

LASER APPLICATIONS IN DENTISTRY: AN EVIDENCE-BASED CLINICAL DECISION-MAKING UPDATE

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SUMMARY

Lasers are being widely used in medicine. In the last two decades laser applications in dentistry have been promoted and backed by randomized controlled clinical trials and laboratory based research. Advances in Laser technology have been accepted in many walks of our daily life. The biological friendly Lasers have been developed and applied for clinical uses in dentistry.

The primary aim of this review is to update general and specialist dental practitioners about the recent advances of various lasers uses in dentistry. The updated review has covered many aspects of lasers, e.g, Physics of lasers, classifications, wavelengths, types, clinical uses of surgical and non-surgical lasers in dentistry, including Implant dentistry. Finally, the Laser safety measures in clinical practice, advantages and disadvantages based on Evidence-based literature review have been discussed.

The secondary aim of the evidence based review on Lasers is to enable general dentists to make good decision when buying the equipment, based on scientific rationale rather than influenced by marketing forces. One should be technology friendly rather than technophobic one should however, be careful in selecting this equipments, as there are advantages, and disadvantages in the use of Lasers both for the patients and the operators. The clinical decision should be based on evidence-based scientific rationales, affordability and predictable outcomes.

Key words: *Laser applications in Dentistry, Evidence-based, Clinical decision making, Laser safety.*

INTRODUCTION

LASER is an acronym for Light Amplification by Stimulated Emission of Radiation. Maiman¹ generated the first laser beam using a ruby rod. In 1961, the first gas and continuously operating laser was described by Javan et al.²

The first laser was developed in 1960, and shortly thereafter, researchers looked at the possibility of using this new medium in dentistry. Stern and Sognnaes³ were pioneers in this area. In the mid 1960s, they were very interested to know the effects of laser on dental hard tissues and published many articles on the surface alterations that occurred after laser irradiation. Goldman et al.⁴, experimented with one of the first ruby laser required significant energy to create a

clinical effect and that the thermal damage was too great to consider this laser as a clinical instrument. Hibst and Keller⁵ theorized that because of the high absorption of Er:YAG laser in water, it would be a good candidate for cutting dental hard tissue. Much of their research led to the development of the laser that is now used in dentistry. Featherstone and Nelson⁶ have extensively researched the surface effects laser (9.3-9.6 μ m), and showed that these wavelengths have a very high affinity for hydroxyapatite.

A laser is a device that emits light through a process called stimulated emission⁷, featuring collimated (parallel) and coherent (temporally and spatially constant) electromagnetic radiation of a single wavelength. When it reaches biological tissues, the laser

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light can be reflected, scattered, absorbed, or transmitted to the surrounding tissues. The emission wavelength mainly influences these modes of interaction in the target tissue and must therefore be selected with caution for any diagnostic or therapeutic interventions.

Water absorption is the most important factor influencing the conversion of energy for surgical lasers operating in the infrared spectrum. Most tissues are 60-80% water, as a result, the degree of water absorption determines the laser's ability to penetrate biological tissue. To understand the different mechanisms of action for the various laser systems, as well as the wavelength suitable for each treatment modality, it is necessary to know the degree of water absorption for each wavelength.⁸ In terms of tissue penetration, lasers can be classified into two types based on wavelength: those that penetrate deep into the tissue (such as Neodymium Nd:YAG and diode laser) and those that are absorbed superficially, including CO₂, Er:YAG, and Er,Cr:YSGG lasers.

The laser systems developed to date are classified according to the active medium that is stimulated to emit photon energy. This divides laser systems into solid-state (Nd:YAG, Er:YAG, Er,Cr:YSGG), gas (CO₂, Argon, Helium-Neon), diode, excimer, and dye lasers. Laser systems also can be classified by their maximum output level, that is, low output (soft) or high output (hard). Lasers may also be classified according to their oscillation mode (continuous or pulsed wave). The pulsed-wave mode can be used by producing independent pulses (a free-running pulse), as with the Nd:YAG, Er:YAG, and Er,Cr:YSGG laser, or by interrupting a continuous wave (gated or chopped pulse), as seen in CO₂ and diode lasers. The digital pulse mode of diode lasers may be increased to an extremely high frequency by switching the electric current on the base compound on and off digitally, reducing the thermal side effect considerably.⁹ **Please see table 1 for** Characteristics of Lasers used in dentistry.

TYPES OF LASERS

There are currently 24 indications for the use of dental lasers, a phrase that means that a specific marketing clearance was granted to a company by the United States Food and Drug Administration (FDA) for dental treatments. The company must submit evidence to the FDA that its laser instrument will perform a certain procedure both safely and effectively. **Please see table 2 for** FDA approved lasers for clinical use in dentistry.

