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Abstract

Objectives: This case report describes the application of an Er,Cr:YSGG laser in regenerative periodontal surgical therapy.

Materials and methods: A patient with extensive periodontal tissue breakdown is treated with an Er,Cr:YSGG laser for granulation tissue removal, bone decorticalization and root decontamination. In the regenerative procedure, demineralized bovine bone mineral and collagen membranes were used.

The following clinical parameters were recorded at baseline, three months, six months, one year, two years and five years: plaque index (PI), bleeding on probing (BOP), periodontal pocket probing depth (PPD), recession (REC), clinical attachment level (CAL).

Results: The operated sites demonstrated uneventful healing. Radiographically, remineralization was observed at six months. At a one year follow-up, significant probing pocket depth reductions and clinical attachment level gains were registered.

Conclusion: In this report, it may be acknowledged that the Er,Cr:YSGG laser could be applied for debridement and decontamination of both the root and the bone defect in guided tissue-regeneration procedures. Further investigation is needed to identify in which treatment protocol in periodontology the Er,Cr:YSGG laser can be integrated and with which benefits.
Background

The application of laser in periodontology is widely discussed, especially as several laser systems with their specific wavelength have a different impact on periodontal tissues. Excellent knowledge of laser applications is essential, which requires the operator to endure a learning curve to avoid adverse effects.

During laser irradiation, the power settings play a significant role and must be regulated appropriately in order to avoid detrimental effects to the irradiated tissues (Ishikawa I. 2002).

Periodontal tissue destruction is treated according to the type of defect and the location, posterior or anterior, in the mouth.

Regenerative therapy is indicated in case of intraosseous defects of which the radiographic angle and number of walls determine which kind of procedure needs to be applied and which kind of materials need to be used. The difficulty of guided tissue regeneration and other treatments of the periodontium lies in the fact that we are dealing with roots, which have an avascular surface in which both the multiple specialized cell types and the microbial environment are involved in all healing processes of the periodontal ligament.

Materials and methods

The Er,Cr:YSGG laser (Biolase, Inc.; San Clemente, Calif.) with a 2,780 nm wavelength, in the far-infrared spectrum, is a class 4 laser, with a pulse repetition rate of 10 Hz to 50 Hz and power output from 0.25 to 8 watt, and pulse energy of 300 mJ. The flexible optical trunk fiber is connected to a straight or angled handpiece.

The laser beam is accompanied by a water and air spray. The water/air spray represents a hydrating and cooling agent reducing thermal effects. Both air and water settings can be modified from 0–100 percent.

Radiation of the Er,Cr:YSGG laser is absorbed mainly by water and calcium hydroxyapatite.

With a pulse duration of 90 or 150 µsec, the Er,Cr:YSGG laser has a high ablation efficiency and low thermal impact on the surrounding tissues (Straßl, 2004) "Comparison of the emission characteristics of three erbium laser systems — a physicals case report." (JOLA 2004).

A 44-year-old female patient with incidental, severe adult periodontitis (Vd Velden U., 2005). Medical conditions and lifestyle: The patient was a non-smoker and she suffered from severe II grade obesity (BMI 35–39.9) and stress. Family history was positive for periodontitis.
Intraoral exams (Fig. 1) demonstrated the central upper left incisor with recessions on the buccal and the distal and a black triangle at the soft tissue outline distally. Second grade mobility, probably because of occlusal trauma, was evident. Periodontal pocket probing depths were buccal 7 mm (Fig. 2), distal 9 mm (Fig. 3), mesial 3 mm and lingual 3 mm.

The plaque index (PI) and bleeding on probing (BOP) was less than 15 percent, and the patient demonstrated high standards of oral hygiene. Radiographic exams (Fig. 4) showed a vital tooth with a normal root length. A wide-angled, non-supportive bone defect was present at the distal side of the root.

Follow-up was monitored with radiographs, with BOP- and PI-indexes and PPD, REC, CAL were registered.

The occlusion was corrected by elimination of the pre-contact, and no splint was placed. After infiltration anesthetics, the soft-tissue incisions were made with a proposed papilla preserve technique (by Takei in 1995), reflecting the lingual papilla to the buccal. The laser's angled handpiece mounts a chisel-shaped tip, with which in contact mode the flap design is made. Laser power settings on 2.0 watt, 30 percent air, 10 percent water and 30 Hz. Granulation tissue was removed (Fig. 5) with laser power settings on 2.5 watt, 40 percent air, 20 percent water and 25 Hz. Root-conditioning (Fig. 6) is performed holding the tip in a 1.5–2 mm distance from the root, in overlapping vertical and horizontal strokes, until the root-surface has a whitish-etched aspect, with laser settings 1.5 watt, 30 percent air, 20 percent water and 20 Hz.
The wide non-sustaining defect (Fig. 7) was filled with the demineralized bovine bone mineral (Fig. 8) to avoid collapse of the soft tissue into the defect. The bone substitute (Bio-Oss, Geistlich Biomaterials) was then covered with a resorbable collagen membrane (Bio-Gide, Geistlich Biomaterials) to avoid fibroblast ingrowth.

After releasing the buccal flap, the papilla was repositioned and sutures were placed, and the wound was perfectly closed without tension. Patient received postoperative instructions.

Results

Initial healing was uneventful, although the tooth demonstrated grade-I mobility, which diminished in the first three months to zero. After two weeks, sutures were removed and oral hygiene was resumed by carefully brushing the operated site.

At six months, remineralization of the defect was evident on a radiographic exam (Fig. 9). At one year, significant CAL gains have been found, both on the buccal and on the distal. To further close the black triangle, a composite filling was made on the mesial side of tooth #22 (Fig. 10). The PPD on the buccal went from 7 mm at baseline to 2 mm and had a CAL-gain of 6 mm, which remained stable (Table 2, Fig. 11). The PPD on the distal went from 9 mm to 4 mm in the first 12 months (Table 3, Fig. 12) and measured at 60 months 3 mm (Table 3, Fig. 14), with a final CAL-gain of 9 mm. Radiographic follow-up showed regular alveolar bone outline with lamina dura at 60 months (Fig. 13).

Discussion

According to evidence-based therapy, a combination of barrier membranes and bone substitutes is a standardized approach to treat wide non-supportive bone defects (Camelo M. 1998).

To introduce the laser treatment in regenerative periodontal surgery for debriding and decontaminating the bone defect, it needs to be taken in consideration that much knowledge in laser dentistry is still experience-based and widely discussed. This is especially so because there are many kinds of wavelengths, as well as very little evidence-based research (Ishikawa I. 2008).

In periodontal regenerative surgery, the appropriate conditioning of root surfaces is likely to be important for enhancing predictability of regenerative therapies (AAP, 2005). The introduction of the Er,Cr laser to debride the defect and decontaminate the root is based on several findings. It is reported that this laser is suitable for the disinfection of even the deeper layers of dentin because of its bactericidal effect (Schoop U. 2004).

With the appropriate settings, an Er,Cr:YSGG laser is capable of performing scaling and root planing to remove calculus, and because of its short pulse, it may be especially suitable for the micro-morphology of the root surface (Hakki SS. 2010). Because of high absorption in water of laser energy, an effective ablation with a very thin surface interaction occurs on the irradiated tissues and without any major thermal damage to the irradiated and surrounding tissues (Straßl M. 2004, Wang X. 2005).

To avoid smear layer caused by hand instruments or detrimental effects of chemical root conditioning (Blomlof J. & Lindskog S. 1995), the Er,Cr laser is used to clean and etch the exposed root surface. Furthermore, the Er-wavelength seems to give comparable results to ultrasonic devices (Crespi R. 2007), without leaving a smear layer.

The AAP consensus statement declared that research should be focused on identifying factors that can detoxify roots and also influence appropriate cell attachment (AAP 2005). Regeneration of periodontal

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Table 1

Table 2
tissues is reported in studies, where lasers’ decontaminative capacity created the right circumstances for fibroblast attachment on root surfaces (Feist IS. 2003), and, in case reports, this might have resulted in clinical improvements in periodontal healing (Schwarz F. 2003).

