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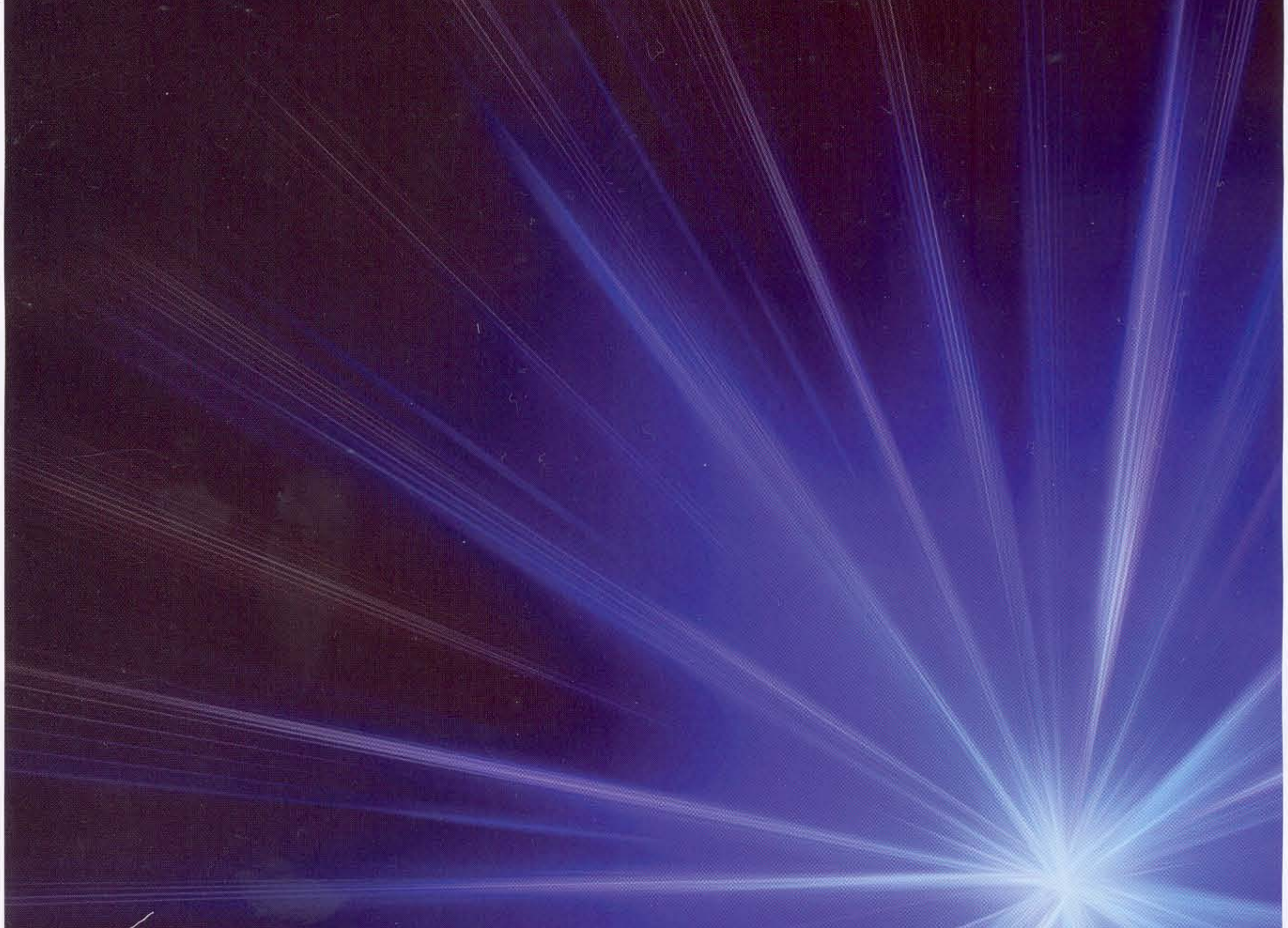

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Lasers and pediatric dental care

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There are several types of lasers that will allow pediatric dentists to remove soft tissue (such as diode or Neodynium:Yttrium-Aluminum-Garnet (Nd:YAG) lasers) or remove both hard and soft tissue (such as the Erbium:YAG laser), in addition to photobiostimulation or therapeutic lasers that produce their healing benefits without producing heat. Lasers allow pediatric dentists to provide optimal care without many of the fear factors that result from conventional dental techniques. Lasers are extremely safe and effective when the user has a proper understanding of laser physics. Using lasers for caries removal, bone removal, and soft tissue treatment can reduce postoperative discomfort and infection and make it possible for dentists to provide safe, simple treatments.

