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Recent Applications Of Laser In Orthodontics

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Abstract

Lasers were introduced in clinical Dentistry with the anticipation of incapacitating some of the shortcomings posed by the conventional methods of dental procedures. Since its first trial for dental application in the 1960's, the use of laser has amplified swiftly in the past couple of decades. The specialty of Orthodontics takes all concepts of dentistry and assimilates effective complete treatment planning. From the daily orthodontic procedure of surface preparation, bonding, de-bonding to the adjunctive procedures of frenectomy, canine exposure and gingivectomy, lasers have shown their importance. Record maintenance, cast analysis in 3D, holography, spectroscopy, welding, scanning and much more can be done with lasers. Individuals who are dreadful of dentistry and have consequently neglected oral health and those who have complex medical histories and thus require more specialized, advanced procedures are suitable candidates for laser therapy. Some also have phobias and/or allergies to anesthetics. Lasers have become an integral part of treatment for these patients. The aim of this review is to describe the current and emerging applications for lasers in orthodontics.

Keywords: De-bonding; Frenectomy; Gingivectomy; Holography; Welding

Introduction

The past decade has seen an absolute explosion of research into the clinical applications of lasers in dental practice and the corresponding emergence of organizations who are showcasing laser dentistry internationally. In this modern age of high-tech devices, the dentist is being offered many sophisticated products designed to improve the quality of treatment rendered to the patient. Already regularly used in the medical field, laser has begun to revolutionize dentistry. Laser is the acronym for "Light amplification by stimulated emission of radiation" and was named by Gordon Gould in 1957 [1]. The first laser was introduced into the fields of medicine and dentistry during the 1960s. Since then, this science has progressed rapidly. Due to their numerous advantages, lasers are indicated for a wide variety of procedures. Traditionally, lasers have been classified based on the physical construction of the laser (e.g., gas, liquid, solid state, or semiconductor diode), the type of medium which undergoes lasing (e.g., Erbium: Yttrium Aluminum Garnet (Er: YAG)) (Table 1). Once considered as a complex technology with restricted uses in clinical dentistry, now there is a rising awareness of the usefulness of lasers in the armamentarium of modern dental practice, where they can be used as an adjunct or alternative to traditional approaches. The purpose of this review is to provide an outline of the various laser applications in Orthodontics and to discuss in more detail several key clinical applications which are enticing a high level of interest.

Different types of lasers used in Dentistry [1]

Several types of lasers are available based on the wavelengths (Table 1, Fig. 1).

1. The Er: YAG laser possesses the potential of replacing the drill.

2. CO_2 laser can be used to perform gingivectomy and to remove small tumors.

3. Argon laser is used in minor surgery.

4. Nd: YAG is used in tissue retraction, endodontics and oral surgery.

5. The diode laser is effective for oral surgery and endodontic treatment. This laser helps to correct aesthetic flaws. It is used for soft tissue procedures.

Figure 1- Absorption curve of various tissue components [1]

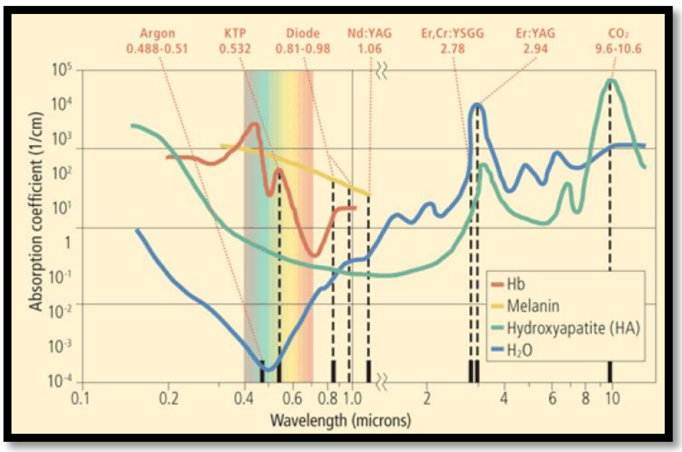

Table 1- Common types of laser used in Dentistry [1]

Laser type	Construction	Wavelength (s)	Delivery system (s)
Argon	Gas laser	488, 515nm	Optical fiber
KTP	Solid state	532nm	Optical fiber
Helium - Neon	Gas laser	633nm	Optical fiber
Diode	Semiconductor	635,670,810,980nm	Optical fiber
Nd:YAG	Solid state	1064nm	Optical fiber
Er,Cr:YSGG	Solid state	2780nm	Optical fiber

Classification of laser

According to ANSI and OHSA standards Lasers are classified as:

Class I - These are low powered lasers that are safe to use. E.g. Laser beam pointer

Class II - Low powered visible lasers that are hazardous only when viewed directly for longer than 1000 seconds, e.g. He-Ne lasers

Class II b - Low powered visible lasers that are hazardous when viewed for more than 0.25 seconds.

