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Review Article

Current Trends and Practice of Lasers in Dental Practice: A Review

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ABSTRACT:
Lasers are well known to all of us since it has several applications in dental practice. Since the ruby laser was developed, researchers have investigated laser applications in dentistry. A laser is a device which transforms light of various frequencies into a chromatic radiation in the visible, infrared, and ultraviolet regions with all the waves in phase capable of mobilizing immense heat and power when focused at close range. Laser usages are now emerged as a boon in treatment technologies worldwide. Dental lasers are particularly utilized and invented over regular conventional methods. Also, dental lasers are reported to exhibit lesser post operative complications and better esthetic results. The introduction of the lasers to the specialties of dentistry like Prosthodontics, Surgery, Orthodontics, Periodontics and Endodontics has clearly enhanced the outcome and perception of therapy. Lasers for hard tissues facilitate accurate diagnosis of caries and improve the resistance of dental hard tissues. Various researchers have put forwarded their concepts and methodologies for successful and effective utilization of dental lasers. Therefore this paper sought to review different aspects and current practices of dental lasers in dentistry especially in prosthodontics and endodontics.
Keywords: Periodontics, Prosthodontics, Lasers, Endodontics, Dentistry, Orthodontics

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INTRODUCTION
Adjunctive instruments, such as lasers have been investigated to address the risk of failure of endodontic therapy due to the complexity of the root canal system. Lasers were introduced into the field of clinical dentistry with the hope of overcoming some of the drawbacks posed by the conventional methods of dental procedures. LASER (Light Amplification by Stimulated Emission of Radiation) was developed in 1960 by a scientist working for the Hughes Aircraft Corporation, Theodore Maiman, who proposed its mechanism based on the emitted beam coming from a ruby crystal. Since its development by Maiman and its application in the field of endodontics by Weichman in 1971, Lasers have been used extensively in this field. These are used therapeutically, in direct irradiation of the root canals or adjunct to irrigants placed into the canals, in combination with a photosensitizer (antimicrobial photodynamic therapy) and in pain management (photobiomodulation). Since then, many type of laser devices and applications have been developed and new laser models and applications are still being created. The most common dental lasers in use today are erbium, Nd:YAG, diode, erbium, chromium doped: yttrium, scandium, gallium and garnet (Cr:YSGG), and CO2. Naturally, different types of lasers possess specific biological effects, are used in different procedures and, thus, are coupled with specific applicators. Therefore authors planned to conduct review on different aspects and current practices of dental lasers in dentistry especially in prosthodontics and endodontics.

Lasers in Prosthodontics & Oral Implantology: Dental lasers can be successfully utilized in implant dentistry in various procedures like osteotomy and removal of diseased tissues from implant surroundings. CO2 & Er:YAG is mainly used for diseased tissues. Lasers are also used for exposure of implant just before impression making procedure. It is highly comfortable from operator and patients point of view since it possess minimal bleeding at surgical site. Lasers can also be used to conduct most preprosthetic procedures including hard and soft tissue tuberosity reduction, torus removal, and treatment of inappropriate residual ridges involving undercut and irregularly resorbed ridges. Dental lasers are also used to remove sharp bony projections and to smooth the residual ridge. Many studies have confirmed that hard tissue surgery can be performed with the erbium family of wavelengths.[1] Treatment of undercut alveolar ridges can also be done by erbium family of lasers. Additionally, treatment of enlarged tuberosity can also be done with any of the soft tissue lasers. Erbium laser is the laser of choice for most of the osseous reduction of removable and fixed prosthetic procedures. Surgical treatment of tori and exostoses are one more avenues of dental lasers. Soft tissue lasers can also be used for the osseous reduction. Many researchers have also discussed successful role of dental lasers in clinical management of epulis fissuratum reduction. Crown lengthening procedure of fixed Prosthodontics can also be performed by lasers. Dental lasers have a benefit in that they cut only at the tip and can be held parallel to long axis of the tooth to remove bone immediately adjacent to cementum without damaging it. Clinical alterations of soft tissue around laminates can also be achieved with minimal injury of surroundings. Bleaching using diode lasers results in immediate shade change and less tooth sensitivity and is preferred among in office bleaching systems. Diode, Nd:YAG, CO2 and erbium lasers are highly useful in managing pigmented gingiva