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Lasers represent a quantum leap forward in the treatment of dental patients, especially pediatric dental patients. In 1997, the FDA approved the Erbium: Yttrium-Aluminum-Garnet (Er:YAG) laser for both hard and soft tissue procedures. That same year, the FDA cleared the first laser system for treating tooth decay. Based on the author's 35 years of treating children, the development and success of the Er:YAG laser has made the treatment of children safer and quicker.

This article will review a wide range of hard and soft tissue dental procedures that may be completed by using lasers as an alternative when treating children. Many of these procedures may be treatments that dentists historically refer to specialists; however, dentists who understand lasers and use them efficiently may be able to complete many of these procedures.

Three types of lasers are particularly useful in the area of pediatric dentistry: photobiostimulating lasers (also referred to as *cold lasers*, *low level lasers*, or *photomodulating lasers*), diode and Neodynium:Yttrium-Aluminum-Garnet (Nd:YAG) lasers (primarily soft tissue lasers), and Erbium lasers (used on both hard and soft tissue).[1-4] As a pediatric dentist, the author uses a Nd:YAG laser (at 1,064 nm), a diode laser (at 810 nm and 980 nm), an Er:YAG laser (at 2,940 nm), and a series of photobiostimulating lasers. Other lasers are available for treating patients; however, their use in a pediatric practice is limited. Argon lasers are used for curing composites and a variety of soft tissue procedures.[5] CO_2 lasers are used for large soft tissue surgical procedures that require coagulation, vaporization, and a more precise incision.[6]

When treating children, it is important to make the dental experience as comfortable as possible without compromising care. This goal can become more challenging as dentists proceed from educating parents and patients about their oral health and care toward prevention, repair, or the correction of dental disease or abnormalities. Traditional dental procedures require needles, numbing, and suturing; in addition, high-speed drills (when utilized) produce noise and vibrations. Traumatic injuries to the head and neck area may result in devitalization/tooth loss, bleeding, and discomfort. Acute illnesses such as primary herpes and recurrent herpes labialis are painful. Gagging may interrupt treatment or prevent the dentist from obtaining diagnostic radiographs.

Photobiostimulating lasers

Photobiostimulating lasers use energy levels below 500 W and do not cause temperature elevation in the target tissue (photothermal effects) but rather have a photobiostimulation or modulation effect on the target tissue. These forms of lasers often are known as *healing lasers* or *low level lasers* and produce a photobiological or photochemical effect on the target tissue.[1] Low level lasers produce 50–500 mW of energy, stimulating and/or suppressing biological processes.

This form of light energy is produced by semiconductor diode lasers consisting of 630–700 nm of Indium-Gallium-Aluminum-Phosphide (InGaAlP). Gallium-Aluminum-Arsenide (GaAlAs) lasers have an invisible therapeutic light range of 800–830 nm and can penetrate to depths of approximately 2–3 cm. The light produced by GaAlAs lasers can penetrate various tissue depths, depending on the specific light wavelength used. Outside of dentistry, the FDA has approved these lasers for carpal tunnel syndrome treatments; however, all

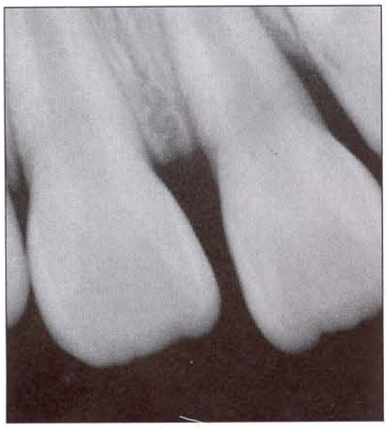

Fig. 1. A radiograph of a partially avulsed central incisor.

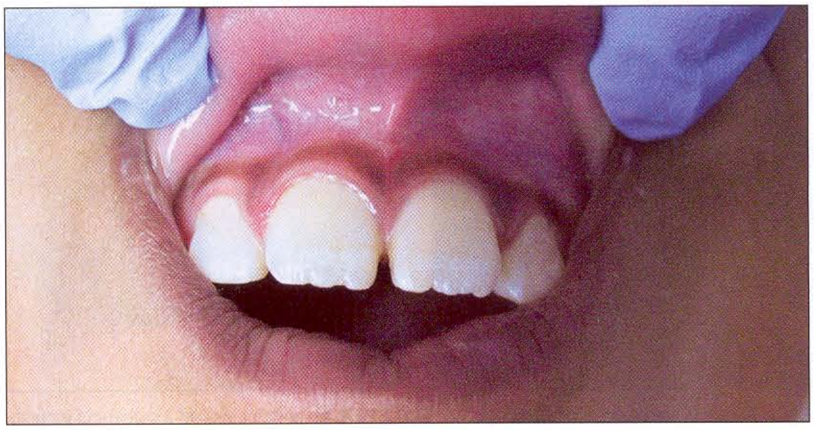

Fig. 2. The patient in Figure 1, 36 months after laser treatment of the partially avulsed central incisor.

