ORIGINAL RESEARCH

Efficacy of Low-level Laser Therapy in Increasing the Rate of Orthodontic Tooth Movement: A Randomized Control Clinical Trial

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Abstract

Aim: The aim of the present study was to assess the effect of low level laser therapy in increasing the rate of orthodontic tooth movement.

Materials and methods: Twenty-four arches in 24 patients above 18 years of age requiring bilateral extractions in the same arch were randomly selected for this study. By this way, both the patient and the postgraduate student were blinded in the study. The experimental side was exposed to biostimulation using 980 nm gallium–aluminum–arsenide (GaAlAs) diode lasers, and the contralateral side was taken as control. Laser irradiation was delivered with a power output of 2 W in a continuous wave mode. The laser beam was delivered using a 1×4 cm diameter tip held perpendicular and in contact with the mucosa at the cervical third of canine on the buccal and palatal surfaces over an area of 4 cm^2. Digital caliper measurements accurate to $\pm$0.001 mm were recorded on study cast models on the 1st day, 28th day, 57th day, and 85th day. The distance between the contact points of the maxillary canine and second premolar was measured on study cast models three times, and the mean value was used for data computations.

Results: On comparison of the rate of tooth movement between the control and laser groups, the tooth movement was greater in the laser group than in the control group, and it was statistically highly significant at all time intervals with the level of significance set at 0.05 at 95% confidence interval.

Conclusion: LLLT with a specified regimen applied once in a month is effective in increasing the rate of orthodontic tooth movement.

Keywords: Double blind, LLLT, Ni-Ti closed coil spring, Randomized control clinical trial, Temporary anchorage device.

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Introduction

Increased duration of orthodontic treatment associated with pain and discomfort is the major fear of the orthodontic patients, especially adults, either to avoid treatment or to seek shorter alternative solutions with compromised results.[1] Orthodontic force induces a cellular response in the periodontal ligament, which brings about bone resorption and bone deposition *via* the receptor activator of nuclear factor kappa B ligand/receptor activator of nuclear factor kappa B system (RANKL/RANK) pathway and various inflammatory mediators such as IL-1, IL-8, and TNF-alpha.[2–4]

Surgical methods have been used before to accelerate tooth movement which were based on the principle of regional acceleratory phenomenon or periodontally accelerated osteogenic orthodontics, which caused increased osteoclastogenesis, generating faster tooth movement. However, these were invasive and not well accepted by the patients.[2]

Recently minimally invasive methods like corticotomy, piezocision technique, intraseptal alveolar surgery, and micro-osteoperforations were proposed to accelerate tooth movement which were also invasive, complicated by postoperative swelling and infection and were least accepted by patients.[5,6] Low-level laser therapy (LLLT), one of the most promising approaches today, has energy output low enough so as not to cause a rise in temperature of the treated tissue above 36.5°C, or the normal body temperature. Optimum wavelength of LLLT is not universally agreed, but most commonly used in dentistry is typically within the 600–1000 nm range and with a power range of 50–200 mW.[7–9]

Earlier researchers have studied the effects of LLLT increasing rate of tooth movement during orthodontic treatments, which were more of animal studies, and clinical evaluation of effect of LLLT on the rate of tooth movement are not studied extensively and also show wide variation in outcome. A clinical trial with appropriate methodology will enlighten us about the effect of LLLT in enhancing the rate of tooth movement. Hence, the aim and objectives of the present study were to assess the effect of LLLT in increasing the rate of orthodontic tooth movement and also to compare and evaluate the effect of LLLT in increasing the rate of orthodontic tooth movement using progress study models.

