Original Article

A Comparison of the Rate of Retraction with Low-level Laser Therapy and Conventional Retraction Technique

Abstract

Background and Objectives: A major concern of orthodontic patients is treatment time. Reducing the treatment time requires increasing the rate of orthodontic tooth movement. Research has proved that bone resorption is the rate-limiting step in tooth movement. Therefore, any procedure that potentiates osteoclastic activity is capable of increasing the rate of orthodontic tooth movement. Low-level laser has been indicated to have the capability to facilitate the differentiation of the osteoclastic and osteoblastic cells, which are responsible for the bone remodeling process. The purpose of this study was to evaluate whether the low-level laser therapy can accelerate orthodontic tooth movement during en masse retraction. **Method:** The study was a split-mouth design. The experimental side was exposed to biostimulation using 810 nm gallium-aluminium-arsenide diode laser. A total of 10 irradiations for 10 s per site were given 5 on the buccal side and 5 on the palatal side of the tooth. The total energy density at each application was 10 J with an interappointment gap of 3 weeks. The retraction was carried using a constant force of 150 gm. A digital vernier caliper measurement was used to measure the distance between the contact points of the maxillary canine and second premolar on 1st and 84th day. **Results:** The rate of orthodontic tooth movement was faster on the experimental side, and the difference between the two sides was statistically significant ($P < 0.014$). **Interpretation and Conclusion:** It was concluded that biostimulation carried out using an 810 nm diode laser is capable of increasing the rate of extraction space closure. Hence, it is capable of increasing the rate of orthodontic tooth movement.

Keywords: *Low-level laser therapy, orthodontic tooth movements, treatment time*

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Introduction

Modern technology has perfected a new equipment that has become almost indispensable in modern dentistry, in accordance with the philosophy of minimally invasive therapy: the laser. Soft-tissue lasers have numerous applications in orthodontics, including gingivectomy, frenectomy, operculectomy, papilla flattening, uncovering temporary anchorage devices, ablation of aphthous ulcerations, exposure of impacted teeth, and even tooth whitening. As an adjunctive procedure, laser surgery has helped many orthodontists to enhance the design of a patient's smile and improve treatment efficacy.[1] Some laser wavelengths, for example, erbium family lasers, work both on hard and soft tissues (2780 nm, 2940 nm); other lasers, such as the diode lasers, have a very good surgical and hemostatic action on soft tissues and an important analgesic and biostimulating effect that can help the healing of both temporomandibular joint (TMJ) painful symptoms as well as the pain following active orthodontic treatment.[2]

Gas lasers to be developed and are one of the most useful. Carbon dioxide lasers are the highest power lasers infrared light with the principal wavelength bands centering around 9.4 and 10.6 micrometers. Neodymium-doped yttrium aluminium garnet (Nd: YAG) is a crystal that is used as a lasing medium for solid-state lasers.[3] The dopant, triply ionized neodymium, Nd (III), typically replaces a small fraction (1%) of the yttrium ions in the host crystal structure of the yttrium aluminium garnet (YAG), since the two ions are of similar size. It is the neodymium ion which provides the lasing activity in the crystal, in the same fashion as red chromium ion in ruby lasers.

We are aware of our patient's expectations and utilize the latest developments to enable us to achieve the best results possible. The soft-tissue laser is an additional tool the

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orthodontist can incorporate in their practice to improve patient comfort during orthodontic treatment and optimize the design of their smile.[4]

Orthodontic lasers have numerous applications that can benefit our patients: cosmetic shaping of gum tissue to make the teeth well proportioned (proper width/height), reducing overgrown/puffy gum tissue to improve oral hygiene, get rid of canker sores quickly (phototherapy), expose impacted teeth to decrease treatment time, decreasing a "gummy smile."

To speed up treatment time

Sometimes when soft tissue (the gum) partially covers a tooth, it prevents us from placing a bracket on the tooth. Previously, we would wait for the tooth to erupt through the gum, which could take several months, or send the patient to an oral surgeon to remove the gum tissue blocking the tooth. Now, orthodontists can use a laser to relieve the gum tissue and free the tooth. Once the tooth can be accessed, the orthodontist can place a bracket on the tooth and begin the process of moving the tooth into its correct place.

