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Review Article

CLINICAL APPLICATIONS OF LASERS IN DENTISTRY - A REVIEW

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Abstract
Lasers can be effectively used in dentistry due to their ability to cut, incise and ablate hard and soft tissues. Other inherent properties of laser light, such as selective absorption, coagulation, sterilization and stimulatory effects on vital structures offer some advantages over traditional techniques, making lasers the treatment of choice in dentistry. This article is about the clinical application of lasers in different branches of dentistry.
Key words: lasers, incision, post operative, dentistry

1. Introduction:

Laser is a kind of electromagnetic irradiation source, having particular and exclusive properties. The word LASER is an abbreviation formed by joining the first letter of the words: Light Amplification Stimulation by Emission of Radiation. **L-** refers to Light; **A -**refers to Amplification.; **S- refers** to Stimulation.; **E-** refers to Emission.; **R-** refers to Radiation. Laser light is a form of radiation that does not ionize, is highly concentrated and, which, on contact with different types of tissue results in photochemical, photoelectric, photo thermal, or photomechanical effects. Laser radiation is not invasive, is well tolerated by tissues, does not have mutagenic effects, and can be used repeatedly without risk.[1]

2. Clinical application of laser's in dentistry:

- Lasers in pediatric and adolescent dentistry
- Caries detection and prevention with laser energy
- Application of laser in conservative dentistry
- Application of laser in endodontics
- Lasers in oral and maxillofacial surgery
- Use of lasers in periodontics
- Lasers in cosmetic dentistry

3. Lasers in pediatric and adolescent dentistry:

Lasers are patient friendly and offer many advantages over more conventional means of treatment. The elimination of hemorrhage calms the patient and permits greater operator vision. Postoperative comfort is probably the greatest benefit to the patient; soft tissue surgical sites do not hurt, do not swell with edema, and do not require pain medication. Many soft tissue procedures can be accomplished with only topical anesthesia. Most hard tissue procedures with teeth also are usually done without anesthesia; there is no numbness afterward.[2, 3] In both cases, there is a happier and more comfortable patient.

The basic principle is the use of light energy instead of rotational forces and sharp blades. Children and adolescents are among the best candidates for laser use because they are especially bothered by pain, bleeding, incapacitation, and a need for office visits for extensive postoperative activities. Parents are justifiably concerned about loss of school time; interference with extracurricular activities such as sports; and the need for extensive personal support, such as transportation[65].

3.1 Caries Detection and Prevention:

The optical properties of specific interest for caries detection, caries removal by ablation, or prevention of caries progression are transmission, scattering, and absorption. The study by Chandler et al[4] on the laser light transmission through the teeth concluded that restorations and caries does not interfere the transmission of the light to the pulp space.

KaVo DIAGNOdent (KaVo, Biberach, Germany), by Hibst and Gall, is a recently introduced laser-based instrument, developed for detection and quantification of dental caries on smooth and occlusal surfaces. It operates with light from a diode laser with a wavelength of λ=655 nm and 1 mW peak power (Hibst and Gall, 1888). The light is transmitted through a descendent optic fiber to a hand held probe with a beveled tip with a fiber optic eye. Both organic and inorganic molecules in the tooth substance absorb the light, and fluorescence within the infrared spectra occurs. The signal is finally processed and presented on the display as an integer between 0-88.

3.2 Early Detection and then Precise Correction

According to Dr. Tom Orient of the Center for Esthetic Dentistry "if there is decay, there is a change in the wavelength. You get a reading of zero to 100 and are able to tell not only where the decay is, but how deep it is, and how much there is." He said "certainly we'll see decay if it is large with conventional means, but that's too late. At that point, you're looking at a very difficult restoration, a large filling or in some cases even a root canal."

Table 1: Laser Reading's vs. Recommended Treatment:

KaVo DIAGNOdent					
Correlation of DIAGNOdent Values to Possible Course of Action					
Possible Course of Action*					
DIAGNOdent Values	No Action	Preventive Therapy	Record & Monitor	Sealant	Preparation
0 to 5	X				
5 to 10	X	X			
10 to 15	X	X	x	X	
15 to 20		X	x	X	
20 to 25		x***	x	X	x**
25 to 30		x***	x	X	x**
30+		x***			X

The Diagnodent is a major step forward in caries detection and should soon represent another milestone in the "standard of care" for conservative restorative treatment. It also allows dentists, hygienists and auxillaries to accurately gather objective numeric data regarding pits and fissures and chart their findings. Additionally, its petite size, light weight and battery operation allow the unit to be easily transported between operatories, eliminating the need for multiple office units. The Diagnodent effectively closes the door on the era of the suspicious "watch" and provides us with a marvelous opportunity to offer patients early, ultra-conservative and objectively diagnosed treatment.