dental applications are considered off-label usage.[7] These lasers are contraindicated for patients who are pregnant or have malignancies and should not be used near the eye or, in some cases, over the thyroid gland. Most of the effects from this type of laser therapy are listed as primary, secondary, or tertiary and in many cases are postulated to be systemic. As a result, few articles acceptable to the scientific community have been published in the U.S.[8] By comparison, more than 2,500 articles have been published outside the U.S.[9]

Photobiostimulation uses in the practice of dentistry

Preparing teeth for a restoration without the need for local anesthesia

Teeth exposed to laser therapy demonstrate lower levels of pain compared to those treated with placebo.[10] A photobiostimulating effect can be accomplished by using specific lasers that are limited to low level energy, such as the Q1000 (2035, Inc., Rapid City, SD; 605.342.5669) or the Aculaser (Laserex, Export Park, Australia; 61.8.8234.3199), or by using an Er:YAG laser in a defocused mode.

The technique of achieving the analgesic effect involves placing the tip of the laser in a defocused mode (non-contact 1–3 mm from the tooth surface) and moving the laser tip over the crown of the tooth (preventing any heating or ablation of the tooth) for approximately one to two minutes. At this point, it often is possible to complete the tooth preparation using an erbium hard tissue laser. In many instances, primary or permanent teeth can be prepared by using a high-speed handpiece to complete an alloy preparation without causing any discomfort for the patient. The patient is able to leave the office without the need for a local anesthetic, regardless of whether a composite or an alloy is placed, eliminating the potential for a traumatic lip injury due to the child biting his or her lip.

Treatment of traumatized anterior primary teeth

Trauma to maxillary or mandibular anterior primary teeth often results in pulpal death and the resulting darkening of the tooth crown.[11,12] Among children, pulpal death and crown discoloration usually will occur within two to six weeks after sustaining an injury to the maxillary incisors. Infants and toddlers ranging from 7 months to 5 years of age have benefited from using a 660 nm laser on anterior primary teeth for one minute. Cases in which the front teeth were slightly mobile, partially avulsed or displaced, and seen within 24 hours of the injury were both clinically and radiographically normal (in color and vitality) and asymptomatic, as demonstrated through clinical evaluations as long as 36 months after the trauma.[13,14]

Treatment of traumatized permanent anterior teeth

A 10-year-old girl with tooth No. 9 partially avulsed sought treatment. The tooth extended out of the alveolus by approximately 5 mm (Fig. 1). The tooth was repositioned gently into the correct position, splinted, and treated with a 660 nm probe for one minute. This procedure was repeated at three days and seven days post-trauma. At the end of 23 months, the tooth remained vital and asymptomatic (Fig. 2).

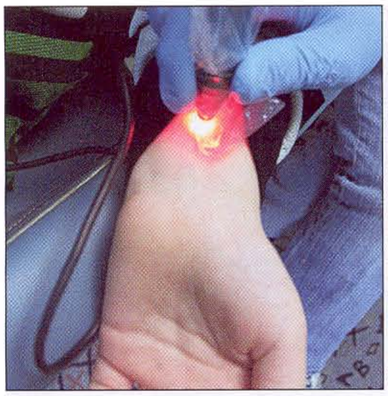

Fig. 3. A laser is placed on an acupuncture point to control gagging.

Fig. 4. An anterior view of a 4-year-old patient, immediately after the placement of sutures to the traumatized area.

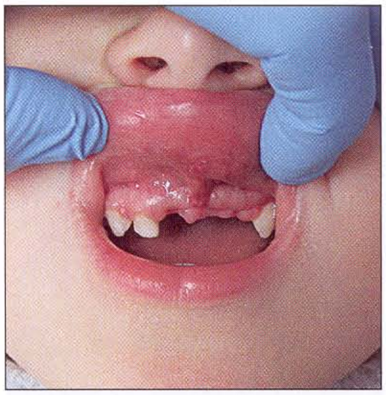

Fig. 5. The patient in Figure 4, six days after laser treatment.