To alleviate canker sores

Canker sores can become uncomfortable and can last 10–14 days. Previously, patients would have to just wait for the pain to subside, use a mouth gel, or have the canker sore cauterized. Now, a dentist can eliminate the pain from the mouth sore through laser therapy. The treatment typically takes about 4 min, and the relief is immediate. Best of all, the canker sore should not return to that location again.

To treat puffy gums

People with braces sometimes develop puffy gums because they cannot get the toothbrush beneath the bracket to effectively clear debris and bacteria from the gum line. That bacteria buildup leads to gum infection, which causes the gums to swell. Orthodontists can relieve puffiness with a laser so patients can start brushing and flossing effectively again.

To treat excess tissue attachment

Sometimes, the tissue attachments that connect the lips or the cheeks to the gums can bulge into spaces between the teeth. These tissue attachments are called frenums and the procedure to relieve the excessive tissue is called a frenectomy. Before lasers, oral surgeons would remove the excessive tissue with a scalpel, which would require sutures to stop the bleeding and could lead to scar tissue that would prevent the gap between the teeth from closing properly. With laser technology, there is no bleeding, sutures, or special postoperative care. Furthermore, the procedure is painless, the healing time is faster, and there was no scar tissue.

To even out the gum line

It can be disappointing if the gums are uneven and some teeth appear shorter than other teeth, even though they are all in line correctly. Lasers are used to contour the gum tissue to achieve symmetry and make the teeth look the same size.

Laser technology gives us another way to help patients smile more, through less-invasive treatment and faster healing time. Lasers are being used in many medical procedures including eye surgery, brain surgery, heart surgery, and skin cancer treatment.

One of the major concerns of orthodontic patients is treatment time. Reducing the treatment time requires increasing the rate of physiologic tooth movement. Many methods have been used in the past to accelerate the orthodontic tooth movement such as electric and magnetic stimulation, drug injections of parathyroid hormone, misoprostol (prostaglandin E1 analog), and prostaglandin E2 (PGE2). Although these substances stimulate the rate of tooth movement, they also have undesirable side effects such as 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. There have been several studies on the effects of lasers on soft and hard tissues in dentistry. In orthodontics, there are *in vivo* studies on the biostimulatory effects of lasers during bone remodeling and dental movement.[1] Hence, the purpose of this present study is to clinically evaluate and compare the effects of low-level laser therapy (LLLT) and rate of retraction of teeth.[1]

The purpose of this study was to clinically evaluate and compare the effects of LLLT and rate of retraction of teeth.

Aims and objectives of the study

1. To compare the rate of en masse retraction using LLLT-assisted technique and conventional technique
2. To draw clinical inferences from the same.

Methodology

Materials required

- 810 nm diode laser
- Vernier caliper
- Study models for evaluation

Method

The study was a split-mouth design. The experimental side and control side was randomly selected by an individual who is not a part of the study. The experimental side was exposed to biostimulation using 810 nm gallium-aluminum-arsenide (GaAlAs) diode laser. The bracket system used in this study was MBT prescription (KODEN) with 0.022 × 0.28 slot. The retraction was carried out by 0.019" × 0.025" SS wires using a constant force of 150 g measured with Dontrix gauge by same operator. A digital vernier caliper measurements accurate to ± 0.001 mm was used to measure the distance between the contact points of the maxillary canine and second premolar on 1st and 84th day.

Inclusion criteria

- Patient requiring extraction of 1st premolar as a part of orthodontic treatment.
- Patient aged between 17 and 35 years.

Exclusion criteria

- Individuals with a history of long-term medication because nonsteroidal anti-inflammatory drug and hormone supplements are known to interfere with bone metabolism
- Individuals with unilateral chewing or parafunctional habit, skeletal crossbite, and occlusal interferences
- Periodontally compromised patient
- Missing of any of the anterior teeth.

Informed consent will be obtained from all patients/parents of all individuals.

Procedure

The study individuals were 12 in number. All cases were patients requiring first premolar extractions with good and normal periodontal condition.