3.3 Caries Prevention Using Laser Light:

Lasers have been introduced for prevention of dental caries either before the caries occurs or in initial stages. The underlying hypothesis for caries prevention that has now been proved is two fold[5]

(1) There are specific sets of the irradiation conditions for laser light that interact most efficiently and effectively with dental hard tissues, and

(2) Efficient conversion of light to heat as the laser light is absorbed results in increased resistance of tooth mineral to dissolution by acid.

Studies have shown that CO_2 laser treatment of dental enamel can inhibit subsequent caries-like progression in the laboratory by up to 85%. The degree of protection against caries progression provided by the one-time initial laser treatment in this model was comparable to daily fluoride treatment by a fluoride dentifrice.

Mechanism of Inhibition of Caries Progression

Carbonate is lost from the carbonated apatite mineral of the tooth during specific laser irradiation.[6,7] Pulsed CO_2 laser irradiation interacts with the phosphate groups in the dental mineral, is preferentially absorbed, is transformed efficiently to heat, and can raise the temperature to levels that drive off the carbonate using low energies with pulses of 100µs or less. The effects depend on wavelength and pulse characteristics. By adjusting the characteristics of the laser, the optimal heating at the surface can be obtained, while maintaining the temperature rise in the pulp at a safe level of less than 4°C. Mechanically, what occurs is that the carbonated hydroxyapatite in the surface and immediate subsurface of the enamel is heated to temperatures greater than 400°C, decomposing the carbonate and leaving behind a hydroxyapatite-like mineral that is much less soluble than the original mineral. It has been shown that a variety of conditions can be used to produce this effect.

Patel et al used pulsed CO_2 found out that there was increased acid resistance when they evaluated it by wet chemical analysis.[8] Zuerlein MJ found out that repeated irradiation is required for complete removal of carbonate, depending on absorption depth and pulse duration.[9]

Harazaki M et al., demonstrated that Nd-YAG laser irradiation with application of APF, acted as an effective method of caries control during orthodontic treatment.[10] S.Tagomori compared fluoride application with laser treatment and concluded that APF application after laser irradiation caused a remarkable increase in acid resistance of the enamel [11]

Konishi et al investigated the inhibition of artificial secondary caries around restoration after using CO_2 laser radiation and concluded that caries removal by a pulsed lambda 8.3 microns CO_2 laser produces a cavity surface morphology with marked resistance to artificial secondary caries as compared to mechanical removal.[12]

4. Application of laser in conservative dentistry

4.1 Hard Tissue Laser Procedures

Apart from using Laser alone for caries removal, nowadays Er: YAG Laser has been combined with chemical means of caries removal (Carisolv).[13, 14] It was revealed that Er:YAG laser and Carisolv could provide an alternative technique for caries removal for conventional mechanical drilling and cutting. Yamada Y et al revealed that Er:YAG laser and Carisolv could provide an alternative technique for caries removal for conventional mechanical drilling and cutting.[15]

Pit arid fissure caries are ideal for Er:YAG treatment. There is another appropriate laser application. Pit and fissure caries typically involve an organic plug in the enamel defect. This plug material consists of food debris, bacteria, and remnants of the enamel forming ameloblasts. Even though there is no absorption in the enamel, the staining of

the organic plug makes the material susceptible to action of Nd:YAG lasers.[16] The FDA has granted clearance for an Nd:YAG laser (American Dental Technologies, Corpus Cristi, TX) used to detect and remove the caries associated with pit and fissure lesions. The laser energy gives visual and acoustic response if organic plug material and caries are present. Otherwise, there is no interaction with the enamel. The approach works well with sealant placement. More extensive caries can be restored with the assistance of bur preparation. The pulsing action of the Nd: YAG laser has been found to reduce tooth sensitivity to reducing the need for anesthesia. Terry D Myers used pulsed YAG laser on enamel fissures and effectively vaporized the organic and inorganic debris.[17]

All types of cavity preparations can be performed with Er:YAG lasers (class I, II, III, IV, V and VI). Crown preparations and removal of metallic restorations are contraindicated. Existing composite materials are suitably removed. Extraordinary large and deep restorations may require anesthesia and could be prepared with bur and laser methods combined, with the bur used for enamel contouring and the laser for decay removal and surface conditioning.

