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Evaluation of the Effects of Low-Level Laser Therapy on the Rate of Relapse of Mandibular Incisors after Fixed Orthodontic Treatment: A Randomized Controlled Trial

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ABSTRACT

Background and Objective: Stability is one of the major issues in orthodontics. The purpose of this study is to investigate the effect of Low-Level Laser Therapy on the rate of relapse of mandibular incisors.

Methods: This Single-blinded Randomized Controlled Trial consisted of twenty patients (aged 12-18 years) seeking orthodontic treatment. The subjects were divided into two groups with randomly permuted blocks (n=10): experimental and control groups. The Little's irregularity index was measured on plaster models prior to treatment using American Board of Orthodontic Measuring Gauge. After unraveling of initial crowding, archwires on mandibular anterior segments of both groups were removed. The experimental group received Low-Level Diode Laser at 808 nm wavelength, 250 mW power, 4J energy and continuous wave mode, on coronal third of lower central and lateral incisors and canines' roots for sixteen seconds three times a week, within a four-week period. The relapse rate was quantified on each plaster model using Little's irregularity index at the end of first (T1), second (T2), third (T3), and fourth (T4) weeks.

Findings: The study population consisted of twenty patients aged 12-18 years who had 5-9 mm crowding and proper oral hygiene. At T1, the relapse rate was 0 mm and 0.05±0.15 mm in experimental and control group, respectively, which was not statistically significant (p=0.343). Over the following weeks, however, there was statistically significant difference between the relapse rate of the two groups (p=0.003). The mean rate of relapse percentage was 4.48±4.31 mm in experimental and 12.06±5.52 mm in control group, which was significantly lower in Low-Level Laser Therapy group.

Conclusion: The application of Low-Level Laser Therapy at 808 nm wavelength on mandibular incisors during orthodontic retention phase may slow down the relapse rate. Therefore, it could be considered as an effective adjunct to reduce immediate relapse.

Keywords: *Relapse, Retention, Low-Level Laser Therapy.*

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Introduction

Orthodontic relapse is defined as the teeth's tendency to return to their pre-treatment position (1) which is inevitable in orthodontic treatment (2, 3). Reitan was the first person to describe this tendency in dogs and humans (4). In his classical studies, he reported that relapse may began within 2 hours after removing orthodontic forces. Thereafter, many researches have shown the relapse tendency of mandibular incisors following orthodontic treatment which occurs quickly in the absence of retention (4).

Biological mechanism of relapse is similar to orthodontic tooth movement. The strain on PDL fibers creates forces in the opposite direction of the intended tooth movement, i.e., compressed fibers return to their former size and shape as do the stretched fibers after removing orthodontic appliances, which could lead to immediate relapse. Therefore, a potent underlying factor for immediate relapse is the memory of altered PDL fibers (5-7). Bone resorption also could be a reason for this tendency, which is 9 times greater than bone apposition at the beginning of tooth movement (8). The immediate relapse that occurs during PDL remodeling should be distinguished from delayed relapse which manifests itself as late changes during post-retention period (9). Retention is a solution to counteract relapse tendency which should be of sufficient duration (10). Other methods have been developed to prevent or reduce the likelihood of undesirable changes including localized and systemic medicinal substances like Bisphosphonates, Osteoprotegerin, Simvastatin, Relaxin, Bone Morphogenetic Protein (BMP) (11) as well as laser application which reveals to have some effects on supporting fibers of the teeth (12).

Low-Level Laser which is known as cold laser is used in dentistry for its clinical effect on hard and soft tissues (13, 14). Low-Level Laser Therapy (LLLT) is a type of phototherapy utilizing Low-Level light irradiation with wavelength of 600 to 1000 nm (infrared range) and output power up to 500 mW; This can alter biological activities through non-thermal reactions using Low-Levels of photon energy (13, 15). The molecular effect of Low-Level Laser Therapy is generally described as Photobiostimulation (16). Photobiomodulation using LLLT is capable of stimulating various cellular mechanisms which eventually results in inflammatory processes acceleration, pain reduction and tooth fibers recovery enhancement (17-19).

