International Journal of Advanced Biotechnology and Research (IJBR)
ISSN 0976-2612, Online ISSN 2278–599X,
Vol-9, Issue-1, 2018, pp119-126
http://www.bipublication.com

Review Article

Effect of laser therapy on orthodontic tooth movement: a literature review

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ABSTRACT

One of the major components of patient to reject orthodontic treatment is the long duration of treatment. If Low intensity laser therapy can promote wound healing by increased cell proliferation and improved micro circulation can bring about faster bone remodeling at fracture sites; then why not to use it with orthodontic forces for better results? Soft tissue laser has now become a part of essential equipment of modern dental clinics. To accelerate the physiologic tooth movement during orthodontic treatment a thorough knowledge of laser unit, mode of action and key factors to gain therapeutic effect is a must which this article illustrates .Study carried out by us did show a 30% reduction in the treatment time. So, the aim of the current research was to determine effect of laser therapy on orthodontic tooth movement using the PubMed and Medline database English literature by the terms “laser therapy”, “orthodontic”, tooth movement”. It is reported Low-level laser therapy (LLLT) is effective on pain reduction after different dental treatments. It is reported LLLT enhanced fibroblast growth, wound healing, and bone repair which can be the result of osteoblasts proliferation, differentiation and intracellular changes.

Keywords: Laser therapy, Orthodontic, Tooth movement

INTRODUCTION

One of the main concerns to the orthodontic patients is treatment time and second is pain or discomfort. Decreasing the treatment time requires increasing the rate of physiologic tooth movement (Nishimura et al. 2008). Numerous techniques have been used to accelerate the orthodontic tooth movement as electric and magnetic stimulation, drug injections of parathyroid hormone and prostaglandins (Bhad-Patil et al. 2014). Even though these substances stimulate tooth movement, they also have undesirable side effects of local pain and discomfort during the injections (Doshi-Mehta et al. 2012). Recently, electric stimulation and resonance vibration used in dental practice but analgesics inhibit prostaglandins and decrease the tooth movement (Kim et al. 2010). Biologically, the orthodontic tooth movement is a result of periodontal tissues remodeling in response to the applied mechanical force. The use of light forces is advocated to prevent bone necrosis or root resorption which prolongs orthodontic treatment duration. Longer treatment duration is detrimental in terms of increased incidence of caries, root resorption, and reduced patient compliance (Kochar et al. 2017). Low-level laser therapy increases osteoblastic activity, vascularization and organization of collagen fibers (Sousa et al. 2011). Controversial reports exist on effect of the LLLT orthodontic tooth movement. It is suggest LLLT might improve orthodontic tooth movement in humans (Domínguez et al. 2015). However, studies have shown no significant increase in the rate of orthodontic tooth movement after LLLT (Heravi et al. 2014). Although various articles are available in literature in effect of LLLT on orthodontic tooth movement, to date researchers believe that data pertaining to it are controversial and questionable (Kasai et al. 2015).

There is a lack of evidence regarding LLLTs effectiveness in accelerating orthodontic tooth movement because of fluctuating reports (Sousa et al. 2014). So, the aim of the current study was to determine effect of laser therapy on orthodontic tooth movement using previous literature.

MATERIAL AND METHODS

The keywords used for the literature search for this review was peer-reviewed articles following key-words: Laser therapy × Orthodontic × Tooth movement. Among them, the papers were fit the criteria selected and available full-text articles read. Related articles were also scrutinized. Hand search was also driven. The search was carried out using Biological Abstracts, Chemical Abstracts, and the data bank of the PubMed and Medline database updated to 2017. The references found in the search were then studied in detail.

LOW-LEVEL LASERS

Laser irradiation has a variety of effects on tissues (Smith and Rose, 2010). Its effects on tissues depend on the wavelength of the laser. The “bio stimulating effects” of laser irradiation on tissues are accompanied by no more than increase in local temperature. Treatments that utilize the bio stimulation potency of laser irradiation are called low-level lasertherapy (Kasai et al. 2015). The low-level laser lights from there dand near-infrared regions correspond with the characteristic energy and absorption levels of the respiratory chain in mitochondria. The laser functions by stimulating antenna pigments, the primary photo acceptors of the respiratory chain, thus increasing the mitochondrial ATP production. The primary reaction occurring in the respiratory chain increases the cellular metabolism and as a result increases DNA synthesis and cell proliferation (Kasai et al. 2015).

