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INFLUENCE OF LOW LEVEL LASER THERAPY ON ORTHODONTIC TOOTH MOVEMENT USING APICALLY DIRECTED FORCES

Dental Science

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ABSTRACT

AIM: To evaluate the effects of low-level laser therapy on rate of tooth movement between laser irradiated and non irradiated maxillary first premolars during the study period.

MATERIALS AND METHODS: This study was designed to test the efficacy of GaAlAs laser irradiation on 10 patients. Apically directed force of 25 grams was delivered by using cantilever springs. Laser irradiation was applied on the mucosa at 6 points around the first premolar on the experimental side. Laser irradiation was started on the day '0' after inserting an intrusion spring, and was repeated on 7th, 14th and 21st day. To permit measurements of intrusion on dental casts, dental impressions were taken at 2 time points immediately prior to application of intrusion force and on 28th day. Tooth movements were recorded on the cast using digital Vernier calipers at the end of four weeks. The collected observational data was subjected to statistical analysis.

RESULTS: The mean orthodontic tooth movement (OTM) was 0.985 ± 366 mm on the laser irradiated side and 1.041 ± 0.315 mm on the control side with no statistically significant difference between them (p = 0.528). Therefore, GaAlAs laser irradiation did not lead to a significantly stimulated intrusion type of OTM.

CONCLUSION: Under the limitations of the present study, it can be concluded that GaAlAs irradiation together with apically directed forces led to no change in the amount of tooth movement on experimental side compared to control side.

KEYWORDS

Low Level Laser Therapy, Tooth Movement

INTRODUCTION

Patients main concern before starting orthodontic treatment is regarding the duration of treatment. Treatment duration is one of the drawbacks of orthodontic treatment. The longer the patient is on treatment, the higher the risks and side effects, which include compliance with treatment, risk of caries, gingival inflammation and root resorption[1]. A number of attempts have been made to try to achieve quicker results. These attempts can be categorized into traditional orthodontic biomechanics (frictionless orthodontic systems), pharmacological, surgical and device assisted therapeutic (DAT) approaches.

However, tooth movements must occur very slowly in order to prevent negative effects of the orthodontic loads such as root resorption. The only effective technique to increase the speed within which teeth move through alveolar bone involve extensive surgery. A distinct disadvantage of this procedure is the additional cost and morbidity associated with surgery[2].

Actual velocity of tooth movement may depend on the rate of bone turnover[3]. The challenge has been how to locally accelerate bone remodeling in a non-invasive manner?

A number of different DAT techniques have been used in an attempt to accelerate tooth movement. These techniques are pulsed electromagnetic field, cyclical forces, static magnetic field, resonance vibration and finally low-level laser therapy. Low level laser therapy or photobiomodulation uses low level laser or light emitting diodes to alter cellular function[4].

Low-level laser therapy (LLLT) has been proposed to increase bone remodeling[5] and tooth movement[6] with the benefits like decreased pain and inflammation, collagen stimulation, and cell proliferation.[7] While injected chemicals and some other medicaments have the problem of systemic side effects, lasers carry the advantage of not having many unwanted impacts on the patients' health status.

Recently Ekizer A et al. (2013)[8] in an experimental study evaluated the effects of light emitting diode mediated photobiomodulation therapy (LPT), on the rate of orthodontic tooth movement (TM) and orthodontically induced root resorption, in 20 rats. They concluded that LPT method had the potential of accelerating orthodontic tooth movement and inhibitory effects on orthodontically induced resorptive activity.

Nimeri G et al.[9] carried out a human study and showed that the photobiomodulation did not cause root resorption greater than the normal range that is commonly detected in orthodontic treatment and could be used clinically for acceleration of tooth movement. However, the limitation of this study was lack of a control group. Therefore, this study was carried out to investigate the effects of LLLT on orthodontic tooth movement during apically directed force application in human first premolar.