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Materials and Methods

The study was performed on 24 orthodontic patients who reported to the Department of Orthodontics and Dentofacial Orthopedics, Sri Siddhartha Dental College and Hospital, Tumkur, and who were willing to participate in the study. A written informed consent was obtained after the nature of the study was explained according to the protocol approved by the Ethics and Review Committee of Sri Siddhartha Dental College and Hospital, Tumkur. Complete intraoral examination was conducted so that patients do not have any active dental disease. The study used a split mouth design with an implant-supported space closure using TADs (temporary anchorage devices) of 8 mm length, 1.5 mm diameter (SKSurgicals) as anchorage units followed by recording spaces by impressions and pouring casts. The space closure was carried out on 0.019″ × 0.025″ S.S (OPTIMA) wires using closed coil Ni-Ti springs of 0.010 inch diameter and 6 mm length with a constant force of 150 g.

Twenty-four arches in 24 patients above 18 years of age requiring bilateral extractions in the same arch were randomly selected for this study. By this way, both the patient and the operator were blinded in the study. The experimental side was exposed to biostimulation using 980 nm gallium–aluminum–arsenide (GaAlAs) diode lasers, and the contralateral side was taken as control. Laser irradiation was delivered with a power output of 2 W in a continuous wave mode. The laser beam was delivered using a 1 × 4 cm diameter tip held perpendicular and in contact with the mucosa at the cervical third of canine on the buccal and palatal surfaces over an area of 4 cm^2.

The application dose was 60 J on either side with an energy density of 15 J/cm^2 and a power density of 2 W/cm^2. The treatment dose/total energy dose was 60 J for this study with inter-appointment gap of 4 weeks. Laser irradiation was done by an expert professional following the standard guidelines of laser administration. The experimental side was irradiated for 30 seconds on the day of activation of the Ni-Ti closed coil spring and visible light of 650 nm wavelength on the control side. Digital caliper measurements accurate to ±0.001 mm were recorded on the study cast model on the 1st day, 29th day, 57th day, and 85th day. The distance between the contact points of the maxillary canine and the second premolar was measured on study cast models three times, and the mean value was used for data computations. The study was conducted according to the protocol approved by the Ethics and Review Committee of Sri Siddhartha Dental College and Hospital, Tumkur.

Fig. 1: Method of canine retraction using mini implants and Ni-Ti closed coil spring

Fig. 2: Laser biostimulation on the buccal side of the canine

Statistical Analysis

The following method of statistical analysis was used in this study. The results for continuous data are averaged (mean ± standard deviation) for each parameter and are presented in tables and figures (Figs 1 and 2).

The data were collected, coded, and fed in SPSS (IBM version 23). Descriptive statistics included mean and standard deviation. Inferential statistics included independent *t* test. Level of significance was set at 0.05 at 95% confidence interval.

Table 1: Descriptive representation of the mean rate of tooth movements observed among control and laser groups at T1 (29th day), T2 (57th day), and T3 (85th day)

		Mean	*Standard deviation*	*t*	*p value*
T1	Control	0.7504	0.03057	−18.793	0.000 (H.S.)
	Laser	1.1250	0.09274		
T2	Control	0.7400	0.07331	−18.415	0.004 (H.S.)
	Laser	1.2629	0.11823		
T3	Control	0.7700	0.04294	−16.243	0.000 (H.S.)
	Laser	1.4279	0.19373		

Results

The results for continuous data were averaged (mean ± standard deviation) for each parameter and showed that the mean rate of tooth movement on the 29th day was 0.75 mm on the control side and 1.12 mm on the intervention side. Likewise, on the 57th day, again the mean rate of tooth movement was measured to be 0.74 mm on the control side and 1.26 mm on the intervention side. Also on the 85th day, the mean rate of tooth movement on the control side was measured to be 0.77 mm and 1.42 mm on the intervention side. On comparison of the mean rate of tooth movement among the control and laser intervention sides, there was a highly significant increase in rate of tooth movement among the laser intervention side compared to the control side at all time intervals (Table 1 and Fig. 3).