Scientific aspect and current trends of Dental Lasers: Dental lasers are essentially a man-made single-photon wavelength. Lasing is defined as a process wherein an atom is excited and stimulated to emit a photon before the process can occur spontaneously. This stimulated emission generates coherent (synchronous waves), monochromatic (a single wavelength), and collimated forms (parallel rays) of light. Thus, lasers can effectively concentrate light energy on the target tissue at an energy level much lower than that of natural light. As a result of their photo-physical characteristics, laser irradiation offers strong ablation, hemostasis, detoxification (removal/ablation of toxic substances), bactericidal effects, and biostimulatory effects on biological tissues (Table 1). Investigation of dental lasers began as early as the 1960s. The first laser, a ruby laser, was constructed in 1960 by Maiman.[2] Stern & Sognnaes (1964) and Goldman et al. (1964) were the first to investigate the potential uses of the ruby laser in dentistry. They began their laser studies on hard dental tissues by investigating the possible use of a ruby laser to reduce subsurface demineralization. Indeed, they did find a reduction in permeability, to acid demineralization, of enamel after laser irradiation. After initial experiments with the ruby laser, clinicians began using other lasers, such as argon (Ar), carbon dioxide (CO2), neodymium: yttrium-aluminum-garnet (Nd:YAG), and erbium (Er):YAG lasers. The first laser use in endodontics was reported by Weichman & Johnson (1971) who attempted to seal the apical foramen in vitro by means of a high power-infrared (CO2) laser. Although their goal was not achieved, sufficient relevant and interesting data were obtained to encourage further study. Subsequently, attempts were made to seal the apical foramen using the Nd:YAG laser (Weichman et al. 1972). Although more information regarding this laser's interaction with dentine was obtained, the use of the laser in endodontics was not feasible at that time. Melcer et al. (1987) first described laser treatment of exposed pulp tissues using the CO2 laser in dogs to achieve haemostasis; Ebihara et al. (1988, 1992) used the Nd:YAG laser in rats and dogs. Their results showed that lasers facilitated pulpal healing after irradiation at 2 W for 2s. Moritz et al. (1998) reported that the CO2 laser was a valuable aid in direct pulp capping in human patients.[1] A predecessor of the laser, called the MASER, for "Microwave Amplification by Stimulated Emission of Radiation", was independently developed in 1954 at Columbia University by Charles Townes and Jim Gordon and in Russia by Nicolay Basov and Alexandra Prokhorov.[3] Laser evolved from 'Pre Maser' to 'Maser' and now finally to 'Lasers.' The evolution period is classified as Pre Masers (1916 to 1953) when the existence of stimulated emission process was discovered and lead to a radiation amplifier, then Maser period (1954 to 1960) when several Maser types came into existence and finally in 1960, Ruby lasers, lead to discovery of various types of lasers leading to excellent clinical success.[4]

Table 1: Shows tissue interaction of various dental lasers

Laser type	Wave length	Color	Soft tissue ablation	Coagulation	Carbonization	Hemostasis	Bacterial killing	Hard tissue ablation	Biostimulation
Diode; Gallium Aluminum Arsenide (GaAlAs)	670-830 nm	Red-infrared	+	++	+	++	+	-	++
Diode; Indium Gallium Arsenide (InGaAs)	980 nm	Infrared	+	++	+	++	+	-	++
Neodymium:YA	1,064	Infrared	+	++	+	++	+	-	++