LASER APPLICATIONS IN CLINICAL DENTISTRY

Diagnostic/curing lasers: The DIAGNOdent is used for caries and calculus detection by emitting a non-ionizing laser beam at a wavelength of 655nm (at a 90 degree angle) toward a specific darkened groove on the occlusal surface of a patient's tooth where bacterial decay is suspected, or along the long axis of a root surface to detect the presence of bacteria-laden calculus. This diagnostic technology, in which the photons of this laser wavelength are absorbed into any existing bacteria in these areas of the patient's tooth is called *laser-induced fluorescence*. The instrument's digital display indicates the number of bacteria in this area of the tooth and may correspond to the extent of decay or existence of calculus.¹²

Mucosal surfaces evaluation: While laser-induced fluorescence enables a clinician to diagnose the presence of bacteria, it is the absence of fluorescence that provides the diagnostic basis for the VELscope device. The VELscope makes it possible to scan the soft tissues of the mouth, allowing a trained eye to see an otherwise undetectable mass beneath the patient's soft tissue epithelial surface. The device uses changes in the pattern of blue light-induced fluorescence that result from disease processes occurring in the oral mucosa, including underlying oral cancer.¹²

Optical impressions: Computer-aided design/computer-aided manufacture (CAD/CAM) technology uses computerized laser systems to assist with the fabrication of custom restorations, such as inlays, onlays, and crown and bridge prostheses.

CAD/CAM technology eliminates the need for conventional intraoral impressions materials, instead, laser scanners take an optical impression of a prepared tooth and the opposing dentition and take a bite registration to produce an interactive three-dimensional image. This three-dimensional laser-based imaging technology, enables the dentist to take an optical impression and create a computer file with this data. A virtual model is created based on the transmitted data and a precise master model is made. The physical model is sent to the laboratory where a final restoration is made.¹³

Optical coherence tomography: Optical coherence tomography (OCT) is a new type of dental diagnostic imaging of both hard and soft tissues that uses an intense, safe laser light beam that is backscattered from the tissue to capture two-dimensional and three-dimensional images.¹⁴

Tables 1-4 and Glossary of Lasers

GLOSSARY OF LASERS.

1. Argon laser – Argon laser
2. CO₂ laser – Carbon dioxide laser
3. Diode laser – Diode laser (or Gallium Arsenide)
4. Er,Cr:YSGG laser – Erbium, Chromium: Yttrium-Selenium-Gallium-Garnet laser
5. Er:YAG laser – Erbium: Yttrium-Aluminium-Garnet laser
6. H:YAG laser – Holmium: Yttrium-Aluminium-Garnet laser
7. Nd:YAG laser – Neodymium-doped: Yttrium-Aluminium-Garnet laser
8. KTP laser – Potassium Titanyl Phosphate (KT₁OPO₄) laser.

TABLE 1: TYPE/CHARACTERISTICS OF LASERS

LASER TYPE	WAVELENGTH	WAVEFORM	APPLICATIONS
Carbon Dioxide	10.6 micrometers	Gated (or interrupted) or continuous	Soft-tissue incisions and ablation*; de-epithelialization of gingiva during periodontal regenerative procedures
Neodymium: Yttrium-Aluminum-Garnet	1.064μm	Pulsed	Soft-tissue incision and ablation*; incipient caries removal
Erbium:Yttrium-Aluminum-Garnet	2.94μm	Pulsed	Caries removal; cavity preparation in enamel and dentin; U.S. FDA clearance for use on cementum and bone; root canal preparation
Erbium, Chromium: Yttrium-Selenium-Gallium-Garnet	2.78μm	Pulsed	Enamel etching; caries removal; cavity preparation; cutting bone in vitro with no burning, melting or alteration of the calcium: phosphorus ratio; root canal preparation
Argon	457 to 502 nanometers	Pulsed or continuous	Curing resins; soft-tissue incisions and ablation*; bleaching
Holmium:Yttrium-Aluminum-Garnet	2.1μm	Pulsed	Soft-tissue incisions and ablation*
Gallium-Arsenide (or Diode)	904nm	Pulsed or continuous	Soft-tissue incisions and ablation*

*Including gingival troughing, esthetic contouring of the gingiva, treatment of oral ulcers, frenectomy and gingivectomy

Photodynamic therapy: Research is ongoing for the treatment of oral cancer using photodynamic therapy (PDT). the advantage of PDT for early carcinoma of the oral cavity is the ability to preserve normal tissues while effectively treating cancers up to 1cm in depth. Clinical studies have demonstrated that PDT is an effective method for the treatment of dysplastic, micro invasive, and early forms of cancer. Mang et al¹⁵ used PDT successfully to treat maxillary gingival squamous

cell carcinoma, avoiding the use of surgery or radiation therapy at this point in the management of the disease. The tissue is exposed to a 630nm laser with dye applications and subsequent laser exposures repeated at specific intervals. As a result, these early tumors are resolved with a minimum of side effects compared to conventional radical surgical resection (maxillectomy or mandibulectomy). While direct effects destroy the majority of tumor cells, there is accumulating evidence