LASERS THERAPY IN DENTISTRY

One of the most exciting developments in medical technology is the laser, with claims of often dramatic reductions in the duration of surgical operations, the degree of postoperative scarring, patient recovery times, postoperative morbidity and oedema, as well as claims of soft tissue biostimulation and management of chronic pain. Dentists have not been slow in examining lasers for possible use in their own field. Initial results met with mixed success, but in the last few years have been much more promising, so that today there are several systems on the market which claim to be of use in almost all facets of dentistry (Amudhalakshmi et al. 2016). The dental lasers of today have benefited from field of quantum mechanics, initially formulated during the early 1900s by Danish physicist Bohr. 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 (CO2) laser (George et al. 2008). Medical and dental lasers are found in wavelengths in a relatively narrow range within the electromagnetic spectrum. They include the range of visible radiation (400-750 nm) and invisible thermal radiation, which can be further broken down into the near infrared (750-2000 nm), mild infrared (2000-3000 nm), and far infrared (3000-10,600 nm) wavelengths (Bhad-Patil et al. 2014). Both high and low intensity lasers are being used in orthodontics. Laser has numerous benefits for an orthodontic office. It allows the orthodontist to perform procedures that might otherwise be referred to other specialists and its use resulting in minimal pain has been shown to reduce dental fears for patients leading to improved cooperation (Fornaini et al. 2013). Laser is also being investigated as a potential replacement of hydrofluoric acid in bonding to porcelain, thereby avoiding gingival burns and the need to repolish porcelain at debonding (Li et al. 2000).

High-level lasers are also being used in soft tissue applications such as gingival recontouring and reshaping, removal of excess tissue from gingival hyperplasia, gaining access to labial tooth surfaces for bracket placement, removal of redundant tissues created by space closure or from poor oral hygiene, removal of opercula on second molars, fiberotomy, and frenectomy (Vikram et al. 2011). The advantages of laser compared with scalpel in these situations are minimal bleeding, reduced postoperative pain and no swelling. The LLLT applications investigated thus far include pain reduction after orthodontic appliance placement, pain management of temporomandibular joint disorders, bone regeneration after rapid palatal expansion, and, of greatest interest, increased orthodontic tooth movement (Torri et al. 2013).

ORTHODONTIC TOOTH MOVEMENT

The biology behind orthodontic tooth movement is a complex interplay of cellular and molecular changes that begins when a force is applied to a tooth (Proffitt et al. 2007). During force to the tooth it is displaced within the periodontal ligament resulting in compression in some areas and stretching in others. These areas experience changes in blood flow stimulate the release of biologically active mediators and leads to increase of cellular activity and differentiation. It seems bone bending creates an ionic change in the crystalline structure that translates into electrical currents (Proffitt et al. 2007). These changes in the periradicular tissues stimulate multinuclear giant cells, osteocytes, osteoblasts, osteoclasts, and fibroblasts that allow for orthodontic tooth movement to occur (Cepara et al. 2012).

LASER THERAPY FOR FASTER ORTHODONTIC TOOTH MOVEMENT

Discomfort pain is a burdensome side effect accompanying orthodontic cure due to force application for tooth movement (Youssef et al. 2008). Clinical reports revealed these sensations usually appear a few hours post force application or during the first day (Hall et al. 2001). Pain reduction without analgesic drugs is critical in orthodontic treatment (Ngan et al. 1994). It is reported LLLT is effective on pain reduction after different dental treatments (Youssef et al. 2008). Orthodontic tooth movement includes both modeling and remodeling activities that are modulated via systemic factors such as metabolic bone diseases, nutrition, age, and drug administration (Youssef et al. 2008). During the mechanical stress of the orthodontic appliances cytokines, interleukins (IL-1β) and enzymes are expressed by cells within the periodontium (Winkler et al. 2003). Bone resorption and the inhibition of bone formation can influence by IL-1β. Also, it has key role in orthodontic tooth movement (Serra et al. 2003). Inflammatory cytokines have been administered to enhance orthodontically induced bone modeling (Youssef et al. 2008). LLLT is an effective tool used to prompt bone repair and modeling post-surgery (Serra et al. 2003). It is reported LLLT enhanced fibroblast growth, wound healing, and bone repair which can be the result of osteoblasts proliferation, differentiation and intracellular changes. Youssef et al. (2008) investigated evaluate the effect of the low-level (GaAlAs) diode laser (809 nm, 100 mW) on the canine retraction during an orthodontic movement and to assess pain level during this treatment and revealed LLLT can highly accelerate tooth movement during orthodontic treatment and can also effectively reduce pain level. Saito and Shimizu (1997) studied the effects of LLLT revealed decreased bone regeneration in midpalatal suture during expansion in the rat. LLLT can influence osteoclast regulation by effecting enzymatic levels of transforming growth factor-β1, cyclooxygenase-2, PGE2, fibronectin, collagen turnover, and tissue vascularity preservation. These enzymes induce the expression or inhibition of members of the osteoprotegerin/receptor activator of nuclear factor kappa B ligand/receptor activator of nuclear factor kappa B system and subsequently manipulate the differentiation, maturation and maintenance of osteoclasts (Bhad-Patil et al. 2014). It is reported LLLT increase teeth movement due to acceleration of bone formation as a result (Saito and Shimizu 1997). Milligan et al. (2017) studied effects of two wattages of low-level laser therapy on orthodontic tooth movement. An orthodontic force was applied to rat upper first molars exposed to 500mW (EX-500) and 1000mW (EX-1000) of laser application. It is reported evidence for molecular changes and the potential dysplastic effects of laser on the surrounding soft tissues (Milligan et al. 2017).

