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Applications of Lasers in orthodontics

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Abstract

The present era of modern dentistry revolves around the procedures and techniques that are convenient and patient friendly although the prime requisite is for advanced aids both in diagnosis and clinical procedures. The result of such quest has led to the introduction of light amplification and stimulated emission of radiation technique in both medicine and dentistry. Many types of dental lasers are currently available that can be efficiently used for soft and hard tissue applications in the field of orthodontics. In this we reviewed the applications of lasers in orthodontics, harmful effects and laser system safety.

Keywords: Low level laser therapy, Gingivoplasty, Ablation, Lazer hazards.

Introduction

In the Era of this modern Dentistry, the technical demands and level of accuracy required for successful performance of clinical procedures have traditionally been achieved by careful manipulation of hand instruments and by strict adherence to the biologic and surgical principles. One upcoming technology making great intervention into lot of areas in dentistry today is LASER technology. Laser is an acronym for “light amplification by stimulated emission of radiation.” A laser is a single wavelength of light traveling through a collimated tube delivering a concentrated source of energy.

The specific characteristics of lasers make it possible to perform treatment modalities which cannot be achieved by conventional techniques which includes ablation of biological tissues, hemostasis, pain relief and minor hard tissue surgeries. Lasers are indicated for a great variety of intraoral and extra oral esthetic procedures because of its many advantages.[1]

Lasers used in dental practice vary between wavelengths of 488 nm and 10,600 nm. Dental lasers can be further classified in terms of the following characteristics:

• Emission type: Spontaneous emission or stimulated emission

• Output power: High powered, mid powered or low powered

- Active medium: Liquid, gas or solid state
- Target tissue: Hard or soft tissue
- Potential biological damage: Class I, Class II, Class III or Class IV.

The lasers used in dentistry today primarily are the Argon laser, Carbon dioxide (CO2), diode, neodymium-doped yttrium aluminum garnet (Nd: YAG) and the erbium lasers, erbium doped yttrium aluminum garnet (Er: YAG) and erbium, chromium: yttrium scand iumgallium garnet (Er, Cr: YSGG), all of which are named for their active medium content and state of suspension.[2]

On target tissues, the effects of the laser will depend on the power output, wavelength, exposure duration and the amount of energy delivered to the tissue.[3]

Most common dental procedures, including the removal of maxillary or lingual midline frenectomies, crown lengthening, composite curing, control of hemorrhage disorders, caries detection and removal, reduction of pain and treatments of hypersensitivity, gingivectomy, gingivoplasty, soft-tissue lesions and aphthous ulcers can all be effectively performed using dental lasers.[4]

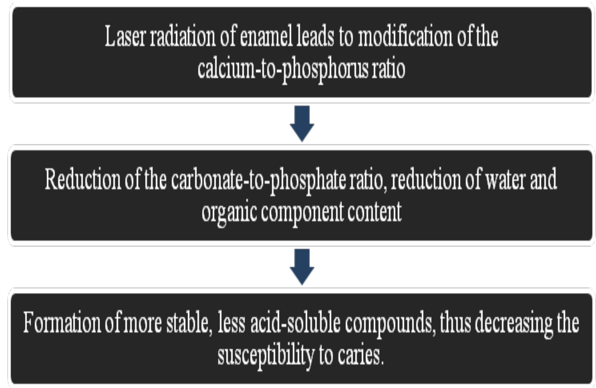
In this article, we are going to review about the use of lasers in the field of orthodontics.

Laser use in orthodontic Practice

Lasers have many common applications in orthodontic practice, which includes enamel etching prior to bonding, debonding of ceramic brackets, pain reduction after orthodontic force, prevention of enamel demineralization, acceleration of tooth movement and bone remodeling. Applications in soft tissue includes minor periodontal surgeries like gingival contouring, crown lengthening and frenectomies.[5]

Enamel Etching prior to bonding

Application of laser irradiation to an enamel surface leads to physical changes such as localized melting, recrystallization and ablation causing formation of numerous pores and bubble-like inclusions.[6] Enamel etching, primarily occurs from the micro explosion of entrapped water in the enamel, along with some melting of the hydroxyl-apatite crystals. The events occurs as follows[7]:



Flowchart: Events occurring on dental hard tissue after exposure to LASER.

