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An Overview: Laser Applications in Dentistry

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Abstract: Dentistry has entered an exciting era of high technology. Lasers provide new powerful tools that is characterized by a bloodless field and applied in most branches of dentistry. There are many types of lasers, such as Gas laser, Chemical laser, Dye laser, Metal-vapor laser, Solid-state laser and Semiconductor laser. Each laser type has its own unique features, advantages and disadvantages. While one laser may be suitable for some procedures, it will be unsuitable for others, so it is important for the dentist to have a back ground information about this technology and its uses in dentistry.

Key words: Oral surgery, maxillofacial surgery, preventive dentistry, restorative dentistry, endodontics

INTRODUCTION

Since the golden years of the 1960s, Lasers were developed and approved for soft tissue procedures. In 1964 Goldman, Ruben and Sherman reported an issue on laser for spectrographic analysis of the inorganic components or supragingival and subgingival calculus. Researchers after that continued to prove the uses of laser in dentistry. There are many different types of lasers used in dentistry and their applications vary. The most common use of lasers is for removing dental caries, old composite fillings, sterilizing infected root canals, bone shaping, aphthous ulcer treatment, crown lengthening, apicoectomy, periodontal treatment and oral surgery. In soft tissue procedures (gignivectomy, frenectomy, curettage, crown lengthening, lesion removal) CO_2 laser, Nd: YAG laser, Ar (Argon) laser, Er: YAG (Erbium doped Yattrium Aluminum Garnet) laser and diode laser are used. While in hard tissue procedures (cutting of enamel) Er:YAG laser is preferable. In composite curing: Argon laser is used (Weesner, 1998).

LASER APPLICATIONS IN ORAL AND MAXILLOFACIAL SURGERY

Lasers are of high value in all types of minor surgery, however, their cost and the difficulty of controlling adverse effects present major limiting factors (Catone and Alling, 1997; Al-Alawi, 2005). In soft tissue cutting, the lasers have a number of advantages over the scalpel or Electro surgery. These advantages are (Catone and Alling, 1997; Caroth and Mckenzie, 1985; Nobor, 1989):

- The non-contact technique employed means that the tissue is distorted minimally while cutting
- The incision is self-sterilizing
- The laser is always sharp in cutting
- Postoperative scarring is extremely reduced

So, it should be emphasized first and foremost that lasers are an alternative to conventional surgical methods. CO_2 and diode lasers have become the routine cutting lasers in oral and maxillofacial surgery. Many surgeons used the Nd-YAG laser for homeostasis (Nobor, 1989; Nabi *et al*., 2010). Many researchers have found that the diode laser can be used to eliminate benign, Premalignent or malignant lesions of the oral soft tissues (Caroth and Mckenzie, 1985; Ashour, 2006). However, it does not possess any greater ability than the scalpel to cure these conditions, but rather it is a precise mean of removing the effected tissue with little upset to the patient. The clinical results that many authors got presume a high degree of healing (Catone and Alling, 1997; Caroth and Mckenzie, 1985; Nobor, 1989). Many of the inherent properties of

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lasers used for performing soft tissue surgery are advantageous in the surgical management of malignant diseases of the oral cavity and related structures. The ability of the laser to perform haemostatic surgery by sealing blood vessels of a smaller diameter than the laser beam is advantageous because it means that more precise surgery can be carried out in a bloodless field and sealing the vessels may decrease the seeding of malignant cells at the time of surgery (Charstpher *et al*., 1995). Similarly, the ability of the laser to seal the lymphatics at the time of surgery is advantageous in decreasing the swelling and edema associated with surgery. This may decrease the need for a tracheostomy to be performed in the management of facial edema and may decrease the need for steroids to be administered postoperatively. Sealing of the lymphatics may also decrease the possibility of seeding malignant cells into the lymphatics at the time of surgery. In addition, the ability to seal nerve endings is advantageous in decreasing postoperative discomfort (Fitzpatrick, 1992; Charstpher *et al*., 1995). The ability of the laser to leave a clean, dry, sealed wound is the probable reason for the noted low infection rate following laser surgery. This is an advantageous in the management of malignant diseases due to decreasing the need for therapeutic and prophylactic antibiotics (Sisecioglu *et al*., 2011; Alanazi *et al*., 2010a, b). This indicate that laser wounds heal with low levels of discomfort and relatively little scaring and wound contractor suggest that formal reconstruction by means of primary closure, skin grafting, or local flap procedures is not necessary because wounds can be left to heal by secondary intention, giving a good functional result with minimal scarring and lack of movement. Also some procedures previously performed in the hospital can now be performed on an outpatient basis using the laser (Alster and Amy, 1996; Conn, 1981). There are another proven uses for dental soft-tissue procedure using lasers: Such as frenectomies, incisional and excisional biopsies, soft-tissue tubrosity reduction, soft-tissue crown lengthening, vestibuloplasty, stage 2 implant recovery, etc. (Caroth and Mckenzie, 1985; Jawad, 2008). Oral and maxillofacial surgery are all have the potential use of laser in the treatment, many of the lesions that occur on the surface of the oral mucosa are easily controlled with laser energy (Fitzpatrick, 1992). The use of lasers in conjunction with endoscopes in facial rejuvenation procedures has literally turned cosmetic surgery inside out. Conventional surgical techniques such as brow lifting, blepharoplosty and rhytidectomy have been adapted to incorporate these new technologies: they provide the desired aesthetic results and concomitantly offer the patient less postoperative discomfort and a more rapid recovery (Tina and Tina, 1996; Nicholas *et al*., 1995; Apfelberg, 1996; Aboud, 2005).