MATERIALS AND METHODS

The sample consisted of 20 maxillary first premolars from 10 patients who required first premolar extractions as part of their fixed appliance orthodontic treatment. Their age ranged from 15 years to 22 years. Patients were recruited according to strict selection criteria: (1) Patients who required upper first premolar extractions for orthodontic treatment; (2) no previous dental treatment to the teeth to be extracted, (3) no previous trauma to the teeth to be extracted, (4) no previous orthodontic treatment involving the teeth to be extracted, (5) no past or present signs or symptoms of periodontal disease, bruxism, (6) no significant medical history, (7) no physical abnormality concerning the anatomy of the craniofacial or dentoalveolar complex, and (8)

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completed apexification. Ethics approval was granted by the Institutional Ethics Committee. All subjects and their guardians consented to participate in this study after receiving verbal and written explanations. Preadjusted edgewise (MBT) brackets 0.022” x 0.028" and molar tubes were bonded on the first premolars and first molars, respectively. A split-mouth design [10,11] was used to compare effectiveness of LLLT on rate of tooth movement. Apically directed force of 25 grams was applied to premolars via a 0.017 x 0.025-inch beta-titanium cantilever from the first molar to the first premolar, bypassing the second premolar. The force produced was verified with a dontrix gauge. The right maxillary first premolar which received low level laser therapy constituted the experimental tooth. The left maxillary first premolar served as the control did not receive laser treatment.

Transpalatal arch made of 0.036” SS wire was inserted into the lingual sheaths of first molars on both sides for stabilization. (Fig.1). Intrusion springs made of 0.017” x 0.025” TMA wire were inserted into the first molar tubes and ligated to first premolar brackets on both sides (Fig.2). Twenty-five grams of force was applied on both premolars and the magnitude of force was measured with a dontrix gauge and checked on 7^{th}, 14^{th} and 21^{st} day and adjusted to 25 grams.

Fig.1: Transpalatal arch

Fig.2 Intrusion springs made of 0.017” x 0.025” TMA wire

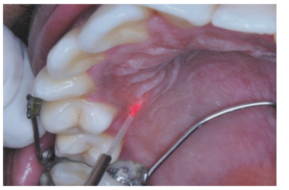
A gallium-aluminum-arsenide (Ga-Al-As) diode laser with a wave length of 810 nm was applied on the experimental tooth. Three points on buccal surface and 3 points on palatal surface of the root corresponding to the cervical third, middle third and apical third were selected for application of laser and probe was held perpendicular on each point for 20 seconds. Laser parameters used were - Output power of 100 mW and power density 0.043 W/cm^2. This dose was set based on Arndt Schultz Law [12]. The total dose delivered for the session was 12 joules (6 points x 20sec x 100 mW) as premolar root surface area is 234 mm^2 i.e. 2.34 cm^2. Dose at each point was 2 J and 5 J/cm^2, in total 12 J per session (Fig 3 A- F**)**. Low level laser irradiation was started on the day '0' after inserting an intrusion spring and was repeated on 7^{th}, 14^{th} and 21^{st} day. After 4 weeks i.e., on 28^{th} day, photographs and impressions were taken.

A

B

C

D



E

F

Fig 3: Laser application on Buccal surface (A) cervical 1/3rd (B) middle 1/3rd (C) apical 1/3rd, on Palatal surface (D) cervical1/3rd (E) middle 1/3rd (F) apical 1/3rd of experimental maxillary first premolar.

MEASURING THE AMOUNT OF INTRUSION: (FIG 4-5)

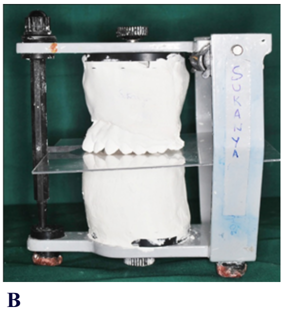
Tooth movement was recorded on the cast using digital vernier calipers at the end of four weeks. The collected observational data was subjected to statistical analysis.

To permit measurements of intrusion on dental casts, dental impressions were taken at 2 time points using a chromatic alginate with long dimensional stability, immediately prior to application of intrusion force and before extraction of premolars. The rate of intrusion of the control and LLLT treated sides were measured and compared with each other.

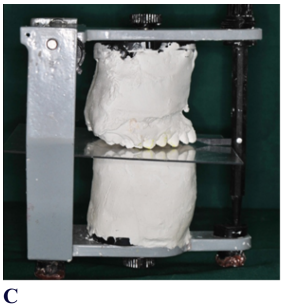
For quantitative measurement of amount of intrusion of premolars, an anatomic articulator has been used in which comparison was made first by mounting pre intrusion maxillary cast to its upper member and a jig was mounted to its lower member over which a flat glass plate was placed to relate its flat plane with maxillary cast occlusal plane (Fig 4 A-B). If the premolar in pre treatment cast was away from the occlusal plane, the space that was present between the buccal cusp of 1st premolar and glass plate was recorded by placing poly vinylsiloxane material that is used for taking inter occlusal record over the occlusal surface of the premolar under study.