Depending on the type of laser and energy applied to enamel surface, it causes surface roughening and irregularity similar to that of acid etching to a depth of 10-20 µm.[8]

Lee et al compared the bond strength of orthodontic brackets using three different etching procedures: Acid etching, Er: YAG laser etching and a combination of these methods, which demonstrated that Er: YAG lasers can be used as an effective alternative to conventional acid etching.[7] Uşümez et al studied the effectiveness of an Er, Cr:YSGG hydrokinetic laser system in two different power settings in etching enamel for direct bonding of orthodontic appliances which showed that etching of the enamel with the Er, Cr: YSGG system yielded lower and less predictable bond strengths than acid etching with 37% orthophosphoric acid for 30 s did. Even though, they found the use of laser etching was more practical and faster than conventional acid etching.[8]

In summary, some authors concluded laser etching of enamel leads to significantly lower bond strengths compared with acid etching, while others have reported laser-etching is comparable with or stronger than acid-etching.[9]

Debonding

Many clinicians often encounter cracks and fractures in the enamel and brackets during the debonding of ceramic brackets. Application of laser irradiation, it is seen that the adhesive resin can be softened, allowing light force to be applied during debonding. An Nd:YAG laser is quite effective during the debonding of polycrystalline and monocrystalline ceramic brackets, with significantly decreasing the bond strength for the polycrystalline ceramic brackets than for monocrystalline brackets.[10] The debonding mechanism works as thermal softening of the resin adhesive due to laser-induced heating of the labial surface of the bracket, which is then transmitted through the bracket to the resin.[11] Laser aided debonding technique proves to significantly reduce the residual de-bonding force, the risk of enamel damage and the incidence of failure over conventional de-bonding techniques. This method has the potential to be more atraumatic as it is less painful and safer as there is less risk of enamel damage for the patient.

Reduction in orthodontic pain

It is not uncommon to find that the patient experiences slight pain or discomfort for 2-4 days following the application of orthodontic appliances. Low-level laser therapy (LLLT) can be used as a convenient analgesic therapy for orthodontic patients, where the energy output is considerably low enough to prevent a temperature rise above normal body temperature in the target tissue.[12] The exact mechanism of the analgesic effect of LLLT is still unknown but it is believed that laser irradiation has neuropharmacological effects on the synthesis, release and metabolism of serotonin and acetylcholine in the central level, as well as histamine and prostaglandin in the peripheral level which results in analgesia.[13]

It has been reported by many researchers that Nd: YAG[14], He-Ne [15], and GaAlAs[16] diode lasers have analgesic effects for reducing orthodontic pain. As well as, local CO2 laser therapy has been found effective in reducing the pain associated with orthodontic force applications.[17] Whereas, some researchers have shown that LLLT Offers no significant reduction in pain after separation or placement of archwires.[14-15] In summary, inducing laser analgesia is a new treatment modality which has the advantages of being non invasive, ease of application having minimal known adverse tissue reactions.

Effect on tooth movement

Various studies were conducted previously investigating the effects of LLLT on tooth movement in animals.[18] Cruz et al. in 2004, investigated the effects of LLLT on humans for the first time. This study was conducted on 11 patients, in which half of the upper arch was served as a control group receiving mechanical activation of the canine teeth every 30 days whereas the opposite half received the same mechanical activation along with irradiation with a diode laser. The results of the study showed significantly greater acceleration of canine retraction on the side treated with LLLT compared with the control.[19] Similar study was carried out by Youssef et al regarding the rate of canine retraction.[20] They irradiated with a GaAlAs diode laser (809 nm, 100 mW) on the 1st, 3rd, 7th and 14th days and reported that LLTH was effective at accelerating the tooth movement rate. Fujita et al. concluded that LLLT causes tooth movement through induction of the receptor activator of the nuclear factor kappa B (RANK) and RANKL. It was seen in their study that the number of cells which showed positive immunoreactions to the primary antibodies of RANKL and RANK were significantly increased in the irradiation group on days 2 and 3 compared to that with the non irradiation group.[21] In contrast to these studies, the study by Limpanichkul et al.

showed that GaAlAs (25 J/cm2) LLLT have no effect on the rate of orthodontic tooth movement. Further studies are needed to determine the optimal dose, taking into account variable dose and wavelength for adequate effectiveness of LLLT.[22]

Effect on Bone Regeneration.