TABLE 2: CURRENT UNITED STATES FOOD AND DRUG ADMINISTRATION
MARKETING CLEARANCE FOR DENTAL LASERS¹¹

Type & Wavelengths (nm)	KTP (532)	Diode (810) or (980)	Nd:YAG (1064)	Er,Cr: YSGG (2780)	Er:Yag (2940)	CO2 (10600)	Argon
Hard tissue application:							
• Curing of composites							X
• Tooth whitening	X	X					X
• Caries removal, tooth preparation				X	X		X
• Illumination for caries detection							X
• Illumination for endodontic orifice							
• Soften gutta percha	X						X
• Selective removal of enamel caries			X				
• Removal of filling materials adjunctive to endodontic treatment			X				
• Aid in diagnosis of caries		X					
• Tooth preparation, pulp extirpation, root canal debridement				X	X		
• Cutting and contouring osseous tissue				X	X		
• Apicoectomy surgery				X	X		
• Osteotomy, osseous crown lengthening and osteoplasty				X	X		
• Aid in detection of subgingival calculus		X					
Soft tissue application:							
• Intraoral soft tissue surgery	X	X	X	X	X	X	X
• Aphthous ulcer treatment							
• Sulcular debridement	X	X	X	X	X	X	
• Removal of coronal pulp		X	X	X	X	X	
• Pulpotomy		X	X				
• Treatment of herpetic lesions		X	X	X	X		
• Blood flow measurements		X					
• Coagulation of extraction sites		X				X	
• Laser-assisted new attachment procedure			X			X	
• Reduction of bacterial level inflammation	X						

TABLE 3: CLINICAL STUDIES ON LASER APPLICATION IN THE SURGICAL TREATMENT OF PERIODONTITIS.³⁶

Author and year (reference)	Laser parameters	Study design	Experimental group	Control group	Observation period	Findings
CO2 laser Centty et al. 1997 ³⁷	8W, 20 Hz	RCT, split-mouth design	OFD+Laser irradiation to outer and inner aspects of mucoperiosteal	OFD	Biopsy during the surgery	Laser eliminated significantly more sulcular epithelium than OFD
Er:YAG laser Shwarz et al 2003 ³⁸	ED: 14.5 J/cm2/ pulse 10 Hz	RCT split-mouth design	OFD+Laser+EMD	OFD+EMD EDTA	6 months	No significant difference in clinical improvements between EMO + laser and control
Er:YAG laser Sculean et al 2004 ³⁹	ED: 14.5 J/cm2/ pulse 10 Hz	RCT split-mouth design	OFD+Laser	OFD	6 months	No significant differences between the test and the control
Er:YAG laser Gaspirc et al 2007 ⁴⁰	100, 140 or 180 mJ/pulse, 10 or 20 Hz	RCT split-mouth design	MWF+Laser	MWF	5 years	The test group showed greater reduction of PD and increase of attachment gain than the control

ED energy density, EMD enamel matrix derivate, MWF modified Widman flap surgery, OFD open flap debridement, PD pocket depth.

TABLE 4: LASER WAVELENGTH AND THEIR POSSIBLE APPLICATION IN ENDODONTICS.⁴¹

Laser	Procedure
Diode (810-980nm)	Desensitisation, pulp capping, root canal disinfection
Nd:YAG (1064nm)	Desensitisation, pulp capping, pulpectomy, root canal cleaning and disinfection
Er,Cr:YSGG (2780nm)	Access cavity preparation, root canal shaping, cleaning and disinfection
Er:YAG (2940nm)	Access cavity preparation, pulpectomy, root canal shaping, cleaning and disinfection
CO ₂ (10600nm)	Desensitisation, pulp capping, pulpectomy

that PDT activates the host immune response and promotes anti-tumor immunity through the activation of macrophages and T lymphocytes.¹⁶

LASER APPLICATION IN PERIODONTAL THERAPY

Periodontitis is a chronic inflammatory disease caused by bacterial infection; as a result, it is possible that laser irradiation (which its bactericidal and detoxifying effects) would be highly advantageous for treating

this disease. Some of the technical advantages of employing lasers in periodontal therapy include the ability to disinfect, ease of tissue ablation, hemostasis, and other potential biological effects stimulate or modulate cells and tissues. These advantages occasionally result in better treatment outcomes, such as reduced periodontal pocket depth and greater periodontal tissue regeneration. Lasers also reduce noise, vibration, and trans- and post operative pain, greatly improving the patient's comfort during treatment.⁹

Some commercially available Laser Equipment for dental use

Companies:

- Biolase



- EZ Lase

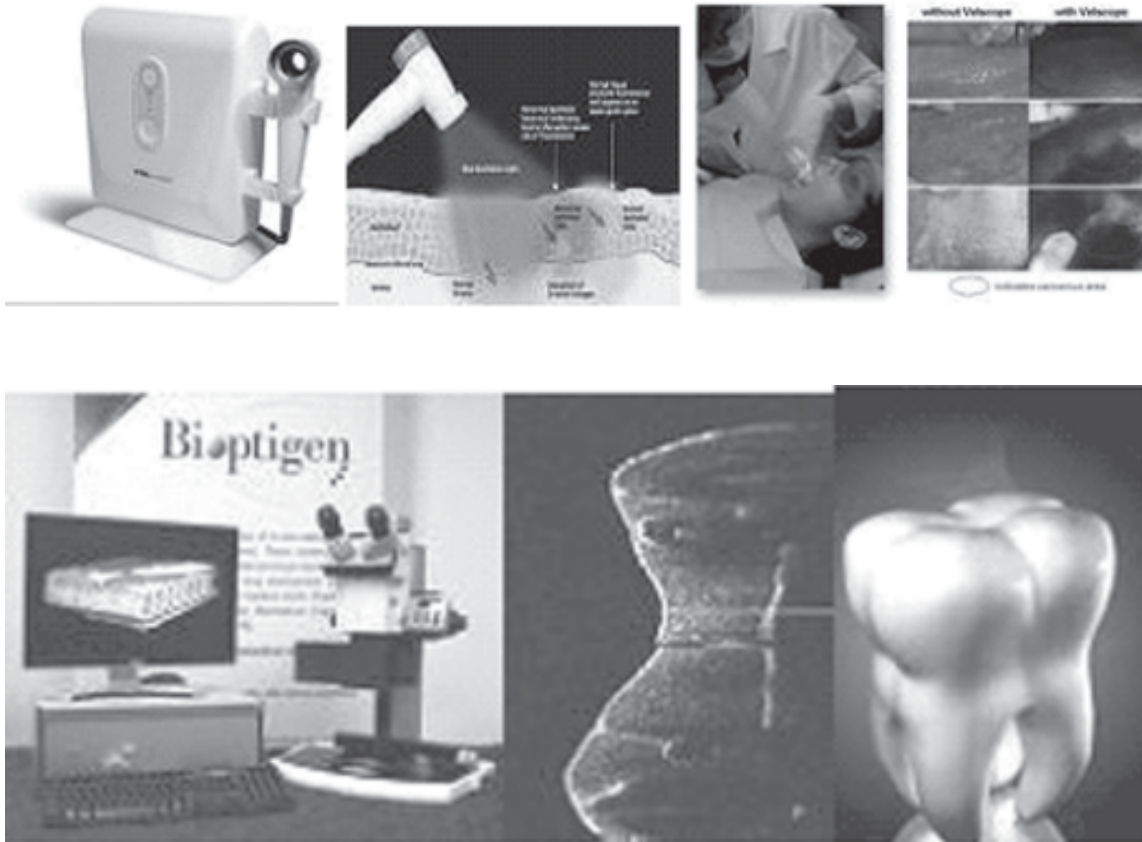


- Dentsply



-DIAGNOdent





a) Laser Non-surgical Periodontal Therapy: The exposed root surfaces of periodontal pockets are contaminated by an accumulation of bacterial plaque and calculus, in addition to bacteria and bacterial endotoxins infiltrating the cementum. High-power lasers are considered one of the most promising new technical modalities for the decontamination of periodontal pockets in nonsurgical treatment due to their strong bactericidal and detoxification effects.¹⁷ In Addition, photodynamic therapy (which utilizes a low-power laser in combination with a photosensitizer) holds great promise as a procedure for decontaminating periodontal pockets.⁹

Diode and Nd:YAG were mainly used for laser-assisted of the periodontal pocket with various degrees of success.¹⁸ However, several studies reported on thermal side effects, such as melting, cracking or carbonization when CO₂ and ND:YAG lasers were used directly on root surface.¹⁹ The Er:YAG laser with a wavelength of 2940nm, this laser provides a capability to effectively remove calculus from periodontally diseased root surfaces without causing thermal side effects to the adjacent tissue.²⁰ Diode laser radiation has been included in an Er:YAG laser device to induce fluorescence in subgingival calculus.²¹ Immunohis-

tochemical characterization of wound healing following non-surgical periodontal treatment, Er:YAG laser radiation was effective in controlling disease progression, and may support the formation of a new connective tissue attachment.²² After one month of healing mean Pocket depth (PD) reduction and Clinical attachment level (CAL) gain was significantly higher in the laser group, a significant difference between groups old not be observed at 4-months examination.²³

The Nd:YAG laser is not appropriate for debriding periodontally affected root surfaces, since the Nd:YAG laser's ability to remove calculus is insufficient and the root surfaces are susceptible to thermal damage when a high energy output is applied.²⁴

Slot at al.²⁵ conducted a systematic review and suggested that there is no evidence to support the superiority of the Nd:YAG laser over traditional modalities of periodontal therapy. Similarly, the CO₂ laser is not appropriate for root debridement, as both calculus and root surface are carbonized instantly.²⁶ By contrast, the Er: YAG laser is capable of removing dental calculus effectively, reacting with the water contained within the structural micropores (as well as in the intrinsic components of the calculus) without

causing significant thermal damage (such as melting or carbonization) to the root surface.²⁷

Schwartz et al.²⁸ reviewed clinical outcomes using a chisel-type laser tip designed especially for the non-surgical treatment of periodontal pockets. This randomly controlled trial used a split-mouth design to compare the results of 20 periodontal patients who received scaling and root planning therapy (SRP) with either an Er:YAG laser or a conventional curette. They reported that laser treatment took less time than conventional therapy; in addition, pocket depths between treatment and laser treatment yielded significantly better results in terms of bleeding on probing (BOP) and (CAL), and the results were maintained up to two years.

Sculean et al.²⁹ compared Er:YAG laser treatment and ultrasonic scaling, reporting equal clinical improvements following therapy. Conversely, Crespi et al.³⁰ reported better result following Er:YAG laser treatment, than Ultrasonic Scaling at 1 and 2 years post-therapy. Derdilopoulou et al.³¹ reported no superior reduction in bacterial number following treatment with the Er:YAG laser in comparison to ultrasonic scaling. When investigating patients perceptions, ultrasonic scaling was more pleasant than therapy with an Er:YAG laser or hand curette instrument.