Er-laserwavelength is able to ablate periodontopathic bacteria with thermal vaporization, and its bactericidal effect on the diseased root surfaces appears to be superior to that of the ultrasonic scaler (Akiyama F. 2010). Furthermore, the Er,Cr laser irradiation to perforate the alveolar bone of the defect to release blood, containing growth factors, could be advantageous for wound healing of bone tissues as comparative studies on bone healing suggested (Pourzarandian A. 2004).

The application of Er-wavelength seems to be slightly more effective when platelet-derived growth factors are involved for regeneration purposes and, therefore, a promising treatment alternative (Belal MH. 2007).

### Clinical relevance: statement and conclusions

The application of an Er,Cr:YSGG laser with 2,780 nm wavelength, which substitutes for the scalpel blade, root conditioning agents and hand- or ultrasonic instruments, demonstrates the possibility to integrate laser treatment successfully in various stages of advanced periodontal therapy.

Clinically, the Er,Cr:YSGG laser seems to contribute with its decontaminative capacities to create ideal circumstances for regenerative procedures, which resulted in significant CAL-gain in this case report.

Randomized controlled clinical trials and more basic studies have to be encouraged and performed to confirm the status of Er,Cr:YSGG laser treatment as an adjunct in traditional periodontal surgical therapy.

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From everyday dentistry to advanced photoacoustic endodontic applications (PIPS): Er:YAG & Nd:YAG dual wavelength laser

Authors Lawrence Kotlow, DDS, Enrico DiVito, DDS & Giovanni Olivi, MD, DDS

Introduction

Lasers provide an exciting new technology that allows the dentist the ability to give patients optimal care without many of the “fear factors” found in conventional dental techniques. Used with proper understanding of laser physics, lasers are extremely safe and effective.

Using lasers for caries removal, perio treatment, endodontic treatment, bone management, cutting and shaping, and soft tissue procedures can reduce postoperative discomfort, infection and provide safe, simple in-office treatment. As a result, we can improve our efficiency, expand what we can do, achieve better results and increase production.

Lasers represent a real quantum leap forward in the treatment of our patients, including the pediatric patient. The U. S. Food and Drug Administration (FDA) gave approval for the use of the Er:YAG laser in 1997 for both hard- and soft-tissue procedures. The erbium doped (erbium particles placed within the YAG crystal) crystal of Yttrium-Aluminum-Garnet’s (Er:YAG) development and success has made the treatment of children safer and quicker.

Plainly stated, a laser is a piece of equipment that creates a concentrated monochromatic beam of visible or infrared light that can be absorbed by a specific target. Since then, laser-assisted dental care has changed forever the way dentists can prepare diseased teeth, ablate bone and treat soft tissue abnormalities and disease. An entire new standard of care is becoming a reality.

Lasers and pediatric dentistry are a perfect fit. There are a wide range of hard and soft dental procedures that may be completed using lasers as an alternative to conventional dental care on adults and, especially, children. Many of these procedures may be treatments dentists historically refer out to other specialists; however, if you understand and use your laser efficiently, you will discover that many of these procedures that every dentist can easily complete.

The question that is often the major concern and barrier to investing in lasers is the how this investment will pay for itself, more recently described as return on your investment (ROI). Will it pay for itself? We prefer to speak of this as the secondary effect. If you understand your laser, it will easily pay premiums on your investment, and the cost factor becomes a non-issue.

The purchasing of lasers is an investment, not an expense, for any dental practice. Lasers represent a fundamental change in the entire way dentistry has been taught. We can now rethink and often modify G.V. Black’s principle of extension for prevention with the concept of minimally invasive micro-dentistry. We need to understand that laser dentistry is one portion of an
The laser that we call the “all-purpose” laser is the Lightwalker Er:YAG & Nd:YAG laser, manufactured by Fotona and distributed in the United States by Technology4Medicine. The Er:YAG produces its effect at 2940 nm and has as its primary tissue target water and hydroxyapatite. It is very safe, relatively quiet, eliminates the smells and vibrations associated with the dental handpiece and, most importantly, is much more comfortable for the patient, significantly reducing the need for local anesthesia.

The use of the new generation erbium lasers for repair of incipient hard-tissue disease allows the dentist to provide a stress-free means of restoring teeth in a minimally invasive manner, most often with no shot and no numb lip, without the need for any local anesthetics.

The erbium laser can be used for restoring primary and permanent teeth, eliminating or reducing the amount of local anesthetics. In most cases, the patient will not require numbing for Class 1, 2 (sometimes), 3, 4, 5, 6 restorative procedures using bonded restorative materials. Using the concept of minimally invasive restorative procedures, the Er:YAG laser allows the operator to remove only diseased tissue and thus preserves much more of the healthy unaffected tooth.

In cases where alloy is preferred, the laser’s analgesia effect may also allow the dentist to create a restorative preparation using a conventional handpiece that is not meant for bonding. The erbium laser is effective because of its effect on its target, water within the tooth structure. This effect occurs when the laser heats up water within the target tissue, causing it to create small microscopic explosions (photothermal followed by photoacoustical effects). When applied to soft tissue, bone or teeth and cavities, the explosions then cause the areas to be vaporized.

There is a wide array of soft-tissue procedures that are able to be completed using the all-purpose laser: maxillary and mandibular frenum revisions, lingual frenum revisions, treatment of pericoronal pain or infection, removal of hyperplastic tissue because of drugs or poor oral care in orthodontic patients, biopsies, treatment of aphthous ulcers and herpes labialis, pulpotomies, removal of impacted teeth and in adults apicoectomies and bone recontouring.

Parents often express concern about the need to take radiographs because of the nature of X-rays and their possible side effects on their child’s overall health. They question the use of alloys because of the chemical makeup of the alloy. Whether these should be a real concern in today’s dental care is open to debate, depending on your individual beliefs. There are also concerns by many, although not as loudly, about the effect of various pulpotomy procedure medicaments used in pulpotomy procedures such as formocresol.

Lasers provide a safe, non-chemical effective alternative treatment for pulpotomies. During eight years, post-treatment results on more than 4,000 pulpotomies using the erbium (2940 nm) laser provides ample evidence that this method is both effective and safe for children without the need for introducing chemicals or using electrosurgery methods.

When the final result of orthodontic positioning of the front teeth results in gingival hypertrophy, the laser can be a useful tool to increase crown length and give the patient a more esthetic smile. This may often be accomplished without the need for local

**Figs. 1–2.** Representative sample images of root canal dentinal walls irrigated with 17 percent EDTA and PIPS for 20 seconds. (Photos/provided by Technology4Medicine)
anesthesia. Patients who have medically induced hyperplastic tissue, such as patients requiring dilantin, can also have their tissue reduced and reshaped with the erbium.

In addition to the many examples described in this article, lasers can be used for additional procedures not usually required in pediatric dentistry, such as revisions of the abnormal mandibular frenum, often avoiding the need for soft-tissue grafts, crown-lengthening procedures where bone requires recontouring, apicoectomies, removal of boney exostoses, removal of root remnants, incising and draining soft-tissue infections, advanced periodontal treatments and the latest in advanced endodontic treatment via photon-induced photoacoustic streaming.

Photoacoustic endodontics using PIPS

The goal of endodontic treatment is to obtain effective cleaning and decontamination of the smear layer, bacteria and their byproducts in the root canal system. Clinically, traditional endodontic techniques use mechanical instruments, as well as ultrasonic and chemical irrigation, in an attempt to shape, clean and completely decontaminate the endodontic system but still fall short of successfully removing all of the infective microorganisms and debris. This is because the complex root canal anatomy and the inability for common irrigants to penetrate into the lateral canals and the apical ramifications. It seems, therefore, appropriate to search for new materials, techniques and technologies that can improve the cleaning and the decontamination of these anatomical areas.

Among the new technologies, the laser has been studied in endodontics since the early 1970s and has become more widely used since the ’90s.