LASER IN PREVENTIVE DENTISTRY

Stern and Sognnaes (1965) reported that the enamel vaporized when subjected to a ruby laser pulse of about 1m sec. duration, focused to approximately 1 mm^2 when the beam contains between 5 and 20 J mm^{-2} (500-2000 J cm^{-2}) (Hemachandran and Arumugam, 1983). Gordon (1966) suggested cavity preparations with laser but the replacement of the dental drill with laser is untenable as the laser energy above 1000 J cm^{-2} at the Dentino Enamel Junction (DEJ) would cause irreversible pulpal changes. Vahl (1968) used electron microscopy and X-ray diffraction to study the effects of laser radiation on enamel. These studies clearly demonstrated ultra-structural and crystallographic changes in response to laser radiation Featherstone and Neslon (1987) concluded that the potential role of the laser in caries prevention has been presented. Laser enamel showed a lesser effect when subjected to an *in vitro* procedure which induced a caries-like subsurface demineralization than enamel which was not irradiated. Yamamoto and Ooya (1974) suggested that caries could be prevented using an Nd:YAG laser. This group discovered that laser irradiation slightly altered the enamel surface, reducing subsequent subsurface demineralization. They found a significant difference in solubility between laser irradiated and non-irradiated enamel. Featherstone and Nelson (1987) had conducted studies with enamel and dentin, using pulsed CO_2 laser radiation in the 9.32 to 10.49 μm region with energy densities in the 10 to 50 J cm^{-2} range (Featherstone and Neslon, 1987). This laser treatment caused surface fusion and inhibition of subsequent lesion progression and markedly improved the bonding strength of a composite resin to dentin. Walsh and Perham (1991) reported the potential of the CO_2 laser for caries prevention using focused infrared laser radiation on sound enamel and early pit and fissure caries. Low-power levels (2-5 W) induced localized melting and resolidification of enamel with little surface destruction. For sound fissures, there is elimination of the fissure space providing a sealant effect. In carious fissures, carious enamel was vaporized and adjacent sound enamel fused to partially eliminate the defect. Argon lasers have been reported to reduce or prevent demineralization of enamel of extracted teeth using energy densities of 25 to 100 J cm^{-2}. At these energy densities no damage would be expected in pulp or in the surrounding enamel. Al-Sayyab (2000) used CO_2 laser (λ = 10.6 μm) and fluoride to evaluate their combined effect on the acid dissolution and the inhibition of the progression of in vitro caries-like lesions in dental enamel and root. He used continuous and pulsed modes of laser operation, different number of laser pulses, different power densities and different terms of topical fluoride application. The caries inhibitory effects reached up to 60% in enamel specimens and up to 69% in root specimens. Al-Tikrity (2001) used polarized light microscope to study the effects of laser radiation on enamel. He used various CW CO_2 laser parameters. A single exposure to CW CO_2 laser radiation was found to be resulted in reductions of in vitro caries like lesion depths. These reductions were up to 61%. The inhibition activity was related directly to the power density and inversely to the exposure time of the CW CO_2 laser radiation. The optimal parameters were 33 W cm^{-2} power density and 0.2 exposure time. The carbon dioxide laser (wavelengths of 9.3 and 10.6 μm) are strongly absorbed by water and therefore likely to have the best effect at the lowest influence. Also the use of pulsed lasers since this would allow for short high intensity delivery of energy with periods of relaxation in between to ensure safety of the pulp and the surrounding tissue (Featherstone and Fried, 2001). De-Melo *et al*. (2010) used low-intensity diode laser (λ = 808 nm) on dentin as preventive measure from dental erosion and also monitored temperature changes during the course of irradiation. Their study concluded that using a diode laser with levels set at 60 J cm^{-1} may induce inhibitory effects on root dentin demineralization without causing any harmful thermal effects. Esteves-Oliveira *et al*. (2010) used pulsed CO_2 laser (10.6 μm) emitting pulses of 10 msec to reduce dentine calcium and phosphorus losses in an artificial caries mode. There results showed that CO_2 laser irradiation (10.6 μm) with 11 J cm^{-2} (540 mJ and 10 Hz) of fluoride treated dentine surfaces decreases the loss of calcium and phosphorous in the demineralization process and does not cause excessive temperature increase inside the pulp chamber.

Laser in periodontology: The CO_2 and the Nd: YAG lasers are the most generally used instruments for surgical procedures performed on oral soft tissues (Cohen and Ammons, 1996). Lasers have several potential applications in periodontology, these applications include laser gingivectomy, laser gingivoplasty, laser curettage, laser sterilization of root surfaces and periodontal pockets, laser scaling, frenectomy, crown lengthening, biopsies, tongue lesions, white lesions, aphthous ulcers, laser root planning, distal wedge and tuberosity reduction (Pick and Powell, 1993; Clayman, 1997). Argon laser is used for soft tissue graft and to treat periodontal pockets (Finkbeiner, 1995) while diode lasers are used in sulcular debridement and in bacterial reduction in periodontal pockets (Barr *et al*., 1998; Moritz *et al*., 1997a, b, 1998a). Gursoy-Mert *et al*. (2010) used Er:YAG laser in the treatment of acute streptococcal gingivitis both clinically and microbiologically. The results showed that Er:YAG laser is a promising and effective as conventional periodontal therapy in the treatment of acute streptococcal gingivitis. De Oliveira *et al*. (2010) reported that Er, Cr: YSGG laser irradiation on root surfaces for adhesion of blood components produced rougher root surfaces than treatment by scaling and root planing. However, it did not interfere with the adhesion of blood components to the root surfaces.