More recently, Tomasi et al.²³ reported that a site treated with an Er:YAG laser produced faster healing (probing depth reduction and CAL gain) and less discomfort during treatment than an ultrasonic scaled site, although the final clinical outcomes for both treatments were similar.

Disinfection and debridement of complex periodontal pockets is limited when conventional mechanical treatment is used. Complementary therapy with lasers helps to eliminate or inactivate bacterial toxic substances by providing a more extensive disinfection of both root and soft tissue walls of periodontal pockets.³²⁻³³ At the same time, laser therapy may stimulate the surrounding cells, alleviate the inflammatory process, and improve the recovery and regeneration of periodontal tissues through the modulation of cell metabolism and promotion of cell proliferation and differentiation.³³

Laser-Assisted New Attachment Procedure (LANAP) could be associated with cementum-mediated new connective tissue attachment and apparent periodontal regeneration of diseased root surfaces in humans.³⁴

Cobb et al.³⁵ in American Academy of Periodontology Commissioned Review, concluded that there is a great need to develop an evidence-based approach to the use of lasers for the treatment of chronic periodontitis. Simply put, there is insufficient evidence to suggest that any specific wavelength of laser is superior to the traditional modalities of therapy. Current evidence does suggest that the use of Nd:YAG or Er:YAG wavelengths for treatment of chronic periodontitis may be equivalent to scaling and root planning (SRP) with respect to reduction in probing depth and subgingival bacterial populations. However, if gain in clinical attachment level is considered the gold standard for non-surgical periodontal therapy, then the evidence supporting laser-mediated periodontal treatment over traditional therapy is minimal at best. Lastly, there is limited evidence suggesting that lasers used in an adjunctive capacity to SRP may provide some additional benefit.

b) Laser in Surgical-Periodontal Therapy: Laser can cut, ablate and reshape oral soft tissues easily; in addition, they promote hemostasis by coagulating and occluding small blood vessels instantly, which helps to keep the surgical field clear of blood and fully visible. The bactericidal effect of laser is another benefit; in addition, it has been reported that laser surgery reduces pain, swelling, and wound contraction while allowing wounds to heal faster. In periodontal surgery, it is necessary not only to debride the root surfaces but also to efficiently remove the diseased granulated tissue from the bone defects, correct the contour of the alveolar bone, and disinfect the surgical field. The curettage of all diseased granulated tissue is indispensable for the regeneration of the bone tissue; however, attempting to access the bottom of narrow intrabony defects and root furcations with conventional tools can be extremely difficult, time-consuming, and ineffective. The hand chisels and rotary cutting instruments used for alveoloplasty cause significant noise and vibration that can affect the patient's stress levels; in addition, these instruments cannot access the molar region easily.⁹ **Please see table 3 for** clinical studies on laser application in the surgical treatment of periodontitis.

LASER APPLICATION IN ENDODONTICS

All current dental laser wavelengths have been used in wide range of endodontic treatments, either to aid the preparation stages or obturation techniques of root canal therapy or to alleviate low-grade pulpal

injury. **Please see table 4 for** Laser wavelength and their possible application in endodontics.

In a study of 83 patients with 93 teeth treated through a pulp capping procedure, Santucci reported survival rates over 54 months of 43% in teeth treated with calcium hydroxide/resin cement as opposed to 90% in those treated with Nd:YAG laser and a similar capping cement.⁴² Moritz et al. reported a tooth vitality two-year survival rate of 93%, using a super-pulsed CO₂ laser under similar conditions.⁴³

Access/shaping of canal walls and morphological changes in structure: The accepted interaction of the Er:YAG and Er, Cr:YSGG lasers with dental hard tissue makes these wavelengths ideal for removal of dentine overlying the pulp chamber. Comparative studies on two common bacterial pathogens, *Escherichia coli* and *E. faecalis* have shown that the more complex cell wall of the latter can reduce the effectiveness of laser action. One study by Schoop et al. concluded that diode 810nm and erbium YAG were better placed to ablate significant numbers of *E. faecalis* organisms.⁴⁴

Sealing with gutta percha obturation material: A number of studies have been carried out to establish the usefulness of lasers in the softening and obturation of gutta percha in the root canal. However, the development of thermoplastic materials and the instruments for such purposes has rendered such application comparatively time consuming and expensive.

SOFT AND HARD TISSUE SURGERY

Soft tissue: Overall, dental lasers are relatively easy to use, as long as the clinician has been trained properly. It is important to understand that lasers function with an “end cutting” action (that is, laser energy is emitted from the end of the laser), while most other dental instruments are “side cutting”, with the cutting edges of abrasive surfaces located on the lateral surface. Although most soft tissue treatments heal by secondary intention, the postoperative course usually is uneventful.