Treatment of cellulitis and muscle trismus

Patients with infected posterior teeth may limit a dentist's ability to clinically examine the oral cavity and open the infected tooth for drainage and pain relief. Placing a photobiostimulating laser over the affected site for three minutes may provide enough relief of muscle trismus to allow for adequate opening and allowing drainage of the infected tooth.

Reducing the gag reflex

For many children, directing laser energy at the 660 nm wavelength (at approximately 4 J) to the P6 acupuncture point can alleviate the gag reflex.[15-18]

The P6 point is located on the undersurface of the wrist, approximately 1 in. from the wrist crease (the width of the distal thumb phalanx) (Fig. 3). Patients whose gag reflexes had been strong enough to prevent intraoral radiographs or, in some cases, complete evaluation of molars were treated successfully when the 660 nm diode was placed on the P6 acupuncture point for one minute.

Healing of facial injuries

Low level Er:YAG laser treatment appears to stimulate the proliferation of fibroblasts within the gingival tissue. When completing surgical procedures, pretreatment of the surgical site was effective in reducing postsurgical pain and inflammation.[1] The photon emission with visible red or invisible infrared light is absorbed by photoreceptors in the surgical site tissue.[1] Changes created by the laser in the cell membrane alter its permeability and increase adenosine triphosphate (ATP) synthesis (in addition to many other metabolic activities), which assists in creating a significant range of physiological changes.[1] Photobiostimulating lasers result in enhanced healing when measured by wound contraction, due to the photobiostimulating action of (photon) light on both of the cell membrane components within the nucleus of the cell.

Photobiostimulation stimulates healing in soft tissues, reduces inflammation, provides nonpharmacologic pain relief, improves the tensile strength of the wound, increases the speed of healing, and stimulates the immune system to resolve infection. Rochkind *et al* also found that irradiating one area affected other wounds on the body, suggesting the systemic effects of low level laser therapy.[19] This systemic effect may explain why trying to create a study using the left and right side of a patient will fail to show a difference between a placebo's effect and the laser's effect.

Facial injury treated using photobiostimulating laser

A 4-year-old girl fell against a hardwood table while running in her home, which led to the avulsion of three anterior teeth and pushed the gingival tissue upward, exposing buccal bone. The area was cleaned of all tooth fragments and bone and the soft tissue was repositioned using restorable sutures (Fig. 4). The area was lasered using the Q1000 (for three minutes extraorally) and the 660 nm probe (for two minutes). The procedure was repeated at three days and at six days. The six-day results displayed excellent healing and no discomfort (Fig. 5).

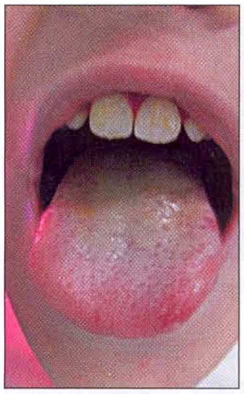

Fig. 6. A 10-year-old patient with primary herpes.

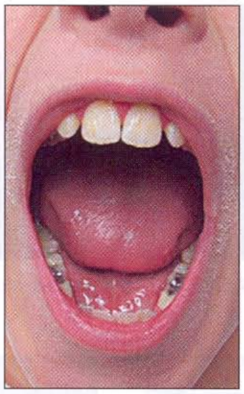

Fig. 7. The patient in Figure 6, four days after laser treatment.

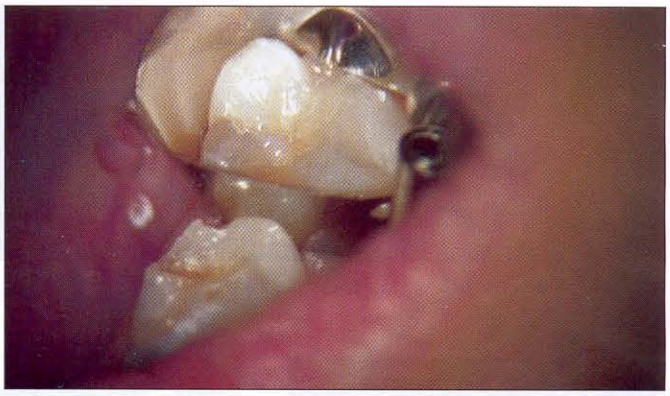

Fig. 8. A metal matrix band is placed on an adjacent tooth prior to laser treatment.

Treatment of intraoral primary herpes

The author treated a 10-year-old boy who had intraoral pain and discomfort and difficulty eating and sleeping. Clinically, the patient had multiple herpetic-like intraoral lesions. The lesions were consistent with the diagnosis of primary herpes stomatitis. The Q1000 laser globe was placed extraorally for three minutes (Fig. 6). At a follow-up visit four days later, the patient reported no discomfort; at that time, a clinical examination of the patient indicated that most of the lesions had resolved (Fig. 7).

