Original Article

Effect of Low-Level Laser Therapy on Orthodontic Tooth Movement: A Clinical Investigation

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Abstract

Objectives: One major drawback of orthodontic treatment is its long duration due to slow tooth movement and the pain at the onset of treatment following application of forces. There is controversy regarding the efficacy of laser for decreasing the treatment time and pain of orthodontic treatment. The purpose of this study was to investigate the effect of low level diode laser on the rate of orthodontic tooth movement and the associated pain.

Materials and Methods: In this double blind randomized controlled clinical trial, 12 orthodontic patients referring to Shahid Beheshti School of Dentistry for first premolar extraction were randomly selected and allocated to gallium aluminum-arsenide laser (GA-AL-AS diode laser, 880 nm, 100 mW, 5 j/cm^2, 8 points, 80 seconds, continuous mode) or control group. The patients initially underwent leveling and alignment using the sectional system. Force (150 gr) was applied to each canine tooth via sectional closing loops. The loops were activated every month. The rate of tooth movement and pain were monitored over the treatment period and recorded on days 1, 3, 7, 30, 33, 37, 60, 63 and 67. Two-way ANOVA was used for comparison of groups.

Results: There was no significant difference in terms of tooth movement and pain scores between the irradiated and non-irradiated sides at any time point (P>0.05).

Conclusion: Although laser enhanced orthodontic tooth movement in the upper jaw, we failed to provide solid evidence to support the efficacy of laser for expediting tooth movement or reducing the associated pain.

Keywords: Orthodontic; Tooth movement; Laser Therapy, Low-Level; Pain

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INTRODUCTION

Low-level lasers have been shown to stimulate epithelialization, vascularization and collagen synthesis due to their photo-biological and photochemical effects [1-3]. Bone regeneration, wound healing and functional rehabilitation of damaged structures are among the outcomes of laser irradiation of injured sites [4,5]. One major drawback of orthodontic treatment is long duration of treatment which may lead to gingival inflammation, root resorption [6,7] increased risk of caries and decreased patient compliance [8].

Researchers have proposed different approaches to expedite the process of tooth movement such as local injection of prostaglandins, [9-11] osteocalcin [12] and activated vitamin D3 [13-15].

Fig. 1. (a) Pre-activated sectional closing loops placed in the middle of the extraction site in laser side. (**b)** The loops were activated about 1 mm by tightening them distally behind the molar tube.

These, however, are accompanied by pain during injection. Numerous recent studies have documented the effects of low level laser therapy on bone regeneration in mid-palatal sutures and collagen synthesis in animals [15-19].

Other studies have demonstrated that low level laser can enhance bone remodeling in the extraction site and expedite orthodontic tooth movement in animals [20,21]. Some evidence suggests that low level lasers are effective in enhancing the rate of orthodontic tooth movement since they increase the rate of bone remodeling without imposing any adverse effects [22-26].

Some studies, however, reported controversial results and failed to observe any significant difference between the rates of orthodontic tooth movement on the irradiated side versus the non-irradiated side [27-29]. Low level lasers have been proven effective in pain reduction during the early phases of orthodontic tooth movement [23]. Thus, this study sought to assess the effect of low level laser irradiation on the rate of orthodontic tooth movement and the initial associated pain in canine tooth intended to move into the first premolar extraction site.

MATERIALS AND METHODS

The present research is a double blind randomized controlled clinical trial and the study protocol was approved by the ethical committee and the research vice chancellor of Shahid Beheshti University of Medical Sciences. In this study, 12 patients (9 women, 3 men; mean age of 20.1 years) were randomly selected among those referring to the Department of those referring to the Department of Orthodontics, Shahid Beheshti School of Dentistry, Tehran, Iran, for premolar extraction. Decision on premolar extraction was made based on dental records (i.e. dental casts, radiographs and photographs). The inclusion criteria were 1) maxillary and mandibular first premolars extracted on both sides at least 3 months before starting to move canines distally after complete aligning and leveling. This period was allowed for bone fill-in of the extraction sockets before the study period; 2) left and right canines, second premolars and first molars were present in the maxillary and mandibular arches; 3) the patient had already well aligned and leveled upper teeth ready for retraction of maxillary canines; and 4) the subject gave informed consent to participate in the trial. The exclusion criteria were: history of infectious diseases, immunodeficiency diseases, systemic conditions, organ transplant, pregnancy, allergy and medications, which interfere with orthodontic tooth movement and drug addiction. Informed consent was obtained from parents and the fixed orthodontic treatment was commenced.