There are specific soft tissue indications for the clinical use of lasers, including anterior gingival esthetic recontouring, gingivectomy/gingivoplasty (for crown lengthening procedures), operculectomy, removal of epuli, incisions when laying a flap, incision and drainage procedures, frenectomy, vestibuloplasty, coagulation of extraction sites, treatment of herpetic and recurrent aphthous ulcer lesions, uncovering of an implant, pre-impression sulcular retraction, and abla-

tion intraosseous dental pathology (such as a granuloma or an abscess). Other excisional laser procedures involve the removal of soft tissue targets that may appear as benign lesion (such as fibromas or papillomas) on the lip, tongue buccal mucosa, or palatal area, the removal of coronary pulp as an adjunct to root canal therapy, excisional biopsy, and sulcular debridement.⁴⁵

Hard tissue lasers: At present, erbium lasers are the only hard tissue laser wavelengths available commercially. The main chromophore for erbium laser is water, although they also are well absorbed in carbonated hydroxyapatite, a component of natural tooth structure and bone. These inherent absorption qualities allow erbium lasers to ablate tooth and bone. Erbium lasers are unique in that they are the only lasers that can cut both hard and soft tissues.⁴⁶ The erbium lasers ability to remove composite restorations is due to their photonic absorption in the water that exists within all composite restorations.

DENTAL LABS/PROSTHETICS

Dental Laser Welding. Laser welding is an advantageous method of connecting or repairing metal prosthetic frameworks because there are fewer effects of heating on the area surrounding the spot to be welded, and no further procedures, such as those used for conventional soldering, are necessary. Laser welding has been increasingly applied for fabricating the metal frameworks of prostheses and for other procedures, such as recovering the metal ridge and cusp, blocking holes on the occlusal surfaces after excess occlusal adjustment, thickening the metal framework, or adding contact points after excess grinding and adjusting of the crown margins.⁴⁷

LASER IN IMPLANT DENTISTRY

Surgical lasers can be used in a variety of ways with regard to implantology, ranging from placement, second stage recovery and gingival management, through to the treatment of peri-implantitis. Within this range of usage, dependant on wavelength employed, exists the ablation of target tissue and the ability to reduce bacterial contamination.

There is a general acceptance that lasers are capable of accurate cutting of materials and tissue, there is no evidence-based advocacy as to the use of any laser wavelength in producing a fully-prepared osteotomy site for the placement of root-form dental implants. However, there are anecdotal reports of the

use of erbium YAG and erbium YSGG lasers to establish a controlled incision of overlying gingival tissue and to initiate a breach of the cortical bone plate, prior to the use of conventional implant drills. Such techniques, although intrinsically correctly based on predictable laser-tissue interaction, run the risk of skepticism amongst practitioners more allied to a conventional surgical approach to implant placement.³⁷

The YSGG laser has assisted in speedy healing, decreasing postoperative pain, and increasing bone to implant contact. Lasers have been FDA-approved for cutting enamel, dentin and soft tissue. For implant dentistry, laser can be used in cutting flap preparations, detoxifying the osteotomy site, starting regional acceleratory phenomenon (RAP), tissue welding, accelerating angiogenesis⁴⁸ and in promoting biomodulation to help repair damaged cells while reducing pain. An easy application of the YSGG laser is the ability to bring the soft-tissue edges together using heat. This is referred to as "tissue welding". The welding together of tissue is accomplished with a uniform heating of 70 to 80 degrees centigrade, where there is adherence between the layers. The layers stick together because of the collagen molecule's helical unfolding and intertwining with adjacent segments.⁴⁹

Laser in peri-implantitis: The significant reduction in bacteria on the implant surface and the peri-implant tissues during irradiation and the cutting effects associated with coagulation properties of the lasers are the main reasons for laser application in the treatment of peri-implant lesions and the successful long term-prognosis of failing oral implants. Bacterial aggregation begins in the soft tissue around the implant neck, and the bacteria may penetrate the implant abutment connection. The inflammation spreads apically and causes vertical and horizontal bone loss. This bacterial infection around the implant is considered to be similar to periodontal disease.⁵⁰ Specifically, putative, periodontal pathogens have been detected, and *Porphyromonas gingivalis*, is found to be in very high proportions. Previous *in vitro* microbiological studies have shown a significant reduction in periodontopathogenic bacteria on implant surfaces when implants are irradiated with different high-intensity (surgical) lasers, or low-intensity (soft) lasers using photosensitizers.

Romanos et al.⁵¹ investigated the bactericidal effect of the continuous wave CO₂ laser, on sandblasted titanium implant surfaces contaminated with *P.*

gingivalis and also showed a significant reduction in *P. gingivalis* after CO₂ laser irradiation of implant surfaces.

Kato and colleagues⁵² showed that the CO₂ laser may have significant bactericidal effect, reducing periodonto-pathogenic bacteria.

Romanos and Nentwig⁵³ demonstrated the successful treatment of peri-implant defects using CO₂ laser in combination with bone grafting with autogenous or xenogenic grafts. Complete bone fill was observed radiologically in all infrabony defects after the use of xenogenic materials in all sites treated with autogenous bone grafts, and at least two-thirds of the bony defect had filled with bone due to some bone graft resorption over time.

An *in vitro* study with different implant surfaces⁵⁴ has shown that 980nm diode lasers using high power settings (10 W) do not damage titanium surface texture. Further, clinical indications for diode laser can be the removal of peri-implant overgrowths as well as decontamination of implant surfaces before augmentative procedures.

