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Effects of Low Level Laser Therapy on the Rate of Orthodontic Tooth Movement and Pain-A Literature Review

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Abstract **Review Article**

Long duration of orthodontic treatment is a major concern for patients. A least invasive method of accelerating tooth movement in a physiologic manner is needed. The aim of this review review article is to conduct a review of current literature to evaluate the effects of low level laser therapy on the rate of orthodontic tooth movement and pain.
Keywords: Low level laser therapy, orthodontic tooth movement, pain perception.

Introduction

LASER is an acronym for Light Amplification by Stimulated Emission of Radiation. The first effective laser was developed in the 1960s, although the theoretical framework was laid in the early 20th century. In Dentistry, lasers are used in two major applications: biostimulation and surgery. The lasers applied for biostimulation procedures i.e, for the activation of regenerative and healing processes are called low-level laser therapy (LLLT) and operates under 500 mW. The diode and helium neon (HeNe) lasers belong to this group. Lasers that work beyond the 500 mW range are applied for high-intensity laser therapies (HILT), also called surgical lasers, because of their tissue cutting capacity. This group includes the CO2, Nd: YAG, Erbium (Er: YAG, and Er, Cr: YSGG) and diode lasers. In Orthodontics, Low level laser therapy has been applied to relieve pain associated with orthodontic movements, and to enhance the velocity of tooth movement by accelerating bone remodeling [1].

Advantages of laser over other methods to increase orthodontic tooth movement

Orthodontic treatment with fixed appliances is a lengthy and painful process. Numerous techniques to reduce the treatment duration have evolved over the time. Reducing the treatment time requires increasing the rate of orthodontic tooth movement [2]. Many studies have examined different methods that can increase the rate of orthodontic tooth movement, including local injections of prostaglandins, 1, 25(OH)$_2$ D$_3$(the active form of vitamin D3), osteocalcin, and relaxin around the alveolar socket. Although these substances stimulate the rate of tooth movement, they also have the undesirable side effects of local pain and discomfort during the injections. Recently, electric stimulation and resonance vibration have been tried in animals, but these methods require an apparatus that is not routinely used in dental practice [3]. Surgical wounding may be used to speed up orthodontic tooth movement by increasing localized healing known as regional accelerated phenomenon (RAP), which lasts for four to six months. Nevertheless, the invasiveness of the surgical approach and the associated pain and swelling limit its clinical application [4]. Low-level laser irradiation (LLLI) has been reported to enhance the velocity of tooth movement by accelerating bone remodeling [2]. Among these methods, low level laser therapy is the least invasive and most comfortable [4].

Mechanism of action of laser

It induces a photochemical reaction (biostimulation) at the cellular level in which the light energy is absorbed by the cellular photoreceptors and is converted into adenosine triphosphate by mitochondria. This subsequently increases the cellular activities such as DNA, RNA, and protein synthesis. Some electromagnetic energy increases the local tissue temperature causing vasodilation, eventually inducing cellular proliferation, differentiation, and tissue healing. Low-energy laser irradiation can induce the proliferation and activation of both osteoblasts and osteoclasts through the expression of receptor activator of nuclear factor kappa- β (RANK) and receptor activator of nuclear factor kappa-β ligand (RANKL), accelerating the remodeling of bone and eventually increasing the velocity of orthodontic tooth movement[2].

Low level laser irradiation has also been shown to have analgesic effects in various clinical and therapeutic applications. It minimizes pain perception by inhibiting the release of arachidonic acid, which decreases the levels of prostaglandin E2. It also induces the release of an endogenous opioid neuropeptide (beta-endorphin) that produces potent analgesic effects. Low level laser irradiation stabilizes the membrane potential and henceforth inhibits activation and transmission of the pain signal [2].

Precautions to be taken while using laser

Although most lasers used in dental practice are relatively user-friendly, but precautions should be taken for securing a safe and effective operation. First, the procedure should be performed in an isolated room, everyone subject to laser exposure should wear safety glasses that includes dental professionals, assistants, patients, and any other people in the room (for example patient's family or friends). The safety glasses should be specifically chosen according to the laser wavelength. Although most lasers emit wavelengths that escape the visible part of the spectrum, their irradiation must not be neglected and caution should be taken. Besides the use of glasses, accidental exposure to laser beams can be avoided by signaling the risk areas with warning signs, limiting access to risk areas, minimizing reflective surfaces, and keeping the equipment under good operation condition [1].