LASER IN RESTORATIVE DENTISTRY

Laser polymerization: The possibility of using lasers for curing has been considered for sometimes. The argon laser, which produces blue light, exactly the right wavelength 488 nm is extremely effective in curing light-activated composite and similar materials (Mercer, 1996). Blankenau *et al*. (1991) have shown that polymerization of microfilled resin is significantly greater when using the argon laser than conventional visible light sources. Vargas *et al*. (1998) suggested comparable polymerization using the argon laser versus a conventional visible light to polymerize light activated composite resins. Resin polymerization was accomplished using the argon laser at reduced exposure times. The argon laser can adequately polymerize composite more rapidly compared to a conventional unit, it is a desirable alternative for polymerizing composite resin restorations.

Cutting/ablation of hard dental tissues: Early in laser history, lasers were used to cut operative cavity preparations. First attempts produced too much heat, melted the enamel and damaged the pulp. In the last few years, newer lasers of different wavelengths (Er:YAG and excimer) have renewed interest in this potential. To cut hard tissue effectively, a wavelength should be used that is strongly absorbed by hard tissue. The suitable lasers are Er:YAG, TEA CO_2 (Transversely Excited Atmospheric CO_2) and the excimer (Excited dimer) lasers respectively and are all currently under investigation as hard tissue cutters (Mercer, 1996).

Mechanism of Er:YAG laser ablation of dental hard tissues: The ability of Er:YAG laser to effectively ablate dental hard tissues is ascribed to its 2.940 μm wavelength which is coincident with the main absorption band of water (˜3.0 μm) which is known as resonance frequency (Niemz, 2004; Apel *et al*., 2002; Walsh, 2003). The absorption of the water in this range is so high that scattering and the absorption of other tissue components can be neglected as a first approximation (Vogel and Venugopalan, 2003). So, the incident radiation is highly absorbed by water molecules in the dental hard structures, causing sudden heating and water evaporation. The resulting high stream pressure leads to the occurrence of successive microexplosions with ejection of tissue particles (Niemz, 2004; Hossain *et al*., 1999; Aoki *et al*., 2004). The microexplosions are characteristics of the ablation process and determine the microcrater like appearance of the lased surfaces (Keller and Hibst, 1993). So that, the ablation of tooth structure is achieved via a themomechanical ablation, with the majority of incident radiation is consumed in the ablation process, leaving very little residual energy for adverse thermal effects on the pulp and the surrounding soft and/or hard tissues (Chimello-Sousa *et al*., 2005).

Effect of Er:YAG laser ablation on dentin: In 1989, the Er:YAG laser was first described as being able of removing dental hard tissues without causing thermal undesirable effects, such as cracking or charring to the remaining dental tissues (Schein *et al*., 2003). The morphological aspect of the irradiated dentin has been reported as presenting an irregular surface with open dentinal tubules and lack of smear layer (Schein *et al*., 2003; Ceballos *et al*., 2001). These aspects, considered favorable for dentin bonding, are a consequence of the thermomechanical ablation pattern of Er:YAG laser due mainly to its wavelength (2940 nm), which is highly absorbed by water molecules present in the tooth structure (Van Meerbeek *et al*., 2002). Keller and Hibst (1989) reported that treatment with Er:YAG laser would create surfaces that appear similar to acid etched surfaces. Other investigations have shown that when bonding composite to tooth structure, the Er:YAG laser alone or combined with acid etching produces a surface with bond strength equal or better than that produced by acid etching alone (Delme *et al*., 2005). Also, Keller and Hibst (1989) and Visuri *et al*. (1996) postulated that the lased dentin surface possessed an advantage because of an apparent enlarged surface area for bonding based on the scaly and flaky surface appearance following Er:YAG irradiation (Dunna *et al*., 2005). Vargas *et al*. (1997) have shown on Scanning Electron Microscopy (SEM) study that Lased dentin surfaces present several characteristics that appear to be advantageous for resin composite bonding including dentin sterilization, opening of dentinal tubules, a surface with microirregularities without a smeared layer that promotes micromechanical bonding and no demineralization of peritubular and intertubular dentin. Ceballos *et al*. (2002) proposed that the ablation of dentin fused collagen fibrils together resulting in a lack of interfibrillar space, restricting resin diffusion into the subsurface intertubular dentin. However, a study was made by the same researchers suggesting that when an acid is applied after Er:YAG laser irradiation on dentin, a microirrigular surface and opened tubules are obtained, so hybrid layer and resin tag formation occurs. This situation could positively influence the bonding between dentin and resin (De Souza *et al*., 2004; Ceballos *et al*., 2001, 2002; Van Meerbeek *et al*., 2002). This comes into agreement with the findings of Delme *et al*. (2005) who found less marginal leakage of Class V composite restorations when phosphoric acid conditioning was accomplished in the Er:YAG lased cavities .This may be due to the fact that Er:YAG laser does not demineralize the dentin surface or widen the tubule entrance with no exposure of the collagen matrix (De Souza *et al*., 2004; Ceballos *et al*., 2001). On other hand, since the intertubular dentin contains more water and has a lower mineral content than the peritubular dentin, it is selectively ablated more than the peritubular dentin, leaving protruding dentinal tubules with a cuff like appearance. This may also contribute to an increase in the bonding area (Ceballos *et al*., 2002). This may be the main difference between acid etching and Er:YAG laser action related to dentin and the effect on the morphology of dentinal tubules. When an acid etchant is applied, the peritubular dentin is preferentially etched, resulting in funnel shaped openings to the tubules and this morphology may contribute with polymerization shrinkage to pull the resin tags away from the walls of the tubules. Er:YAG laser irradiation produces no demineralization of the peritubular dentin and the dentinal tubules remain open with no widening. Visuri *et al*. (1996) also showed by SEM analysis that the Er:YAG laser created open dentin tubules that allowed for the development of resin tags (Ceballos *et al*., 2001) (Fig. 1). Also it had been reported the presence of peritubular dentin even after acid etching that might be due to increased acid resistance of the dentin surface by the laser, since it has been reported