4.2 Laser in Etching/Bonding:

The argon, CO_2 Nd: YAG and excimer lasers have also been used to etch enamel/dentin in preparation for bonding procedure using a composite resin material. Laser etching is a process of continuous vaporization and micro explosions due to vaporization of water trapped within the hydroxyapatite matrix. In general, more material is removed by the micro explosion of entrapped water than by direct vaporization of the hydroxyapatite crystals[14]. Several studies have shown that changes in the morphology of enamel/dentin surface from laser energy are similar to those produced in acid-etched specimens. The potential use of lasers as an alternative to acid etching has resulted in extensive composite resin bonding with CO_2 and Nd: YAG laser. Many authors reported that laser treatment of dentin surfaces increased the retention between composite and dentin. The results showed that laser treated dentin and enamel had significantly higher bond strength than the untreated dentin and enamel. Contradictory to these findings, it was also observed that treating the enamel surface exclusively by laser resulted in the highest degree of leakage.[9,18,19,20] Some authors have also concluded that laser treatment alone is not sufficient for etching[21,22] .

Dana C and Thressiamma J (1886) showed that the lased enamel can be used as an alternative to acid treated enamel.[23] But study done by Varma B et al(1887) showed that the shear bond strengths of composite bonded to laser etched enamel appeared inferior as compared to those on acid etched enamel.[24]

Ceballos L and other researchers showed that lased dentin surfaces presented several characteristics that appear to be advantageous for bonding. But certain researchers such as Ariyaratnam M T showed that etched dentin surfaces produced by the Nd:YAG laser were not superior to those obtained with conventional dentin bonding.[25,26] Drummond JL et al, from their study concluded that the laser-etched teeth resulted in lower bond strengths to enamel and the use of a primer increased the bond strength for laser-etched teeth only.[27]

4.3 Laser Curing

More recent studies have indicated that argon laser light is effective in photopolymerization of these systems and improves the physical properties of the restorations.[2,10] When used to photopolymerize camphorquinone- activated composite resins, the argon laser increases the depth of cure, increases the diametric tensile strength, increases the adhesive bond strength, increases the degree of polymerization of the material, reduces the acid solubility of the surrounding enamel, and decreases the time of activation significantly. Major problems associated with the use of light activated bases and liners is the, time required to polymerize them and gaining access in deep areas of preparations to bring the conventional light to these areas. The argon laser with a wide variety of fiber sizes provides access to all locations of a cavity preparation. This feature will most certainly make the argon laser a primary instrument for the general practitioner.

Lalani N et al., on doing a study on polymerization of a light-cured orthodontic adhesive concluded that 5-second cure using an argon laser produced bond failure loads comparable to those obtained after 40 seconds of conventional light cure, with less than half the frequency of enamel fracture at debond.[28] Vargas. M et al., comparing argon laser and conventional light, this study concluded that there was comparable polymerization using the argon laser and the visible light curing. He also concluded that resin polymerization was accomplished using argon laser at reduced exposure times.[29] Westerman G et al study showed increase in bond strength and a reduction in unpolymerized dental material. The curing time was one quarter the amount required for visible light curing.[30] He also demonstrated the there was decrease in caries reduction and alteration in the remineralization of the tooth.

4.4 Application of Laser in Hypersensitivity:

Recently lasers have been introduced for treatment of dentin hypersensitivity. It was hypothesized that the hypersensitivity relief observed after laser treatment was caused by the laser sealing of dentinal tubules. This could increase hydraulic resistance to fluid movement. There has been much conflicting data in the literature about how laser irradiation can alter dentin resistance. Under some conditions, laser irradiation has been observed to increase dentinal permeability. In this case, physical alteration were held responsible, including crack formation and removal of the smear layer, and restructuring, involving vaporizing organic material and diminution of crystal size of dentinal components. It has also believed that Lasers makes a hard

surface layer in the hypersensitive dentine, thereby reducing the hypersensitivity[31].

Root hypersensitivity is considered to be the presence of open dentinal tubules at the root surface. Dentin exposure can occur due to trauma (acute or chronic), gingival recession, or various restorative procedures. Thereby, an increased number of exposed dentinal tubules can result in increased dentinal fluid movement and patient discomfort. To reduce hypersensitivity, attempts have been made to seal the dentinal tubules or to alter their contents. Various agents have been recommended to occlude dentinal tubules. However, most treatments are either ineffective or relatively short lived.