G (Nd:YAG)	nm								
Erbium, chromium:YSGG (Er,Cr:YSGG)	2,780 nm	Infrared	++	+/-	+/-	+	+	++	+
Erbium:YAG (Er:YAG)	2,936 nm	Infrared	++	+/-	+/-	+	+	++	+
Carbon Dioxide (CO2)	10,600 nm	Infrared	++	+	++	++	+	-	+

Role of Lasers in Dentinal Hypersensitivity: One of the most painful and the least treated conditions in dentistry is dentinal hypersensitivity (DH), which affects one in six people. Lasers were used to eliminate DH first in 1985; however, DH is so complicated that researches have been carried out by many investigators on its mechanism of action, advantages, and unclear points. Researchers hypothesized many theories while trying to explain its mechanism; the most popular one is the hydrodynamic theory of Brännström et al. who postulated that abrupt fluid transfer in the dentinal tubules stimulate mechanosensitive nerve ends close to the odontobastic layer.[5] This condition can arise through incorrect tooth brushing, gingival recession, inappropriate diet, and because of other factors (Schuurs et al. 1995). Grossman (1935) suggested a number of requirements for treatment of this condition; these still hold true today. Therapy should be nonirritant to the pulp; relatively painless on application; easily carried out; rapid in action; effective for a long period; without staining effects; and consistently effective. To date, most of the therapies have failed to satisfy one or more of these criteria, but some authors report that lasers may now provide reliable and reproducible treatment.[1] The lasers used for the treatment of the dentinal hypersensitivity are divided into two groups: low output power lasers [He-Ne and gallium/aluminum/arsenide (GaAlAs) lasers], and middle output power lasers (Nd:YAG and CO2 lasers). The rationale for laser-induced reduction in dentinal hypersensitivity is based on two possible mechanisms that differ greatly from each other. The first mechanism implies the direct effect of laser irradiation on the electric activity of nerve fibers within the dental pulp, whereas the second involves modification of the tubular structure of the dentin by melting and fusing of the hard tissue or smear layer and subsequent sealing of the dentinal tubules.[6] Senda et al were the first to apply the helium-neon laser in treating dentinal hypersensitivity. They used an output power of only 6 mW, which does not affect the morphology of the enamel or dentin surface but allows a small fraction of the energy to reach the pulp tissue. It was reported that the effectiveness of this treatment ranges from 5.2% to 100%. Although the mechanism causing the reduction in hypersensitivity is not apparent, it was claimed that helium-neon laser irradiation affects electric activity (action potential) rather than Ad- or C-fiber nociceptors.[6-8] Matsumoto et al were the first to report the use of a diode laser with a power output of 30 mW in a continuous wave irradiation mode for 0.5 to 3 min and reported treatment effectiveness ranging from 85% to 100%. The investigators considered that the analgesic effect was related to depressed nerve transmission caused by the diode laser irradiation blocking the depolarization of C-fiber afferents.[9,10] Dederich et al were the first to describe the melting and recrystallization of root canal wall dentin following Nd:YAG laser exposure. Direct nerve analgesia and a suppressive effect achieved by blocking the depolarization of Adelta and C fibers also were considered possible mechanisms. Moritz et al used a CO2 laser with an output power of 0.5 W in a continuous wave mode for 5 seconds to treat dentin hypersensitivity and postulated that the CO2 laser reduced dentin hypersensitivity by occluding or narrowing the dentinal tubules. Watanabe et al recently reported the use of the erbium: yttrium aluminum-garnet (Er:YAG) laser for the treatment of dentin hypersensitivity with treatment effectiveness ranging from 16% to 61%.[6] The ability of other lasers to vaporize, fuse, melt, or seal dentinal tubules by recrystallization of the mineral component of dentin has been reported with varying success. Stabholz et al investigated the effects of excimer lasers on exposed dentinal tubules of extracted human teeth and found melting of dentin and closure of exposed dentinal tubules. Such modification of the dentin surface may be accepted as a treatment modality applicable to hypersensitivity and the prevention of bacterial penetration through dentinal tubules under fillings because melting and resolidification of the dentin and the closure of the tubules may be permanent. A possible advantage in using excimer lasers could be their relative safety (ie, the lack of thermal damage to the surrounding tissues). The feasibility of introducing excimer lasers into dental offices, however, remains questionable at present, making these lasers interesting tools for research but impractical in the clinical setting.