Low-Level Laser Therapy has multiple biological effects on cells and fibers; It promotes wound healing, reduce pain, accelerate inflammatory process and bone remodeling (20, 21), postoperative regeneration (22), proliferation and differentiation of osteoblast, fibroblast and osteoclast cells (14, 16), matrix formation and calcification (23) and production of collagen. Laser therapy is most effective in the early stages of bone healing and remodeling when cellular proliferation is maximal (23).

Currently, Low-Level Laser Therapy is used as an adjunct in multiple fields of dentistry including orthodontics (23, 24). It has been shown that LLLT can be used to manage post adjustment orthodontic pain and accelerate orthodontic tooth movement (25).

Few studies have been conducted to investigate the effects of Low-Level Laser Therapy on the rate of relapse after orthodontic treatment and the majority of them were animal studies. Therefore, the purpose of this study is to investigate the effect of Low-Level Laser Therapy on mandibular incisors' relapse rate.

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Methods

After being approved by the Ethics Committee of Babol University of Medical Sciences with the code IR.MUBABOL.HRI.REC.1398.280 and registered in the Iranian Clinical Trials System with the code IRCT20200208046415N1 with two parallel arms and 1:1 allocation ratio, this single-blinded randomized controlled trial was performed on 20 patients referred to the Orthodontics Department of Babol University of Medical Sciences, Mazandaran, Iran. Ten cases were estimated in each group as sample size with a confidence level of 95% and a power of 80% and the assumption of σ_1=6.5 and σ_2=4 for the number percentage in the control and study groups (based on similar studies) to find d=7 (difference in the number percentage in the two groups). The research process was fully explained to the patients, participation in the research was completely voluntary, and people entered the study if they wanted to participate in the project and signed the consent form.

The study population consisted of twenty patients aged 12-18 years who had 5-9 mm crowding, proper oral hygiene and similar treatment plan (tooth extraction). Patients with gingival inflammation or periodontal problems and those with proximal caries, deep caries extending to the cementoenamel junction, or teeth with more than 45-degree rotations were excluded from the sample. The exclusion criteria also involved patients who consumed medicine that interrupted bone metabolism and those with conditions for which laser therapy could cause contraindication (e.g., pregnancy).

Prior to the start of fixed orthodontic treatment (T0), an alginate impression (Bayer, Germany) was taken from each participant and poured with orthodontic plaster (Hinridur, Germany). The Little's irregularity index was measured in millimeters on each model using American Board of Orthodontics (ABO) measuring gauge. AutoCAD software and CNC device were used for designing and milling of the gauge, respectively.

As orthodontic treatment proceeded and the initial crowding unraveling was performed, the archwires of mandibular anterior segments were removed while they kept in the buccal segments.

At this stage, patients were randomly assigned to experimental (Subjects receiving Low-Level Laser during dental relapse period) and control groups (n=10) with randomly permuted blocks. Allocation sequence was generated using www.randomization.com website by an independent individual.

The experimental group received Ga-Al-As Low-Level Diode Laser (Knoftec, Taiwan) at a wavelength of 808 nm, 250 mW power, 4J energy and continuous wave mode which was radiated from a probe with a 2 mm diameter. Probe was placed perpendicular to the tissue with a gentle contact without pressure. Low-Level Laser was applied on 4 points (Mesiobuccal, distobuccal, mesiolingual, distolingual) on coronal third of lower central and lateral incisors and canines' root for 16 seconds. Protection glasses with special lenses were used for both operators and patients during laser irradiation. The procedure was performed three times a week during a four-week period (12).

At the end of the first (T1), second (T2), third (T3) and fourth (T4) week, an alginate impression was taken from participants of both groups and plaster models were prepared to calculate the Little's Irregularity Index once again. Distance from mesial contact point of the right canine to mesial contact point of the left canine was measured in millimeters with ABO measuring gauge. Relapse in the vertical dimension was also calculated separately by measuring the vertical difference between the incisal edges with ABO measuring gauge. The mean vertical difference from mesial of the right canine to mesial of the left canine was recorded.

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Relapse percentage was calculated based on the following formula:

$$\text{Relapse percentage} = \frac{\text{Little's Irregularity Index after laser irradiation}}{\text{Little's Irregularity Index prior to orthodontic treatment}} \times 100$$

Vertical relapse was also calculated by comparison of the mean vertical difference between incisal edges from T0 to T4. Each measurement was done three times under identical conditions.