In contrast to the promising results of the CO₂ laser and diode laser, Nd:YAG laser leads to sufficient decontamination, in terms of sterilization of the implant, but also significant changes (melting and crater-like formation) of the implant surface. Furthermore, a significant temperature increase during laser irradiation has also been reported. For these reasons the application of Nd:YAG laser for peri-implantitis is contraindicated. Several studies have demonstrated that the Er:YAG laser cuts bone precisely, with minimal thermal damage of 10-15µm.⁵⁵

Kesler et al.⁵⁶ demonstrated that the Er:YAG laser could promote the growth of new bone around titanium implants and better osseointegration than with the conventional osteotomies. Sasaki et al.⁵⁷ demonstrated that surfaces prepared by Er:YAG laser revealed only minimal changes without severe thermal damage, limited to a width of approximately 30µm, microstructural changes of the original apatites, and reduction of the organic matrix. Pourzarandian and co-workers⁵⁸ presented a histological and electron microscopy evaluation of bone formation using the Er:YAG laser, the conventional bur, and the CO₂ laser, in the calvarial bone of rats. The initial healing following Er:YAG laser irradiation was faster. In contrast to these studies, Schwarz et al.⁵⁹ observed safe healing after Er:YAG

laser osteotomy, but the osseointegration of the implants was no better than that in the conventional osteotomy.

Promising results in the treatment of peri-implantitis have been demonstrated histologically in a study by Takasaki et al.⁶⁰ Experimentally induced peri-implant infections were treated with Er:YAG laser and compared with curette group. The study showed that there were better results and a tendency to produce greater bone-to-implant contact (re-osseointegration) when the Er:YAG laser was used.

LASER IN RESTORATIVE DENTISTRY

Dentinal Hypersensitivity (DH): A combination of dental laser with dentin bonding agents has been reported to be an efficient method for improving dentin bonding. Theoretically this combination could provide better and more lasting occlusion of the dentinal tubules, although robust evidence to support this assertion is lacking. Vlacic et al⁶¹ reported the utility of using a laser-activated fluoride therapy to protect enamel from erosive challenges that could cause dental exposure and hypersensitivity. Unfortunately, these were also *in vitro* studies that have yet to be tested in clinical setting. Kimura et al⁶² in a review of the literature from 1985-2000, ranged the effectiveness of laser in the treatment of dentine hypersensitivity from 5-100%, dependent upon wavelength and fluence. The most commonly explored lasers are the low-level diode (HeNe 633nm, GaAlAs 810nm) group and moderate power and Nd:YAGG. Of these, the use of Nd:YAG wavelength appears to be more successful.

Some of the clinical studies using various lasers for treatment of DH have reported very encouraging results. However, additional studies are needed to conclusively demonstrate the utility and safety of such interventions.

LASERS IN PEDIATRIC DENTISTRY

Historically, oral soft tissue surgery on infants and young children was completed in the operating room under general anesthetic agent. Traditional methods of oral surgery using scalpels or electrosurgery may produce significant postoperative discomfort and require sutures and prolonged healing. Lasers provide a simple and safe in-office alternative for children while at the same time reducing the chances of infection, swelling, discomfort, and scarring.

Pulpal Analgesia: In selected patients, using the 660nm laser probe can achieve adequate pulpal analgesia.⁶³ Successful analgesia may allow a dentist to use a high speed drill to prepare a class II restoration without the need for any local anesthesia. Success in primary molars varies from 50-75%. Success in bicuspid varies but is greater than that found in permanent molars. Analgesia effect may be effected by things such as pigmentation of the patient gingival tissue, because the diode may react with the pigment in the tissue rather than be absorbed by the pulpal tissue.

Maintaining pulpal vitality after trauma: In young patients where an anterior primary central or lateral incisor has received a traumatic injury, placing the 808nm probe over the root may prevent the tooth from devitalizing.

Healing of soft tissue trauma: Patients who fall and receive facial lacerations⁶⁴ and swelling benefit from placing the laser/light-emitting diode (LED) unit over the area for approximately 3 minutes and placing the 660 or 808nm probe over the most injured are for 1 to 2 minutes, helping to heal the lesions more quickly and with less post trauma discomfort.

Controlling gag reflex: During the taking of intraoral radiographs or during intraoral examination, some patients may gag in extreme cases vomit. Using the 3 J to 4 J of energy with the 660nm probe placed over the P-6 acupuncture point on each wrist may prevent the gag⁶⁵ from occurring.

Treatment of herpetic type lesions: One of the most painful and debilitating intraoral lesions a child can develop is primary herpes⁶⁶ or a similar herpetic-like stomatitis. Placing the laser/LED unit in mode 3 for 3 minutes and the 880nm probe for 1 minute over large lesions reduces the disease outbreak period in many children.

Orthodontic and temporomandibular joint discomfort: Patients having orthodontic adjustments or having temporomandibular joint discomfort may experience relief using the laser/LED unit⁶⁷ over the area for 3 minutes using mode 3.

Lingual frenum revisions: Revision of an abnormal lingual frenum attachment is one of the most undertreated developmental abnormalities of the oral cavity.⁶⁸ Treatment with a diode laser or the Erbium family of lasers significantly reduces postoperative discomfort, and sutures may not be required in some cases.