Chengfei Zhang, Mohamed I Fayed and other researchers showed that there was reduction of hypersensitivity when laser was used.[32, 33] Wan-Hong et al used NaF along with Nd:YAG laser and reported that more than 80% of the dentinal tubules were occluded by NaF varnish combined with Nd:YAG laser irradiation.[34]

5. Application of laser in endodontics

Many dentists throughout the world have raised questions about the validity of how to perform laser therapy in endodontics. With the advent of different kinds of laser delivery systems almost anything is possible for pulpal treatment be it a vital pulp therapy or a nonvital pulp therapy

5.1 Pulp Vitality Testing:

Reliable vitality assessment of the dental pulp has always been problematic. This is where Laser Doppler Flowmetry comes in to the picture. This system obtains a direct assessment of dental pulp vitality as determined by the presence or absence of pulpal blood flow.[35] Laser light is transmitted to the dental pulp by means of a fiber-optic probe placed against the tooth surface. The reflected light is returned by afferent fibers within the same probe to photodetectors in the flowmeter. When used to assess the vitality of the teeth, the size of the signal obtained from a vital control tooth can be compared with the suspected tooth. The signal of the vital tooth should be greater than that of the non vital tooth.Roebuck et al from his study reported that reliability of the test is dependent on the recording method used. They advised the placement of the probe 2-3 mm away from the gingival margin so as not to superimpose the blood vessels of the pulp and the gingival.[35]

5.2 Accessory Treatment by Laser for Indirect Pulp Capping

The discovery of closure of dentinal tubules by laser energy and the sedative effects on pulpitis has led to the development of several new treatments that are soon to be put into practice. Deep cavities, hypersensitive cavities, and cavities that require sedative treatment are some of the indications for this treatment. When using the pulsed Nd:YAG laser, it is necessary to combine the application of black ink to the tooth surface and air spray cooling to prevent dental pulp damage resulting from the laser energy provided by 2 W and 20 pps for less than 1 second on the area. The mechanism of sedation by the laser is thought to be identical to that of sedation of dentin hypersensitivity by the laser.[36] When using the CO_2 laser, the dental tissue must not be irritated by exposure to high energy lasers for long periods of time. In some cases, it is recommended that this laser be used with 38% silver ammonium solution. These treatments should be performed under local anesthesia.

5.3 Treatment by Laser for Direct Pulp Capping

Laser treatment has advantages with respect to control of hemorrhage and sterilization, laser use for direct pulp capping has attracted dentists' attention. When using the CO_2 laser for this treatment, laser irradiation of the exposed dental pulp must be performed to stop bleeding and sterilize the area around the exposure. Laser irradiation should be performed irrigating alternatively with 8% sodium hypochlorite and 3% hydrogen peroxide for more than 5 minutes. Calcium hydroxide paste must be used to dress the exposed pulp after the laser treatment, after which the cavity should be tightly sealed with cement such as carboxylate cement. An 88% success rate is reported. The high success rate is thought to be due to control of hemorrhage, disinfection, sterilization, carbonization, and stimulation effects on the dental pulp cells. Nd:YAG, argon, CO_2 semiconductor diode, and Er:YAG have been tested for direct pulp capping.[37]

5.4 Laser Ablation and Accessory Treatment for Vital Pulp Amputation

Laser can be used to stop bleeding and for cell stimulation during vital pulp amputation procedures. The CO_2 laser usually is used at a power of 1 to 4 W. The laser irradiation should be conducted as intermittently as possible to prevent excessive exposure of laser energy. When it is necessary to ablate the pulp tissue into the apical portion of the root canal, several laser exposures are required. As a result, the carbonization layer formed on the surface of the pulp tissue by the laser energy must be removed by irrigating alternatively with 3% hydrogen peroxide and 5.25% sodium chloride. Although it is possible to use only the CO_2 laser, this requires significant time, and the pulp tissue may be damaged by the laser energy. A CO_2 laser technique that is carried out only for pulpal hemostasis after vital pulp amputation with an excavator or a bur is recommended. There are some problems concerning the application of the pulsed Nd:YAG laser for vital pulp amputation. This laser should not be used instead of an excavator and a bur. The pulsed Nd:YAG laser should be used only for pulpal hemostasis, sedation, anti-inflammatory effects, and stimulation of the remaining pulpal cell.[36] The He:Ne and low-power semiconductor diode lasers are alternative lasers for these purposes. The middle-power semiconductor diode laser is being developed and put into practice for this purpose.

5.5 Access Cavity Preparation and Enlargement of the Root Canal Orifice by Laser

The Er: YAG and Er, Cr:YSGG laser, which ablate enamel and dentin, have been developed and improved. As a result, these lasers may soon replace the air turbine, Peeso reamer, and Gates Glidden drill as the primary method of treatment. Extirpation of infected root canals is one indication for these lasers.[2,29] In particular, this technique seems applicable for cases in which the Peeso and Gates Glidden instruments cannot be inserted into the tooth because of difficulty of opening the mouth and for cases in which it is difficult to find the root canal orifices.