Table 2: Showing list of lasers used for the treatment of dentinal hypersensitivity

Lasers	Parameters	Effective rate (%)	References
He-Ne (632.8nm)	6mW for 2-3 min 6mW for 1-3min	84 90	Senda etal.1985 Matsumoto et al.1986

GaAlAs (780nm)	30mW for 0,5-3min 30mW for 0.5-3min	>85 94.6	Matsumoto et al.1985a,b Kawakami et at.1989
GaAlAs (830nm)	30mW for 0.5-3min 30mW for 5 min	83.9 58	Hamachi et al.1992 Mezawa et al.1992
Nd:YAG (1.064µm)	10W for 0.5-2.5s 10- 100mJ/p for 2min	100 100	Matsumoto et al.1985c Renton-Harper & Midda (1992)
CO2 (10.6µm)	0.5W for 5-30s 1W for 5-10s	98.6 100	Moritz et al.1996 Zhang et al.1998a

Laser in Determining the Pulp Vitality: Vitality tests indicate vitality of the sensory fibers within pulp; however, up to 16% of test results were proved to be false positive. It can be explained with the resistance of neurons including sensory fibers against degenerative processes of inflammation even though the surrounding connective tissues are necrotic or degenerated. On the other hand, teeth with calcific metamorphosis, cases of recent trauma and teeth with ongoing root development may result in a false-negative response (i.e., no response). Although vitality tests work based on the nerve response in pulp, condition of the sensory fibers does not define the vitality of pulp. Pulp vitality is rather determined by the condition of the vascular supply of pulp which enters pulp through the apical and accessory foramina. Branches of this vascular network connects its arterioles and venules under the odontoblast layer and venules leave pulp using the same apical foramen.[5] Laser Doppler flowmetry, which was developed to assess blood flow in microvascular systems, also can be used for diagnosis of blood flow in the dental pulp. This technique uses helium-neon and diode lasers at a low power of 1 or 2 mW. The laser beam is directed through the crown of the tooth to the blood vessels within the pulp. Moving red blood cells causes the frequency of the laser beam to be Doppler shifted and some of the light to be backscattered out of the tooth. The reflected light is detected by a photocell on the tooth surface and its output is proportional to the number and velocity of the blood cells. The main advantage of this technique, in comparison with electric pulp testing or other vitality tests, is that it does not rely on the occurrence of a painful sensation to determine the vitality of a tooth. Moreover, teeth that have experienced recent trauma or are located in part of the jaw that may be affected following orthognathic surgery, can lose sensibility while intact blood supply and pulp vitality are maintained. Laser Doppler flowmetry has some limitations. It may be difficult to obtain laser reflection from certain teeth. Generally, the anterior teeth, in which the enamel and dentin are thin, do not present a problem. Molars, with their thicker enamel and dentin and the variability in the position of the pulp within the tooth, may cause variations in pulpal blood flow. Furthermore, differences in sensor output and inadequate calibration by the manufacturer may dictate the use of multiple probes for accurate assessment. Laser Doppler flowmetry assures objective measurement of pulpal vitality. When equipment costs decrease and clinical application improves, this technology could be used for patients who have difficulties in communicating or for young children whose responses may not be reliable.[6]