Different wavelengths have been shown to be effective in significantly reducing the bacteria in the infected canals, and important studies have confirmed these results in vitro. Studies reported that near infrared laser are highly efficient in disinfecting the root canal surfaces and the dentinal walls (up to 750 microns the diode 810 nm and up to 1 mm the Nd:YAG 1064 nm). On the other hand, these wavelengths did not show effective results in debriding and cleansing the root canal surfaces and caused characteristic morphological alterations of the dentinal wall. The smear layer was only partially removed and the dentinal tubules primarily closed as a result of melting of the inorganic dentinal structures.

Other studies reported the ability of the medium infrared laser in debriding and cleaning root canal walls. The bacterial load reduction after erbium laser irradiation, demonstrated high on the dentin surfaces, but low in depth of penetration because of the high absorption of laser energy on the dentin surfaces. Also the laser activation of commonly used irrigants (LAI) resulted in statistically more effective removal of debris and smear layer in root canals compared with traditional techniques (CI) and ultrasound (PUI). Additionally the laser activation method resulted in a strong modulation in reaction rate of NaOCl significantly increasing production and consumption of available chlorine in comparison to ultrasound activation.

A recent study has reported how the use of an Er:YAG laser, equipped with a newly designed radial and stripped tip, in combination with 17 percent EDTA solution, using very low pulse duration (50 microseconds) and low energy (20 mJ) resulted in effective debris and smear layer removal with minimal or no thermal damage to the organic dentinal structure through a photoacoustic technique called photon induced photoacoustic streaming or “PIPS.” Also the same photoacoustic protocol in combination with 5.25 percent sodium hypochlorite solution has been investigated and shown to reduce the bacterial load and its associated biofilm in the root canal system three dimensionally.
Other similar studies are in progress for publication and the results are promising and suggest a three-dimensional positive effect of this laser-activated decontamination (LAD) method.

The purpose of this article is to present briefly the experimental background of this laser technique and to introduce the clinical protocol.

**Scientific background**

The microphotographic recording of the LAI studies suggested that the erbium lasers used in irrigant-filled root canals generate a streaming of fluids at high speed through a cavitation effect.\(^\text{17}\) The laser thermal effect generates the expansion-implosion of the water molecules of the irrigant solution, generating a secondary cavitation effect on the intracanal fluids. To accomplish this streaming, it is suggested the fiber be placed in the middle third of the canal, 5 mm from the apex and stationary.\(^\text{18}\) This concept greatly simplifies the laser technique, without the need to reach the apex and to negotiate radicular curves.

Also, the recorded video of the new technique, PIPS, showed a strong agitation of the liquids inside the canals. It differs from the already cited LAI technique by activating the irrigant solutions in the endodontic system through a profound photoacoustic and photomechanical phenomena. The use of low energy (50 microsecond pulse, 20 mJ at 15 Hz, 0.3 W average power, or less) generates only a minimal thermal effect. The study with thermocouples applied to the radicular apical third revealed only 1.2 degree C of thermal rise after 20 seconds and 1.5 degrees C after 40 seconds of continuous radiation.\(^\text{14}\) When the erbium laser energy is delivered at only 50 microsecond pulse duration through a special designed tapered and stripped 400 microns tip (Fotona LightWalker, Technology4Medicine), it produces a large peak power of 400 watts when compared to a longer pulse duration. Each impulse, absorbed by the water molecules, creates a strong “shock wave” that leads to the formation of an effective streaming of fluids inside the canal while also limiting the undesirable thermal effects seen with other methodologies. The placement of the tip in the coronal portion only of the treated tooth allows for a more minimally enlarged canal preparation with less thermal damage as seen with those techniques placed into the canal system.

The root canal surfaces irrigated with 17 percent EDTA and laser activated for 20 seconds showed exposed collagen matrix, opened tubules and the absence of smear layer and debris (Figs. 1-3). The rinsing with 5.25 percent sodium hypochlorite and laser irradiation for 20 seconds produced a strong activation of the solution, as reported by Macedo,\(^\text{13}\) improving the disinfecting action of the sodium hypochlorite.\(^\text{16}\) The disinfecting action of PIPS is very effective both on the root surface, the lateral canals and the dentinal tubules, as confirmed with SEM and confocal studies (Fig. 4).

The profound and distant effect of PIPS eliminates the need to introduce the tip into the root canal system. Unlike traditional laser techniques requiring placement of the tip 1 mm from the apex, or even 5 mm from the apex as proposed for LAI18, the PIPS tip is placed in the coronal portion of the pulpal chamber only and left stationary allowing the photoacoustic effect to spread into the openings of each canal. A new tip design consisting of a 400-micron diameter, 12 mm long, tapered end is used for this technique (Fig. 5). The final 3 mm of coating is stripped from the end to allow for greater lateral emission of energy compared to the frontal tip.

This mode of energy emission allows for improved lateral diffusion with low energy and enhanced photoacoustic effect.

**Discussion**

Laser irradiation is a common technique used in endodontics to improve both the cleaning, the debriding and disinfection of the root canal system. Many wavelengths and protocols are used. Near infrared lasers are used for the three-dimensional decontamination of the endodontic system. Nd:YAG and diode lasers use thermal energy to destroy bacteria. Observations reveal a certain grade of thermal injury to the root canal surface and create a typical morphological damage. Moreover, they are not able to thoroughly remove the smear layer.

On the contrary, erbium lasers are used for their effective smear layer removal while their bactericidal activity is limited to the root surface. The placing of the tip close to the apex and its back movement during the activation process is related to the risk of apical perforation, ledging and surface thermal damage,
because of the ablation ability of this wavelength. Also a combination of the near and medium infrared lasers has been proposed. A technique, called twinkle endodontic treatment (TET), uses the erbium laser energy first, to clean the root canal surface and remove the smear layer, and the Neodimium:YAG laser second, used in dry mode as the final disinfecting step. All these techniques utilize traditional tips and fibers placed into the canal, close to the apex (1 mm) with all the corresponding thermal disadvantages observed in long, narrow and curve canals.

The erbium lasers are also used as a medium of activation of commonly used irrigants (LAI), avoiding the risk of thermal damage, while increasing the cleaning and disinfecting activity of the fluids. PIPS, in particular, reduces all these risks and disadvantages, thanks to the position of the tip in the coronal orifice only and to the use of minimally ablative energy levels of 20 mJ or less.

The findings of our studies demonstrated that PIPS technique resulted in a safe and effective debridging and decontaminating the root canal system. Our clinical trials showed that PIPS technique greatly simplifies root canal therapy while facilitating the search for the apical terminus, debriding and maintaining patency.

As a result of the efficacy of PIPS the final size required for canal shaping can be significantly reduced, often to a size 25/04, allowing for a more minimally invasive and biomimetic preparation which can then be obturated three dimensionally.

_In conclusion_

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

_References_


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Lasers have been a part of the dental scene for more than 25 years. Unfortunately, they have tended to be big, clunky, hard-to-use, expensive machines that were largely ignored. Affordable, effective, user-friendly diode lasers have only recently arrived on the scene. In fact, the diode laser, in a very short time, has proven itself to be the ideal “soft-tissue hand piece.”

The diode laser functions as the essential hand-piece for all soft-tissue procedures, just as the dental handpiece is essential for all hard-tissue procedures. The advantages of the diode laser for soft tissue applications include: surgical precision, bloodless surgery, sterilization of the surgical site, minimal swelling and scarring, minimal suturing and virtually no pain during and after surgery.

What about using the diode laser for the treatment of periodontal disease (laser assisted periodontal treatment)? An early version of the diode laser was used effectively in the treatment of periodontal pockets in 1998. So why is there so much confusion and controversy regarding the use of lasers in the treatment of periodontal disease today? There is need for clarification and simplicity.

First, as the name laser assisted periodontal therapy (LAPT) implies, the laser is only part of the treatment equation. The laser should not be viewed as a stand-alone treatment for periodontal disease.

Second, the laser may not be of any help in very advanced cases of periodontal disease. These cases may require a surgical approach.