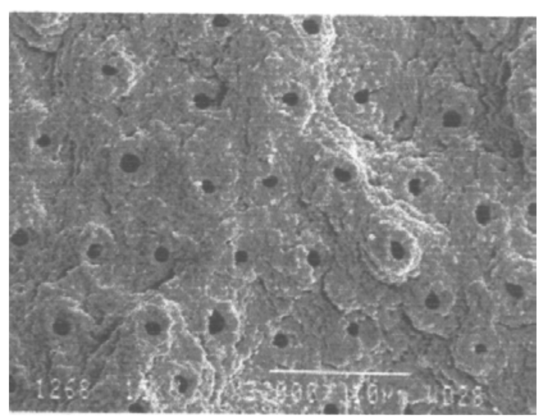

Fig. 1: Scanning electron microscopic picture of a dentin surface after Er: Yag laser preparation (X3000) (Bar = 10 μm) (Delme *et al*., 2005)

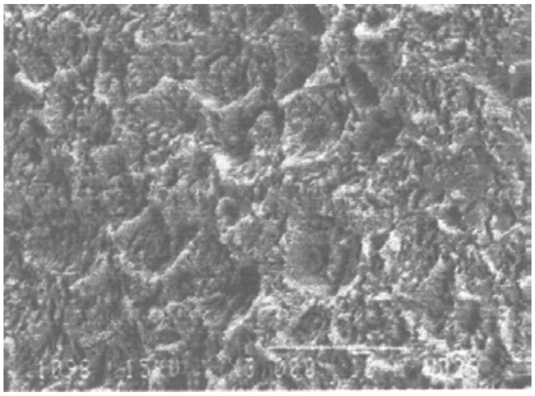

Fig. 2: Scanning electron microscopic picture of an enamel surface after Er:YAG laser preparation (X3000) (bar = 10 μm) (Delme *et al*., 2005)

the possibility of Er:YAG laser diminishing the solubility of irradiated dentin when immersed in acid solution (Burnnet *et al*., 2001; Schein *et al*., 2003).

Effect of er:yag laser ablation on enamel: The Er:YAG laser produces microexplosions during hard tissue ablation that results in macroscopic and microscopic irregularities. These irregularities make the enamel surface microretentive and may constitute the mechanism of bonding when an acid etchant is not applied (Ceballos *et al*., 2001; Estephan, 2007). Niu *et al*. (1998) have reported that cavity margins at enamel appear whitened when the Er:YAG laser is applied, with a similar appearance to the acid etching effect. The prospect of laser ablation of enamel surfaces was welcomed because of the potential disadvantages with enamel acid etching. Acid demineralization with 37% phosphoric acid can make enamel surfaces more susceptible to caries, especially if resin impregnation is incomplete or defective. It was thought that laser ablation might reduce caries risk because demineralization would not occur and that water and organic components would be reduced (Dunna *et al*., 2005) (Fig. 2).

Ablation of dental filling material; The Er:YAG lasers can be used to ablate a range of restorative filling materials (Clarkson, 1992).

Laser in endodontics: The first laser use in endodontics was reported by Weichman and Johnson (1971) who attempted to seal the apical foramen in vitro by means of a high power-infrared (CO_2) laser. Dentine hypersensitivity is characterized by short, sharp pain arising from exposed dentine in response to stimuli typically thermal, evaporative, tactile, osmotic or chemical and which cannot be ascribed to any other form of dental defect or pathology (Holland *et al*., 1997). The first laser use for the treatment of dentine hypersensitivity was reported by Matsumoto *et al*. (1985) using Nd:YAG laser. The lasers used for the treatment of dentine hypersensitivity are divided into two groups: low output power (low level) lasers [He-Ne and GaAlAs (diode) lasers] and middle output power lasers (Nd:YAG and CO_2 lasers) (Kimura *et al*., 2000b). In general, the efficacy of lasers is higher than other methods, but in severe cases, it is less effective. It is necessary to consider the severity of dentinal hypersensitivity before laser use (Abdul Qader, 2006).

Pulp capping and pulpotomy: If a laser is used for these procedures, a bloodless field would be easier to achieve because laser has the ability to vaporize tissue, coagulate and seal small blood vessels. Moreover, the treated wound surface would be sterilized (Kimura *et al*., 2000b). Moritz *et al*. (1998a,b) reported that the CO_2 laser was a valuable aid in direct pulp capping in human patients. The first laser pulpotomy was performed using the CO_2 laser in dogs (Shoji *et al*., 1985), similar work using the Nd: YAG laser was performed in dogs and rats. The Ga-As semiconductor laser was used for this purpose in mice and the Ar laser in swines (Kimura *et al*., 2000b). No detectable damage was observed in the radicular portions of irradiated pulps with the CO_2 laser (Shoji *et al*., 1985). Wound healing of the irradiated pulp seemed to be better than that of controls at 1 week and dentine bridge formation in the irradiated pulp was stimulated at 4 and 12 weeks after operation using the Nd:YAG laser (Ebihara, 1989). Direct effects on the pulp were examined using Nd:YAG laser and CO_2 laser. In both cases, no underlying tissue damage was found in using ablated laser, with the presence of secondary dentine and a regular odontoblast layer. For pulp capping and pulpotomy, an appropriate parameter must be selected, because of unsuccessful treatment by the too strong laser energy (Kimura *et al*., 2000a).