Maxillary frenectomy revisions: Many oral conditions can be intercepted or prevented by examining children by 1 year of age approximately 6 months after the first teeth erupting to the oral cavity.⁶⁹ The diode laser will usually prevent any bleeding, because it is a better laser for hemostasis. Healing using the diode takes longer with the potential of more post operative discomfort than when using the Erbium laser.

ADVANTAGES AND DISADVANTAGES OF LASERS

Advantages

The ability to precisely interact and, in some cases, remove almost a few cell layers at a time. Compared to conventional high speed handpiece interaction on the tooth surface, there is an elimination of microstructures and a reported lowering of pulpal temperature. Osseous tissue removal and contouring can also proceed easily faster healing. The reduction of the amount of the bacteria and other pathogens in the surgical field and in the cavity preparation is easily achieved. In the case of soft tissue procedures, very good hemostasis with the reduced need for sutures and surgical packing are normal results. Postoperative scar is minimized, because laser incision is more broad and irregular than that of a scalpel. Laser-assisted periodontal therapy can be provided safely to a wide range of population, such as children and pregnant women. The patient will not experience allergic reactions and bacterial resistance. There is greatly improved visualization of the surgical field because of bleeding control, and some laser procedures can be performed with less local anesthesia. Initial postoperative discomfort and swelling are reduced.¹⁰

Relative disadvantages of Lasers

Although the lasers are useful for caries removal and tooth preparation, the erbium family of lasers is unable to remove gold and vitreous porcelain, and has only a small interaction with amalgam. In some cases, accessibility can be limited. Lasers produce heat, the clinician must carefully observe and monitor the rate of tissue removal to prevent overheating and lateral thermal damage. For enamel removal, the laser is not as fast as a rotary bur. The initial investment for some devices can be considerable. Logistic space can also become a factor.¹⁰

DENTAL LASER SAFETY

Safety is an integral part of providing dental treatment with laser instrument. There are three factors to

laser safety: 1) the manufacturing process of the instrument, 2) proper operation of the device, 3) the personal protection of the surgical team and patient.

The FDA through the CDRH (Center for devices and Radiological Health), regulates the laser manufacturer, ensuring compliance with medical device legislation.⁷⁰ A laser manufacturer must prove the safety and efficacy of that specific device and dental procedure

Laser Safety Officer (LSO) is defined by worldwide standards as being designated, trained person (usually a chair-side dental assistant) who directs lasers safety practices and ensures a safe environment while a laser is in use.⁷¹ The LSO needs training/education through an accredited safety program. The LSO also oversees inventory and maintain laser supplies and accessories and is the person responsible for supervising staff education and training.⁷²

Connections and Traffic. All lasers require a cooling system, some use an internal fan and others use a fan and a radiator with self-contained coolant. Electric power cords and the footswitch cable also should be inspected each time to make sure that they are in safe condition.

Eye Protection. Lasers produce an intense, highly directional beam that is absorbed to some degree if directed, reflected, or focused on an object. The eye is a critical target for laser injuries. The dentist, assistant, patient, and others who are inside the nominal hazard zone risk from the direct and reflected radiation of lasers. Wearing the correct protective eyewear when using dental lasers is essential because different available wavelength can and will damage various parts of unprotected eyes quickly. Generally, protective glasses must have an optical density (OD) of at least 4 for the particular laser emission and device.

Sterilization and infection control. Steam sterilization is the standard of care.⁷³ The small flexible optic fibers, handpieces, or tips must be steam sterilized in separate sterilization pouches after each use.

Adverse effects. An adverse effect is defined as a serious and undesirable patient experience that results from a medical instrument or product. Such events include, death life-threatening injury, disability, hospitalization, etc. Specific device problems such as defects, safety, or performance are also reportable. When faced with such events, the clinician should shut down the laser.⁷⁴

CONCLUSION

Use of lasers in dentistry has expanded and improved some treatment options for those clinicians who have adopted the technology. As with all dental materials and instruments, the practitioner must use clinical experience, receive proper training, become very familiar with the operating manual, and proceed within the scope of his or her practice. The potential purchaser should carefully analyze the style and type of the practice to decide, how useful the device could be. Because of the varied composition of human tissue and the differing ways that laser energy is absorbed there is no single perfect laser. However, our patients continue to agree that the dental laser is a wonderful instrument.⁷⁵

Laser prices must decrease over the next 10 years. Market penetration must double in the next 4-5 years. Meeting these criteria would generate the necessary revenues for increased expenditures for research and development of short-pulsed hard tissue laser to replace air turbines, and combine wavelengths into a single package, while looking into new wavelengths. The last 20 years have witnessed many new developments in dental technologies and the next 20 years promise to be even richer in technologic advancements. Lasers will be in the forefront of that growth.

It is hoped that the Evidence-based review would help practitioners to make learned decision regarding selection of Laser Equipment. Besides a marketing tool, Laser can be a useful adjunct to clinical armamentarium. Though the evidence is controversial but clinical applications are there.

The Evidence-based literature review would help practitioners for their clinical decisions making appropriate to their practices, resources and standard of care they wish to offer their patients.

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