Third, when discussing the benefits of LAPT, we must specify the particular type of laser used. Several categories of lasers have shown positive results. For the sake of clarity and simplicity, the following discussion will deal exclusively with the diode laser, because its ease of use and affordability have made it the predominant laser in dentistry.

Diode lasers for periodontal treatment

Two types of diode lasers have been studied for their effects in laser assisted periodontal therapy: the diode laser (which emits high levels of light energy), and the low-level diode laser (which emits low intensity light energy).

There is very compelling evidence in the dental literature that the addition of diode laser treatment to scaling and root planing (SRP) will produce significantly improved and longer lasting results. SRP is the gold standard in nonsurgical periodontal treatment.

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effect is non-cutting and low intensity and covers a much wider area than the traditional laser. Low-level laser therapy (LLLT) is treatment where the light energy emitted by the laser elicits beneficial cellular and biological responses. On a cellular level, metabolism is increased, stimulating the production of ATP (adenosine triphosphate), the fuel that powers the cell. This increase in energy is available to normalize cell function and promote tissue healing. 3,4

The functions of the diode and low-level diode laser have remained separate until recently. With the introduction of the biostimulation delivery tip, the diode laser is able to provide both cutting and therapeutic effects. When the low level tip is used, the laser energy is delivered over a wider area, decreasing the energy level, and producing the low level therapeutic effect. Two laser companies have made these auxiliary tips available (Figs. 1–4).

Used together, these two laser treatment modalities provide benefits that help to heal the chronic inflammatory response in the periodontal pocket. This works well in treating mild to moderate periodontitis. Patients can be treated in a minimally invasive way, without surgery, in the general practice. There is time to try the surgical approach, if needed, at a later date.

_The periodontal pocket_

Periodontal disease is a chronic inflammatory disease caused by bacterial infection. The inflammation is the body’s response to destroy, dilute or wall off the injurious agent. 5

Unfortunately, if the situation remains chronic, this protective mechanism of the body to defend itself against injury, becomes destructive to the tissues.

The periodontal pocket, in periodontal disease, contains several substances that contribute to the continuation of the unhealthy condition (Fig. 5):

1. Calculus and plaque on the tooth surface.
2. Pathogenic bacteria.
3. An ulcerated epithelial lining with granulation tissue and bacterial by-products.

What do we need for healing of the pocket?

1. **SRP:** Elimination of calculus, plaque and other debris on the tooth to create a totally clean surface
2. **Decontamination:** Elimination of all pathogenic bacteria dispersed through the pocket
3. **Curettage:** Elimination of granulation tissue, bacterial products, and ulcerated areas to create a clean, even epithelial lining without tissue tags (epithelial remnants)
4. **Biostimulation:** To kick-start the healing process

The following is a sequence to show how this can be easily accomplished in a minimally invasive, non-surgical way:

1. Calculus is removed with SRP. This procedure has been well documented throughout the dental lit-
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2. Because a bacterial infection is the initiator of the chronic inflammatory response of periodontitis, the bactericidal and detoxifying effect of laser treatment is advantageous.6 The diode laser’s bactericidal efficacy, particularly against specific periopathogens, has been well-documented.7-10 Moreover, there is a significant suppression of A. Actinomycetemcomitans, an invasive bacterium that is not easily treated with conventional scaling and root planing. A. A, as it is generally called, is not only present on the diseased root surface, but also invades the adjacent soft tissue, making it virtually impossible to remove with mechanical means alone.11-13 The diode laser energy is able to penetrate into the soft tissue to eliminate this pathogen.

3. The diode laser is a specific instrument well suited in dealing with diseased soft tissue. The diode laser energy is well absorbed by melanin, hemoglobin and other chromophores that are present in periodontal disease.14 The 2002 American Academy of Periodontology statement regarding gingival curettage15 proposes that “gingival curettage, by whatever method performed, should be considered as a procedure that has no additional benefit to SRP alone in the treatment of chronic periodontitis.”

However, the diode specifically targets unhealthy gingival tissues, performing an effective curettage that produces a clean, even epithelial lining without tissue tags. Also stated is that all the methods devised for curettage (including lasers) “have the same goal, which is the complete removal of the epithelium”
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and “none of these alternative methods has a clinical or microbial advantage over the mechanical instrumentation with a curette.” This was the science in 2002. By 2010, this AAP statement had not been updated. Studies have shown that instrumentation of the soft tissues in the diseased periodontal pocket with the diode laser leads to complete epithelial removal while conventional instrumentation with curettes leaves significant epithelial remnants. Thus, in fact, the diode laser does have a clinical advantage over the mechanical instrumentation with a curette.

4. This step requires the low-level laser tip. Studies have shown that low-level laser light affects damaged but not healthy tissue. Laser biostimulation normalizes cell function and promotes healing and repair. Secondary effects include increased lymphatic flow, production of endorphins, increased microcirculation, increased collagen formation and stimulation of fibroblasts, osteoblasts and odontoblasts. This stimulates the immune response, pain relief and wound healing. Studies have shown that low-level laser therapy performed in conjunction with SRP on patients with both mild periodontitis and chronic advanced periodontitis can significantly improve treatment outcomes and the long-term stability of periodontal health parameters.

The above four steps create the ideal environment in the periodontal pocket for healing to take place.

Lasers are an adjunct to SRP, not a stand-alone procedure. On the other hand, SRP is not a stand-alone procedure. We need all the pieces of the puzzle to create health.

---

**The protocol so far**

Now that we know what we need, how do we achieve it?

The protocol must incorporate the four steps discussed above to create the ideal environment for periodontal healing to occur: a clean, calculus-free hard tissue surface, no pathogenic bacteria, a smooth, clean soft tissue surface and biostimulation.

Biostimulation tips are at present only available for two diode lasers: the Picasso by AMD and the ezlase by Biolase.

Individual parameters vary depending on the clinician and the particular diode laser used. However, most protocols follow a simple formula:

1. The hard-tissue side of the pocket is first debrided with ultrasonic scalers and hand instruments (Fig. 6).
2. This is followed by laser bacterial reduction and coagulation of the soft-tissue side of the pocket (Figs 7, 8). The laser fiber is measured to a distance of 1 mm short of the depth of the pocket. The fiber is used in light contact with a sweeping motion that covers the entire epithelial lining, starting from the base of the pocket and moving upward. The fiber tip is cleaned frequently with a damp gauze to prevent debris buildup.
3. The low-level laser tip is applied at right angles and with direct contact to the external surface of the pocket (Fig. 9) for biostimulation.
4. Re-probing of the treated sites should be performed no earlier than three months after treatment to allow for adequate healing (Fig. 10).
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The tissue remains fragile for this period of time. The power settings and duration are determined by the particular laser used. The manufacturers should be consulted for the proper parameters to achieve the best results. With experience, the user will feel comfortable enough to adapt the protocol to his or her particular practice. This protocol may be performed by the dentist and/or hygienist as determined by the regulating organization in the geographic location of the dental practice.

Many of our patients have periodontal disease, but they want to be treated in a minimally invasive way. They are not rushing out to the periodontist to have “gum surgery.” We need to treat their disease before it spirals out of control, especially when considering the periodontal health/systemic health link.

There is significant proof that the addition of laser-assisted periodontal therapy to scaling and root planing improves outcomes in mild to moderate periodontitis. The treatment is not invasive. It is not uncomfortable.

We now have the tools and protocol to treat our periodontal patients with an effective procedure that they are ready to accept. What are we waiting for?

Editor’s note: A complete list of references is available from the publisher.
Technology-enhanced caries detection and treatment options

Abstract

Here we present a case report illustrating technology-enhanced caries detection and treatment systems on occlusal surfaces during a 26-month follow-up. The use of ozone therapy and a laser-induced fluorescence device on incipient occlusal caries lesions in a 25-year-old woman is described. The utilization of the ozone therapy monitored by the laser-induced fluorescence device enabled an alternative and comfortable treatment for incipient caries lesions on occlusal surfaces. Thus, technology-enhanced caries detection and treatment systems are helpful tools during clinical practice.