Laser in Pulp Capping And Pulpotomy: Pulp capping, according to AAE, is when ‘‘a dental material is placed over an exposed or nearly exposed pulp to encourage the formation of irritation dentin at the site of injury.’’ Pulpotomy entails surgical removal of a small portion of vital pulp as a means of preserving the remaining coronal and radicular pulp tissues. Pulp capping is recommended when the exposure is very small, 1.0 mm or less and the patients are young; pulpotomy is recommended when the young pulp already is exposed to caries and the roots are not yet fully formed (open apices). Since the introduction of lasers to dentistry, several studies have shown the effect of different laser devices on dentin and pulpal tissue. Although ruby lasers caused pulpal damage, Melcer et al showed that the CO2 laser produced new mineralized dentin formation without cellular modification of pulpal tissue when tooth cavities were irradiated in beagles and primates. Shoji et al applied CO2 laser energy to the exposed pulps of dogs using a focused and defocused laser mode and a wide range of energy levels (3, 10, 30, and 60 W). Charring, coagulation necrosis, and degeneration of the odontoblastic layer occurred, although no damage was detected in the radicular portion of the pulp. Jukic et al used CO2 and Nd:YAG lasers with energy densities of 4 J/cm2 and 6.3 J/cm2 , respectively, on exposed pulp tissue. In experimental groups, carbonization, necrosis, an inflammatory response, edema, and hemorrhage were observed in the pulp tissue. In some specimens, a dentinal bridge was formed.[6] Patients in whom direct pulp capping treatment was indicated Moritz et al used a CO2 laser with an energy level of 1 W at 0.1s exposure time with 1s pulse intervals until the exposed pulps were completely sealed and were then dressed with calcium hydroxide. Vitality and other symptoms were examined regularly for 1 year and concluded that 89% of the experimental group had no symptoms and responded normally to vitality tests.[11]

Laser Applications in Endodontic Surgery: Root apex resection is performed when root canal treatment fails and orthograde retreatment is not possible. In its procedure, apex is cut and removed. When a laser is chosen for the surgery, it provides a clean visual of the operative area without blood contamination owing to the ability of the laser to vaporise the tissues, to coagulate and to seal small blood vessels. It is thought that laser irradiated dentin surfaces are sterile and sealed.[1,5] Weichman and Johnson, who attempted to seal the apical foramen of freshly extracted teeth in which the pulp had been removed from the root canal, were the first to use lasers in endodontics. They used high-power (CO2) laser energy to irradiate the apices of the teeth but could not achieve the desired effect. Miserendino applied CO2 laser energy to the apices of freshly extracted human teeth and demonstrated recrystallization of apical root dentin. The recrystallized structure was smooth and suitable for placement of retrograde filling material. He suggested that the rationale for laser use in endodontic periapical surgery should include the following: improved hemostasis and concurrent visualization of the operative field, potential sterilization of the contaminated root apex, potential reduction of the permeability of the root surface dentin, a reduction in postoperative pain, and a reduced risk of surgical site contamination by eliminating the use of aerosol producing air turbine hand-pieces for apicoectomy. Despite its potential to lower dentin permeability, the conclusions of an in vivo study were that the use of CO2 laser in apical surgery on dogs did not improve the success rate following surgery. Various in vitro studies using the Nd:YAG laser have shown a reduction in the penetration of dye or bacteria through resected roots. It was suggested that the reduced permeability in the lased specimens probably was the result of structural changes in the dentin following laser application. Ebihara et al used Er:YAG laser for retrograde cavity preparations of extracted teeth and concluded that Er:YAG laser does not melt or seal the dentinal tubules. The authors believe that after the appropriate wavelength for melting the hard tissues of the tooth has been established, the main contribution of laser technology to surgical endodontics (apicoectomy and so forth) is to convert the apical dentin and cementum structure into a uniformly glazed area that does not allow egress of microorganisms through dentinal tubules and other openings in the apex of the tooth. Hemostasis and sterilization of the contaminated root apex also have a significant input.[6] The use of laser for apicectomy procedure has some merits, but it takes more time to perform when compared to more conventional methods.[1]