Before commencement of study, the patients were advised good oral hygiene methods. The experimental side was exposed to biostimulation using 810 nm diode laser and the contralateral side taken as control. All irradiations are done by the same operator using 810 nm GaAlAs diode laser delivered with a power output of 100 mW in a continuous wave mode. Experimental doses were delivered on the buccal and palatal surfaces. A total of 10 irradiations was given 5 on the buccal side and 5 on the palatal side, to cover the entire periodontal fibers and alveolar process around the tooth, the distribution and order were as follows:

On the buccal and palatal side, (1) 2 irradiation doses on the cervical third of the root (1 mesial and 1distal), (2) 2 on the apical third of the root (1 mesial and 1 distal), and (3) 1 on the middle third (center of the root) of canine lateral and central incisor of experimental side. The experimental side was irradiated for 10 sec per site [Figures 1 and 2]. The total energy density (dose) at each application was 10 J (2 × 50 s × 100 mW) with an interappointment gap of 3 weeks; on days 1, 21, 42, and 63. The en masse retraction was carried out on 0.019" × 0.025" SS wires using closed coil spring with a constant force of 150 g measured with Dontrix gauge by the same operator. Study model's was made before retraction and on the 84th day. Digital caliper measurements accurate to ± 0.001 mm were used to record on 1st and 84th day [Figure 3]. The distance between the contact points of the maxillary canine and second premolar was measured on both sides. Each distance was measured three times, and the mean value is used for data. The data were then be subjected to statistical analysis.

Statistical methods to be applied are

The data were collected, coded, and fed in the SPSS (IBM version 23). The descriptive statistics were calculated. The inferential statistics included parametric test, i.e. independent *t*-test. The level of significance is set at 0.05 at 95% confidence interval [Graph 1].

Results

The study was carried out in the Department of Orthodontics and Dentofacial Orthopaedics to compare the rate of en masse retraction using LLLT-assisted technique and conventional technique. The study was a split-mouth design, where experimental side was exposed to biostimulation using 810 nm diode laser and the contralateral side taken as control. The sample consisted of 12 individuals. The study concluded that biostimulation carried out using an 810 nm diode laser is capable of increasing the rate of extraction space closure [Graph 2 and Table 1]. Hence, it is capable of increasing the rate of orthodontic tooth movement. In the present study, the low-level laser therapy accelerates the orthodontic tooth movement by 12.555% than that of conventional retraction technique in every dose of laser application (21 days) [Graph 3 and Table 2].

Discussion

One of the major concerns of orthodontic patients is treatment time and second is pain or discomfort. Reducing the treatment time requires increasing the rate of physiologic tooth movement. Many methods have been used in the past to accelerate orthodontic tooth movement such as electric and magnetic stimulation, drug injections of parathyroid hormone, misoprostol (prostaglandin E1 analog), PGE2.[5]

Although these substances stimulate the rate of tooth movement, they also have an undesirable side effect of local pain and discomfort during the injections.[6] 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. The special wavelengths of laser light with investigated energy densities are suggested to be applied for bone remodeling. The benefit of such irradiations instead of chemicals or medicaments shows that they have no negative systemic effect on the patient body. The interactions of low-level lasers (LLL) with bone components have been studied under different conditions and with different wavelengths and energy densities in the field of medicine.[7]

Low-level laser therapy

Therapeutic lasers are classified as Class III medical devices, and surgical lasers are Class IV. The biological effects of the therapeutic lasers are laser photobiostimulation or biostimulation. In addition to the stimulating effects, the cellular effects also include bioinhibition which

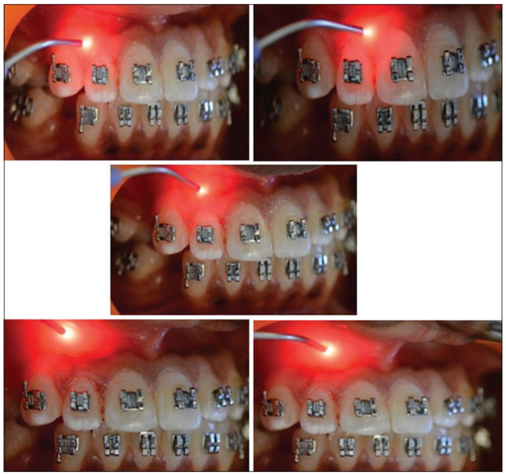


Figure 1: Laser irradiation on buccal sites

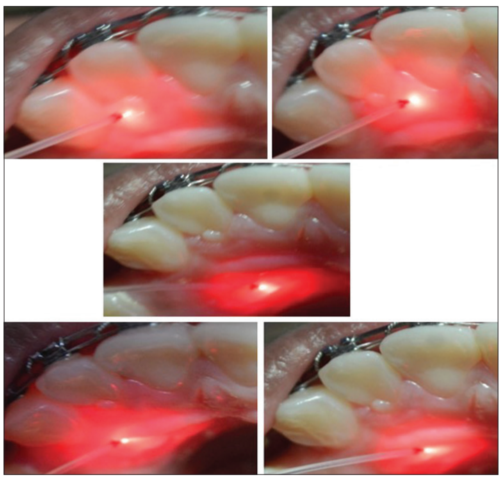


Figure 2: Laser irradiation on the palatal sites

Figure 3: A digital vernier caliper was used to measure the distance between the contact points of maxillary canine and second premolar