Modification of root canal walls: Endodontic instrumentation produces organic and mineral debris on the wall of the root canal. Although this smear layer may be beneficial, that provides an obstruction of tubules and decrease dentine permeability, it also may harbour bacteria and bacterial products (Fogel and Pashley, 1990). For these reasons, the removal of the smear layer by laser and its replacement with an uncontaminated chemical sealant, or sealing by melting the dentine surface, has become a goal. The CO_2 laser, emitting in the 9.3-10.6 μm region caused surface fusion and inhibition of subsequent lesion progression in dentine and improved the bonding strength of a composite resin to dentine. Using the Nd:YAG laser stimulate the application of a thin fiber in root canals (Kimura *et al*., 2000b). Argon laser irradiation can achieve an efficient cleaning effect on instrumented root canal surfaces and laser irradiation can be enhanced by the presence of Ag $(NH_3)_2F$ solution (Harashima *et al*., 1998). 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, therefore the removal of smear layer and debris by lasers is possible. However, it is hard to clean all root canal walls because the laser is emitted straight ahead, making it almost impossible to irradiate the lateral canal walls (Kimura *et al*., 2000b).

Sterilization of root canals: Numerous studies in sterilization of root canals have been performed using CO_2 and Nd:YAG lasers (Goff *et al*., 1999; Khosravi *et al*., 2008). The Nd:YAG laser is more popular, because a thin fibre-optic delivery system for entering narrow root canals is available with this device (Kimura *et al*., 2000b). It was observed that the argon laser using the 100 μm fiber, was more effective than the 200 μm fiber for obtaining a sterilized root canal under the test conditions. Gutknecht *et al*. (2000) concluded that the diode laser radiation (810 nm) reduces the number of bacteria in deep layers of infected root canal wall dentin. Mehl *et al*. (1999) stated that Er:YAG-laser radiation exerts very effective antimicrobial properties in dental root canals. This sterilizing effect of the laser results from the generated heat, which should not however, damage the healthy tissue adjacent to the irradiated area. Recently Nd:YAG laser was proved to be useful to remove debris and smear layer causes melting of the internal structure in instrumented root canal wall (Al-Qalamjy, 2001).

Effect 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. It was found that the threshold level for bone survival was 47°C for 1 min (Kimura *et al*., 2000b). It was observed that the temperature elevation on the root. Surface during Nd:YAG laser irradiation in the root canal did not exceed 10°C only when the laser energy output was below 100 mJ pulse and under 20 pulses sec^{-1} (Lan, 1999), so that 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*., 2000b).

Table 1: Laser applications in dentistry

Laser type	Wavelength (nm)	Mode of operation	Power (W)	Applications
Argon	488, 514	CW	1-20	•Curing composite resin •Excition and photocoagulation of the vascular lesion-caries detection
Diode	650, 980	CW pulsed	1-10	•Biostimulation •Excision of soft tissue pathology. •Gingivectomy
Nd:YAG	1064	CW Pulsed	50-100	Coagulation •Cutting (frenectomy, gingivectomy) •Subgingival curettage
Ho:YAG	2100	Pulsed	25	•Arthroscopic surgery for TMJ •Gingivectomy, frenectomy, implant exposure
Er:YAG	2940	Pulsed	3	Cavity preparation, Periodontal treatment, excision and incision of soft tissue (for dental use)
CO^2	9600, 10600	CW	10-100	For excision of benign and malignant lesion, cutting, drilling, vaporization of tissue and caries prevention

Lasers in orthodontics: Lasers are used to etch enamel and to cure resins. They are used in the two steps involved in the attachment of orthodontic brackets to teeth. Although, generally, the strength of laser-etched bonds is not better than that obtained with acid, great precision in the demarcation of the etch site should be possible (Walsh and Perham, 1991). Also Low Level Laser Therapy (LLLT) is now being used for Biostimulation in orthodontics in order to improve bone and soft tissue remodeling during orthodontic treatment with reducing the time of treatment. Altan *et al.* (2010) used 820 nm diode laser on osteoclastic and osteoblastic cell proliferation-activity during orthodontic tooth movement. Their findings showed that low-level laser irradiation accelerates the bone remodeling process by stimulating osteoblastic and osteoclastic cell proliferation and function during orthodontic tooth movement.

Laser types used in dental treatments: The laser applications in dentistry are wide and dependant on the laser type used. They are listed in the Table 1 (Jarjees, 2005).

CONCLUSION

In this study, Laser applications in dentistry are reviewed. The laser types were categorized based on it dentistry application. This academic review shows that the usage of lasers in dentistry is beneficial and promising. It is widely used in different dental fields and treatments that give good results compared with traditional treatments. However, it still needs time to be better accepted by dentists and require farther studies to explore more of its advantages.

REFERENCES

Abdul Qader, S.T., 2006. Evaluation of calcium and hydroxyl ions release from non-sttingcalicium hydroxide paste and mineral trioxide aggregate through three different apical aperture sizes during apexification procedure. M.Sc. Thesis, University of Baghdad.

Aboud, G.T., 2005. Treatment of oral ulcerations. M.Sc. Thesis, University of Baghdad.

Al-Alawi, A.S., 2005. Evaluation of low level diode laser in skin wound healing (experimental study clinical observation). M.Sc. Thesis, University of Baghdad.

