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RESEARCH ARTICLE

COMPARATIVE EVALUATION OF EFFECTIVENESS OF LOW- LEVEL LASER THERAPY AND LIGHT EMITTING DIODE IN THE RATE OF ORTHODONTIC TOOTH MOVEMENT

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ABSTRACT

***Background and Objectives*:** The duration of orthodontic treatment is a major concern for patients. Many methods to accelerate tooth movement have been tested in the past, each having their own advantages and disadvantages. A non-invasive, more patient friendly method of accelerating tooth movement is the use of photobiomodulation. The aim of this study is to compare and evaluate the effect of Light emitting Diode and Low level laser therapy in accelerating orthodontic tooth movement. ***Materials and Methods*:** Thirty two patients undergoing fixed orthodontic therapy with Preadjusted edgewise appliance (MBT prescription) after extraction of all first premolars were considered for the study. Individual canine retraction was initiated with NiTi closed coil spring on all the quadrants. One side was randomly allocated for Low level laser irradiation and other for Light emitting diode irradiation. Irradiation was done on 0, 3rd, 7th and 14th day. Pretreatment impression is taken and a pretreatment model is made at the beginning of canine retraction and another impression is taken on the 30th day. Rate of tooth movement was compared using the treatment models. ***Results and Discussion*:** In this study, the LLLT group showed a significant increase in tooth movement of 1.54(+/-0.23) mm in the maxilla and 1.64(+/-0.26) mm in the mandible. LED irradiated group showed tooth movement of 0.49(+/-0.62) mm in the maxilla and 0.69(+/-0.30) mm in the mandible, which is within the range of normal orthodontic tooth movement. ***Conclusions*:** Low Intensity Laser Therapy is a non invasive, cost - effective method of accelerating orthodontic tooth movement. LED diode used in the present study was unable to bring about any change in the rate of tooth movement.

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INTRODUCTION

Fixed orthodontic therapy is a discipline in dentistry which requires, a long duration of time for its completion. An average non extraction treatment takes 21-27 months for finishing while extraction treatment takes around 25-35 months[1]. Potential side effects like periodontal problems, increased risk of root resorption, dental caries and decalcification can occur as a result of prolonged orthodontic treatment. Therefore, it is critical to explore safe modalities to improve the rate of tooth movement, thereby reducing the entire treatment time. Increasing the rate of tooth movement has been shown to improve post-treatment retention, reduce post-appointment pain and reduce other treatment related adverse effects[2]. The rate of orthodontic tooth movement possible with conventional methods is less than 1mm per month[3]. In the present day, various modalities are available to accelerate the tooth movement.

These include pharmacological, physical and surgical methods. But most of these methods are either invasive or have some adverse effects. Physical approaches which includes photobiomodulation is one of the most clinically used approach for accelerating orthodontic tooth movement. It is non invasive as well as patient friendly. Low-level light therapy (LLLT) or low-intensity LASER therapy or light-accelerated orthodontics or photobiomodulation therapy includes use of Low level laser and also Light Emitting Diode[4]. Photobiomodulation accelerates bone remodelling and increases the rate of tooth movement by stimulating the proliferation of osteoblasts, osteoclasts, fibroblasts[3]and also mitochondrial Cytochrome C oxidase, resulting in increased cell metabolism[5].ATP production is regulated by Cytochrome C oxidase which is increased twofold by infrared light[6]. Higher ATP availability during the tooth movement phase increases the cell turnover resulting in an increased remodeling process which in turn increases the rate of tooth movement[4].

This study is designed to compare and evaluate the rate of orthodontic tooth movement using Light Emitting Diode and Low-intensity Laser Therapy.