can increase or decrease the physiologic functions to reach normalization. A more appropriate designation of the phenomenon is laser photobiomodulation or laser bioactivation. The word "therapeutic laser" describes the purpose and intent of the treatment.[8]

The major components of an LLLT system are the laser device itself, a delivery system, and a controller. All common commercially available LLLT systems use semiconductor diode lasers. These are generally variants of either GaAlAs which emit in the near infrared spectrum (wavelength 700–940 nm) or Indium: Gallium: Arsenide: Phosphorus (InGaAsP) devices which emit in the red portion of the visible spectrum range (wavelength 600–680 nm).[9]

Mechanism of action of low-level laser therapy

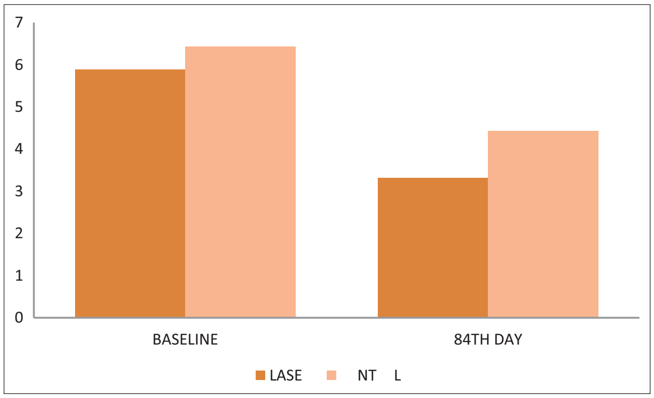
The mechanisms of low-level laser therapy are complex, but essentially rely on the absorption of particular visible red and near-infrared wavelengths in photoreceptors within subcellular components, particularly the electron transport (respiratory) chain within the membranes of mitochondria.[10] The absorption of light by the respiratory chain components causes a short-term activation of the respiratory chain and oxidation of the NADH pool. This stimulation of oxidative phosphorylation leads to changes in the redox status of both the mitochondria and the cytoplasm of the cell. The electron transport chain is able to provide increased levels of promotive force to the cell, through increased supply of ATP, as well as an increased in the electrical potential of the mitochondria membrane, alkalization of the cytoplasm, and activation of nucleic acid synthesis. Because ATP is the "energy currency" for a cell, LLLT has a potent action that results in stimulation of the normal functions of the cell.[11]

By increasing the respiratory metabolism of the cell, LLLT can also affect the electrophysiological properties of the cell. This has relevance in terms of mast cells, which are triggered to respond by ionic gradients.[12]

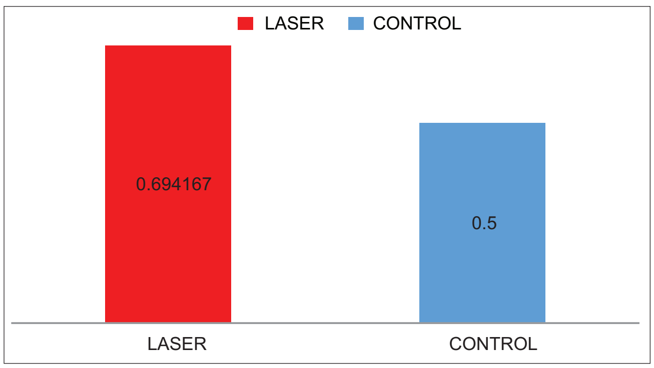
In addition, it has been demonstrated that laser irradiation stimulates cellular proliferation and differentiation of osteoblast lineage nodule-forming cells, especially in committed precursors, resulting in an increase in the number of differentiated osteoblastic cells as well as in bone formation.[13]

LLLT has also been shown to cause vasodilatation, with increased local blood flow. This vasoactive effect is of relevance to the treatment of joint inflammation such as those may occur in the TMJ.[14]