Al-Qalamjy, B.M.M., 2001. Effect of Nd: YAG laser radiation for the removal of intracanal debris and smear layer in extracted human teeth. M.Sc. Thesis, University of Baghdad.

Al-Tikrity, M.S., 2001. Caries-like lesion initiation in sound enamel following CW CO_2 laser irradiation. M.Sc. Thesis, University of Baghdad.

Alanazi, H.O., H.A. Jalab, G.M. Alam, B.B. Zaidan and A.A. Zaidan, 2010a. Securing electronic medical records transmissions over unsecured communications: An overview for better medical governance. J. Med. Plants Res., 4: 2059-2074.

Alanazi, H.O., M.L.M. Kiah, A.A. Zaidan, B.B. Zaidan and G.M. Alam, 2010b. Secure topology for electronic medical record transmissions. Int. J. Pharmacol., 6: 954-958.

Alster, T.S. and B. Amy, 1996. Dermatologic Laser Surgery. Esevier Science Inc., Washington, DC .

Altan, B.A., O. Sokucu, M.M. Ozkut and S. Inan, 2010. Metrical and histological investigation of the effects of low-level laser therapy on orthodontic tooth movement. Lasers Med. Sci., 10.1007/s10103-010-0853-2

Al-Sayyab, M.A., 2000. The potential effect of combined CO_2 laser and fluoride on acid resistance of human dental enamel and root surfaces. Ph.D. Thesis, College of Dentistry, University of Baghdad.

Aoki, A., K.M. Sasaki, H. Watanab and I. Ishikaua, 2004. Laser used in the non surgical periodontal treatment. Periodontology, 36: 59-97.

Apel, C., J. Meister, N. Schmitt, H.G. Graber and N. Gutknecht, 2002. Calcium solubility of dental enamel following sub ablative Er:YAG and Er: YSGG laser irradiation *in vitro*. Lasers Surg. Med., 30: 337-341.

Apfelberg, D.B., 1996. The ultra pulse carbon dioxide laser with computer pattern generator automatic scanner for facial cosmetic surgery and resurfacing. Ann. Plastic Surg., 36: 522-526.

Ashour, H.S., 2006. Tuning semiconductor laser diode lasing frequency and narrowing the laser linewidth using external oscillating driving field. J. Applied Sci., 6: 2209-2216.

Barr, R.E., D.J. Coluzzi, G. Monson and N. Raffetto, 1998. Laser sulcular debridement: The newest weapon in fighting periodontitis. Dent. Today, 17: 94-95.

Blankenau, R.J., W.P. Kelsey, G.L. Powell, G.O. Shearer, W.W. Barkmeier and W.T. Cavel, 1991. Degree of composite resin Polymerization with visible light and argon laser. Am. J. Dent., 4: 40-42.

Burnnet, L.H., E.N. Conceicao, J.E. Pelio and C.P. Eduardo, 2001. Comparative study of influence on tensile bond strength of a composite to dentin using Er:YAG laser, air abration or air turbine for preparation of cavities. J. Clin. Laser Med. Surg., 19: 199-202.

Caroth, J.A.S. and A.L. Mckenzie, 1985. Medical Lasers. Mosby Inc., Saint Louis, MO.

Catone, G.A. and C.C. Alling, 1997. Laser in Maxillofacial Surgery. W.B. Saunders Co., Philadelphia.

Ceballos, L., R. Osorioa, M. Toledanoa and G.W. Marshallb, 2001. Microleakage of composite restorations after acid or Er-YAG laser cavity treatments. Dent. Mater., 17: 340-346.

Ceballos, L., M. Toledano, R. Osorio, F.R. Tay and G.W. Marshall, 2002. Bonding to Er: YAG laser treated dentin. J. Dent. Res., 18: 119-122.

Charstpher, H.O., Q. Nguyen and J. Nicholas, 1995. Laser Resurfacing in Pigmented Skin. Esevier Science Inc., Washington, DC.

Chimello-Sousa, D.T., A.E. de Sousa, M.A. Chinelatti, J.D. Pecora, R.G. Palma-Dibb and S.A.M. Corona, 2005. Influence of Er:YAG laser irradiation distance on the bond strength of a restorative system to enamel. J. Dent., 34: 245-251.

Clarkson, D.M., 1992. Lasers in dentistry. Dent. Update, 19: 115-116.

Clayman, L., 1997. Clinical controversies in oral and maxillofacial surgery: Part two. Management of dental extractions in irradiated jaws: A protocol without hyperbaric oxygen therapy. J. Oral Maxillofac Surg., 55: 275-281.

Cohen, R.E. and W. Ammons, 1996. Lasers in periodontics (position paper). J. Periodontal., 67: 826-830.

Conn, H.O., 1981. Laser in ophthalmology. New Engl. J. Med., 304: 9-9.

De Melo, M.A., V.F. Passos, J.J. Alves, E.B. Barros, S.L. Santiago and L.K. Rodrigues, 2010. The effect of diode laser irradiation on dentin as a preventive measure against dental erosion: An *in vitro* study. Lasers Med. Sci.,

De Oliveira, G.J., J.E. Sampaio and R.A. Marcantonio, 2010. Effects of Er,Cr:YSGG laser irradiation on root surfaces for adhesion of blood components and morphology. Photomed. Laser Surg., 28: 751-756.

De Souza, A.E., S. Corona, R.G. Dibb, M. Borsatta and J.D. Pecora, 2004. Influence of Er: YAG laser on tensile bond strength of a self-etching system and a flowable resin in different dentin depths. J. Dent., 32: 269-275.

