of tissue damage beyond the cut edge and, therefore, minimal gingival recession during healing.

Apically repositioned flap

Apically repositioned flap surgery requires much more extensive surgical intervention and healing time. Because this surgery is usually beyond the scope of the restorative dentist, close cooperation and communication is required between the surgeon and the restorative dentist to insure the final result. As in scalpel gingival recontouring, it cannot be used at the time of preparation or impression but results in minimal gingival recession during healing. For most cases where altering the gingival tissues only is required, apically repositioned flap surgery is not the treatment of choice. In cases of extreme "gummy" smile where substantial osseous reduction along with gingival repositioning is the treatment of choice, apically repositioned flap surgery is a viable alternative.

Radiosurgical gingival recontouring

If recontouring of only the gingival tissues and mucosa is the desired result, a radiosurgical device can be used. The advantage of these devices is the ability to remove and reshape tissues without causing bleeding, allowing a clear view of the operative field. The difficulty using a radiosurgical device in esthetic modification is the potential for significant gingival recession after treatment due to collateral tissue damage and contracture. In