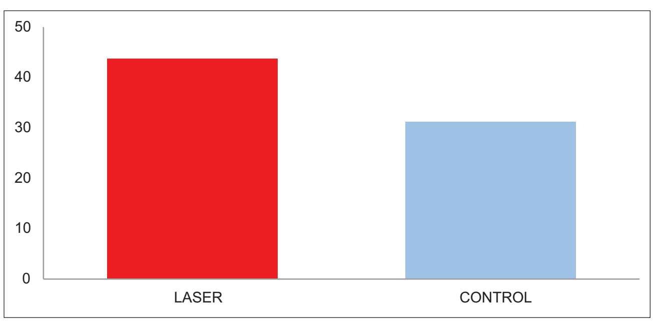
The effects of different types of light on mast cells are well recognized. There is direct evidence that 660, 820, and 940 nm light can trigger mast cell degranulation. These types of cell are distributed preferentially about the microvascular endothelium in skin, oral mucosa, and dental pulp. Mast cells in these locations contain the pro-inflammatory cytokine tumor necrosis factor (TNFα) in their granules. Release of TNFα promotes leukocyte infiltration of tissues by enhancing expression of endothelial-leukocyte adhesion molecules.



Graph 1: Interpretation: The difference in the amount of extraction space closure between the laser side and control side shows that laser side was statistically significant (*P* = 0.014) using unpaired *t*-test



Graph 2: Interpretation: The rate of retraction was measured from the difference in the measurements taken at 1st and 84th, divided by the number of laser application (4). The difference in the rate of extraction space closure between the laser side and control side was statistically significant (*P* = 0.017) using unpaired *t*-test



Graph 3: Comparison of space closure between laser side and control side in percentage. Interpretation: the percentage of space closure in laser side is 43.748% and control side is 31.193%

In addition, mast cell proteases, such as chymase, facilitate entry of leukocytes into tissues. Because mast cells play a fundamental role in controlling leukocyte traffic, modulation of mast cell functions by LLLT can be of considerable importance in the treatment of sites of inflammation in the oral cavity.

A final aspect of the effect of LLLT on cells is related to the effects of laser light on the cytoskeleton. Several studies have suggested that LLLT can modulate cell behavior by causing re-arrangements of the cytoskeleton. Myofibroblasts are responsible for the contraction force during wound healing. These cells are observed in normal tissue, granulation one, and some pathological conditions. Because LLLT is an effective stimulator of differentiation to myofibroblasts, the process of wound healing should be accelerated.[16]

Table 1: Comparison of amount of space closure between laser side and control side

Groups	*n*	Mean (mm)	SD	*t*	*P*
Baseline					
Control	12	6.4383	0.94565	−1.213	0.238 (NS)
Laser	12	5.8917	1.24265		
84th day					
Control	12	4.4300	1.02247	−2.685	0.014 (S)
Laser	12	3.3142	1.01376		

SD: Standard deviation; NS: Not significant; S: Significant

Table 2: Comparison of rate of retraction between laser side and control side

Rate of retraction	Mean	SD	*t*	*P*
Laser	0.694167	0.2438128	1.956	0.017 (S)
Control	0.50000	0.2424871		

SD: Standard deviation; S: Significant

LLLT has also been proven to reduce synthesis of inflammatory mediators in neural tissue, as well as more rapid maturation and regeneration, particularly axonal growth. It also reduces pain in patients suffering from postherpetic neuralgia, from cervical dentinal hypersensitivity, and from periodontal pain during orthodontic tooth movement.[17]

In conclusion, low-level laser therapy accelerates wound healing and reduces pain, by stimulating oxidative phosphorylation in mitochondria and modulating inflammatory responses. By influencing the biological function of a variety of cell types, it is able to exert a range of several beneficial effects on inflammation and healing.

Comparison with other similar studies

Our study showed similarity with another study done by Cruz DR, Kohara EK, Ribeiro MS, Wetter NU (2004)[4] to analyze the effect of low-intensity laser therapy on orthodontic movement velocity in humans; in this study, eleven patients were recruited for this 2-month study. One half of the upper arcade was considered control group (CG) and received mechanical activation of the canine teeth every 30 days. The opposite half received the same mechanical activation and was also irradiated with a diode laser emitting light at 780 nm, during 10 s at 20 mW, 5 J/cm^2, on 4 days of each month. Data of the biometrical progress of both groups were statistically compared. The results showed that all patients showed significant higher acceleration of the retraction of canines on the side treated with LILT when compared to the CG.