Cleaning and Shaping the Root Canal System: In various laser systems used in dentistry, the emitted energy can be delivered into the root canal system by a thin optical fiber (Nd:YAG, erbium,chromium:yttrium-scandium-gallium-garnet [Er,Cr:YSGG], argon, and diode) or by a hollow tube (CO2 and Er:YAG). Thus, the potential bactericidal effect of laser irradiation can be used effectively for additional cleansing of the root canal system following biomechanical instrumentation. This effect was studied extensively using lasers such as CO2, Nd:YAG, excimer, diode, and Er:YAG . The apparent consensus is that laser irradiation emitted from laser systems used in dentistry has the potential to kill microorganisms. In most cases, the effect is directly related to the amount of irradiation and to its energy level. It also has been documented in numerous studies that CO2 , Nd:YAG, argon, Er,Cr:YSGG , and Er:YAG laser irradiation has the ability to remove debris and the smear layer from the root canal walls following biomechanical instrumentation.[6] Weichman & Johnson (1971) first applied a laser to the root canals by attempting to seal the apical foramen in vitro by means of a high-power CO2 laser. Although the goal was not achieved, sufficient data were obtained to encourage further study. After CO2 laser irradiation, dentine permeability was reduced (Pashley et al. 1992), and a wide range of morphological changes were observed (Tanji & Matsumoto 1994, Lopes et al. 1995, Anic et al. 1996, Khan et al. 1997). Moreover, debris removal and morphological changes were facilitated by the laser irradiation with diamine silver fluoride [Ag(NH3)2F] (Eto et al. 1999). The CO2 laser emitting in the 9.3–10.49 µm region (Featherstone & Nelson 1987, Onal et al. 1993, Takahashi et al. 1998, Kimura et al. 2000), caused surface fusion and inhibition of subsequent lesion progression in dentine and improved the bonding strength of a composite resin to dentine depending on laser parameters. Using the Nd:YAG laser Weichman et al. (1972), attempted to seal the entrance to the root canal at the apex of a tooth in vitro. The development of a thin fibre for the Nd:YAG laser stimulated its application in root canals. Many reports on Nd:YAG laser preparation of root canals have been published (Dederich et al. 1984, 1988, Levy 1992, Bahcall et al. 1993, Goodis et al. 1993, Marques et al. 1995, Miserendino et al. 1995, Lopes et al. 1995, Saunders et al. 1995). Debris and smear layer were removed using appropriate laser parameters (Morita 1994, Koba 1995, Harashima et al. 1997a, Koba et al. 1998a,b, 1999a), and dentine permeability was reduced (Miserendino et al. 1995, Anic et al. 1996). Since absorption of Nd:YAG laser irradiation is enhanced by black ink, it potentiates laser effects on root canals (Zhang et al. 1998b). Argon laser irradiation can achieve an efficient cleaning effect on instrumented root canal surfaces (Moshonov et al. 1995a, Matsuoka et al. 1996, Zhang et al. 1996, Khan et al. 1997, Harashima et al. 1997b, 1998), and laser irradiation in the presence of Ag(NH3)2F solution enhances the effect (Zhang et al. 1996). Er:YAG laser irradiation was more effective in removing the smear layer and debris on root canal walls than the Ar or Nd:YAG laser (Takahashi et al. 1996, Matsuoka et al. 1998, Takeda et al. 1998a,b,c, 1999). Potassium titanyl phosphate (KTP) laser (wavelength of 532 nm) (Tewfik et al. 1993, Machida et al. 1995) irradiation was able to remove smear layer and debris from root canals. The effects of a nanosecond-pulsed, frequency-doubled Nd:YAG laser emitted at 532 nm