All data were blindly evaluated, supporting the single-blinded design of the study, and were analyzed using SPSS ver.17 software and T-Test, Paired T-Test, Repeated Measures ANOVA. $P<0.05$ was considered to be statistically significant.

Results

A total of twenty patients (13 female, 7 male) with a mean age of 16.65±2.20 years participated in this trial. At baseline (T0), the Little's Irregularity index of experimental and control group was 6.90±1.85 mm and 6.70±1.70 mm, respectively, which did not differ significantly. After one week of Low-Level Laser Irradiation (T1), the experimental group had no relapse while the control group experienced 0.05±0.15 mm of relapse; The difference was not statistically significant (p=0.343).

However, during the following weeks of Low-Level Laser Irradiation (T2, T3, T4), a significantly lower relapse occurred in the experimental group ($p<0.05$). Relapse in vertical dimension was only observed in one of the patients in the third week (T3) which implied no statistically significant difference between the relapse rate of experimental and control groups in vertical dimension (p=0.343). The relapse percentage was 4.48±4.31 and 12.06±5.52 in the experimental and control groups, respectively, which was significantly different between the two groups (p=0.003) (Table 1). Relapse occurred in both experimental and control groups but is more severe in experimental group as compared to control group and this difference become evident from week 2 ($p<0.001$).

Table 1. comparing Little's Irregularity Index before and after treatment and average relapse in weeks 1 through 4 after Low-Level Laser Radiation

	Study group (n=10) Mean±SD (mm)	**Control group (n=10) Mean±SD (mm)**	**p-value**
Irregularity index (T0)	6.90±1.85	6.70±1.70	0.804
Relapse (T1)	0.00±0.00	0.05±0.15	0.343
Relapse (T2)	0.00±0.00	0.30±0.25	0.005
Relapse (T3)	0.25±0.26	0.75±0.26	0.000
Relapse (T4)	0.30±0.25	0.75±0.26	0.001
Relapse (vertical)	0.1±0.31	0.00±0.00	0.343
Relapse (%)	4.48±4.31	12.06±5.52	0.003

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Discussion

In this study, a significant reduction in the rate of relapse occurred particularly toward the fourth week. Relapse percentage demonstrated statistically significant difference between LLLT and control groups which has clinical importance as well. Most researches have evaluated the effect of Low-Level Laser Therapy on tooth movement velocity during orthodontic treatment rather than its effect on treatment stability during the retention phase (21, 26). Selection of laser should be on the basis of its effect on target tissues. The best wavelength for biological stimulation is considered to be 550 to 950 nm (2).

In this trial we applied Low-Level Laser with the wavelength of 808 nm to investigate its impact on the rate of relapse which was measured on 3D models and Little's Irregularity index that are more accurate than two-dimensional photography. Salehi et al. reported that Low-Level Laser Therapy can reduce the relapse tendency of rotated teeth in dogs (2) which is consistent with our findings. According to the study by Kim et al, Low-Level Laser Irradiation diminished the duration of retention phase if laser therapy was carried out in the presence of retainers; Otherwise LLLT would cause an increase in the rate of relapse (7). The results of Kim's study are different from the findings of our study, which show a decrease in relapse in the absence of a retainer. On the other hand, Franzen stated that the decrease in relapse tendency occurred in the absence of retainer during LLLT in rats (11). Jahanbin et al. and Meng et al. recommended LLLT with high energy density as an effective adjunct to slow down the relapse process (12, 27). In a systemic review, Sonesson et al. concluded that none of the studies regarding the effects of LLLT on post orthodontic relapse have proper inclusion and exclusion criteria which necessitate the need for compatibility in research design and consistency of laser therapy method (13). Al-Jasser et al. also stated in a systemic review in 2020 that the quality of the evidence on LLLT in preservation of orthodontic treatment results or better prognosis is still low (28).