Our study is in accordance with a study conducted by Garg NJ, Singh G, Kannan S, Rai D, Kaul A (2014)[7] to determine if biostimulation using an 810 nm diode laser was capable of affecting the rate of extraction space closure during orthodontic treatment. The study included forty dental arches of patients above 17 years of age requiring bilateral first premolar extractions were exposed to an 810 nm diode laser with a power density of 3.97 W/cm^2 at 3 weeks' intervals for total duration of 12 weeks during the space closure phase under direct anchorage using miniscrews. Space closure measurements were taken using digital calipers, and the unpaired *t*-test was used to compare the differences between the experimental and control sides. Thus, the study showed that rate of orthodontic tooth movement was greater on the experimental side and the difference between the two sides was statistically significant.

Our study is in accordance with a study conducted by Genc G, Kocadereli I, Tasar F, Kilinc K, El S, Sarkarati B (2013)[9] to evaluate the effects of LLLT on (1) the velocity of orthodontic tooth movement and (2) the nitric oxide levels in gingival crevicular fluid (GCF) during orthodontic treatment. In this study sample size was 20 patients (14 girls, six boys) whose maxillary first premolars were extracted and the canines were distalized. A gallium-aluminum-arsenide (Ga-Al-As) diode laser was applied on the day 0, and the 3rd, 7th, 14th, 21st, and 28th days when the retraction of the maxillary lateral incisors was initiated. The right maxillary lateral incisors composed the study group (the laser group), whereas the left maxillary lateral incisors served as the control. The teeth in the laser group received a total of ten doses of laser application: five doses from the buccal and five doses from the palatal side (two cervical, one middle, two apical) with an output power of 20 mW and a dose of 0.71 J/cm2. Gingival crevicular fluid samples were obtained on the above-mentioned days, and the nitric oxide levels were analyzed. The results showed that the application of LLLT accelerated orthodontic tooth movement significantly; there were no statistically significant changes in the nitric oxide levels of the gingival crevicular fluid during orthodontic treatment.

Our study is in accordance with a study conducted by Doshi MG, Bhad PW (2012)[2] to evaluate the efficacy of low-intensity laser therapy in reducing pain and orthodontic treatment duration. In this study, twenty patients requiring extraction of first premolars were selected. Canine retraction by nickel-titanium-closed coil spring was studied individually. The infrared radiation from a semiconductor diode laser with a wavelength of 810 nm was given to the experimental group. The laser was applied on days, 0, 3, 7, and 14 in the 1st month and on every 15th day until complete canine retraction was obtained to the experimental group. In each patient, pain response and tooth movement were measured according to visual analog scale and progress models, respectively. The results showed that an average of 30% increase in the rate of tooth movement was observed with the low-intensity laser therapy.

Conclusion

The present study was conducted comparing the rate of en masse retraction using LLLT-assisted technique and conventional technique.

In the present study, the low-level laser therapy accelerates the orthodontic tooth movement by 12.555% than that of conventional retraction technique in every dose of laser application (21 days).

It was concluded that biostimulation carried out using an 810 nm diode laser is capable of increasing the rate of extraction space closure. Hence, it is capable of increasing the rate of orthodontic tooth movement.

Summary

The present study was undertaken to evaluate that the low-level laser therapy (LLLT) could accelerate orthodontic tooth movements. The study was a split-mouth design. The study individuals were 12 in number. All cases were patients requiring first premolar extractions with good and normal periodontal condition. The experimental side was exposed to biostimulation using 810 nm diode laser and the contralateral side taken as control. All irradiations are done by the same operator using 810 nm GaAlAs diode laser delivered with a power output of 100 mW in a continuous wave mode. Experimental doses were delivered on the buccal and palatal surfaces. A total of 10 irradiations were given 5 on the buccal side and 5 on the palatal side, to cover the entire periodontal fibers and alveolar process around the tooth, the distribution and order were as follows:

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In the present study, the low-level laser therapy accelerates the orthodontic tooth movement by 12.555% than that of conventional retraction technique in every dose of laser application (21 days).

However, to utilize the LLL as an adjunct in orthodontic practice on patients, further research studies are needed for finding the appropriate dosage for the human tissues.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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