Class III a - Medium powered lasers that are normally hazardous if viewed for less than 0.25 seconds without magnifying optics.

Class III b - Medium powered lasers that can be hazardous if viewed directly.

Class IV - These are high powered lasers (> 0.5 W) that produce ocular, skin and fire hazards.

Advantages of laser over other techniques [2]

It is a painless, bloodless technique that results in a clean surgical field. Fine incision with precision is possible. There is no need for anesthesia. If at all anesthesia has to be administered, then it needs to be used minimally only. The risk of infection is reduced as a more sterilized environment is created as the laser kills the bacteria. There is no/minimal post-operative discomfort and minimal swelling which generally doesn't require medication. Overall there is superior and faster healing which ultimately offers better patient compliance.

Disadvantages of laser [2]

Lasers cannot be used to remove defective crowns or silver fillings or to prepare teeth for bridges nor can they be used on teeth with filling already in place. They don't completely eliminate the need for anesthesia. Laser treatment is more expensive than conventional method as the cost of the laser equipment itself is much higher.

Uses of laser in Orthodontics:

Lasers are now being used in a variety of procedures in orthodontics.

Diagnostic lasers

1.1 Three-dimensional laser scanning and reconstruction (Holography)

Three-dimensional (3D) laser scanners are progressively being used in orthodontics to create databases for normative populations and cross-sectional growth variations and also to evaluate clinical results in orthognathic surgical and non-surgical treatments. The laser system consists of two vertically fanned out low power helium-neon laser beams which are projected on to the face and viewed from an oblique angle by a television camera. Ayoub et al. (1996) developed a video-capture stereoscopic method of imaging which could be used to measure facial landmarks and volumes [3]. The various applications of laser holography in orthodontics include facial soft tissue analysis, digital models, etc.

1.2 Laser Doppler Flowmetry

The laser doppler flowmetry (LDF), developed in the 1970s as a non-invasive electro-optical technique to measure the velocity of red cells in skin capillaries, utilizes a light beam from a helium-neon (He-Ne) laser emitting at 632.8 nm. LDF assistance to record pulpal responses to orthodontic forces or the orthopedic forces created by rapid maxillary expansion have previously been investigated by McDonald et al. 1994 [4]. LDF is also a trustworthy method for blood flow measurements after orthognathic surgery.

2. High Intensity Laser Therapy in Orthodontics

Argon laser

It seems that argon laser holds promise in the polymerization of dental restorative materials because one of the argon laser's emission peaks (488 nm) matches well with the absorption peak of the photoinitiator, camphorquinone (CQ) in light-curing dental restorative materials. It was claimed that the argon laser can polymerize a light-cured orthodontic adhesive four times faster with the same or even higher bond strength and with less frequency of enamel fracture at de-bonding than with the conventional curing light [5].

Diode-Pumped Solid-State (DPSS) laser

Recently, Kim et al. (2010) assessed the effectiveness of DPSS laser with a wavelength of 473 nm on the bonding of orthodontic brackets to teeth [6]. It shows similar features to the argon laser due to the similar emission wavelength. Furthermore, since this DPSS laser is compact and much cheaper than the argon laser, it has further potential applications in dentistry than the latter.

2.1 Enamel conditioning for bracket bonding with laser

Laser etching has become an alternative to acid etching of enamel. Laser etching is painless and does not involve either vibration or heat; also, the easy handling of the apparatus makes this treatment highly attractive for routine clinical use [7]. Laser etching of enamel creates microcracks that are ideal for resin penetration [8]. The surface produced by laser irradiation is also acid resistant. As water spraying

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and air drying are not needed with laser etching, time can be saved. From a clinical perspective, saving chair time also improves adhesion because it reduces the risk of salivary contamination. Different types of laser such as CO_2, Er:YAG, Nd:YAG, and Er,Cr:YSGG have been used in orthodontics for enamel conditioning to bond brackets.

2.2 Bonding to Porcelain

Conventional acid etching is unable to produce sufficient bond strength of orthodontic brackets to porcelain surfaces. It has been proved that the application of 9.6% hydrofluoric acid for two minutes offers suitable surface alterations for orthodontic bonding. However, the use of hydrofluoric acid can damage the surrounding teeth and soft tissues. Li et al. (2000) prepared porcelain with Nd:YAG lasers for bonding and concluded that this type of laser in combination with light cure composites produced acceptable bond strength to porcelain [9]. It seems that using an Nd:YAG laser not only eradicates the need to rough up the porcelain, it would also remove the potential gingival burns associated with HF acid and the need to re-polish the porcelain at de-bonding.