As shown in the studies mentioned above, a remarkable controversy exists in the effects of Low-Level Laser Therapy on post orthodontic relapse. This can be contributed to disparate treatment subjects and biological differences between animals and humans. In animal studies, properly positioned teeth are moved to create malocclusion whereas in human subjects, the teeth are moving to their proper position during orthodontic treatment to correct the malocclusion. Also, it is possible that similar laser therapy protocol does not create identical cellular response in animals and humans.

Another reason for contradictory results is different types of tooth movement between experiments. During rotation, translation, and tipping movements, supporting fibers undergo varying strains in which the pattern and amount of fibers compression and tension brings about different outcomes. Furthermore, the pattern of bone resorption and apposition will not be similar in applying different types of forces. Laser radiation protocol can also be responsible for contradictory results between studies i.e. the duration, interval, wavelength and energy of laser irradiation and whether it is applied only on the labial surface or both the labial and lingual surfaces. In the present study, Low-Level Laser Radiation with wavelength of 808 nm was applied to 4 points on buccal and lingual surfaces: mesiobuccal, mesiolingual, distobuccal and distolingual. Each area received Low-Level Laser Radiation for 16 seconds, 3 times a week over a 4-week period. The timing of laser therapy also differs between researches; in some studies, Low-Level laser beam is applied during the active phase of orthodontic treatment while in some others, irradiation is carried out in the retention phase, either with or without retainers.

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In this study, Laser Therapy was applied at the beginning of the retention phase. Orthodontic archwires were removed and the teeth were free to relapse in the absence of any retainers. We concluded that the application of Low-Level Laser Therapy on mandibular incisors during orthodontic retention phase may decelerate the relapse rate significantly. Therefore, it could be considered as an effective adjunct to reduce immediate relapse.

However, Randomized Clinical Trials on human subjects with similar inclusion and exclusion criteria and compatible methods for laser therapy is necessary to achieve clinically useful outcomes.

Conflict of interest: The authors have no conflicts of interest to declare.

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References

1.Abdulraheem S, Schütz-Fransson U, Bjerklin K. Teeth movement 12 years after orthodontic treatment with and without retainer: relapse or usual changes?. Eur J Orthod. 2020;42(1):52-9.

2.Salehi P, Heidari S, Tanideh N, Torkan S. Effect of low-level laser irradiation on the rate and short-term stability of rotational tooth movement in dogs. Am J Orthod Dentofacial Orthop. 2015;147(5):578-86.

3.Ben Mohimd H, Bahije L, Zaoui F, Halimi A, Benyahia H. Is systemetic mandibular retention mandatory? A systematic review. Int Orthod. 2018;16(1):114-32.

4.Maltha JC, Kuijpers-Jagtman AM, Von den Hoff JW, Ongkosuwito EM. Relapse revisited—Animal studies and its translational application to the orthodontic office. Semin Orthod. 2017;23(4):390-8.

5.Shaughnessy TG, Proffit WR, Samara SA. Inadvertent tooth movement with fixed lingual retainers. Am J Orthod Dentofacial Orthop. 2016;149(2):277-86.

6.Leea SH, Kim KA, Anderson S, Kang YG, Kim SJ. Combined effect of photobiomodulation with a matrix metalloproteinase inhibitor on the rate of relapse in rats. Angle Orthod. 2016;86(2):206-13.

7.Kim SJ, Kang YG, Park JH, Kim EC, Park YG. Effects of low-intensity laser therapy on periodontal tissue remodeling during relapse and retention of orthodontically moved teeth. Lasers Med Sci. 2013;28(1):325-33.

8.Sutjiati R, Rubianto, Narmada IB, Sudiana IK, Rahayu RP. The Inhibition of Relapse of Orthodontic Tooth Movement by NaF Administration in Expressions of TGF-β1, Runx2, Alkaline Phosphatase and Microscopic Appearance of Woven Bone. Int J Med Health Sci. 2017;11(10):567-74.

9.Graber LW, Vanarsdall Jr RL, Vig KW, Huang GJ. Orthodontics: Current Principles and Techniques, 6th ed. Mosby; 2016. p. 81.

10.Nanda R. Esthetics and Biomechanics in Orthodontics, 2nd ed. Elsevier- Saunders; 2015. p. 216.