on dentine (Arrastia-Jitosho et al. 1998) demonstrated that this laser irradiation can achieve complete smear layer removal. However, the results were inhomogeneous, and at higher energy densities thermal damage was observed. At specific fluences, the xenon chlorine (XeCl) laser (wavelength of 308 nm) can melt dentine and seal exposed dentinal tubules (Pini et al. 1989b, Stabholz et al. 1993a, 1995, Lee et al. 1995, Dankner et al. 1997). The Ar-fluoride (F) excimer laser emitting at 193 nm (Stabholz et al. 1993b, Arima & Matsumoto 1993, Wilder-Smith et al. 1997b) caused significant removal of peritubular dentine at relatively high fluence (10~15 J/cm2), melting and resolidification of the dentinal smear layer being observed under the SEM. The effects of holmium (Ho):YAG laser irradiation emitted at 2.10 µm (Stevens et al. 1994, Cernavin 1995) demonstrated that this laser is an effective means of ablating dentine and may be suitable for cutting dentine. The Nd:yttrium alminum perovskite (YAP) laser emitting at 1340 nm (Blum & Abadie 1997, Farge et al. 1998) was suggested as an effective device for root canal preparation in endodontic retreatment.[1] There are several limitations that may be associated with the intracanal use of lasers that cannot be overlooked. The emission of laser energy from the tip of the optical fiber or the laser guide is directed along the root canal and not necessary laterally to the root canal walls. Thus, it is almost impossible to obtain uniform coverage of the canal surface using a laser. Another limitation is the safety of such a procedure because thermal damage to the periapical tissues potentially is possible.[12] Direct emission of laser irradiation from the tip of the optical fiber in the vicinity of the apical foramen of a tooth may result in transmission of the irradiation beyond the foramen. This transmission of irradiation, in turn, may affect the supporting tissues of the tooth adversely and can be hazardous in teeth with close proximity to the mental foramen or to the mandibular nerve. In their review, Matsumoto and colleagues also emphasized the possible limitations of the use of lasers in the root canal system. Similar inferences were presented by other workers also.[10-15] They suggested that ‘‘removal of smear layer and debris by laser is possible, however it is difficult to clean all root canal walls, because the laser is emitted straight ahead, making it almost impossible to irradiate the lateral canal walls.’’ These investigators strongly recommended improving the endodontic tip to enable irradiation of all areas of the root canal walls.[6] Stabholz and colleagues[13] recently reported the development of a new endodontic tip that can be used with an Er:YAG laser system. The Er:YAG laser has gained increasing popularity among clinicians following its approval by the Food and Drug Administration for use on hard dental tissues. The beam of the Er:YAG laser is delivered through a hollow tube, making it possible to develop an endodontic tip that allows lateral emission of the irradiation (side-firing), rather than direct emission through a single opening at its far end. This new endodontic side-firing spiral tip (RCLase; Lumenis, Opus Dent, Israel) was designed to fit the shape and the volume of root canals prepared by nickel-titanium rotary instrumentation. It emits the Er:YAG laser irradiation laterally to the walls of the root canal through a spiral slit located all along the tip. The tip is sealed at its far end, preventing the transmission of irradiation to and through the apical foramen of the tooth.[6]