The steps of fixed orthodontic treatment

The initial phase of the treatment consisted of the sectional alignment and leveling of canines, second premolars and the first molars.

The bracket system used for this purpose was MBT Ortho organizer system with 0.022 inches slot. Canines were subsequently retracted using sectional closing loops (fabricated from 16×22

Fig. 2. Digital caliper (Mitutoyo, Japan)

Fig. 3. Low level Ga-Al-As laser (photo lase III, Brazil)

steel wire 5 ,7 mm leg length in the mandible and maxilla, respectively) placed in the middle of the extraction site (Fig. 1-a) and a force of 150 gr was applied. The amount of force was measured using a Correx (Haag-Streit Ber) force gauge. The loops were reactivated on both sides every month (Fig. 1-b).

Measurement of tooth movement

The distance between the canine cusp tip and first molar mesiobuccal cusp tip determined the amount of tooth movement and was recorded on dental casts after the application of force on days 1, 3, 7, 30, 33,37, 60, 63 and 67 using a digital caliper (Mitutoyo, Japan) (Fig. 2).

Laser irradiation

The four quadrants were randomly (in a complete block randomization manner using Microsoft Excel software) divided into laser and control groups. Laser group was irradiated with low level Ga-Al-As laser (photo lase III, Brazil) (880 nm, 5 j/cm^2) (Fig. 3) at 8 spots for 10 seconds on were aware of the irradiation side and the results were recorded by a third party. Laser was irradiated to the cervical, middle and apical thirds of the canine roots on buccal and lingual surfaces and distopalatal and distobuccal line angles. A validated questionnaire was designed to record the pain level in patients at the scheduled time points and the irradiation parameters were adjusted accordingly.

To evaluate the level of pain, the Wong-Baker Faces Pain Rating Scale was utilized. This technique was used to assess the pain perceived during dental procedures. It consists of a number of faces ranging from happy to crying. The patients were asked to indicate the level of pain they perceived on this pictorial index [30].

Dental radiographs were obtained from canines after the spaces were closed to detect any periodontal damage, tissue destruction or root resorption (Fig. 4).

Statistical analysis

To compare the intercuspal distance between the canine and the first molar teeth among the laser and the control groups in the upper and lower jaws, two-way repeated measures ANOVA was used. Pain was comparisons of groups at different time intervals were performed using the Wilcoxon Signed rank test. $P< 0.05$ was considered statistically significant. The analyses were performed using SPSS 20 for windows (Microsoft, Chicago, IL, USA).

RESULTS

Table 1 summarizes the mean and standard deviation of tooth movement in laser and control groups in the maxilla and mandible. The effect of laser irradiation on the amount of tooth movement was not significant (P=0.45).

It means that the amount of tooth movement in laser irradiated and control sides at each time interval was identical. Also, the amount of movements in the maxilla were the same as in the mandible (P=0.35). Table 2 presents the mean faces scale pain scores of the laser group and the control group in the maxilla and mandible. No significant difference was observed in terms of pain between the laser group and the control group in either jaw at any time point (P>0.05).

DISCUSSION

The process of bone remodeling in the periodontal tissues is a major determinant of orthodontic tooth movement [31,32], which is influenced by external factors such as nutrition, age and medications [9] and internal factors such as cytokines [33-36], interlokine-1β [11] and prostaglandins (especially PGE2) [10,11,37-40].