Hard tissue lasers (erbium family of lasers)

The Er:YAG laser produces a wavelength of 2,940 nm and its primary tissue target is water and hydroxyapatite. It is very safe, is relatively quiet, eliminates the smells and vibrations associated with the dental handpiece, and, most importantly, significantly reduces the need for local anesthesia. Examples include the VersaWave (HOYA ConBio, Fremont, CA; 800.532.1064) and the PowerLase AT (Lares Dental, Chico, CA; 888.333.8440).

Hard tissue procedures

The erbium laser can be used for restoring primary and permanent teeth while using a minimum amount of local anesthesia. In most cases, the patient will not require numbing for Class I–VI restorative procedures that involve bonded restorative materials. Using the concept of minimally invasive restorative procedures, the erbium family of lasers allows the operator to remove only diseased tissue, thus preserving much more of the healthy, unaffected tissue. For cases in which alloy is preferred (for example, large lesions where composites may not bond well), the laser's analgesic effect also may allow the dentist to create a restorative preparation using a conventional handpiece that is not meant for bonding.

The erbium laser heats water within the target tissue, causing it to create small microscopic explosions (that is, photothermal and photoacoustical effects). When applied to soft tissue, bone or teeth, and cavities, the explosions cause those areas to be vaporized. For both hard and soft tissues, erbium lasers that can provide variable pulse durations, multiple pulse repetition (or Hz), and variable mJ rates increase the dentist's ability to cut enamel quickly, create an analgesic effect when cutting tooth structure, and allow the dentist to control bleeding in a manner similar to those of diode and Nd:YAG lasers.

When preparing a Class II cavity form, it may be advantageous to place a metal matrix band on the adjacent tooth (Fig. 8) to prevent etching its enamel accidentally. While it is possible to use minimally invasive techniques (for which erbium lasers are ideal) to reduce a tooth to allow for the placement of a crown, the amount of tissue that needs to be removed and the time required make this approach impractical. The analgesic effect of the erbium laser means that the patient does not need to receive a local anesthetic when preparing most Class III, Class I, and Class V cavities (Fig. 9 and 10).

Erbium lasers may be used for a wide array of soft tissue procedures that can be performed on pediatric

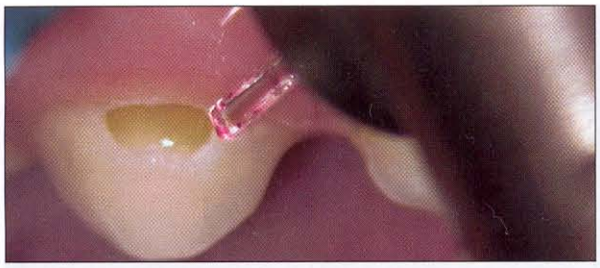

Fig. 9. Class V caries is removed using the Er:YAG laser.

Fig. 10. A Class V lesion is restored using the Er:YAG laser.

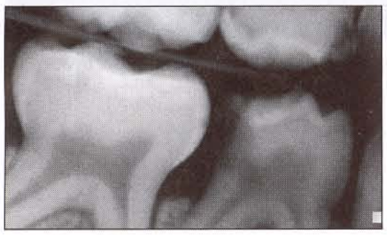

Fig. 11. A radiograph of caries on the mandibular right first primary molar.

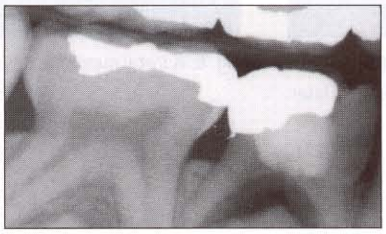

Fig. 12. A radiograph of the patient in Figure 11, four years after laser pulpotomy.

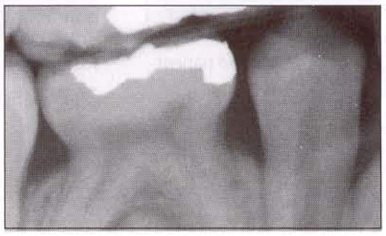

Fig. 13. A radiograph of the patient in Figure 11. Note the exfoliated tooth and the eruption of the first premolar.

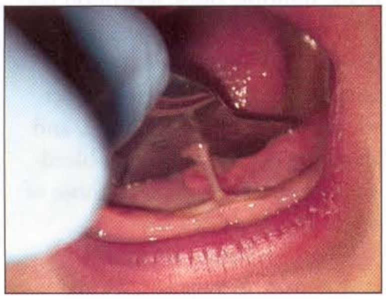

Fig. 14. An infant with severe ankyloglossia.