2.3 Increasing the acid resistance of enamel to prevent formation of white spot lesions

One of the most important problems during orthodontic treatment is the occurrence of enamel demineralization around orthodontic appliances. These lesions are more commonly seen in upper anterior teeth and upper and lower premolars. In 1965, Sognnaes and Stern were the first to report that when the enamel was exposed to ruby laser irradiation, the resistance of enamel to acid attack was improved [10]. Several investigators have demonstrated that treatment with various lasers can reduce the rate of sub-surface demineralization in enamel.

2.4 Bracket de-bonding

For de-bonding of ceramic brackets, special pliers have been used conventionally to apply a sufficiently high force to fracture the bond. However, ceramic brackets are brittle and cannot be removed easily by pliers. Enamel damage and bracket fracture have been reported frequently with conventional de-bonding of ceramic brackets [11]. The use of laser eliminates the problems such as enamel tear outs, bracket failures and pain that are encountered during conventional ceramic bracket removal techniques. Additionally, lasers have the advantage of decreasing de-bonding force and operation time. This was confirmed by Nalbantgil et al. (2010) who stated that six sec lasing with the Er:YAG laser may be an effective and safe way to remove ceramic brackets without causing intra-pulpal and enamel damage [12].

2.5 Laser welding

Spot Welding process is used to join flat structures, such as orthodontic bands and brackets and also to join some types of orthodontic wires. Another method employed for joining metal frameworks is laser welding using Nd:YAG laser. In laser welding, laser light is focused on small regions, applying high energy to these areas in a very short amount of time. Heating is mainly focused at the point of application and so the surrounding areas are not damaged. In some studies, laser welded joints exhibited greater mechanical resistance than that achieved by traditional welding [13]. Laser welding is recently being used in bracket manufacturing as an alternative to brazing. This technique eliminates the need to brazing alloy, reduces the risk of corrosion and provides acceptable mechanical performance in association with a low risk of joint failure.

2.6 Laser minor surgery

Laser surgery offers numerous advantages compared with traditional scalpel surgery. Soft tissue excision is more precise with a laser than a scalpel. A laser coagulates blood vessels, seals lymphatic and sterilizes the wound during ablation, maintaining a clear and clean surgical field. The use of soft-tissue lasers result in a shorter operative time and faster post-operative recuperation. Laser surgery is routinely performed by using only topical anesthetic, which is particularly beneficial in an open orthodontic clinic [14].

Various applications of laser surgery in orthodontics are:

2.6.1 Gingival enlargements, gingival hyperplasia and reshaping gingival shape and contours

Sometimes removal of excessive gingival tissues is essential to provide optimal display of teeth. For example, inadequate tooth display during smiling in an adolescent patient may be related to altered passive eruption or gingival encroachment, making the teeth appear shorter. In these cases, gingivectomy may offer sufficient tooth display and appropriate tooth proportions. Gingival hyperplasia is commonly observed during orthodontic treatment, especially in patients with poor oral hygiene. Generally, it is preferred to postpone the treatment of gingival hyperplasia until the end of orthodontic treatment, unless the gingival tissue or enlargement interferes with the tooth movement. If this occurs, the excess gingiva must be removed surgically during the treatment. Orthodontists should also consider gingival shape and contour of the teeth and make necessary corrections to provide optimal treatment results at the end of orthodontic treatment. Recontouring gingival shape and contour can be readily accomplished in the orthodontist's office with a diode laser. Laser gingivectomy has advantages such as minimal bleeding and postoperative pain and no swelling. Correction of gingival hyperplasia can also be performed easily with the aid of laser light.

2.6.2 Fibrotomy and Frenectomy

Fibrotomy (pericision) is frequently indicated to provide long term stability of teeth with severe rotation before treatment. This procedure is usually performed for upper and lower anterior teeth where maintaining treatment results is of great importance. Fibrotomy or severing of transeptal fibers should be performed at the end of orthodontic treatment and before appliance removal [15]. The teeth should be held in good alignment after fibrotomy when the gingival healing occurs. Supra-crestal fibrotomy is an effective procedure to decrease relapse after tooth rotation, causing no apparent damage to the supporting periodontal structures. Frenectomy is usually indicated to prevent relapse after correction of midline diastema. The presence of a very thick frenum may prevent space closure. If this occurs, frenectomy should be performed after partial space closure and orthodontic treatment should be resumed immediately after frenectomy to complete the space closure.