Due to pain and discomfort associated with the injection of prostaglandins, vitamin D3 and osteocalcin [11-13], recent studies have focused on low level lasers to achieve better results in terms of the rate of orthodontic tooth movement [20,21] and the associated pain [23].

According to the results of the present study, there was weak evidence in support of the efficacy of diode laser in increasing the rate of orthodontic tooth movement and reducing the associated pain.

The radiation wavelength we used in this study (880nm) resembled that of previous studies for diode lasers and ranged between 830-980 nm in the near-infrared zone [27,28]. Infra-red radiations have a low absorption coefficient in water and body fluids and thus, are thoroughly absorbed by bone cells [41]. Similar to the current study, in 2010 Marquezan et al failed to observe any significant difference between the rate of orthodontic tooth movement on the irradiated side with GA-AL-AS (830 nm, 100 mW, 6000 j/cm^2) versus the non-irradiated side [27]. In 2005, Limpanichkul et al, also reported the same results. They evaluated the effect of GA-AL-AS laser on the rate of orthodontic tooth movement and initially retracted a canine tooth using a NiTi coil spring and subsequently irradiated it with GA-AL-AS laser (860 nm, 25 J/cm^2/site, 2.3 J/point) [43].

They observed no significant difference between the irradiated and the non-irradiated sites and concluded that this finding was probably due to the low energy applied (25J/cm^2) [28]. One major flaw with Limpanichkul's study was the technique they used to retract the canine tooth. Retracting the tooth via the sliding method affects tooth movement on the control side [43]. Hence, we used the frictionless method to achieve space closure. Likewise the latter study, we irradiated the teeth on 8 spots.

Table 1. The means and standard deviations of tooth movement in laser and control groups in the maxilla and mandible at days 3, 7, 30, 33, 37, 60, 63 and 67 (mm)

Day	Maxilla		Mandible	
	Laser Mean±SD*	Control Mean±SD	Laser Mean±SD	Control Mean±SD
3	0.75±1.32	0.83±1.23	0.42±1.14	0.65±1.36
7	1.88±1.57	1.75±1.11	1.23±0.53	1.41±1.54
30	2.61±1.59	2.49±0.98	2.29±1.36	2.03±1.56
33	3.75±1.3	3.89±0.56	2.46±0.49	3.17±1.50
37	4.79±1.09	4.31±0.66	2.9±0.89	3.39±0.98
60	4.98±0.78	4.5±0.23	3.73±1.08	4.01±1.44
63	5.44±0.98	4.85±0.70	4.6±1.06	4.6±1.08
67	5.79±0.78	5.72±0.12	5.58±1.24	5.15±0.80

* Standard Deviation

Fig. 4. Periapical radiograph was obtained from canine after the spaces were completely closed. Note: there were no periodontal damage, tissue destruction or root resorption

Long et al, in 2013 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 wavelength of 780 nm, and fluency of 5 J/cm^2 and/or the output power of 20 mW for acceleration of orthodontic tooth movement after 2 and 3 months [42]. 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. compact) and the absence of anatomical barriers (i.e. tongue) in the upper jaw. This finding was previously reported by Abtahi et al [28].

They evaluated the effect of low-level laser irradiation on tooth movement following the separator placement. Low-level laser was applied to one quadrant of each jaw for 5 days while the other quadrant served as the control. They showed that low-level laser irradiation accelerated tooth movement in the maxilla more than in the mandible, but the difference between the mean amount of total tooth movement in laser irradiated side and the control side was not statistically significant. The difference between our study and that of Abtahi et al was assessment of tooth movement for 2 months in our study rather than 5 days in their study [28]. In 2010, Da silva et al concluded that laser irradiation may hasten orthodontic tooth movement. They irradiated a canine tooth undergoing orthodontic tooth movement with diode laser (780 nm, 20 mW, 25 J/cm^2) [25].

In 2007, Youssef et al studied the effect of GA-AL-AS laser (809 nm, 2 mW, 8 J/cm^2) on orthodontic tooth movement of frictionless retracted canine teeth. They revealed that the irradiated side moved 2.5-3 times faster than the other side [24].