Laser Applications in the Removal of the Root Canal Filling Material and Medicaments: Smear layer may cover dentinal tubules and thus it is thought that smear layer may help to seal dentin and decrease microleakage. However, smear layer may also contain microorganisms and their by products[4]. Therefore, removal of smear layer should be preferred and it is possible to seal dentin tubules by laser irradiation while removing its smear layer[16]. On the other hand, irradiation with CO2 laser removed smear plugs in an in vitro study where increased dentin permeability was observed in the end. Takeda et al. showed that irrigation with 17% EDTA, 6% phosphoric acid and 6% citric acid was not able to remove the entire smear from the root-canal system. Acidic solutions cause erosion and widening of tubules. CO2 laser was useful to remove smear, and Er:YAG laser was proved to be more effective. However, dentin permeability was promoted by Er:YAG laser irradiation[17], and using sodium hypochlorite irrigation afterwards also fortifies this effect.[5]

Disinfection of the Root Canal System: Numerous studies into the sterilization of root canals have been performed using CO2 (Zakariasen et al. 1986) and Nd:YAG lasers (Rooney et al. 1994, Ebihara et al. 1994, Fegan & Steiman 1995, Moshonov et al. 1995b, Goodis et al. 1995, Sekine et al. 1995, Gutknecht et al. 1996a, Ramskold et al. 1997). The Nd:YAG laser is more popular, because a thin fibre-optic delivery system for entering narrow root canals is available with this device. Many other lasers such as the XeCl laser emitting at 308 nm (Stabholz et al. 1993c), the Er:YAG laser emitted at 2.64 µm (Gomi et al. 1997), a diode laser emitting at 810 nm (Moritz et al. 1997a), and the Nd:YAP laser emitting at 1.34 µm (Blum et al. 1997) have also been used for this purpose. All lasers have a bactericidal effect at high power that is dependent on each laser. There appears to exist a potential for spreading bacterial contamination from the root canal to the patient and the dental team via the smoke produced by the laser, which can cause bacterial dissemination (Hardee et al. 1994). Similar presumptions was presented by other researchers also.[18-23] Thus, precautions such as a strong vacuum pump system must be taken to protect against spreading infections when using lasers in the root canal (McKinley & Ludlow 1994).[1]

Lasers in Tooth Bleaching: Patients' awareness of options available for changing the color of natural dentition has caused an increase in the public demand. The known indications are superficial stains, penetration, absorbed stains, and age-related stains. Patients who prefer conservative treatment to improve appearance, color change related to pulp trauma and necrosis, and interproximal discolorations are also seen everywhere nowadays. The whitening efficacy of LED and diode laser irradiation was compared by Wetter et al.[24], using the two agents Opalescence Xtra and HP Whiteness. The results of the comparison indicated that significant differences in the chroma value were obtained for the two whitening agents and for the different light sources. Under the conditions of lightness, the togetherness of laser and Whiteness HP bleaching gel showed significantly better results than the cases in which the same agent was used alone or in combination with LED. As a result laser bleaching is a power bleaching technique that produces quickly results without the long-term commitment of wearing trays.[5]

Effect of Lasers on Periodontal Tissues: The tooth root is in contact with the alveolar bone via the periodontal membrane and ligament. During laser usage for intracanal applications, thermal injury to periodontal tissues is of concern. Several studies investigating laser-induced thermal effects on the pulp have been published, but few studies have dealt with the effects on the periradicular tissues from energy introduced into the root canal.[25-30] Eriksson & Albrektsson (1983) found that the threshold level for bone survival was 47°C for 1 min. The first report on the effect of the Nd:YAG laser on periodontal tissues was performed using dogs (Bahcall et al. 1992). The results showed that the laser-treated teeth exhibited ankylosis, cemental lysis, and major bone remodeling. However, the parameters used in this study (3 W and 25 pps for 30 s) were excessive. Since that time, many other studies on periodontal effects of lasers in dogs and rats have been published (Morita 1994, Koba 1995, Sekine et al. 1996, Inamoto et al. 1997, Koba et al. 1998a,b, 1999a). No adverse effects by lasers on periodontal tissues were observed if appropriate parameters were selected. Laser systems operate in various modes, such as continuous wave, pulsed, chopped-wave, and Q-switched. To minimize the rise in tissue temperature within the target and around areas, use of the Q-switched nanosecond pulsed mode is beneficial (Kimura et al. 1997, 1998b). If the Ho:YAG laser was used within the root canal at the parameter below 1 W, 5 Hz and total energy 58 J, the root surface temperature rise remained below 2.2°C (Cohen et al. 1996). To make the treatment successful, the effects on periodontal tissues must be considered. It is very important to select the appropriate parameter and method.[1]

CONCLUSIONS

Dental treatments using lasers are preferred more often every day and lasers provide results in shorter time than the conventional treatment methods and have more effective results in some conditions and cases. Contrary, the most significant disadvantages of lasers appear as their cost and maintenance. Further studies are required to obtain long-term results of therapies done by lasers.

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