11.Franzen TJ, Zahra SE, El-Kadi A, Vandevska-Radunovic V. The influence of low-level laser on orthodontic relapse in rats. Eur J Orthod. 2015;37(1):111-7.

12.Jahanbin A, Ramazanzadeh BA, Ahrari F, Forouzanfar A, Beidokhti M. Effectiveness of Er:YAG laser-aided fiberotomy and low-level laser therapy in alleviating relapse of rotated incisors. Am J Orthod Dentofacial Orthop. 2014;146(5):565-72.

13.Sonesson M, De Geer E, Subraian J, Petrén S. Efficacy of low-level laser therapy in accelerating tooth movement, preventing relapse and managing acute pain during orthodontic treatment in humans: a systematic review. BMC Oral Health. 2016;17(1):11.

14.Abtahi M, Saghravanian N, Poosti M, Shafaee H. Histological evaluation of orthodontic tooth movement following low level laser irradiation in rabbits. Electron Physician. 2018;10(1):6219-22.

15.Mussttaf RA, Jenkins DF, Jha AN. Assessing the impact of low level laser therapy (LLLT) on biological systems: a review. Int J Radiat Biol. 2019;95(2):120-43.

16.Elson N, Foran D. Low Level Laser Therapy in Modern Dentistry. Periodon Prosthodon. 2015;1(1):1-3.

17.Deana AM, de Souza AM, Teixeira VP, Mesquita-Ferrari RA, Bussadori SK, Fernandes KP. The impact of photobiomodulation on osteoblast-like cell: a review. Lasers Med Sci. 2018;33(5):1147-58.

18.Schalch TD, Mesquita-Ferrari RA, Souza NH, Albarello PM, França CM, Bussadori SK, et al. Effect of steroid nandrolone decanoate on osteoblast-like cells. Med Sci Tech. 2013;54:107-11.

19.Asai T, Suzuki H, Kitayama M, Matsumoto K, Kimoto A, Shigeoka M, et al. The long-term effects of red light-emitting diode irradiation on the proliferation and differentiation of osteoblast-like MC3T3-E1 cells. Kobe J Med Sci. 2014;60(1):E12-8.

[DOI: 10.22088/jbums.25.1.152]

20.Kim SJ, Paek JH, Park KH, Kang SG, Park YG. Laser-Aided Circumferential Supracrestal Fiberotomy and Low-Level Laser Therapy Effects on Relapse of Rotated Teeth in Beagles. Angle Orthod. 2010;80(2):385-90.
21.Chintavalakorn R, Saengfai NN, Sipiyaruk K. The protocol of low-level laser therapy in orthodontic practice: A scoping review of literature. J Int Soc Prev Community Dent. 2022;12(3):267-86.
22.Kasai K, Yuching Chou M, Yamaguchi M. Molecular effects of low-energy laser irradiation during orthodontic tooth movement. Semin Orthod. 2015;21(3):203-9.
23.Monea A, Monea M, Pop D, Bereşescu G. The effect of low level laser therapy on orthodontic tooth movement. Optoelectron Adv Mat. 2015;9(1-2):286-9.
24.Lepcha PT, Nakib AA, Nair V, Kumar M, Garai D. Recent Applications Of Laser In Orthodontics. Int J Med Sci Cur Res. 2022;5(5):26-32.
25.AlSayed Hasan MMA, Sultan K, Hamadah O. Low-level laser therapy effectiveness in accelerating orthodontic tooth movement: A randomized controlled clinical trial. Angle Orthod. 2017;87(4):499-504.
26.Omar M, Kaklamanos EG. Does the rate of orthodontic tooth movement change during pregnancy and lactation? A systematic review of the evidence from animal studies. BMC Oral Health. 2020;20(1):237.
27.Meng M, Yang M, Lv C, Yang Q, Yang Z, Chen S. Effect of Low-Level Laser Therapy on Relapse of Rotated Teeth: A Systematic Review of Human and Animal Study. Photomed Laser Surg. 2017;35(1):3-11.
28.Al-Jasser R, Al-Jewair T, Al-Rasheed A. One-year rotational relapse frequency following conventional circumferential supracrestal fiberotomy. World J Clin Cases. 2020;8(2):284-93.

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