5.6 Root Canal Wall Preparation by Laser, Pulpotomy and Pulpectomy

Pulpal therapy can be aided with laser applications. With children, the most common procedure is laser assistance for pulpotomies.[29] Although it is possible to use a laser to ablate the tissue within the pulpal chamber, that approach is time-consuming and messy. Round bur and spoon excavators are preferred for the bulk removal. Then a soft tissue laser is applied to the amputated pulpal stumps for hemostasis, bactericidal effects, and surface coagulation. Research with Nd:YAG and CO_2 lasers has verified the value of avoiding formocresol. The progressive mummification down the canal is eliminated, resulting in a truly vital pulpal procedure. Study done by Shigeru Shoji et al[38] on mongrel dogs found out that there was good success rate in pulpotomies and there were no detectable damages in the radicular portion of the pulp. The time taken for the procedure was also reduced.

Pulpectomy procedures can be aided by laser debridement and decontamination[39]. The fiber optic systems used with most soft tissue lasers allow penetration into exposed root canals. A 200µm. fiber size is highly flexible and can be introduced most of the way to the apex. Ablation of debris, destruction of bacteria, and a glazing of the canal walls are accomplished. When a fistula is present, the laser fiber can be passed into the fistula canal to the site of abscess formation. At that site, laser action can disrupt the infection temporarily and reduce the symptoms. Recurrence is certain if the offending root canal is not treated. Food and Drug Administration (FDA) marketing clearance for laser use in endodontics has been obtained by several manufacturers. Koba et al in their research concluded that the clinical application of pulsed Nd:YAG laser might be advantageous for the one-visit treatment of root canals immediately after pulpectomy shaping and to reduce postoperative pain.[36]

5.7 Laser Application for Removing Pulp Remnants and Debris at the Apical Foramen

The pulsed Nd: YAG laser was used for removing pulp remnants and debris that are deposited at the apical foramen & a power of 2 W at 20 pps for 1 second is recommended. A 5 second interval should be used if laser irradiation is performed two or three times. A little black ink should be applied to the root canal wall or to the apical foramen. The effects of this laser irradiation on the apical foramen include sterilization, removal of pulp remnants, control of hemorrhage, and stimulation of cells surrounding the root apex as well as debridement of the surface. Researchers have shown that the cleanliness of the canal is improved when compared to conventional techniques.[40]

5.8 Sterilization or Disinfection of Infected Root Canals

The laser is an effective tool for killing microorganisms because of the laser energy and wavelength characteristics. [40, 41, 42] To prevent thermal damage to the periodontium surrounding the tooth, various techniques are considered and recommended. Infected root canals are an indication for this laser treatment, but application to extremely curved and narrow infected root canals appears difficult. Pulsed Nd:YAG argon, semiconductor diode, CO_2, Er:YAG, and other lasers have been considered for use in this treatment. The pulsed Nd:YAG laser has been recommended for this treatment because of the ease with which the laser energy and laser fiber can be controlled. To increase the effect of sterilization in the infected root canal, placement of about 38% silver ammonium solution into the root canals is recommended and irradiated using the pulsed Nd:YAG laser at 2 W and 20 pps for 5 seconds. Sodium chloride 5.25% or EDTA 14% has also been used instead of silver ammonium.

5.9 Prevention of Tooth Fracture by Laser

Pulpless teeth have a tendency to fracture. Many dentists encounter at least one case in which they are obliged to extract a tooth because of fracture despite finishing the endodontic treatment. To prevent such cases, new laser techniques are being developed. Teeth lased with 38% silver ammonium solution become difficult to fracture. Pulsed Nd:YAG, CO_2 and argon lasers can be used for this treatment. The laser irradiation is performed at 2 or 3 W and for about 20 seconds in combination with 38% silver ammonium solution until the tooth surface becomes silver and mirror-like under air cooling. Lin CP et al successfully developed a DP-bioactive glass paste which could form a melting glass within seconds after exposure to a medium energy density continuous-wave CO_2 laser. The paste could be used in the near future to bridge the enamel or dentin surface crack by the continuous-wave CO_2 laser. [43]

5.10 Laser in Apicoectomy:

The rationale for laser use in endodontic periapical surgery includes, improved hemostasis and concurrent visualization of the operative field; potential sterilization of the contaminated root apex; potential reduction in permeability of root surface dentin; reduction of postoperative pain and reduced risk of contamination of the surgical site through elimination of the use of aerosol-producing air turbine handpieces. [36, 42, 44] It was found that recrystallization of apical root dentin and carbonization of organic material could be accomplished with the CO_2 laser at specific power densities. The resultant recrystallized apical dentin was observed to be loosely bound to the underlying tooth

structure, thus simplifying removal of the material. Removal was effected with surgical bone curettes. The remaining apical stump was found to have a smooth, hard surface suitable for placement of a retrograde filling if necessary.