Introduction

Although the prevalence of dental caries in children has declined in the past several decades, there has been a continuing increase in occlusal caries. This fact may be explained by the changes in caries pattern and progression. Additionally, this may be due to the increased use of fluoride and its superficial remineralization, which seems to delay the cavitation (Strassler and Sensi 2008). In this way, incipient occlusal caries have become more difficult to detect.

The difficulty in diagnosing incipient caries has stimulated the development of new detection methods. Recently, new methods have become available as adjuncts to traditional methods, such as the fluorescence-based devices. These are based on the phenomenon that caries lesions fluoresce more strongly than sound tissues when stimulated by light at specific excitation wavelengths (Hibst et al. 2001, Bader and Sugars 2004).

The most common laser-induced fluorescence device for caries detection used in dentistry is the DIAGNOdent (LF, DIAGNOdent 2095, KaVo, Biberach, Germany). This device emits a red light at 655 nm and quantifies the fluorescence from bacterial porphyrins and other chromophores present in caries lesions (Hibst et al. 2001). The changes in the fluorescence intensity are numerically quantified and translated into values ranging from 0.0 to 99, according to the lesion’s depth. This can be used to help clinicians decide whether a tooth should be restored (Young 2002). The device has been used as an auxiliary to detect and quantify mineral loss in caries.

It is important to point out that the management of dental caries is based on appropriate detection of pathological changes and, consequently, on the correct diagnosis to provide the best treatment for each patient (Tranaeus et al. 2005).

Recently, a novel concept for the treatment of dental caries using ozone gas as a potent microbi-cide has been introduced (Baysan et al. 2000, Baysan and Lynch 2004, Dähnhardt et al. 2006, Baysan and Beighton 2007). Ozone is a gas that quickly kills microorganisms by oxidative degradation of the unsaturated fatty acids in the cell wall (Dähnhardt et al. 2006). The device delivers ozone, through a handheld, directly to the carious lesion in a concentration of 2,100 ppm with a changeover of 300 times per second. A silicon cup is able to tightly seal the covered area (Baysan et al. 2000).

Previous reports have assessed the effect of ozone gas on occlusal caries, non-cavitated occlusal caries and primary root caries, showing significant reductions in the number of microorganisms (Baysan et al. 2000, Brazzelli et al. 2006, Baysan and Beighton 2007). However, the inhibitory effect of ozone in the caries process is discussed and controversial (Hauser-Gerspach et al., 2009; Kronenberg et al., 2009).

To date, there are some clinical studies evaluating improvements in the clinical status of non-cavitated occlusal caries and root caries after ozone therapy monitored by laser-induced fluorescence readings. The patient was instructed with respect to the maintenance of her oral hygiene. An informed consent contract was signed by the patient agreeing with the treatment.

The laser-induced fluorescence device used was the LF (DIAGNOdent 2005; KaVo, Biberach, Germany). The occlusal surfaces were measured according to the manufacturer’s instructions (Fig. 2). The device was first calibrated using a ceramic standard and then calibrated on the buccal surface of the right permanent central incisor. For measurements, tip A for occlusal surfaces was used. The device was moved through the entire occlusal surface until the highest value was obtained (peak value).

The ozone device used was the HealOzone delivery system (Oz; KaVo, Biberach, Germany). The occlusal surfaces were measured according to the manufacturer’s instructions (Fig. 3). The device was first calibrated using a ceramic standard and then calibrated on the buccal surface of the right permanent central incisor. For measurements, tip A for occlusal surfaces was used. The device was moved through the entire occlusal surface until the highest value was obtained (peak value).

The ozone device used was the HealOzone delivery system (Oz; KaVo, Biberach, Germany). Ozone was applied on each tooth at room temperature according to the manufacturer’s instructions (Fig. 3). In each session, the occlusal surface of each tooth was cleaned for 10 s with a water-powder jet cleaner (PROPHYflex II, KaVo, Biberach, Germany).

A 25-year-old Caucasian woman was referred to the clinic of the Preventive, Restorative and Pediatric Dentistry department of the Dental School of Bern, Switzerland, presenting incipient caries lesions.

During the clinical interview, the patient reported that she presented a normal systemic status. The caries risk assessment indicated that she was at low risk.

Visual examination was performed by direct visualisation of the teeth with the aid of a light reflector and a three-in-one air syringe. The patient presented incipient caries lesions on the distal fossae upper right first molar (16), on the distal fossae upper left first molar (26) and on the central fossae lower right first molar (46) (Fig. 1). The visual and tactile characteristics observed were the presence of brown and white opacities and roughness on the fissures, indicating caries activity.

Bitewing radiographs were taken and then analyzed using an X-ray viewer. No radiolucency was observed in the occlusal surfaces.

Based on clinical and radiographic observations, and considering anamnesis data, the treatment proposed was ozone therapy application (to reduce the microflora in the lesion) monitored by laser-induced fluorescence readings. The patient was instructed with respect to the maintenance of her oral hygiene. An informed consent contract was signed by the patient agreeing with the treatment.

Fig. 3a. Ozone device (HealOzone)
Fig. 3b. Ozone gas application after carefully drying the occlusal surface. Note that the silicon cup tightly seals the covered area.
Fig. 4a. Clinical aspect of the incipient caries lesion on tooth 46 at baseline.
Fig. 4b. After two months.
Fig. 4c. After 26 months of follow-up. Note that the lesion’s characteristics and severity changed over time, indicating that the treatment is effective.
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Fig. 5a. Clinical aspect of the incipient caries lesion on tooth 26 at baseline.

Fig. 5b. After 26 months of follow-up. Note that the lesion’s characteristics, such as smoothness and brightness, indicate caries inactivity.

Table 1. Laser-induced fluorescence (LF) readings and ozone therapy (Oz) application time for each session during a 26-month follow-up.

<table>
<thead>
<tr>
<th>Tooth</th>
<th>Baseline</th>
<th>2 months</th>
<th>4 months</th>
<th>10 months</th>
<th>12 months</th>
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<td>LF</td>
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<td>40 s</td>
<td>18</td>
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<td>26</td>
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<td>18</td>
<td>40 s</td>
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<td>46</td>
<td>19</td>
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<th>24 months</th>
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The purpose of ozone therapy is to reduce the microflora in the lesion, to increase its pH and to oxidise pyruvic acid to acetate and CO2, which opens up "channels" within the dentin to allow the penetration of calcium, phosphate and fluoride ions. This makes remineralization of the demineralised hard tissue possible (Dähnhardt et al. 2006, Hodson and Dunne 2007).

A significant reduction in the clinical status of small and non-cavitated occlusal caries lesions after ozone therapy has been reported (Huth et al. 2005). In the present case, we clinically observed that the incipient lesions arrested after 26 months of follow-up, indicating that ozone therapy remineralized lesions over time. However, the treatment adopted in this case was better achieved when the ozone therapy was applied for 80 s on each tooth compared with 40 s. Polydorou et al. (2006) evaluated the antibacterial activity of 40- and 80-s HealOzone application. The authors concluded that the 80-s ozone application is a very promising therapy for eliminating residual microorganisms in deep cavities.

This case report shows it is possible to treat incipient caries lesions using an ozone-delivering device monitored by laser-induced fluorescence. The treated caries showed lower readings compared with the baseline, indicating that the ozone therapy was successful. At the first recall visit, the LF readings were substantially reduced for tooth 26 and 46. This is in accordance with Dähnhardt et al. (2006), who observed that the use of ozone gas results in an average reduction of 13 percent of the laser fluorescence values immediately after ozone therapy.

In the present case, the clinical characteristics and severity of the carious lesions changed over time, indicating that the treatment was effective. Recently, an in vivo study compared the performance of the LF device with visual and radiographic...
The authors concluded that the LF device may be a useful complement to visual examination, and its diagnostic performance seems to be superior for dentin caries detection. The same result was also observed by a systematic review (Bader and Shugars 2004) that showed laser-induced fluorescence tended to be more sensitive than the visual method in detecting occlusal caries in dentin and less sensitive in detecting enamel caries. The case presented in this paper was monitored by laser-induced fluorescence as an adjunct to visual examination because the LF device is supposed to be an auxiliary method for occlusal caries detection.