Subsequently pre intrusion cast was demounted and post intrusion maxillary cast was mounted following the same procedure (Fig 4 C - D). The space that was present between the buccal cusp of 1st premolar and glass plate was recorded as explained above (Fig 5 A and B). Once the material is set, longitudinal section of it was taken and the thickness of material at the buccal cusp region was measured with digital vernier calipers. If the premolar in pre treatment cast was away from the occlusal plane, the distance was measured and subtracted from the post intrusion measurement. In this way the amount of premolar intrusion was measured for all the study subjects on experimental and control sides.

A



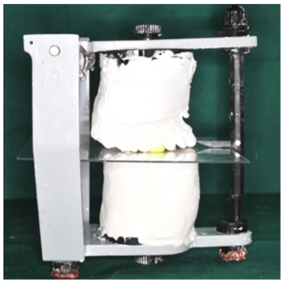
B

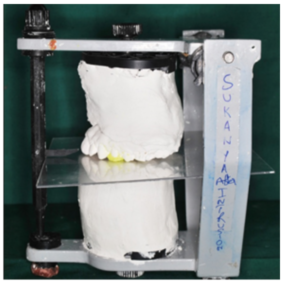


C

D

Fig 4:A-D. Pre intrusion cast on experimental (A) and control side (B), after intrusion cast on experimental side (C) and control side (D).





5A 5B

Fig 5: A, B. Mounted cast with inter occlusal record material on experimental (A) and control tooth (B).

STATISTICAL ANALYSIS

Kolmogorov- Smirnov test revealed that the data regarding root tooth movement was normally distributed. Therefore, the difference in distance of tooth movement between the experimental and control sides was tested by paired t-test. The data were analyzed by SPSS (Statistical Package for Social Sciences) and the significance level was predetermined at $p<0.05$.

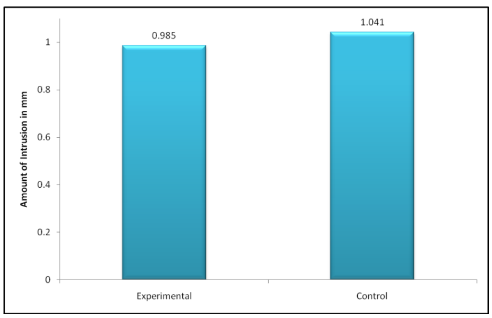
RESULTS

The mean orthodontic tooth movement (OTM) was 0.985 ± 366 mm on the laser irradiated side and 1.041 ± 0.315 mm on the control side with no statistically significant difference between them (p = 0.528). Therefore, GaAlAs laser irradiation did not lead to significantly stimulated intrusion type of OTM (Table 1 and graph 1).

Table 1: Amount of tooth intrusion of maxillary first premolar on experimental and control sides

	Experimental side		Control side		p value	Sig
	Mean	S.D	Mean	S.D		
Tooth intrusion	0.985	0.366	1.041	0.315	0.528	NS

Graph 1: Amount of tooth intrusion of maxillary first premolar on experimental and control sides



DISCUSSION

A split-mouth design[10,11] was used to compare the effectiveness of LLLT on rate of tooth movement. Split-mouth designs first appeared in dental clinical trials in the late sixties. The main advantage of this study design is its efficiency in terms of sample size as the patients act as their own controls. Apically directed force of 25 grams was applied to premolars via a 0.017 x 0.025-inch beta-titanium cantilever from the first molar to the first premolar. In previous studies by Schwarz [13], Ogura et al[14], Oman-Moll et al.[15] 25grams was selected as the light force and a 9-fold increase was selected as the heavy force.

COMPARISON OF AMOUNT OF TOOTH MOVEMENT ON EXPERIMENTAL AND CONTROL SIDES:

Tooth movement occurred in all the premolars in both groups by the end of the experiment. Statistical analysis showed that there was no significant difference in the amount of tooth movement between two groups, irrespective of LLLT (p = 0.528).