The aerosol producing hand-pieces posses a potential hazard to the surgical procedure by introducing contaminants and to the surgical staff by spreading pathogens via the aerosol sprays. Maintenance of hemostasis in a highly vascular granulomatous area is also demanding. If a laser is used for the surgery, a bloodless field would be easier to achieve due to the ability of the laser to vaporize tissue and coagulate and seal small blood vessels. Moreover, the potential of the Er:YAG laser to cut hard dental tissues without significant thermal or structural damage would eliminate the need for mechanical drills[66].

5.11 Sterilization of Endodontic Reamers:

There is general agreement that the sterilization of endodontic instruments is an extremely important aspect of endodontic therapy. The currently accepted techniques include the dry heat sterilizer, the steam autoclave, the Harvey alcohol vapor sterilizer, ethylene oxide gas, and the salt (glass bead) sterilizer. The need exists for a rapid chair side technique of sterilizing endodontic instruments, since endodontic instruments are quickly contaminated by contact with the oral flora and also by digital manipulation. At present the only rapid chair side sterilization technique involves the use of the salt (glass bead) sterilizer. Unfortunately, this is not consistently reliable. Currently the CO_2 laser is being used in many areas of medicine. Steller and associates have reported that living bacteria in tissue can be quickly vaporized and destroyed by the CO_2 laser beam. Adrian and Gross have shown that .the CO_2 laser is capable of effectively sterilizing a scalpel blade which had been previously contaminated with spores. There is also evidence to show that the CO_2 laser can sterilize a sharp instrument without significantly decreasing its cutting efficiency. The CO_2 laser is reflected by metal surfaces; however, biologic tissues absorb virtually all the CO_2 laser beam resulting in their vaporization. By virtue of these characteristics, the CO_2 laser may function as an effective chair side sterilization technique[45].

6. **Lasers in oral and maxillofacial surgery**

More than with any other dental specialty, lasers have played an integral part in the evolution of the practice of ***Oral and Maxillofacial Surgery*** (OMFS) and rapidly are becoming the standard of care for many procedures performed by oral surgeons

Because of its excellent affinity for all water-based tissues, the carbon dioxide (CO_2) laser at 10,600µm wavelength has long been the workhorse in OMFS[46-49]. It is an ideal wavelength for most soft tissue surgeries performed intraorally and extraorally. Many other wavelength lasers have been used for a variety of specific indications that best take advantage of the properties of that particular wavelength. Examples include the argon (514 nm) and potassium titanyl phosphate (KTP): YAG (532 nm) for intraoral vascular lesions, the Ho: YAG (2140 rum) for temperomandibular joint arthroscopy, Er:YAG (2840 run) for cosmetic skin resurfacing, and copper (Cu)-vapor (578 µm) lasers for extraoral vascular lesions.

6.1 Principles of Laser Physics for Oral Maxillofacial Surgery

With oral surgical procedures or any medical or dental procedure using a laser, a thorough understanding of the physics involved and the differences between systems is important if a successful and safe outcome is to be expected. Soft tissue surgery with a laser is deceptively simple, but grave consequences can result if the principles of appropriate laser physics, beam modulation, and beam delivery are not carefully integrated into the procedure.

The most commonly used lasers are the CO_2 and the Er:YAG, both of which are absorbed primarily by water.[50] Absorption into the target tissue results in four effects: photoacoustic, photochemical, photoablation, and photothermal. The photothermal effect, or the generation of heat, plays the most significant role. Since these lasers are so well absorbed by water, they are essentially totally absorbed within the first 0.1 mm of the tissue surface, causing the intracellular water to vaporize and expand at 100°C, leading to cellular rupture and loss of 75% to 85% of the cell volume as steam. At higher temperatures, the residual organic matrix also vaporizes, resulting in total tissue ablation.

6.2 Use of the laser for Implantology.

The CO_2 laser in incisional mode can be used safely to uncover implants as long as care is taken to prevent conduction of heat from surrounding tissues to conduct back into the implant (this is done simply by limiting prolonged exposure). Using this wavelength, titanium does not absorb, and, in fact, reflects, the laser energy. Another excellent use of the laser is for removal of any hyperplastic peri-implant tissue. This removal is accomplished easily by maintaining the tip of laser parallel to the long axis of the implant and running the laser under the implant body

Joob-Fancsaly et al from their study concluded that advantage of laser surface treatment lies in special micromorphology and the increased cleanliness of the implant surface.[51] Bach G et al in their 5 year comparative reported study that integrating diode laser light decontamination in the approved treatment schemes for periimplantitis and parodontitis contributes considerably to the success of this therapy.[52]