Discussion

Present study was done to evaluate the efficacy of LLLT in increasing the rate of tooth movement by a randomized double-blinded placebo-controlled trial.[10] Once the activation of Ni-Ti spring was done, patients were sent to the principal operator where he assigned the quadrant of maxillary arch to the laser and placebo/control group by lottery technique of randomization and administered laser to the experimental side and infrared light to

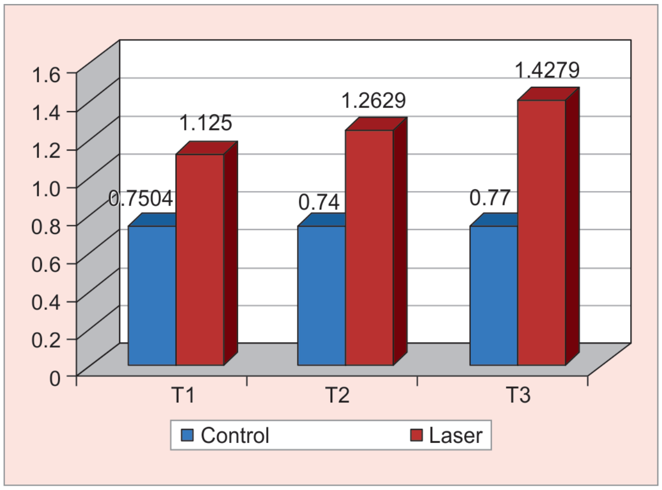

Fig. 3: Graphical representation of the mean rate of tooth movements observed among control and laser groups at different time intervals

the placebo side. Thus both operator and patients were blinded in order to prevent formation of any kind of bias.

This study included the split mouth design since it can achieve meaningful results with a relatively small sample size and also intersubject variation can be minimized when the individual is self-matched.[11] The laser used was a GaAlAs diode laser with 980 nm wavelength, power output of 2 W, energy density of 15 J/cm^2, and exposure time of 30 seconds to accelerate the orthodontic tooth movement and achieved a highly significant result of 1.5 fold increases after 1 month, 1.7 fold increases after 2 months, and 1.8 fold increases after 3 months on comparison of tooth movement between the laser and control groups. The increase in the rate of tooth movement can be attributed to the presence of RANKL. Low level laser therapy cause RANKL increase in periodontal ligament, and it can increase the rate of tooth movement during orthodontic treatment.

The wavelength used in the present study has an appreciable penetration depth of 2.2 cm from the point of its application, which was concluded in a study done by Hudson et al where they have used the same wavelength laser with 1 W/cm^2 and found the penetration depth to be 2.2 cm from the point of application.[12] However, this distance is within the premises of the tooth and its surrounding structure, and it is convincing that LLLT of 980 nm can induce the rate of tooth movement. Hence, care was taken in the current study to use laser parameters within the general acceptable range which helped in achieving a positive outcome. The energy density used was 15 J/cm^2 which is well within the suggested ranges of study done by Goulart et al. who concluded that LLLT within the ranges of 5.25–25 J/cm^2 per treatment point has the ability to accelerate tooth movement.[13] Hence the present study achieved a significant increase in tooth movement on the laser side compared to the control side.

LLLT biostimulation was done once in a month for 3 consecutive months using a laser of wide window output with the advantage of reducing the number and duration of exposure since it covers a larger surface area. The frequency of biostimulation is similar to the study done by Naseem et al., but they have used laser probes and have given biostimulation once in every 21 days.[14] In the present study, a wide window output laser of 1 × 4 cm was used in close approximation to the alveolar mucosa on the buccal and palatal surface of maxillary canine for 30 seconds, which yielded a positive outcome.