In 2004, Delma et al evaluated the effect of low-level laser irradiation on orthodontic movement velocity of human teeth. In their study, 11 patients were evaluated for 2 months. One half of the upper arch was considered as the control group and received mechanical activation of the canine teeth every 30 days. The opposite half received the same mechanical activation and was also irradiated with diode laser emitting light at 780 nm [45].

Table 2. The Mean Faces Scale Pain Scores in the upper and lower jaws among both groups at days 1, 33 and 63

Jaw	Time (day)	N	Laser	Control	P value*
	1	12	2.7500±1.13	2.9167±1.24	0.862
Maxilla	33	12	2.3333±0.77	2.3333±0.98	1
	63	12	2.2500±0.86	2.4167±0.79	0.795
	1	12	3.2500±1.13	2.9167±1.31	0.126
Mandible	33	12	2.4167±0.79	2.7500±0.96	0.319
	63	12	2.5833±0.90	2.5000±0.67	0.878

* $P < 0.05$ was considered significant.

They suggested that diode laser emitting light did accelerate human tooth movement and could therefore considerably shorten the treatment duration [45]. The majority of such studies have documented the efficacy of low level laser therapy for collagen synthesis [3], expedited bone remodeling [5], improved tissue healing [1] and bone remineralization [1,3]. This controversy may be due to differences in radiation parameters. Studies reveal that the stimulatory effect of low level lasers on bone remodeling is directly affected by the power density [43] and exposure time rather than the total energy dose [44]. Other factors which may account for differences among studies include: beam movement [2], wavelength [21], power density [43,45], laser mode [44], exposure time [5], total energy [1], energy density [21], type of coolant [43], contact versus noncontact modes [1], angle of beam [5], tissue thickness [15], and tissue composition [4]. Although Youssef et al previously demonstrated that laser significantly decreased the pain associated with orthodontic tooth movement, our findings failed to support this hypothesis [24]. We believe that the systemic effects of lasers and the subjective nature of pain may explain the obtained results [23]. Finally, due to the lack of long-term in vivo studies to confirm these reports, further studies are required to determine the optimal radiation parameters for low level lasers to pose significant effects on the rate of orthodontic tooth movement and the pain associated with orthodontic treatment.

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REFERENCES

1- Consolaro A. Effects of medications and laser on induced tooth movement and associated root resorption: four key points. Dental Press J Orthod. 2013 Mar-Apr;18(2):4-7.

2- Takeda Y. Irradiation effect of low-energy laser on alveolar bone after tooth extraction. Experimental study in rats. Int J Oral Maxillofac Surg. 1988 Dec;17(6):388-91.

3- Walsh LJ. The current status of low level laser therapy in dentistry. Part 1. Soft tissue applications. Aust Dent J. 1997 Aug;42(4):247-54.

4- Shirazi M, Ahmad Akhoundi MS, Javadi E, Kamali A, Motahhari P, Rashidpour M, et al. The effects of diode laser (660 nm) on the rate of tooth movements: an animal study. Lasers Med Sci. 2015 Feb;30(2):713-8.

5- Hopkins JT, McLoda TA, Seegmiller JG, David Baxter G. Low-Level Laser Therapy Facilitates Superficial Wound Healing in Humans: A Triple-Blind, Sham-Controlled Study. J Athl Train. 2004 Sep;39(3):223-229.

6- Owman-Moll P, Kurol J, Lundgren D. Repair of Orthodontically induced root resorption in adolescents. Angle Orthod. 1995;65(6):403-8.

7- Seifi M, Badiee MR, Abdolazimi Z, Amdjadi P. Effect of basic fibroblast growth factor on orthodontic tooth movement in rats. Cell J. 2013 Fall;15(3):230-7.