Studies in the literature reveal that LLLT enhances fibroblast proliferation and the quantity of osteoid tissue.[23] Bone formation is induced because of two principal roles of laser irradiation. The first consist of stimulation of cellular proliferation of nodule-forming cells of osteoblast lineage. The second is commencement of cellular differentiation resulting in increase in number of differentiated osteoblasts leading to bone formation.[24]

Saito and Shimizu reported that GaAIAs diode laser accelerates bone regeneration in midpalatal suture during rapid palatal expansion and inhibits relapse and reduces the retention period.[23] Angeletti et al. evaluated that bone regeneration can be accelerated during early stages of laser therapy. Although, the outcome of LLLT on bone regeneration depends on total laser dose, the frequency of irradiation and application timing.[25]

Soft tissue application related to orthodontic treatment.

Convenience and accuracy during soft-tissue incision is provided by Lasers as there is minimal tissue damage, better hemorrhage control and reduction in post-operative pain. Soft-tissue applications related to orthodontic treatment include gingival recontouring, exposure of unerupted and partially erupted teeth, removal of hypertrophic and inflamed tissues, frenectomies, miscellaneous tissue and treatment of aphthous lesions.

1. Gingivectomy and Gingivoplasty

The diode laser can be used to tissue removal and provide access for bracket/band/button attachment. These procedures provide earlier involvement of teeth in orthodontic therapy and can probably reduce treatment duration. Oftenly, canines are the last teeth bonded due to their slow eruption, delayed passive eruption or impaction. The diode laser can be useful in such scenario by directly bonding the bracket on the tooth.[26,27.]

2. Establishing tooth proportionality

The Bracket positioning by most of the clinicians is done (directly or indirectly) either by measuring a prescribed distance from the incisal edge or visualizing and positioning the bracket in FACC. Both techniques have been performed adequately for many years and are acceptable. Problems with these techniques tend to arise when the length of clinical crown is not equal to the anatomic crown, which is a common in adolescent orthodontic patients. Measurement from the incisal edge may result in an acceptable occlusal outcome but may cause poor oral hygiene due to proximity of the bracket on the gingival margin of tooth. Bracket position in the center of the clinical crown would be too incisal, resulting in unwanted incisor intrusion and inadequate expression of torque, thus reduction of the incisal display at rest and on smile. The diode laser can be used at the prior visit to positioning the bracket, to improve the proportionality and allowing the position of the central incisors to be maintained during smile.[26]

3. Gingival contouring and shaping

Gingival shape refers to the two dimensional curvature of the gingival margin. Gingival-shape problems include gingival margin discrepancies and improper zenith locations. Gingival contour refers to the three dimensional architecture of the gingiva characterized by sharp interdental papillae and tapered gingival margins. Gingival contour problems consist of rolled margins and inflamed papillae. Use of LLLT can be beneficial for correction of these dimensional defects.[26]

4. Frenectomy

(Recommend laser settings: diode laser: 1.0–1.5 W, erbiumdoped solid-state laser: 1.5–2.5 W followed by coagulation at <1.0 W with no water) A frenectomy is the surgical removal of a small band of muscle tissue known as the frenum from its attachment into the mucoperiosteal covering of the alveolar process. The frenum is a normal component of oral anatomy; however, a large, wide or short frenum might interfere with the normal function of the lip, cheek or tongue. A thick, low labial frenum in children may result in a large maxillary diastema, interference with oral hygiene, tooth eruption, esthetics, and psychosocial concerns which contributes to necessitating treatment of the labial frenum. The conventional surgical excision of the frenum leads to increased bleeding, use of sutures for wound healing and scar tissue formation. Use of Diode lasers: 1.0-1.5 W or erbium doped solid-state laser: 1.5-2.5 W shows superiority than the conventional technique in precision incision, bloodless field and more accuracy. The surgical procedure is completed very quickly and no sutures are indicated thus overpowering the conventional technique.[27]

5. Ablation of minor aphthous ulceration

Minor aphthous ulcers occurs commonly in the orthodontic patient due to tissue irritation along with stress from discomfort of tooth movement. The ulcerations are characterized as 3–10 mm diameter yellowish-white, removable fibroino-purulent membrane encircled by an erythematous halo, localized almost exclusively on nonkeratinized tissue such as the buccal mucosa, alveolar mucosa, tongue, and lips. Several types of treatment options are present for management of aphthous ulcerations, which includes simply waiting till self-healing, warm saline water rinses, hydrogen peroxide, antifungal medications, liquid topical anesthetics, and diode laser surgery treatment. Unlike other surgical procedures with a diode laser, ablation of aphthous ulcerations are performed 1–2 mm away from the tissue. Recommended diode laser dose is 0.5–1.0 W. The clinician should proceed with short, side-to-side brush strokes over the ulcerated area. Typically, anesthesia is not required. Postoperative management can include routine palliative treatment.[27]