It is also important to consider that confounding factors might contribute to false-positive laser-induced fluorescence readings in clinical practice, such as the presence of stains, calculus, hypoplasia, polishing pastes and filling materials (Neuhaus et al. 2009). For this reason, a prophylaxis procedure was done on the occlusal surface of each tooth in each session to avoid possible false-positive readings.

While in this case report it was possible to monitor the caries status after ozone therapy by laser-induced fluorescence, there are some important aspects that clinicians should consider regarding this procedure. For instance, ozone has not been proven superior to other clinical approaches in caries management, such as fluoride or chlorhexidine, sealants, and stepwise excavation (Hodson and Dunne 2007).

It may work better than these approaches, work well in combination with these approaches, or may prove to be entirely unnecessary (Hodson and Dunne 2007). In a systematic review of the literature by Rickard et al. (2004), there was no reliable evidence that the application of ozone gas to the surface of decayed teeth stops or reverses the decay process. The authors emphasised the need for more evidence of appropriate strictness and quality before the use of ozone can be accepted into primary dental care or can be considered a viable alternative to current methods for the management and treatment of dental caries. Additionally, the laser-induced fluorescence device should be considered as a second opinion because, to date, there is no method available that is completely reliable.

**Conclusions**

The utilization of ozone therapy monitored by laser-induced fluorescence enabled an alternative and comfortable treatment for incipient caries lesions on occlusal surfaces. However, the ozone therapy parameters and cost effectiveness is unknown. It should be recommended to increase the exposure time during the ozone therapy to achieve a better outcome.

In addition, the laser-induced fluorescence device cannot be considered a standard diagnostic tool by itself. It should be used as an adjunct to the traditional methods, especially considering important patient factors, such as caries risk, caries activity, oral hygiene, diet and fluoride supplements.

**References**


*Editorial note: This article originally appeared in the international edition of Laser magazine. The complete reference list is available from the publisher upon request.*
Laser-assisted frenectomy in pediatric dentistry

Author: Gabriele Schindler-Hultzsch, MSc, DDS

Abstract

The greatest challenge in pediatric dentistry is the child’s fear of pain, fear of dental treatment, fear of noise and fear of something they do not know. This is the reason why dental surgery in pediatric dentistry is a special challenge for the child, the parents and the dentist.

Dental fear, anxiety and dental behavior management problems often go together with a perceived lack of control. This leads to a lack of compliance and a high percentage of untreated and unhealed children (Klingberg 2008; Butz, Goebel 2006). Laser-assisted frenectomy offers a treatment alternative for children, providing a more convenient therapy.

Introduction

Labial frenectomy is the surgical procedure of removing the frenulum. A labial frenulum is the tissue attached to the upper lip and extends into the gums between the two upper front teeth. The labial frenulum may sometimes extend and intrude into the inner, palatal side of the upper front teeth. A labial frenulum also appears at the lower teeth between the two lower central incisors or as lingual frenulum attached to the tongue and the inner lingual-side of the two lower central incisors.

Indications for frenectomy are a diastema of the upper or lower central incisors, retraction of the gingiva, pain during tooth brushing or orthodontic problems.

Often no treatment is necessary because most of these “abnormal” frenula and diastema disappear as the permanent incisors and canines erupt (Koch, Poulsen 2009). The best time for frenectomy is shortly after the beginning of the eruption of the permanent canines.

Frenectomy can be performed conventionally by scalpel or laser-assisted with: diode lasers at wavelengths of 810 nm, 940 nm, 980 nm, or Nd:YAG (1,064 nm); CO2 lasers (10,600 nm); or lasers of the erbium-group (Er:YAG 2,940 nm or Er,Cr:YSGG: 2,780 nm) (Gutknecht 2007).

Clinical procedure

In this article, laser-assisted frenectomy will be presented with the clinical procedure of the Laserkids® concept. The Laserkids concept (Schindler 2008) is a comprehensive guideline for laser-
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assisted pediatric dentistry including aspects of dental anxiety, behavioral management, desensitizing, special laser parameters and treatment procedures for pediatric dentistry from the first visit to lifetime care (Schindler, Gutknecht 2009).

In this case, the general medical and dental anamnesis shows a healthy 12-year-old boy who was very anxious and did not want to have surgery because of previous bad experiences. He was referred from the orthodontist for frenectomy because of the persistent gap between the two upper central incisors. The referral for frenectomy was late because canines were fully erupted. Further orthodontic treatment was considered.

The clinical findings were a strong, three-way labial frenulum extending to the gap between the two upper central incisors leading to a diastema mediale with an incisal spacing of 5 mm and a cervical spacing of 4 mm. The patient showed an Angle Class I denticulation with a slight protrusion of the front teeth, a convex profile and a swallowing dysfunction.

The diagnosis was a diastema mediale between the two upper central incisors with spacing of the upper central incisors. The treatment plan was laser-assisted frenectomy because of the boy’s fear of surgical treatment. The clinical procedure followed the Laserkids concept.

The treatment procedure for the upper labial frenectomy took eight minutes. In this case, topical and local anesthesia was used because of the strong and deep, three-way frenulum. In many cases, only topical anesthesia is necessary. After applying Cherry GINGICAINE® GEL (Belport Co., Inc. Camarillo, Calif., USA) and waiting for 30 seconds, 1 ml local anesthesia Ultracain® D-S forte 1:100,000 Epinephrine (Sanofi-Aventis Deutschland GmbH, Germany) was applied buccally on the left and right side of the frenulum.

Safety goggles were put on the patient, mother, assistant and dentist while waiting for the anesthetic to work. The time was used to desensitize the child and to get acquainted. A tell-show-show-do technique was used to explain the laser beam, its function and the procedure. The laser beam was shown first on a puppet and then on the finger of the child, following the Laserkids concept. The surgical procedure started when the child felt comfortable. The frenectomy was completed within 4:30 minutes.

For this frenectomy the Er,Cr:YSGG laser with a wavelength of 2,780 nm was used. The procedure was performed with a MC3 tip, 1.5-2 W, 30 Hz, pulse duration 700 µs, 7 percent water and 11 percent air, in contact mode.

The first cut was placed incisally in V-form from the right side at an angle. The second cut followed from the left at an angle with the tissue under tension to allow the edges of the fibres to be seen. The next step was an extension to a rhomboid shape, cutting fibres at depth to avoid later relapse and retraction of the tissue. The fibres and excessive tissue were removed. Almost no bleeding occurred during surgery, enabling a clear view for the surgeon and making the procedure fast. No further coagulation was necessary. No sutures were required. A swab was placed for 30 seconds at the end of the laser treatment. The compliance of the patient during treatment was very good.

No painkillers and no antibiotics were prescribed. The patient’s post-operative instructions were to take no milk products, no alcohol, no smok-
ing, no caffeine and no theine for the day, and not to participate in sports that day. The lip should be left down and cooled. The teeth should be brushed as always. Repeat visits after one day, six days and four months.

Postoperative findings after one day showed no complications. No bleeding, no pain and no swelling appeared. The healing process was very fast, showing fibrine coating after one day and good vascularisation. There was slight scarriing after four months. The spacing reduced by about 1.5 mm incisally. The patient was referred back to the orthodontist.

__Conclusion__

Laser-assisted dental surgery has benefits compared with conventional treatment methods: selective, minimally invasive, less traumatic, and less pain. There was almost no bleeding and therefore a good, clear view for the surgeon during the treatment.

The bactericidal and biostimulating effect of the laser resulted in very good and rapid healing. The advantages for this patient were obvious: less post-operative pain, no swelling. In addition, no sutures were necessary and a further appointment for suture removal was not needed.