Gaggl A et al reported that optimal surface structure with the least contamination was found for the laser-treated titanium surface.[53] Dostalova et al from their study showed that osseointegration of Laser treated dental implant was good.[54] The results of Deppe H et al support the hypothesis that peri-implant defects can be treated successfully by laser

decontamination without damaging the surrounding tissues.[55]

6.3 Cardiac-Anticoagulated Patients

The anticoagulated patient presents many potential problems when presenting for dental treatment such as spontaneous bleeding; prolonged bleeding after dental procedures that injure soft tissue or bone. The use of lasers as haemostatic instruments is well documented in the literature. Lasers have been shown in many studies to cauterize and coagulate as they cut. The mechanism of action is by denaturation of the protein and collagen in the walls of the small blood vessels. This denaturation causes desiccation and contraction of the walls of the vessels. The concern of the dentist for adjusting or decreasing the patient's warfarin (Coumarin) levels may no longer be of relevance during laser treatment of the anticoagulated patient. As with all medically compromised patients, however, the ultimate decision regarding a change in the patient's medication should be made by the dentist in collaboration with the physician.

7. Use of lasers in periodontics

The evolution of laser therapy for soft tissue manipulation and as an adjunct in the management of the infectious aspect of periodontitis is progressing quite rapidly.

7.1 Mucogingival Surgeries

Soft tissue procedures can be accomplished well with several types of lasers. Argon, carbon dioxide, diode, and neodymium: yttrium-aluminum-garnet (Nd: YAG) lasers all work well to cut, decontaminate, coagulate, and contour tissues. The gingivoplasty procedure is considered separate from the restoration and separately billable. Abnormal frenum attachments can be encountered in the maxillary and the mandibular midlines. Ankyloglossia is associated with the mandibular lingual frenum. Removal with any soft tissue laser provides immediate and easy relief.[56] Caution is needed to avoid damage to the submaxillary salivary gland ducts. If the ligament within the frenum is thick and heavy, scissor cutting may facilitate the procedure after the laser removes all of the surrounding mucosa. The presence of a heavy fibrous attachment to the alveolar bone at the midline may call for a scalpel incision at the fibrous insertion because actual laser contact with bone and periosteum is contraindicated. Minimal formation of fibrous material during healing is seen with laser resection, seemingly less than with a scalpel wound.

Gingival hyperplasia resulting from drugs is a growing problem. Anticonvulsants, such as phenytoin, Dilantin have long been known to induce gingival overgrowth. Immunosuppressant's, such as cyclosporine, which also stimulate gingival hyperplasia, are administered to transplant patients. Gingival growth stimulation leads to abnormal tooth coverage. An equivalent condition is seen with adults taking calcium channel blocker medications. Cosmetic gingival contouring with a soft tissue laser provides a refined way to improve esthetics. Primarily with older adolescents and adults, irregular and abnormal gingival margins make patients self-conscious about their smile.

Lasers allow incision through tissue and surface recontouring by removal of tissue layers. The lack of hemorrhage allows precision. Gingival tissue ablates easily, giving precise control. Proportional dimensions for the width and length of incisors and the height of gingival contours are manipulated easily. The location of the cementoenamel junction and maintenance of a reasonable border of attached gingiva are guides. The less frequent use of local anesthesia and the comfortable postoperative course are special advantages of laser treatment versus use of a scalpel and diamond burs.

Robert M. Pick et al reviewed 12 cases of phenytoin hyperplasia which he treated with laser with good success. Abnormal gingival architecture associated with tooth movement has become more common as the mechanics of orthodontic tooth movement have improved markedly the speed of dentition realignment. Gingival recontouring may not keep pace. [57]

Fibrotic gingiva over molars may impede orthodontic attachments and movement. Orthodontic procedures started before the full eruption of mandibular second molars may require leveling of these molars to aid in completion of the procedure. Timely surgical exposure to allow bracket or bond attachment may save months of prolonged orthodontic therapy. The constant flexure of tissues in this area contributes to a possibility of postoperative discomfort.

Fibroma removal can be performed quickly and easily with any of the soft tissue lasers. The lesion is encircled with a border of normal tissue. When the depth of the lesion is reached, traction and retraction are used to elevate the tissue for undercutting and complete removal. Specimens submitted for biopsy should always be noted as laser treated. The remaining crater is asymptomatic and heals by secondary intention without scar formation. Within 1 month, the site is healed fully and usually cannot be discerned.[58]

Aphthous ulcers are painful and often recurrent. Minor and major-sized ulcers can be painful, interfering with eating and speaking. Locations vary throughout the oral mucosa, including the soft palate and uvula. Energy directed into the surface of these legions with lasers in the defocused mode removes the exposed nerve endings. The lesion usually can be rendered insensitive at low wattages within 4 minutes or less. More difficult cases can be completed with light surface contact.