Laser safety and harmful effects of lasers

Dental practitioners should be aware of dental laser safety including awareness of the potential risks and hazards related to lasers used, as well as recognition of existing standards of care and a thorough understanding of safety control measures. According to the standards of American National Standards Institute and Occupational Safety and Health Administration, lasers are classified into four different classes based on potential danger, as follows:

Class I: These are low-powered lasers that are safe to view

Class IIa: These are low -powere
not cause damage unless one looks directly along the beam for longer than 1,000s

Class II: These are low -powere
dangerous when viewed along the beam for longer than 0.25s

Class IIIa: These are medium -powere
dangerous when viewed for less than 0.25s

Class IIIb: These are medium -powere
dangerous when viewed directly along the beam for any length of time

Class IV: These are dangerous high -powere
can cause damage to the skin and eyes. Even the reflected or radiated beams are dangerous. It is necessary to take appropriate safety measures. Most of the lasers used for medical and dental purposes are in this category. As such, a clinician is supposed to follow the following safety precautions:

- Creation of a danger zone – typically this entails a designated surgical chair or room with a warning sign indicating that a laser is operational
- Presence of a laser safety officer (typically the orthodontist)
- Proper training of users (the orthodontist and staff)
- Consideration of potential fire hazards.[5,27.]

Eye injury is the highest risk of soft-tissue laser surgery depending on laser wavelength, distance from the laser, and power of the laser. As the eye is precise at focusing light, a split-second exposure to laser radiation can be sufficient to cause permanent injury. Retinal damage can occur at 400 to 1400 nm. The major danger is from a stray laser beam reflected from a table, jewelry, or a belt. Retinal burns and cataracts are most common risked from Diode lasers. Corneal burns, aqueous flare-ups, and infra-red cataracts are caused by Erbium lasers.

Largest organ of the body is skin and thus poses a high risk of radiation exposure. Wavelengths of 300 to 3000 nm can penetrate skin. Most prone body parts exposing to laser irradiation are arms, hands and head. The patient and the clinician should strictly be fully covered and should wear protective goggles during the procedure. These goggles must block light at the appropriate wavelength and protect all reflected paths to the eyes. Covering or removal of all nearby reflective surfaces should be done. Class 4 laser systems poses fire hazard if the beam comes in proximity of flammable substances, and flame-retardant materials should be available.[29]

Conclusion

Lasers have become a ray of hope for recent advances in dentistry. Ethical and efficacious use of lasers are an exceptional modality of many treatment procedures. The use of soft tissue lasers like Diode and Erbium lasers offers many advantages like improved oral hygiene, practice efficiencies, and esthetic finishing. Laser etching, bio-stimulant effects and softening of adhesives during de-bonding are promising areas of laser use in the clinical orthodontic practice. At present, lasers are predominantly used for research studies in the field of orthodontics.

Lasers are one of the advances, which have definite potential, but in the present era, additional effort has yet to be made both for hard and soft tissue laser procedures to find a single laser that can satisfy the needs of all dental procedures, to be cost effective, and at the same time to have long term clinical safety record.

Reference

1. Pick RM. Using lasers in clinical dental practice. J Am Dent Assoc 1993;124:37-4.
2. Harris DM, Pick RM. Laser physics. In: Miserendino LJ, Pick RM, editors. Lasers in Dentistry. Singapore: Quintessence Publishing Co, Inc.; 1995. p. 27 -38.
3. Lomke MA. Clinical applications of dental lasers. Gen Dent 2009;57:47 59.
4. Miserendino LJ, Pick RM. Current applications of lasers in dentistry. In: Lasers in Dentistry. Singapore: Quintessence Publishing Co, Inc.; 1995. p. 126 8.
5. Ruhi Nalcaci. Lasers in orthodontics European Journal of Dentistry 2013; Vol 7:119-125.
6. Lee BS, Hsieh TT, Lee YL, Lan WH, Hsu YJ, Wen PH, et al. Bond strengths of orthodontic bracket after acid-etched, Er: YAG laser irradiated and combined treatment on enamel surface. Angle Orthod 2003;73:565 70.
7. Von Fraunhofer JA, Allen DJ, Orbell GM. Laser etching of enamel for direct bonding. Angle Orthod 1993;63:73-6.
8. Uşümez S, Orhan M, Uşümez A. Laser etching of enamel for direct bonding with an Er, Cr: YSGG hydrokinetic laser system. Am J Orthod Dentofacial Orthop 2002;122:649 56.