Laser wavelengths used in dentistry fall within the range of 488 to 10,600nm (Nalcaci and Cokakoglu, 2013) and tissue interactions occur within the energy range of 1-1000J/cm2 (Niemz, 2007). Studies have been performed with diode lasers to alter the rate of orthodontic tooth movement. While the diode laser has the benefits of being non-invasive, safe, painless and cost effective, its true value as a modality to increase tooth movement remains controversial in the literature (Torri and Weber, 2013). Laser therapy is used extensively in dentistry and the implications of the soft tissue histological changes after laser exposure are therefore clinically highly significant. The recommended wattage in the literature and commercial product literature is 500mW for the treatment of aphthous ulcers for pain reduction and healing (Vinck et al. 2003). For soft tissue ablation procedures, usually a onetime procedure, 800mW is recommended by Biolase (EZlase, USA). The possibility exists, therefore, that at that particular wattage (which is just slightly lower than the 1000 mW in this current study), dysplastic changes may occur. Dalaie et al. (2015) studied effect of low-level laser therapy on orthodontic tooth movement and reported application of the gallium aluminum-arsenide laser (GA-AL-AS diode laser, 880 nm, 100 mW, 5 j/cm2, 8 points, 80 seconds, continuous mode) had no difference in terms of tooth movement and pain scores between the irradiated and non-irradiated sides at any time point. Long et al, in 2015 in a meta-analysis study assessed the critically appraised current evidence and determined the effectiveness of low-level laser therapy in accelerating orthodontic tooth movement. The meta-analysis revealed that there was weak evidence supporting the efficacy of low-level laser irradiation at a wave-length of 780 nm, and fluency of 5 J/cm2 and/or the output power of 20 mW for acceleration of orthodontic tooth movement after 2 and 3 months. In our study, laser irradiation was deemed more effective in the maxilla compared to the mandible, which is probably due to the difference in the type of bone (spongy vs. com-pact) and the absence of anatomical barriers (i.e. tongue) in the upper jaw (Abtahi et al. 2013). It is reported irradiated a canine tooth undergoing orthodontic tooth movement with diode laser (780 nm, 20 mW, 25 J/cm2) may hasten orthodontic tooth movement (Da silva et al. 2010). Also, Youssef et al. (2008) studied the effect of GA-AL-AS laser (809 nm, 2 mW, 8 J/cm2) on or-thodontic tooth movement of frictionless re-tracted canine teeth. They revealed that the ir-radiated side moved 2.5-3 times faster than the other side.