3 Low intensity laser therapy in orthodontics

3.1 Pain reduction

Pain or discomfort is a common experience during fixed orthodontic treatment. Pain usually appears several hours after orthodontic force application. For patients, pain may be the most important side effect of orthodontic treatment and one of the main reasons for their lack of compliance or missing appointments [16]. If the orthodontists are able to prevent or control pain, patients may have a better quality of life and show more tendencies to cooperate with treatment recommendations. The mechanism through which orthodontic forces produce pain has not been well recognized, but there is some evidence indicating that pain is related to the change in blood circulation of periodontal ligament, causing ischemic areas in the PDL. Pain is also dependent to the formation of metabolic products such as prostaglandins and substance P which stimulate pain receptors. To relieve pain, most orthodontists recommend their patients to use nonsteroidal anti-inflammatory drugs (NSAIDs), to inhibit the formation of pain producing agents such as prostaglandins and thus reduce the pain. However, these drugs may have side effects and therefore are contraindicated in some patients. Furthermore, most drugs used for pain control can have negative effects on tooth movement if used chronically, due to their inhibitory effects on prostaglandins. Considering the side effects of analgesics, researchers have looked for other new, but safer approaches, such as Low Level Laser Therapy (LLLT) to reduce pain from orthodontic procedures [17]. Although only a few studies have dealt with the response of orthodontic patients to LLLT, all concluded that LLLT reduces pain during orthodontic treatment [18]. Lim et al (1995) observed in orthodontic patients that pain for teeth irradiated with a gallium-arsenic-aluminum diode laser was lower compared with pain when a placebo was used. Overall, based on the efficacy of LLLT to control pain in orthodontic treatment, it could be recommended for pain control during fixed orthodontic appliance therapy. The reason for reducing its clinical use seems to be the total time (32–37.5 minutes) for application to both dental arches. Yet many diverse opinions exist concerning the duration of treatment, radiant power, frequency and energy density.

3.2 Tooth movement

The biological control of tooth movement has still not been well recognized. The most accepted theory of tooth movement is pressure-tension theory, which is based on stimulating cellular differentiation through chemical mediators. Several studies have represented the effects of LLLT on orthodontic tooth movement. It was concluded in all of the five studies that laser radiation had stimulated tooth movement. Cruz et al. (2004) conducted an experiment on 11 young patients who required tooth movement for extraction space closure [19]. They were irradiated with LLLT of 780 nm wavelength on one side of the maxilla for 4 days in a month and were not irradiated on the opposite side, which acted as the control. The results showed that the experimental side demonstrated significantly more rapid progression of space closure than the control side. However, Limpanichkul et al. (2006) found no difference in tooth movement rate after application of LLL for three days in a month [20]. They claimed that the energy capacity of LLL (25 J/cm2) in their study was probably too low to produce stimulatory effects on orthodontic tooth movement. However, their LLL application method for orthodontic tooth movement was different from the others.

3.3 Distraction osteogenesis

Distraction osteogenesis is a method to induce new bone formation and investing soft tissue under the influence of tensional stress at osteotomized sites of a healing bone. Distraction osteogenesis not only induces bone formation but also results in the formation of new soft tissue (histogenesis) over the new bone. Distraction osteogenesis makes it possible to achieve a greater amount of bone lengthening than that achieved with conventional orthognathic surgery without the need for placing bone grafts. Miloro et al. (2007) evaluated the effect of LLLT during mandibular distraction osteogenesis and concluded that LLL accelerates the process of bone regeneration during the consolidation phase after distraction osteogenesis [21]. Further, Kreishner et al. (2010) evaluated the action of LLLT on the percentage of newly formed bone in rabbit mandibles that underwent distraction osteogenesis and reported positive outcome [22].

3.4 Maxillary expansion

Saito and Shimizu (1997) studied the effects of LLLT on the expansion of mid-palatal sutures in rats, comparing the bone regeneration obtained with and without laser treatment [23]. Their results showed that the therapeutic effects of laser are dependent on the total dosage, the frequency and the duration of the treatment. Their laser-irradiated group showed 20-40% better results when compared to the control group. It was proposed that if LLLT increases bone and cartilage formation, the treatment might be easier and more stable. In 2010, Seifi et al investigated the effects of low level GaAs diode laser on chondroblastic and osteoblastic activity of condyles in rats [24]. Laser irradiation was performed either bilaterally or on the right condyle. They showed that LLLT had a significant effect on the increase of mandibular length in rats and might be helpful in the correction of class II malocclusions. However, further studies are required to confirm these results.

Conclusion

Lasers have become a ray of hope in Orthodontics. When used effectively and ethically, lasers are an exceptional modality of treatment for many clinical conditions that orthodontists treat on a daily basis. But lasers has never been the “magic wand” that many people have hoped for. It has got its own limitations. If a clinician decides to use a laser for a dental procedure, he or she needs to fully understand the character of the wavelength being used and the thermal implications and limitations of the optical energy. However, the future of the dental laser in orthodontics is bright with some of the newest ongoing researches. From operative dentistry to periodontics, paediatrics and prosthetics to cosmetics and implantology, lasers have made a tremendous impact on the delivery of dental care in the 21st century and will continue to do so as the technology continues to improve and evolve.

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