Delme, K.I.M., P.J. Deman and R.J.G. De Moor, 2005. Microleakage of class V resin composite restorations after conventional and Er:YAG laser preparation. J. Oral Rehabilitation, 32: 676-685.

Dunna, W.J., J.T. Davisb and A.C. Bush, 2005. Shear bond strength and SEM evaluation of composite bonded to Er:YAG laser-prepared dentin and enamel. Dent. Mater., 21: 616-624.

Ebihara, A., 1989. Effects of Nd: YAG laser irradiation on the amputated pulp. Jpn. J. Conser. Dent., 32: 1670-1684.

Estephan, R.K., 2007. Efficacy of different Er:YAG laser parameters and conventional bur cavity preparation on the microleakage of class V cavities restored with composite restoration: An *in vitro* study. M.Sc. Thesis, University of Baghdad.

Esteves-Oliveira, M., D.M. Zezell, P.A. Ana, S.S. Yekta, F. Lampert and C.P. Eduardo, 2010. Dentine caries inhibition through CO(2) laser (10.6im) irradiation and fluoride application, *in vitro*. Arch. Oral. Biol.,

Featherstone, J.D. and D.G. Neslon, 1987. Laser effects on dental hard tissues. Adv. Dent. Res., 1: 21-26.

Featherstone, J.D.B. and D. Fried, 2001. Fundamental interactions of lasers with dental hard tissues. Med. Laser Appl., 16: 181-194.

Finkbeiner, R.L., 1995. The results of 1328 periodontal pockets treated with the argon laser: Selective pocket thermolysis. J. Clin. Laser Med. Surg., 13: 273-281.

Fitzpatrick, R.E., 1992. Laser therapy for benign pigmented cutaneous lesions. West J. Med., 156: 194-194.

Fogel, H.M. and D.H. Pashley, 1990. Dentine permeability: Effects of endodontic procedure on root slabs. J. Endodontics, 16: 442-445.

Goff, A.L., A.D. Morazin, M. Guigand, J.M. Vulcain and M.B. Mallet, 1999. An evaluation of the CO_2 laser for endodontic disinfection. J. Endodontics, 25: 105-108.

Gordon, Jr. T.E., 1966. Laser Interaction with extracted teeth: A preliminary report. Dent. Digest, 72: 154-158.

Gursoy-Mert, H., M. Altan-Koran, U. Noyan, T. Kadir, S. Cologlu and S. Yilmaz, 2010. Evaluation of the effectiveness of Er:YAG laser and conventional periodontal treatment in a patient with acute streptococcal gingivitis: A 2-year follow-up. Photomed. Laser Surg., 28: 441-445.

Gutknecht, N., D.V. Gogswaardt, G . Conrads, C. Apel, C. Schubert and F. Lampert, 2000. Diode laser radiation and its bactericidal effect in root canal wall dentin. J. Clin. Laser Med. Surg., 18: 57-60.

Harashima, T., F.H. Takeda, C. Zhang, Y. Kimura and K. Mastumoto, 1998. Effect of argon laser irradiation on instrumented root canal walls. Endod. Dent. Traumatol., 14: 26-30.

Hemachandran, N. and N.V. Arumugam, 1983. Laser and its applications in dentistry. J. Indian Dent. Assoc., 55: 459-461.

Holland, G.R., M.N. Narhi, M. Addy, L. Gangarosa and S. Orchardson, 1997. Guidelines for the design and conduct of clinical trails on dentine hypersensitivity. J. Clin. Periodontol., 24: 808-813.

Hossain, M., Y. Nakamura, Y. Yamada, Y. Kimora, G. Nakamura and K. Matsumoto, 1999. Ablation depths and morphological changes in human enamel and dentin after Er:YAG laser irradiation with or without water mist. J. Clin. Laser Med. Surg., 17: 105-109.

Jarjees, R.K., 2005. The efficacy of Er:YAG laser in the removal of dental deposits and root planning in comparison with ultrasonic and manual instrumentation. M.Sc. Thesis, University of Baghdad.

Jawad, M.M., 2008. Healing response of soft tissue incisions made by diode laser versus metallic scalpel on rabbits skin. M.Sc. Thesis, University of Baghdad.

Keller, U. and R. Hibst, 1989. Ablative effect of an Er: YAG laser on enamel and dentin. Dtsch Zahnarztl Z., 44: 600-602.

Keller, U. and R. Hibst, 1993. Effects of Er:YAG laser on enamel bonding of composite materials. Lasers Orthopaedic Dent. Vet. Med., 2: 163-168.

Khosravi, A.D., J. Rostamian and P. Moradinegad, 2008. Investigation of bactericidal effect of low level laser of galium-aluminium-arsenide on *Cariogenic* species of *Streptococci* and *Lactobacillus*. J. Med. Sci., 8: 579-582.

Kimura, Y., P. Wilder-Smith and K. Matsumoto, 2000a. Lasers in endodontics: A review. Int. Endod. J., 33: 173-185.

Kimura, Y., P. Wilder-Smith, K. Yonaga and K. Matsumoto, 2000b. Treatment of dentine hypersensitivity by lasers: A review. J. Clin. Periodontal., 27: 715-721.

Lan, W.H., 1999. Temperature elevation on the root surface during Nd:YAG laser irradiation in the root canal. J. Endodontics, 125: 155-156.

Matsumoto, K., H. Funai, T. Shirasuka and H. Walkabayashi, 1985. Effects of Nd: YAG-laser in treatment of cervical hypersensitive dentine. Jpn. J. Conserv. Dent., 28: 760-765.

Mehl, A., M. Folwaczny, C. Haffner and R. Hickel, 1999. Bactericidal effects of 2.94 microns Er:YAG-laser radiation in dental root canals. J. Endod., 25: 490-493.