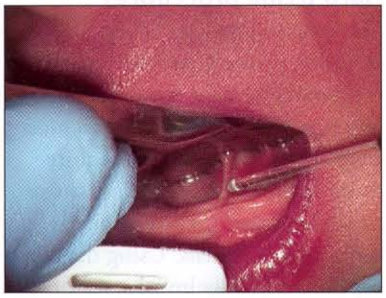

Fig. 15. The Er:YAG laser is used for revision of lingual frenum without local anesthesia.

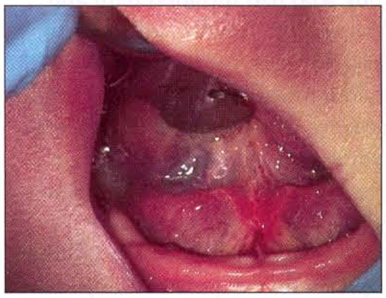

Fig. 16. An immediate postoperative view of the patient in Fig. 14.

patients, including maxillary and mandibular frenum revisions; lingual frenum revisions; the treatment of pericoronal pain or infection, aphthous ulcers, and herpes labialis; biopsies; the removal of impacted teeth; and the removal of hyperplasic tissue from orthodontic patients (due to drug use or poor oral care).

Pulpotomies

Parents often express concern about the need to take radiographs, due to the nature of x-rays and their possible side effects on their child's overall health. They question the use of alloys, due to the chemical makeup of the alloy. Whether these should be a real concern in today's dental care is open to debate; however, there also is concern about the effect of various procedural medicaments (such as formocreosol) used in pulpotomy procedures. Lasers provide a safe, non-chemical, effective alternative treatment for pulpotomies.[13,14,20-28]

A 2004 study reviewed more than 5,000 pulpotomies performed with the erbium laser (2,940 nm) and five-year post-treatment results provided ample evidence that this method is both effective and safe for children without the need for chemicals or electrosurgery methods (Fig. 11–13).[28] Settings in the range of 1.6 W for 15–30 seconds intracoronally using the Er:YAG

Fig. 17. An infant with severe maxillary frenum attachment.

Fig. 18. An immediate postoperative view of the patient in Figure 17.

Fig. 19. The patient in Figure 17, six days after laser treatment.

Fig. 20. Maxillary frenum revision in the permanent dentition using the Er:YAG laser.

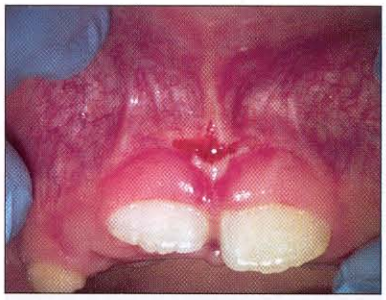

Fig. 21. A maxillary frenum six days after laser treatment.

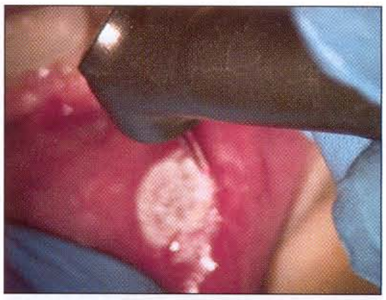

Fig. 22. An Er:YAG laser is used in defocused mode to treat an aphthous ulcer.

Fig. 23. An orthodontic patient with gingival hyperplasia.

Fig. 24. Immediately after Er:YAG laser reshaping of the patient's gingival tissue.

laser appear to provide maximum treatment. The case presented in Figures 14–16 depicts normal exfoliation of tooth No. S.

Lingual frenum revisions, maxillary frenum revisions, and treatment of aphthous ulcers

Using the Er:YAG laser, all soft tissue surgical settings are in the range of 30–40 Hz and 35–55 mJ (when using the VersaWave) or 10–20 Hz and 75 mJ (when using the PowerLase AT without water). Examples of soft tissue surgical procedures commonly completed by the author include maxillary frenectomy (Fig. 17–21), lingual frenectomy (Fig. 11–13), and treatment for aphthous ulcers (Fig. 22).

Post-orthodontic crown lengthening and gingival tissue reshaping

When orthodontic positioning of the anterior teeth results in gingival hypertrophy (Fig. 23), a laser can be used to increase crown length and give the patient a more esthetic smile. As with other procedures, this may be accomplished without the need for local anesthesia (Fig. 24).