The mean intrusive type of orthodontic tooth movement (OTM) was 0.985 ± 366 mm on the laser irradiated side and 1.041 ± 0.315 mm on the control side with no statistically significant difference between them (p = 0.528). Therefore, GaAlAs laser irradiation did not lead to significantly stimulated OTM.

However, findings of the present study are not in accordance with the results reported by Kawasaki and Shimizu (2004),[16] Doshi-Mehta and Bhad-Patil (2012)[17]. This difference can be attributed to different laser parameters.

The study of Kawasaki and Shimizu[16] in rats showed that, in their laser irradiation group, the amount of tooth movement was 30% more than that of a non irradiated group. The laser parameters of Kawasaki and Shimizu were 830 nm, 100 mW, 0.6 mm diameter, 35.3 W/cm^2, with an energy density of around 6000 J/cm^2 from calculation. The energy density was very much higher than it should be for the stimulatory effects according to Arndt Schultz Law.

In a recent clinical study by Doshi-Mehta GD and Bhad-Patil WA in (2012)[17] tooth movement acceleration of 1.3- times higher was detected. The authors used a laser wavelength of 800 nm, a continuous wave mode, an output of 0.25 mW, and exposure of 10 seconds.

Results of this study were concordant with the results shown by Limpanichkul et al. (2006)[18], Gama et al. (2010)[19], Seifi M et al. (2014)[20] and Heravi F et al (2014)[21].

Limpanichkul et al[18] in a human study on canine retraction showed that there was no significant difference in tooth movement after application of LLLT. However they used a different set of standards during laser application: 860 nm, 100 mW, power density 1.11 W/cm2, energy dose 2.3 J/point and energy density 25 J/cm^2/site and was used to irradiate the alveolar mucosa at three points on buccal and palatal sides, and two points at the distal of the canine (23 s/point). Their results did not show significant statistical differences between the experimental and control groups. They concluded that energy density of LLLT (GaAlAs) at the surface level in their study (25 J/cm^2) was probably too low to express either stimulatory effect or inhibitory effect on the rate of orthodontic tooth movement.

This study findings are in agreement with the outcome of Gama et al.[19] who indicated that LLLT had no stimulatory effect on the rate of orthodontic tooth movement. Forty grams of force was applied for moving the first upper molar mesially by using a 0.010-inch wire fixed to both extremities of one NiTi coil spring. Low-intensity laser, wavelength 790 nm, 40mW, 20 J/cm^2 per session was used in their experimental group.

This study results agree with those of Seifi M et al. (2014)[20], who in an animal study showed that laser therapy led to limited effect on rate of tooth movement but has reduced root resorption. Their results showed that the mean orthodontic tooth movements (OTM) were 5.68 ± 1.21 mm in the control teeth and 6.0 ± 0.99 mm in the laser irradiated teeth with no statistically significant difference between them (p > 0.57).

Heravi F et al.[21] study results showed LLLT did not affect canine movement velocity. In their study one half of the upper arch was irradiated with a GaAlAs laser (810 nm, 200 mW, 10 points, 21.4 J/cm^2/point) and the other half served as the placebo group.

Laser parameters used in the present study were - Output power of 100 mW and power density of 0.043 W/cm^2. This dose was set based on Arndt Schultz Law. The total dose delivered for session was 12 J (6 points x 20sec x 100 mW) as premolar root surface area is 234 mm^2 i.e. 2.34 cm^2. Dose at each point was 2 joules and 5 J/cm^2, in total 12 joules per each session. Low level laser irradiation was started on the day '0' after attaching an intrusion spring and was repeated on 7th, 14th and 21st day. However, we found no difference between the tooth movement of groups that received LLLT and those that did not. It should also be noted that in this study, assessment was done only for a period of one month.

LIMITATIONS OF THE PRESENT STUDY:

1. Small sample size.
2. Duration of study was 4 weeks, further investigation is needed with longer duration of time to determine the effect of LLLT on tooth movement, as well as its influence on the various phases of tooth movement.

CONCLUSION:

Under the limitations of the present study, it can be concluded that GaAlAs irradiation together with apically directed forces led to no change in the amount of tooth movement on experimental side when compared to control side. However, further research is required with patients undergoing a full course of orthodontic treatment and LLLT application.

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