Table-1: Various studies that evaluated the effect of LLLT on the rate of orthodontic tooth movement and pain

Author	Study design	No of patients	Laser specifications	Energy density and intervention schedule	conclusion
Cruz *et al.* [9]	Human study (random split mouth design)	11	Ga-Al-As 780 nm Continuous mode 20 mW power	5 J/cm2/point 50J/cm2/session 200J/cm2/month Days 0, 3, 7, 14, 33, 37, 44 Total 60 days	Tooth movement accelerated.
Limpanichkul *et al.* [17]	Human study (random split mouth design)	12	Ga-Al-As 860 nm Continuous mode 100 mW power	25 J/cm2/point 204 J/cm2/session 612J/cm2/month Days 0, 1, 2, 28, 29, 30, 58, 59, 60, 88, 89, 90	No significant results. Author stated that energy input was too low.
Youssef *et al.* [8]	Human study (randomized clinical trial)	15	Ga-Al-As 809 nm 100 mW power	1 J/point on 4 areas and 2 J/point on 2 areas 8 J/session Days 0,3,7,14	Tooth movement accelerated.
Fujiyama *et al.* [23]	Human study (random split mouth design)	90	CO2 laser 2 W power	5 pulses per 1000 s Applied once immediately after separation 60 s/tooth	Reduction in pain was reported, but there was no significant difference in movement of molars.
Yoshida *et al.* [24]	Animal study in rats	60	Ga-Al-As 810 nm Continuous mode 100 mW power	once daily on days 0–6, days 13, and days 20 Total energy corresponding to a 9-min exposure was 54.0 J⁄ cm.	LLLI accelerates the velocity of tooth movement via stimulation of the alveolar bone remodeling
Masaru Yamaguchi *et al.* [27]	Animal study in rats	50	Ga-Al-As diode laser wavelength of 810 nm continuous waves 100 mW power	once a day on days 0–7 The total energy corresponding to an exposure time of 9 minutes was 54.0 J	Low-energy laser irradiation facilitates the velocity of tooth movement and MMP-9, cathepsin K, and integrin subunits of a(v)b3 expression in rats.
Sous *et al.* [7]	Human study (random	10	Ga-Al-As 780 nm Continuous mode	5 J/cm2/point 50 J/cm2/session 150	Rate of tooth movement

	split mouth design)		20 mW power	J/cm2/month Days 0, 3, 7, 30, 33, 37, 60, 63, and 67 Total 90 days	accelerated twice
Doshi-Mehta and Bhad-Patil [3]	Human study (random split mouth design	20	Ga-Al-As 800 nm Continuous mode 250 mW power	8J/session Days 0,3,7,14 then every 15 days until the canines are retracted completely	Tooth movement accelerated.
Genc *et al*. [10]	Human study (random split mouth design)	20	Ga-Al-As 808 nm Continuous mode 200 mW power	0.71 J/cm2/point Days 0, 3, 7, 14, 21,28, 35	Significant acceleration in movement. No significant difference in nitric oxide levels in GCF
Naseem Joy Garg[28]	Human study (random split mouth design)	25	Ga-Al-As laser Continuous noncontact wave mode. power output of 2 W	Power density of 3.97 W/cm2 at 3 weeks intervals for total duration of 12 weeks.	Biostimulation carried out using a 810 nm diode laser is capable of increasing the rate of extraction space closure in humans. Hence, it can be concluded that it is capable of increasing the rate of orthodontic tooth movement.
Herav *et al*. [6]	Human study (random split mouth design)	20	Ga-Al-As 810 nm Continuous mode 200 mW power	21.4 J/cm2/point Days 0, 3, 7, 11 15	No significant difference in canine movement velocity and pain. Pertaining to different dosage and point of application and interval between applications
Parisa Salehi[29]	Animal study (interventional study) in dogs	8	Ga-Al-As 810 nm Continuous mode 200 mW power	2 J/session 32 J/cm2 /point days 0, 1, 2, 3, 4, 7, 14, 21, and 28 during 4 weeks of movement, and the amount of relapse was then observed for 3 months.	The total energy dose of the laser used in this study could not accelerate rotational tooth movement, but it did effectively reduce the relapse tendency in teeth rotated by orthodontic movements
Irfan Qamruddin [2]	Human study (random split mouth design)	20	Ga-Al-AS 940 nm Continuous mode 100 mW power	7.5 J/cm2 each point Days 0, 21,42	Rate of tooth movement accelerated twice. Significant reduction in pain associated with movement.
Li-Fang Hsu[11]	Animal study (split mouth design) in rats	14	Ga-Al-AS 970 nm Chopped wave mode 200 ms on/ 300 ms off 500mw power	At interval of 3 days for 14 days with energy 1250 J/cm^2.	Experimental group showed significantly increased OTM compared to the control group

Alissa Maria Varella [5]	Human study (random split mouth design)	10	Ga-Al-AS 940nm continuous mode 100mw power	For 3 consecutive days at the following intervals: start of canine retraction, 4 weeks later, and 8 weeks later with energy density of energy density, 8 J/cm^2	Application of low-level laser therapy increased the levels of IL-1b in gingival crevicular fluid and accelerated orthodontic tooth movement

Conclusion

Low-intensity laser therapy 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. Low-intensity laser therapy also is an effective method of analgesia during orthodontic treatment.

Most of the studies that evaluated the effect of low level laser therapy on the rate of tooth movement concluded that low level laser therapy causes increase in tooth movement and the pain associated with orthodontic tooth movement can also be significantly reduced with low level laser therapy.

A few studies concluded that low level laser therapy has no effect on orthodontic tooth movement because of inappropriate amount of energy and frequency of laser therapy used in the study. Thus we can conclude that Low level laser therapy increases the rate of OTM in a dose-sensitive and frequency-dependent manner.

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