Erbium lasers can be used to reduce and reshape the tissue of patients with medically induced hyperplasic tissue (for example, those who require dilantoin). When using a diode laser, it is especially important to understand the physics of how a soft tissue laser works, because the target of the diode is pigment, and, when tissue is fibrotic, it may not ablate as well with a diode laser as it does with an erbium laser.

Fig. 25. An 8-year-old boy with an open fissure on his lower lip.

Fig. 26. The patient in Figure 25, immediately after treatment with an Er:YAG laser.

Fig. 27. The patient in Figure 25, after laser treatment.

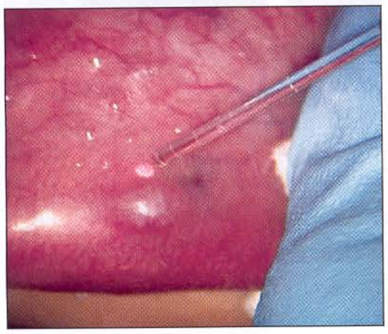

Fig. 28. A mucocele of the lower lip is removed using an Er:YAG laser.

Fig. 29. The patient in Figure 28, immediately after removal of the lesion.

Fig. 30. The patient in Figure 28, after healing of the site.

Surgical removal of impacted teeth

During the surgical removal of mesiodens, the erbium laser tip can be used as a scalpel to cut palatal soft tissue and gain access to unerupted teeth. High laser energy can be used to incise tissue, since the tissue has received a local anesthetic. At higher energy levels (such as 20 Hz and ≥100 mJ), the erbium laser can be used as a scalpel to make a quick incision and remove bone that covers an impacted tooth. The real advantage of using the laser is the reduction in both healing time and postsurgical discomfort. Laser energy used with very long pulse durations and low energy levels (20 Hz, 65 mJ, 600 µsec) can produce hemostasis as successfully as dedicated soft tissue lasers.[29,30]

Tissue welding

An 8-year-old boy had dry, cracked lips and an area on the lower lip that continued to open and did not heal. The tissue areas on the lower lip where the lesion would not mend were blended and "welded" together by using the Er:YAG laser in a defocused mode (Fig. 25) and keeping the tissue temperature at approximately 70°C. This blending led to improved healing (Fig. 26 and 27). Based on the author's experience, diode lasers will work equally well for this purpose.

Lesion removal and biopsy

When using a laser for a biopsy, always provide this information to the pathologist so that he or she can make an accurate diagnosis of the tissue specimen (Fig. 28–30).[31]

Diode lasers

Although the erbium laser can be used to accomplish most soft tissue procedures with little or no bleeding, there are instances in which a diode laser is more suitable. The hemostatic nature of the diode laser—coupled with its ability to seal blood vessels—can benefit patients taking Coumadin (Bristol-Myers Squibb, New York, NY; 212.546.4000), as well as those with bleeding disorders. In the author's experience, all diode wavelengths available commercially at present (980 nm, 940 nm, 810 nm)

Fig. 31. A patient in the initial stages of herpes labialis.

Fig. 32. A herpes labialis lesion 48 hours after treatment with an 810 nm diode laser.

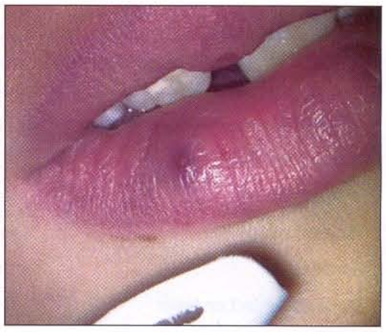

Fig. 33. A patient with a venous lake lesion.

Fig. 34. The patient in Figure 33, three months after the lesion was treated with the 810 nm diode laser.

Fig. 35. The 810 nm diode laser is used to perform maxillary frenum revision on a 7-year-old child with Von Willebrand's disease.

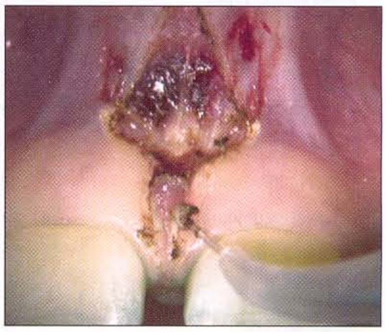

Fig. 36. The patient in Figure 35, immediately after laser treatment.

Fig. 37. The patient in Figure 35, one week after laser treatment.

will achieve similar results when used at levels of 1–2 W.

Herpes labialis

Herpes labialis responds well to both erbium and diode lasers; however, the diode laser appears to be a better choice for treating herpes labialis lesions, due to the depth of penetration it offers. If the lesion is treated at the first prodromal tingling signs of a herpes labialis reoccurence, it often can be aborted (Fig. 31 and 32). Based on the experience of the author in using lasers to treat this condition, it also appears that the next time an episode occurs, it does so in another area. In some instances, the lesions have not recurred.