9. Walsh LJ, Abood D, Brockhurst PJ. Bonding of resin composite to carbon dioxide laser modified human enamel. Dent Mater 1994;10:162 6.
10. Hayakawa K. Nd: YAG laser for debonding ceramic orthodontic brackets. Am J Orthod Dentofacial Orthop 2005;128:638 -47.
11. Strobl K, Bahns TL, Willham L, Bishara SE, Stwalley WC. Laser -aided debonding of ceramic orthodontic brackets. Am J Orthod Dentofacial Orthop 1992;101:152 -8.
12. Harris DM. Biomolecular mechanism of laser biostimulation. J Clin Laser Med Surg 1991;8:277 80.
13. De Nguyen T, Turcotte JY. Lasers in dentistry and in oral and maxillofacial surgery. J Can Dent Assoc 1994;60:227 8, 231.
14. Harazaki M, Isshiki Y. Soft laser irradiation effects on pain reduction in orthodontic treatment. Bull Tokyo Dent Coll 1997;38:291 5.
15. Fukui T, Harazaki M, Muraki K, Sakamoto T, Isshiki Y, Yamaguchi H. The evaluation of laser irradiated pain reductive effect by occlusal force measurement. Orthod Waves 2002;61:199 206.
16. Lim HM, Lew KK, Tay DK. A clinical investigation of the efficacy of low level laser therapy in reducing orthodontic postadjustment pain. Am J Orthod Dentofacial Orthop 1995;108:614 22.
17. Fujiyama K, Deguchi T, Murakami T, Fujii A, Kushima K, Takano -Yamamoto T. Clinical effect of CO (2) laser in reducing pain in orthodontics. Angle Orthod 2008;78:299 -303.
18. Sun G, Tunér J. Low -level laser therapy in dentistry. Dent Clin North Am 2004;48:1061 -76.
19. Cruz DR, Kohara EK, Ribeiro MS, Wetter NU. Effects of low intensity laser therapy on the orthodontic movement velocity of human teeth: A preliminary study. Lasers Surg Med 2004;35:117 20.
20. Youssef M, Ashkar S, Hamade E, Gutknecht N, Lampert F, Mir M. The effect of low level laser therapy during orthodontic movement: A preliminary study. Lasers Med Sci 2008;23:27 33.
21. Fujita S, Yamaguchi M, Utsunomiya T, Yamamoto H, Kasai K. Low energy laser stimulates tooth movement velocity via expression of RANK and RANKL. Orthod Craniofac Res 2008;11:143 55.
22. Limpanichkul W, Godfrey K, Srisuk N, Rattanayatikul C. Effects of low level laser therapy on the rate of orthodontic tooth movement. Orthod Craniofac Res 2006;9:38 43.
23. Saito S, Shimizu N. Stimulatory effects of low -power laser irradiation on bone regeneration in midpalatal suture during expansion in the rat. Am J Orthod Dentofacial Orthop 1997;111:525 -32.
24. Ozawa Y, Shimizu N, Kariya G, Abiko Y. Low energy laser irradiation stimulates bone nodule formation at early stages of cell culture in rat calvarial cells. Bone 1998;22:347 54.
25. Angeletti P, Pereira MD, Gomes HC, Hino CT, Ferreira LM. Effect of low -level (GaAlAs) on bone regeneration in midpalatal anterior suture after surgically assisted rapid maxillary expansion. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2010;109:e38 -46.
26. Arjun Karra, Mohammadi Begum, “Lasers in orthodontics,” Int J Contemp Dent Med Rev, vol. 2014, Article ID 041014, 2014.
27. Neal D Kravitz. The Application of Lasers in Orthodontics. Integrated Clinical Orthodontics, First Edition. Edited by Vinod Krishnan, Ze’ev Davidovitch.
28. Neal D. Kravitz and Budi Kusnoto. Soft-tissue lasers in orthodontics: An overview. AJODO;133,4: 110-114.