MECHANISM OF ACTION OF THE LLLT ON ORTHODONTIC TOOTH MOVEMENT

The cellular responses assessed in vitro with LLLT are broadly classified under increase in metabolism, migration, proliferation, and increases in synthesis and secretion of various proteins (Kaipatur et al. 2014). To characterize if LLLT could be used for photobiostimulation of orthodontic tooth movement several in vitro experiments have been conducted. Increase reported in basic fibroblast growth factor after keratinocytes and fibroblasts were irradiated with 0.5-1.5J/cm2 HeNe laser (Yu et al. 2003). This was confirmed by others reporting an increased proliferation of fibroblasts and increased collagen type I production (Frozanfar et al. 2013). In vitro studies have also shown upregulation of RANK/RANKL and c-Fms gene expressions, which are known mediators for osteoclast activity, demonstrating an enhanced proliferation of osteoblast-like cells (Frozanfar et al. 2013). Investigations by Yamaguchi et al.43 found that there was an acceleration of bone remodeling found in the rat after LLLT through stimulation of MMP-9, cathepsin K, and integrin alpha (v) beta expression during orthodontic tooth movement. It is reported the biomodulating effects of LLLT include fibroblast proliferation, collagen synthesis, and organization of collagen fibers. They also found that LLLT in combination with orthodontic tooth movement resulted in increased vascularization, which may allow for accelerated pulp tissue repair in rats (Abi-Ramia et al. 2010). Several animal studies concluded that LLLT increased tooth movement by stimulating bone remodeling, yet there were a few that found no significant difference between irradiation and controls (Torri et al. 2013). These and other studies of similar nature have supported the potential for LLLT to influence orthodontic tooth movement in humans. Several animal studies have been performed with diode lasers to accelerate the rate of orthodontic tooth movement (Xue et al. 2013). The rat model is the most commonly utilized animal but studies have also included monkeys, dogs, and cats (Xue et al. 2013). Kim et al. (2015) studied effect of low-level laser therapy on orthodontic tooth movement into bone-grafted alveolar defects. Based on their report irradiated with a diode laser (dose, 4.5 J/cm2) every other day for 2 weeks decreased the rate of orthodontic tooth movement into the bone-grafted surgical defects by accelerating defect healing and maturation, particularly when the start of postoperative orthodontic tooth movement was delayed. All the studies confirmed the application of laser accelerated the velocity of tooth movement (Limpanichkul etal. 2006). The effects of the laser poses variant results depending up on the wave length, power, spectral area, dose, application frequency, and exposure time of the laser. The wave length is presumably not the decisive factor of facilitating tooth movement amongst the physical configurations of the laser (Seifi et al. 2006) however, it is rather predominantly attributable to the total energy dose exposed to the subject. The Arndt–Schulz rule is a claimed law concerning the effects of drugs or poisons in various concentrations. It states that for every substance small doses stimulate, moderate doses inhibit, and large dose skill. It is relevant to setup the optimal level of the laser dosage towards the therapeutic window, since an excessive dosage may inhibit the effect of tooth movement with insufficient amount leading to no effect. Both animal studies and clinical trials for human subjects which employ the laser approach may imply such a rule to be valid regarding the energy density and dose (Seifi et al. 2006).

CONCLUSION

In conclusion the present systematic review reveals very low quality of evidence that LLLT accelerates orthodontic tooth movement and low quality of evidence that LLLT modulates acute orthodontic pain. No studies on LLLT to prevent orthodontic relapse met the inclusion criteria. Tooth movement is dependent on a painful, inflammatory adaptation of the alveolar process. LLLT is supposed to reduce pain, to accelerate wound healing, and to have a positive effect on inflammatory processes. LLLT is an effective tool to manage the post-adjustment orthodontic pain (de Almeida et al. 2016). Laser therapy has been used in dentistry, e.g., caries detection, tooth desensitization, composite resin curing, sterilization of infected root canals, and in soft tissue procedures (Walsh, 2003). In the field of orthodontics, LLLT has been used in the treatment of pain reduction after orthodontic appliance placement and for temporomandibular joint disorders, bone regeneration after rapid palatal expansion, and in increasing the rate of orthodontic tooth movement (Torri and Weber, 2013). Further studies are required to optimize treatment parameters and explain the action mechanisms of the therapy. Orthodontically induced tooth movement associated with LLLT produced an increase in the vascularization, and this factor could accelerate pulp tissue repair. Laser therapy is beneficial to orthodontic movement. Also, LLLT accelerates the bone remodeling process by stimulating osteoblast and osteoclast cell proliferation and function during orthodontic tooth movement. Since the bio-stimulant effects of laser therapy have been shown in many studies, further studies with different doses should be performed to determine the appropriate dose to provide clinical advantage. LLLT increases the rate of orthodontic tooth movement in a physiologic manner. It causes no side effects on the vitality or the periodontium of the teeth. Thus, it can safely and routinely be used during orthodontic treatment to shorten the treatment time. LLLT also is an effective method of analgesia during orthodontic treatment.

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