Mercer, C., 1996. Lasers in Dentistry: A Review. Part 2: Diagnosis, Treatment and Research. Dental Up Date, 23: 120-125.

Moritz, A., N. Gutknecht, O. Doertbudak, K. Goharkhay, U. Schoop, P. Schauer and W. Sperr, 1997a. Bacterial reduction in periodontal pockets through irradiation with a diode laser: A pilot study. J. Clin. Laser Med. Surg., 15: 33-37.

Moritz, A., N. Gutknecht, K. Goharkhay, U. Schoop, J. Wernisch, P. Schauer and W. Sperr, 1997b. *In vitro* irradiation of infected root canals with a diode laser: Results of microbiologic, infrared spectrometric and stain penetration examinations. Quintessence Int., 28: 205-209.

Moritz, A., U. Schoop, K. Goharkhay and W. Sperr, 1998a. The CO_2 laser as an aid in direct pulp capping. J. Endodontics, 24: 248-251.

Moritz, A., U. Schoop, K. Goharkhay, P. Schauer, O. Doertbudak, J. Wernisch and W. Sperr, 1998b. Treatment of periodontal pockets with a diode laser. Lasers Surg. Med., 22: 302-311.

Nabi, M.S.A., M.L.M. Kiah, B.B. Zaidan, A.A. Zaidan and G.M. Alam, 2010. Suitability of SOAP protocol in securing transmissions of EMR database. Int. J. Pharmacol., 6: 959-964.

Nicholas, J., G. Lask and A. Maxwell, 1995. Skin resurfacing with the Ultra Pulse CO_2 laser. Esevier Science Inc., Washington, DC.

Niemz, M.H., 2004. Laser-Tissue Interactions: Fundamentals and Applications. 3rd Edn., Springer, Germany.

Niu, W., J.N. Eto, Y. Kimura, F. Hirono and K. Takeda, 1998. Matsumoto, A study on microleakage after resin Ælling of Class V cavities prepared by Er:YAG laser. J. Clin. Laser Med. Surg., 16: 227-231.

Nobor, T., 1989. Contact Nd-YAG laser technique applied to heal to head and neck reconstructive surgery. J. Laser Surg., 1066: 177-177.

Pick, R.M. and G.L. Powell, 1993. Lasers in dentistry. Soft-tissue procedures. Dent. Clin. North Am., 37: 281-297.

Schein, M.T., J.S. Bocangel, G.E.C. Nogueira and P.A.L. Schein, 2003. SEM evaluation of the interaction pattern between dentin and resin after cavity preparation using Er:YAG laser. J. Dent., 31: 127-135.

Shoji, S., M. Nakamura and H. Horiuchi, 1985. Histopathological changes in dental pulps irradiated by CO_2 laser: A preliminary report on laser pulpotomy. J. Endodontics, 11: 379-384.

Sisecioglu, M., M.T. Uguz, M. Cankaya, H. Ozdemir and I. Gulcin, 2011. Effect of ceftazidime pentahydrate, prednisolone, amikacin sulfate, ceftriaxone sodium and teicoplanin on bovine milk lactoperoxidase activity. Int. J. Pharmacol., 7: 79-83.

Stern, R.H. and R.F. Sognnaes, 1965. Laser effect on dental hard tissues. A preliminary report. J. South Calif Dent. Assoc., 33: 17-19.

Tina, S. and B. Tina, 1996. Resurfacing of Atrophic Facial Acne Scars with a High-Energy Pulsed CO_2 Laser. Esevier Science Inc., Washington, DC.

Vahl, J., 1968. Electron microscopical and X-ray crystallographic investigations of teeth exposed to laser rays. Caries Res., 2: 10-18.

Van Meerbeek, B., R. Yudhira, P. Lambrechts and G. Vanherle, 2002. Micro-tensile bond strength of two adhesives to Er:YAG-lased vs. bur-cut enamel and dentin. Eur. J. Oral. Sci., 110: 322-329.

Vargas, M.A., S.D. Cobb and S.R. Armstrong, 1997. Resin-dentin shear bond strength and interfacial ultrastructure with and without a hybrid layer. Oper. Dent., 22: 159-166.

Vargas, M.A., D.S. Cobb and J.L. Schmit, 1998. Polymerization of composite resins. Argon laser VS conventional light. Oper. Dent., 23: 87-93.

Visuri, S.R., J.L. Gilbert, D.D. Wright, H.A. Wigdor and T.J. Jr. Walsh, 1996. Shear strength of composite bonded to Er: YAG laser-prepared dentin. J. Dent. Res., 75: 599-605.

Vogel, A. and V. Venugopalan, 2003. Mechanism of pulsed laser ablation of biological tissue. Chem. Rev., 103: 577-644.

Walsh, L.J. and S.J. Perham, 1991. Enamel fusion using a carbon dioxide laser: A technique for sealing pits and fissures. Clin. Prevent. Dent., 13: 16-20.

Walsh, L.J., 2003. The current status of laser applications in dentistry. Aust. Dental J., 48: 146-155.

Weesner, B.W. Jr., 1998. Lasers in medicine and dentistry: Where are we now. J. Tenn. Dent. Assoc., 78: 20-25.

Weichman, J.A. and F.M. Johnson, 1971. Laser use in endodontics. A preliminary investigation. Oral Surg. Oral Med. Oral Pathol., 31: 416-420.

Yamamoto, H. and K. Ooya, 1974. Potential of Yttrium-aluminum-garnet laser in caries prevention. J. Oral Pathol., 3: 7-15.