7.2 Crown Lengthening Procedures

The bloodless field allows immediate access to areas covered with gingival tissue. Class V cavity preparations are the most common examples. Occasionally the gingival area of a class II preparation is obscured by gingival

overgrowth, usually with vascular tissue. Laser resection leaves an exposed gingival margin with much better access for a proper marginal finish. Gingival troughing with the pulsed Nd:YAG laser is a convenient, painless method of preparing for accurate impressions and is an excellent substitute for retraction cord. There is no blood in the field, and lased circumferential tissues heal quickly and painlessly.

7.3 Scaling and Other Pocket Therapy

Before the development of contact mode tip technology for the Nd:YAG laser, most oral soft tissue laser procedures were carried out with the CO_2 laser. The CO_2 laser in periodontal therapy, as are all other laser types, is considered as an adjunct to mechanical root instrumentation. It alters the surface characteristics of the root and destroys the viability of the calculus and microbial plaque deposits, but it does not remove them from the root surface. The CO_2 laser's ability to act as a bactericidal form of instrumentation makes it a useful adjunct to the inflammatory reduction phase of periodontal therapy. Its use is followed by instrumentation of the root leaving a smooth surface, so as to delay the reformation of adherent plaque. There is apparent justification for adjunctive lasing of the periodontal pocket, with many different laser types. Ongoing research is investigating the usefulness of the CO_2 laser for retarding epithelial migration into the periodontal surgical wound, as a form of guided tissue regeneration. [59, 60]

The diode laser is a new addition to the periodontal armamentarium. When used in a contact mode, the continuous-wave diode laser at low power is a useful instrument for excising tissues and for reducing bacteria in periodontal pockets. The diode laser has been approved by the Food and Drug Administration (FDA) for virtually all of the soft tissue procedures performed by the Nd:YAG and CO_2 lasers. These procedures include soft tissue curettage, incisions, pocket debridement, and ablative excisions. [60,61] The affinity of the diode laser wavelength for anaerobic pathogens may be a useful method for decontaminating the surface of failing implants in peri-implantitis. The Er:YAG have been introduced recently and some studies have shown that Er:YAG lasers are more effective than the other type of lasers in eliminating dental hard tissues[62]. Er:YAG lasers alone or in conjunction with conventional root planing techniques have shown their capacity in removing plaque and calculus present on periodontally diseased root surfaces.[62, 63]

8. Lasers in cosmetic dentistry

When considering a smile's components, cosmetic dentists focus on improvements related to the color, shape, alignment, and function of the teeth as well as the quality of the gingival architecture.

8.1 Laser Bleaching

The objective of laser bleaching is to achieve the ultimate power bleaching process using the most efficient energy source, while avoiding any adverse effects. Using the 488-nm argon laser as an energy source to excite the hydrogen peroxide molecule offers more advantages than other heating instruments. The argon laser rapidly excites the already unstable and reactive hydrogen peroxide molecule the energy then is absorbed into all intramolecular and intermolecular bonds and reaches Eigenstate vibrations. The hydrogen peroxide molecule falls apart into different, extremely reactive ionic fragments that swiftly combine with the chromophilic structure of the organic molecules, altering them and producing simpler chemical chains. The result is a visually whitened tooth surface[64]. Three dental laser wavelengths have been cleared by the Food and Drug Administration (FDA) for tooth whitening: argon, CO_2 and the most recent 880nm GaAlAs(Gallium aluminum and arsenide) diode.

Concept for laser bleaching involves the mixture of 50% hydrogen peroxide in a sodium perborate, proprietary powder base. Argon laser energy is used first to remove deep-colored stains, followed by a CO, laser, which emits the mid-infrared thermal energy that is absorbed rapidly by water and the moist bleaching paste. The bleaching paste is applied several times; the teeth are then cleaned, followed by a final coating of fluoride gel. The CO_2, laser then is activated to promote the remineralization of the tooth surface. Caution should be exercised when using the CO_2, laser because the characteristic of this wavelength is thermal and well absorbed into water and hydroxyapatite, which are the primary components of enamel.

9. Conclusion:

Lasers have many advantages in dentistry such as bloodless operative and postoperative course, absence of suturing, minimal postoperative pain, and high patient acceptance. Some clinicians are still leery of entering this exciting field because of the size and cost of equipment. Today's dental Lasers are smaller, light weight, highly portable and more reasonably priced. Waiting for cheaper, newer lasers and smaller lasers, may mean that technology will pass you by.

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