The rate of tooth movement in the present study is greater than the results obtained by Kawasaki and Yoshida et al. who reported 1.3 fold increases in the rate of tooth movement in 3 months on animal models.[15,16] Studies done by Cruz et al., Youssef et al., and Doshi and Bhad achieved a positive outcome of 30% increase in their study on humans on the accumulated moved distance of tooth on the laser side at the end of 3–4.5 months.[8,17,18] The present study achieved 1.5 fold increases in tooth movement within the first 28 days (T1) with similar LLLT parameters like wavelength, energy density, and power output. The LLLT dosimetry used in the present study is similar to the study done by Paulo et al. and Naseem et al. who also achieved a positive outcome.[14,19] Whereas studies done by Limpanichkul et al., Seifi et al., Farzin et al. showed negative results with a similar range of wavelength showing no significant differences among the rate of tooth movement between the control and laser groups.[20–22] Negative results obtained might be due to less frequency of biostimulation, less energy densities which may not be sufficient to penetrate the tissue being irradiated, and use of laser probes irradiating less area of tissue.

Titanium orthodontic mini implants of 8 mm length and 1.5 mm diameter were used as the mode of anchorage to provide absolute skeletal anchorage and Ni-Ti closed coil spring of 6 mm length were used as a mode of retraction in the present study. The amount of force was measured to be 150 gm and adjusted at every interval of activation. However, studies done by Cruz et al., Doshi et al., and Xu et al. have used different methods of anchorage reinforcement like modified Nance arch, vertical loop stops, and transpalatal arch for reinforcing the anchorage.[8,17,23] Disadvantage of these methods were some amount of anchor loss exhibited by reciprocal forces acting on anchors and retracting teeth could be misinterpreted as increased rate of tooth movement. Five out of 48 mini implants failed in the present study showing a stability of 89.5%, which is in the close range of 87.7% of survival rate reported by Chaddad et al. in their study on the survival rate of two titanium mini implants of machined and sand-blasted variety.[24] The patients in whom implants failed were excluded from the study.

The rate of tooth movement was measured on progress models at each appointment by measuring the distance between the distal surface of the canine and mesial surface of the second premolar by using a digital caliper, capable of measuring 0.001 mm difference. A similar method of measuring rate of tooth movement was included by Wang et al., Youssef et al., Fujiyama et al., and Doshi et al. in their studies.[8,18,25,26] However, the method used can have some errors in calculating the rate of tooth movement. Newer methods like CBCT with fixed implants can represent rate of tooth movement in a better manner.[27] Due to lack of facility and patient compliance to repeated X ray exposure, the study was based on clinical measurements.

Correlating the findings of the present study and comparing them with previous clinical trials, LLLT can be proposed to be a superior adjunct to increase the rate of orthodontic tooth movement with the advantage of noninvasiveness. Further research with better study design, appropriate sample power, and controlled laser dosimetry can be used to obtain more reliable evidence.

Limitations of the Study

The present study is an *in vivo* study where the rate of tooth movement was measured on progress models. However, the method used can have some errors in calculating the rate of tooth movement. Newer methods like CBCT with fixed implants could have represented the rate of tooth movement in a better manner. Due to lack of facility and patient compliance to repeated X-ray exposure, the study was based on clinical measurements.

In order to extrapolate the results into the general population, studies with larger sample size are required. Hence, it is proposed that further studies need to be conducted in future for the clinical application of LLLT.

Conclusion

Based on the results obtained, the conclusion drawn from the current study are

- Low-level laser therapy has the ability to increase the rate of orthodontic tooth movement thereby decreasing the treatment duration.
- Low-level laser therapy regimen of 980 nm, 2 W power output, 15 J/cm^2 of energy density in continuous mode application once in a month is effective in increasing the rate of orthodontic tooth movement.

Clinical Significance

LLLT can be a better adjunct to reduce the duration of orthodontic treatment with the benefit of noninvasiveness.

Ethics Approval and Consent to Participate

The present study was an *in vivo*, randomized control, split mouth study approved by the ethics and review committee (IEC 10/2016) of Sri Siddhartha Dental College and Hospital, Tumkur. All the participants have signed the consent form to actively participate in this study.

Consent for Publication

We declare that the article is original and has not been published in any other journal. *Progress in Orthodontics* shall have the consent for publication of the article.

Availability of Data and Material

Not applicable.

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