8- Patil AK, Shetty AS, Setty S, Thakur S. Understanding the advances in biology of orthodontic tooth movement for improved orthoperio interdisciplinary approach. J Indian Soc Periodontol. 2013 May;17(3):309-18.

9- Cağlaroğlu M, Erdem A. Histopathologic investigation of the effects of prostaglandin E2 administered by different methods on tooth movement and bone metabolism. Korean J Orthod. 2012 Jun;42(3):118-28.

10- Gameiro GH, Pereira-Neto JS, Magnani MB, Nouer DF. The influence of drugs and systemic factors on orthodontic tooth movement. J Clin Orthod. 2007 Feb;41(2):73-8.

11- Saito M, Saito S, Ngan PW, Shanfeld J, Davidovitch Z. Interleukin 1 beta and prostaglandin E are involved in the response of periodontal cells to mechanical stress in vivo and in vitro. Am J Orthod Dentofacial Orthop. 1991 Mar;99(3):226-40.

12- Hashimoto F, Kobayashi Y, Mataki S, Kobayashi K, Kato Y, Sakai H. Administration of osteocalcin accelerates orthodontic tooth movement induced by a closed coil spring in rats. Eur J Orthod. 2001 Oct;23(5):535-45.
13- Collins MK, Sinclair PM. The local use of vitamin D to increase the rate of orthodontic tooth movement. Am J Orthod Dentofacial Orthop. 1988 Oct;94(4):278-84.
14- Takano-Yamamoto T, Kawakami M, Kobayashi Y, Yamashiro T, Sakuda M. The effect of local application of 1,25-dihydroxycholecalciferol on osteoclast numbers in orthodontically treated rats. J Dent Res. 1992 Jan;71(1): 53-9.
15- Bartzela T, Türp JC, Motschall E, Maltha JC. Medication effects on the rate of orthodontic tooth movement: A systematic literature review. Am J Orthod Dentofacial Orthop. 2009 Jan;135(1):16-26
16- 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 May;111(5):525-32.
17- Abergel RP, Lyons RF, Castel JC, Dwyer RM, Uitto J. Biostimulation of wound healing by lasers; experimental approaches in animal models and in fibroblast cultures. J Dermatol Surg Oncol. 1987 Feb;13(2):127-33.
18- Van Breugel HH1, Bär PR. Power density and exposure time of He–Ne laser irradiation are more important than total energy dose in photo-biomodulation of human fibroblasts in vitro. Lasers Surg Med. 1992;12(5):528-37.
19- Trelles MA, Mayayo E. Bone fracture consolidates faster with low power laser. Lasers Surg Med. 1987;7(1):36-45.
20- Kawasaki K, Shimizu N. Effects of low-enegy laser irradiation on bone remodeling during experimental tooth movement in rats. Lasers Surg Med. 2000;26(3):282-91.
21- 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(2):117-20.
22- Seifi M, Shafeei HA, Daneshdoost S, Mir M. Effects of two types of low-level laser wave lengths (850 and 630nm) on the orthodontic tooth movements in rabbits. Lasers Med Sci. 2007 Nov;22(4):261-4.
23- Kreisler MB, Haj HA, Noroozi N, Willershausen Bd. Efficacy of low level laser therapy in reducing postoperative pain after endodontic surgery a randomized double blind clinical study. Int J Oral Maxillofac Surg. 2004 Jan;33 (1):38-41.
24- 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 Jan;23(1):27-33.
25- Da Silva Sousa MV, Scanavini MA, Sannomiya EK, Velasco LG, Angelieri F. Influence of Low-Level Laser on the Speed of Orthodontic Movement. Photomed Laser Surg. 2010 Dec;28(6):823-30.
26- Pretel H, Lizarelli RF, Ramalho LT. Effect of low-level laser therapy on bone repair: histological study in rats. Lasers Surg Med. 2007 Dec;39(10):788-96.
27- Marquezan M, Bolognese AM, Araújo MT. Effects of two low-intensity laser therapy protocols on experimental tooth movement. Photomed Laser Surg. 2010 Dec;28(6):757-62.
28- Abtahi SM, Mousavi SA, Shafaee H, Tanbakuchi B. Effect of low-level laser therapy on dental pain induced by separator force in orthodontic treatment. Dent Res J (Isfahan). 2013 Sep;10(5):647-51.
29- Savino F, Vagliano L, Ceratto S, Viviani F, Miniero R, Ricceri F.Pain assessment in children undergoing venipuncture:the Wong-Baker faces scale versus skin conductance fluctuations. Peer J. 2013 Feb 12;1:e37.
30- Davidovitch Z. Tooth movement. Crit Rev Oral Biol Med. 1991;2(4):411-50.
31- Meikle MC. The tissue, cellular, and molecular regulation of orthodontic tooth