Venous lake lesions

A venous lake or pool lesion manifests as a bluish, soft, discrete, painless nodule beneath the epithelium of the lower lip (Fig. 33), usually as a result of injury.[32-36] Although it usually is seen after age 40, one patient demonstrated it at age 8. Initial treatment consisted of using the diode laser in a non-contact mode at low power (<1 W) for a few minutes, then using the laser in contact mode to open the tissue and remove the remaining dried blood. The lesion was removed without local anesthetic and the patient remained lesion-free at three months (Fig. 34) and at one year.

Maxillary frenectomy

Patients who have bleeding disorders and require hemostasis for soft tissue surgery can benefit from treatment with a diode or Nd:YAG laser. The diode laser targets the pigmented vessels and shuts down the potential

Table. Review of lasers and their uses in pediatric dental procedures.

Characteristic/procedure	Er:YAG	810 nm diode	980 nm diode	Nd:YAG	Photobiostimulating
Investment cost	>$50,000	>$10,000	≥$7,000	≥$20,000	≥$3,500
Caries removal	Yes	n/a	n/a	Limited	n/a
Bone ablation	Yes	n/a	n/a	n/a	n/a
Hemostasis	Controlled	Yes	Yes	Yes	Limited
Analgesic effect on teeth	Yes	Limited	Limited	n/a	Yes
Healing compared to scalpel	Faster	Similar	Similar	Similar	Somewhat faster
Bactericidal	Yes	Yes	Yes	Yes	n/a
Limited postoperative pain	Yes	Yes	Yes	Yes	Yes
Reduced gag reflex	n/a	n/a	n/a	n/a	Yes
Aphthous ulcer	Yes	Yes	Yes	Yes	Yes
Pulpotomy	Yes	Unknown	Unknown	Yes	n/a
Maxillary frenum revision	Yes	Yes	Yes	Yes	n/a
Mandibular frenum revision	Yes	Yes	Yes	Yes	n/a
Lingual frenum revision	Yes	Yes	Yes	Yes	n/a
Gingival recontouring	Yes	Yes	Yes	Yes	n/a
Gingivectomy	Yes	Yes	Yes	Yes	n/a
Biopsy	Yes	Yes	Yes	Yes	n/a
Tissue welding	Yes	Yes	Yes	Yes	n/a
Primary herpes treatment	Yes	Yes	Yes	Yes	Yes
Herpes labialis treatment	Yes	Yes	Yes	Yes	Yes
Periodontal therapy	Selective uses	Yes	Yes	Yes	n/a
Impression taking	Limited use	Yes	Yes	Yes	n/a
Apicoectomy	Yes	n/a	n/a	n/a	n/a
Venous lake lesion removal	Limited use	Yes	Yes	Yes	n/a

for bleeding. For this reason, patients with hemophilia or Von Willebrand's disease may be treated without medical intervention. This saves the patient from bleeding complications as well as the cost of medications to control bleeding. The diode laser also can be used to treat patients taking blood thinner medications due to organ transplants or cardiac valve replacements; such treatment may allow these patients to continue their blood thinner medications with no alterations. A 7-year-old child with Von Willebrand's disease was treated successfully using the 810 diode laser (Fig. 35–37).

In addition to the many examples described in this article, lasers can be used for additional procedures not normally performed in pediatric dentistry, such as revisions of the abnormal mandibular frenum, often avoiding the need for soft tissue grafts; crown lengthening procedures in which bone requires recontouring; apicoectomies; the removal of bony exostoses, third molar impactions, and root remnants; and the incision and draining of soft tissue infections. A list of pediatric dental procedures for which lasers can be used is cited in the table.

Summary

Lasers are an extremely versatile addition to the dental practice and can be used in many instances in place of the conventional methods employed by the vast majority of dentists. Incorporating a laser into the dental practice should be viewed as an investment rather than a cost. Dentists with a knowledge of laser physics and safety can provide patients with a new standard of dental care.

Disclaimer

Dr. Kotlow has presented educational seminars on pediatric dentistry and lasers for HOYA ConBio.

He consults and provides professional guidance in the development of products for many laser- and technology-associated manufacturers such as Isolite, Schick, and Lares Research and various laser safety glass manufacturers. For his professional speaking engagements or product input, he receives an honorarium or new products to evaluate.

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Dr. Kotlow is in private practice in Albany, New York and is a recognized standard proficiency course provider for the Academy of Laser Dentistry.

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