The compliance and acceptance of the child was high. Laser-assisted frenectomy in pediatric dentistry following the Laserkids clinical procedure is a gentle treatment option._

__References__


__contact__

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Use of the Er,Cr:YSGG and Er:YAG lasers in restorative dentistry

**Introduction**

In 1989, Keller and Hibst illustrated the potential of the Er:YAG laser (2.94 µm wavelength) for the effective ablation of dental hard tissues. As a result, there was new development and marketing of free-running, mid-infrared wavelength lasers during the 1990s. Such laser wavelengths were complementary to target tissue elements, enabling clinically significant ablation rates that did not cause pulpal or collateral thermal injury when using proper energy levels. The erbium chromium YSGG (2,780 nm) and the erbium YAG (2,940 nm) laser wavelengths are well absorbed by water and hydroxyapatite contained at different component rates in hard tissue and appeared to offer safe use in cavity preparation.

The vaporization of interstitial water provided by the Er,Cr:YSGG and Er:YAG lasers results in an explosive dislocation of target hard tissue. These laser wavelengths offer several advantages for restorative dentistry, including precision, selective ablation of target hard tissue and carious lesions, less conductive thermal stimulation of the pulp, reduced collateral damage that might result from rotary instrumentation (such as tactile and thermal damage), and so forth.

This article examines the principles for using the Er,Cr:YSGG and Er:YAG lasers in clinical restorative dentistry.
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dentistry and reviews the literature concerning different aspects of laser energy on hard tissues.

_**Basic considerations**_

Using a laser requires delivering light energy of sufficient value to effect tissue change without causing unwanted collateral thermal damage by conducting excess heat into the surrounding tissues.6 To do this, it is essential to establish a rate of interaction that is commensurate with a time frame that enables such interaction to be clinically acceptable in terms of total time required for each procedure.

The rate and the speed of dental hard tissue ablation depends on the appropriate laser energy, in addition to the wavelength, pulse duration, pulse shape, repetition rate, power density, thermal relaxation time of the tissue, and delivery mode.6–8

The speed of ablation is also affected by the fluoridation of the tissue, the presence of ablation products and the incident angle of the delivery tip relative to the tooth: Placing the delivery tip parallel to the axis of the enamel prisms, in order to access the interprismatic, higher-water content structure maximises the speed of ablation. Ablation is more efficient and heat transfer is minimized when the pulse width is reduced and peak power values rise.9–11

In addition, the use of sharp curettes to remove gross caries can reduce laser use to an acceptable time frame. The depth of laser ablation depends on the parameters utilized, principally on the energy used per pulse and the number of pulses delivered. To avoid and prevent cracks or structural modifications, the tip (where present) must not touch the surface, nor should excessive energy be applied. When relatively high fluences are involved, it is possible that the laser light is absorbed by the mineral, which results in ablation and/or disruption of the mineral with some structural modification.12–14

Many conflicting factors interfere with the recommended power value for laser-assisted ablation of dental hard tissue. The ablation threshold of human enamel has been reported to be in the range of 12–20 Joules/cm² for dentin, 8–14 Joules/cm² for the Er:YAG and Er,Cr:YSGG laser wavelengths. For an average laser delivery spot-size, using a free-running pulsed emission mode, this may equate to approximately 150–250 mJ/pulse.

It is recommended that the clinician follow manufacturer’s guidelines in establishing laser treatment protocols for a given laser, keeping in mind the differing operating parameters of air/water/spot size and any power losses that may occur within differing delivery systems.

_**Use of co-axial water spray**_

The use of water spray with mid-infrared lasers enables working on hard tissues with thermal increases of less than 5 degrees Celsius: It is essential to prevent debris from accumulating at the bottom of the cavity, which can lead to conductive heat damage.15–16

The effects of excessive incident power, the build-up of ablation products, which cause thermal damage to the target and surrounding tissue, and the removal of such products by means of a co-axial water spray, have been discussed in the literature.17–21 The affinity of mid-infrared laser wavelengths with water contained in the tissue enables selective ablation, in which greater absorption takes place in demineralised tissue, which is richer in organic material and has a higher percentage of water. This absorption
offers some protection to the sound underlying tissue while reducing penetration from the beam. To prevent build-up, ablation products should be removed by means of a co-axial water spray. If water spray is not used, laser light is then absorbed by the mineral and the hydroxyapatite crystal themselves may be heated above their melting point.

In consequence, either some disruption of the crystal structure occurs with subsequent resolidification in a different form, or direct ablation of the mineral occurs, but there also is conductive heat transfer to interstitial free water. Relatively high fluorences are needed at these wavelengths for this transfer of heat to occur. A micro-cavitated surface that may enhance retention of composite resin can be achieved by using Er,Cr:YSGG or Er:YAG lasers to irradiate enamel and dentin but water spray must be utilized.

Conversely, the absence of water spray can lead to cracks in enamel or melted dentin, resulting in un-substained enamel prisms and flat adhesion dentin surfaces with closed tubules. The negative effects could lead to marginal leakage and non-adhesion of the composite material.

Exceptions to using water spray

There are two clinical situations that can be treated with lasers without the simultaneous use of a co-axial water spray: desensitizing technique and pulp capping. The desensitizing technique must be done without water and without the laser tip making direct contact with the tooth.

In addition, the laser should be used for a short time only and with low power (few pps, very long release time, few mJ). For pulp capping, the technique must be carried out without water but with air-cooling and the tip must touch the surface for only a few seconds.

Cavity margin considerations

A succession of studies has identified the fragility of laser-irradiated enamel, relative to the stability of the post-restoration margins. Studies have proposed a combined approach of laser-irradiation and acid-etch techniques to overcome such potential problems. It may be necessary to remove grossly overhanging and unsupported enamel with a rotary bur, scalpels or an ultrasonic device to expedite cavity preparation or provide a stable post-restoration margin.22–27

Acid–etch considerations

Er:YAG laser irradiation produces a surface visually similar to an acid-etch pattern but without a smear layer. While the surface produced by the Er:YAG laser is similar to the conventionally prepared, etched enamel surface, it still requires acid etching to obtain an equivalent bond strength. The use of acid etching for enamel and dentin surface modification must be carried out each time before bonding application.

Laser irradiation of enamel is not a valid alternative to acid-etching pre-treatment for resin composite materials adhesion. As a result, Er,Cr:YSGG and Er:YAG irradiation alone cannot be recommended as a viable alternative to acid etching.28, 29

Avoidance of dehydration

Before bonding application, the dentin surface must not be dehydrated: The use of lasers without
water-mist before composite restorations is no longer recommended. Laser ablation does not produce a smear layer, which would impede adhesion to laser-irradiated surfaces. Nevertheless, a selective ablation of organic tissue occurs when these lasers are used; as a result, there is less collagen left to be exposed — or hybridized — after laser conditioning of dentin, indicating that acid-etching and water-spray after laser treatment is advisable.30, 31

Choice of composite restorative materials

The choice of composite materials must be made on the basis of the depth and width of dentin craters. The laser irradiation of enamel and dentin by Er,Cr:YSGG or Er:YAG lasers results in a “super-rough,” micro-cavitated surface that may predispose to ideal retention of composite resin but it is necessary to remember this difference from laser to bur in the choice of materials. The use of composite nano or micro-filled is fundamental to properly restore laser ablated cavities. Whenever possible, it is advisable to first use a layer of flowable composite. The seal at enamel margins in Er,Cr:YSGG and Er:YAG lased cavities depends on the resin composite formulation of the corresponding adhesive.32, 33

Isolation and safety considerations

A rubber-dam isolation technique must be used in every procedure to maintain decontamination provided by the laser. Safety measures should include the use of specific protection glasses for the doctor, the assistant and patient — and the use of appropriate facemasks to avoid plume aspiration, high-speed aspiration of plume and debris. In addition, the dentist must use non-reflecting instruments. Magnification is recommended to improve the dentist’s control of his or her work.

Summary

The Er,Cr:YSGG laser has an active medium of yttrium-scandium-gallium-garnet doped with erbium and chromium ions and emits free-running pulsed laser energy at a wavelength of 2,780 nm. The Er:YAG laser has an active medium of yttrium-aluminium-garnet doped with erbium ions and emits free-running pulsed laser energy at a wavelength of 2,940 nm. These wavelengths have a high absorption in water, which makes their application appropriate when ablating oral soft tissue as well as dental hard tissue.