movement: 100 years after Carl Sandstedt. Eur J Orthod. 2006 Jun;28(3):221-40.
32- Davidovitch Z, Nicolay OF, Ngan PW, Shanfeld JL. Neurotransmitters, cytokines, and the control of alveolar bone remodeling in orthodontics. Dent Clin North Am. 1988 Jul; 32 (3):411-35.
33- Krishnan V, Davidovitch Z. Cellular, molecular, and tissue-level reactions to orthodontic force. Am J Orthod Dentofacial Orthop. 2006 Apr;129(4):469.e1-32.
34- Burstone CJ, Tanne K. Biomechanical basis of tooth movement. Nihon Kyosei Shika Gakkai Zasshi. 1986 Dec;45(4):541-51.
35- Garlet TP, Coelho U, Silva JS, Garlet GP. Cytokine expression pattern in compression and tension sides of the periodontal ligament during orthodontic tooth movement in humans. Eur J Oral Sci. 2007 Oct;115(5):355-62.
36- Yamasaki K, Miura F, Suda T. Prostaglandin as a mediator of bone resorption induced by experimental tooth movement in rats. J Dent Res. 1980 Oct;59(10):1635-42.
37- Yamasaki K, Shibata Y, Fukuhara T. The effect of prostaglandins on experimental tooth movement in monkeys (Macaca fuscata). J Dent Res. 1982 Dec;61(12):1444-6.
38- Yamasaki K, Shibata Y, Imai S, Tani Y, Shibasaki Y, Fukuhara T. Clinical application of prostaglandin E1 (PGE1) upon orthodontic tooth movement. Am J Orthod. 1984 Jun;85(6): 508-18.
39- Seifi M, Eslami B, Saffar AS. The effect of prostaglandin E2 and calcium gluconate on orthodontic tooth movement and root resorption in rats. Eur J Orthod. 2003 Apr;25(2):199-204.
40- Pinheiro AL1, Martinez Gerbi ME, de Assis Limeira F Jr, Carneiro Ponzi EA, Marques AM, Carvalho CM, et al. Bone repair following bone grafting hydroxyapatite guided bone regeneration and infra-red laser photobiomodulation: a histological study in a rodent model. Lasers Med Sci. 2009 Mar;24(2):234-40.
41- Gandini P, Orsi L, Sfondrini MF, Scribante A. Opening and closure forces of sliding mechanisms of different self-ligating brackets. J Appl Oral Sci. 2013;21(3):231-4.
42- Long H, Zhou Y, Xue J, Liao L, Ye N, Jian F, et al. The effectiveness of low-level laser therapy in accelerating orthodontic tooth movement a meta-analysis. Lasers Med Sci. 2015 Apr;30(3):1161-70.
43- 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 Feb;9(1):38-43.
44- Domínguez A, Gómez C, Palma JC. Effects of low-level laser therapy on orthodontics: rate of tooth movement, pain, and release of RANKL and OPG in GCF. Lasers Med Sci. 2015 Feb;30(2):915-23.
45- Delma R, Eduardo K, Martha S, Niklaus U. Effects of low-intensity laser therapy on the orthodontic movement velocity of human teeth: A preliminary study. Lasers Surg Med. 2004; 35(2):117-20.