Advantages of using these laser wavelengths in restorative dentistry include precision, selective ablation of target hard tissue and carious lesions, reduced collateral damage that might be caused by rotary instrumentation (tactile and thermal damage), less conductive thermal stimulation of the pulp, no vibrations, and so forth.

However, it is essential to apply knowledge and accepted laser settings and modes of application and to follow the clinical aspects and rules to obtain the best results. Using these lasers and co-axial water spray simultaneously is always advisable, with the two clinical exceptions of the desensitising technique and pulp capping.

Other main points to consider are the cavity margins that need to be finished, the use of acid after laser treatment that permits the best adhesion, and the choice of composite materials, which must be based on the surfaces produced by the laser treatment. Specific safety is necessary when using these devices._

Editorial note: The complete literature list is available from the author.

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Diode-laser-assisted combination therapy of a lip haemangioma

Author_Georg Bach, Dr med dent

As a general rule, haemangioma, also referred to as a "blood sponge," is a broader term for many different vascular abnormalities. The treatment of haemangiomas, especially in dental practice, requires a clear distinction between congenital vascular tumours and vascular malformations.

Congenital vascular haemangiomas are relatively rare in dental practice. They occur in babies and toddlers and show a typical three-phase course: The initial phase is often marked by massive growth ("proliferation phase"), and the subsequent remission phase is then followed by an obligatory regression ("regression phase"). The typical three-phase clinical course usually enables a unique differentiation from a malformation, which contrary to congenital haemangiomas, is often encountered in dental practice and affects primarily the lip area.

A multitude of possible treatment options is mentioned for treatment of a vascular malformation of the lip.

Surgical treatment
Owing to intra-surgical complication rates (haemorrhaging), which are the exception to the rule today, surgery is only carried out in special clinics, especially if functional disruptions are expected because of a rapidly growing haematoma and non-surgical treatments do not promise success.

Fig. 1. Equipment needed for creating an ice-block: toothpick, rubber bands, fibre holder and cut-off bottom portion of a single-serving yogurt container.

Fig. 2. To prevent the fibre-holding channel from icing up, its end is sealed with sticky wax, which can also be used for placement on the bottom of the plastic container.

Fig. 3. To affix the fibre holder securely, it is stabilized with rubber bands and a toothpick, which serves as a holding strip.

Fig. 4. The container is filled with water.

Fig. 5. An ice-block with a fibre holder is molded in the freezer.
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Fig. 6. Hemangioma on right half of lower lip.

Fig. 7. The fibre can be pushed through the fibre channel in the ice-block to the lip haemangioma that requires treatment.

Fig. 8. Pre-surgical cooling around the haemangioma using an ice-block without a fibre holder.

Modified surgical procedure according to Prof. H. Deppe:
- tapping of the haemangioma;
- aspiration of the blood;
- injection of polyether impression material;
- hardening of the material; then
- surgical removal of the haemangioma into which the impression material has been injected with considerably reduced intra-surgical haemorrhaging.

Cryotherapy
This treatment is usually successful in haemangiomas with a thickness of up to 5 mm, with very few side effects. However, cryotherapy for the lip is the subject of controversial discussion because of the risk of scar formation.

Laser-assisted treatment
Nd:YAG and diode lasers are primarily used here; isolated cases of treatment with yellow-light and argon lasers are also described in the literature. Medication (corticosteroids, in some cases also cytostatics) often used in the treatment of other haemangiomas is not relevant in the case of lip haemangiomas.

This report describes a combination treatment consisting of pre-surgical cooling and intra-surgical diode-laser use with simultaneous cooling with an ice-block into which the fibre is directed.

Goal
Diode lasers are the most common dental lasers in German dental clinics and dental clinics worldwide. These lasers are used primarily and very successfully for combating biofilm in the treatment of peri-implantitis, marginal periodontitis and endodontics.

Diode-laser light with a wavelength of 810 nm is absorbed extremely well by dark surfaces and thus also by blood. Use of a diode laser for the treatment of haemangiomas in an ideal situation, that is, with controlled thermal coagulation, would thus be conceivable. Reports on treatment with other laser wavelengths (Nd:YAG, CO2, Argon and yellow-light lasers), which have been used for treating haemangiomas for years, often mention tissue necrosis and post-surgical complications after laser treatment. These consequences are undesirable for tissue in aesthetically relevant areas, which most certainly include the lips, and are viewed critically by patients.

The central idea of the treatment of lip haemangiomas with diode-laser-assisted therapy is to combine the excellent absorption of diode-laser light with a wavelength of 810 nm and simultaneous cooling with an ice-block in order to keep the side-effects described to a minimum or, ideally, to prevent them.

Making a combination ice/fibre-holding block
The ice-block should be an ideal size and shape. Based on our experience, this can easily be achieved by using the cut-off bottom portion of a single-serving drinkable yogurt container as a mould for the ice-block. In order to direct the fibre through this ice-block, a disposable fibre holder (diameter must fit the fibre to be inserted) must be placed with the aid of a toothpick and rubber bands in such a way that it is centred and in contact with the bottom of the container.

The container is then filled with water and placed in a freezer to freeze the block. A second (and possibly third) ice-block without a fibre holder should be created for the pre-surgical "cooling phase," which should occur approximately 10 minutes prior to the laser treatment. The block’s bulbous form conforms ideally to the shape of the lips.

Clinical application
Prior to the laser-assisted treatment, small amounts of local anaesthetic (approximately 8 x 0.1 ml) are injected around the haemangioma. The number of areas in which anaesthetic is injected can be reduced slightly in the case of smaller haemangiomas (this treatment is not suitable for very large lip haemangiomas).

Immediately after the local anaesthetic, the ice-block without fibre is used to cool the area for 10 minutes (if possible, covering the entire haemangioma). The ice-block is then exchanged, the ice-block with the integrated fibre holder is placed onto the haemangioma, fitting as closely as possible, and the laser fibre is then pushed through. Fibres with a diameter of 400 µm have proven to be suitable for this application; they are
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a good compromise between the achievable surface effect and minimum tissue trauma.

In the subsequent application of the laser, the fibre penetrates the lip surface and is inserted into the haemangioma up to a maximum of 5 mm. Ideally, the final position of the fibre will be in the centre of the haemangioma surface. After a 10-second application of the laser, the fibre is removed and the position of the ice-block adjusted a little; then the same procedure is followed on a different, untreated area of the haemangioma. Treatment is completed when all areas of the haemangioma have been treated.

It is recommended that a second ice-block with fibre holder be available as a backup to ensure that the haemangioma is constantly and perfectly covered. During treatment, the patient is covered with absorbent sheets to catch the melting water from the ice-block running from the lip to the ventral area.

**Laser parameters**

A diode laser that uses high pulse or digital pulse technology (elexxion) and emits laser light with a wavelength of 810 nm was used for combination treatment of a lip haemangioma. Pulse performance is 30 W at a frequency of 20,000 Hz with a pulse duration of 16 µs.

**Conclusion**

The combination treatment presented here, which entails simultaneous cooling during the use of a laser for treatment of a lip haemangioma, is a high-quality alternative to established procedures.

Its application is fairly simple and the advantage is that there are only minimal post-surgical complaints (minimal pain or swelling, very little scarring). Laser-assisted treatment of a lip haemangioma using a diode laser has distinct advantages compared with lasers with other wavelengths for treatment of medium-sized and small haemangiomas. The application of diode lasers is limited in the case of extensive haemangiomas.

The prevalence of diode lasers in dental, oral, and maxillofacial surgical clinics supports the availability of this treatment.
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- the complete literature list and
- contact info (bio, mailing address, e-mail address, etc.)

must be combined into one text document. Please do not submit multiple files for each of these items.

In addition, images (tables, charts, photographs, etc.) must not be embedded in the text document. All images must be submitted separately, and details about how to do this appear below.

If you are interested in submitting a C.E. article, contact us for additional instructions before you make your submission.

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