MATERIALS AND METHODS

The sample for the present study comprised of 32 orthodontic patients of Azeezia Dental College, Kollam in the age group 17- 30. Patient's who require extraction of all first premolars were considered for the study. Patient's under long term medication, smoking, poor oral hygiene, periodontal disease were excluded from the study. The study design was approved by the Ethics Committee of Azeezia College of Dental Sciences and Research. The orthodontic treatment was performed with 0.022-inch Pre-Adjusted Edgewise Appliances (MBT prescription). Aligning was done using 0.014" NiTi, and 0.016" NiTi followed by 0.018" stainless steel wire. Leveling of the upper and lower arch was achieved following the sequence 0.016x0.022" NiTi, 0.017x0.025" NiTi, 0.019x0.025" NiTi. Leveling and aligning was completed, six months to one year after initiating fixed orthodontic treatment. Following which individual canine retraction was started in the maxillary and mandibular arch. The retraction was initiated only after inserting 0.019 x 0.025-inch Stainless Steel wire both arches. Consolidation was done from one lateral incisor to the other. The canine was ligated to the arch wire to prevent rotation during retraction. A transpalatal arch in maxilla and a lingual arch in mandible were given for anchorage preservation. Nickel Titanium closed coil springs (Prime Orthodontics, Sawbros) were used for individual canine retraction, as they showed more consistent force delivery compared to elastic chain or modules. Nickel titanium coil spring of 9 mm was used, with an active coil portion of approximately 5mm and eyelet portion of 2mm on either side of the coil. The NiTi coil spring was attached to the hook of the first molar, then stretched to give 150 g of force and secured to the canine with a ligature wire. A force gauge (Morelli Orthodontia) was used to determine that 150 g traction force is delivered.

Just before starting canine retraction, an alginate impression of the maxillary and mandibular arch is taken to prepare the initial study model. After 30 days another alginate impression is made of the maxillary and mandibular arch, which serves as the final model, that is used to compare the amount of canine retraction during this one month period. The low-intensity laser device used in this study was an infrared Gallium-Aluminium-Arsenide (GaAlAs; photon soft tissue diode laser, Zolar technologies and Mfg) diode laser, emitting a wavelength of 810 nm. The laser operated at the maximum output power of 200 mW and in continuous wave mode, and the beam was delivered through a hand piece. A total energy of 6 J was given. The laser irradiated 5 points on the buccal side and 5 points on the palatal/lingual side of each canine tooth: 2 points on the cervical third of the root (one mesial and one distal), one point on the middle third of the root (at the center of the root), and 2 points on the apical third of the root (one mesial and one distal). The laser probe was used in a non contact mode held 1mm away from the alveolar mucosa for 30 seconds on each of the above mentioned areas. In each patient, one side was randomly allocated to the laser treatment and another side to LED. Low-level laser therapy was started on the day of attaching coil springs. It was repeated on days 3, 7 and 14. On the 30th day, a final impression was taken.

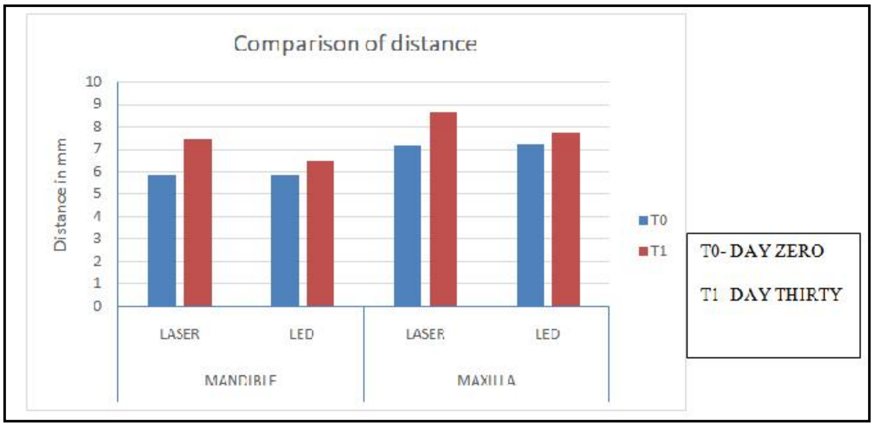
The Light Emitting Diode used in this study was of wavelength in the range 450-480 nm,(Woodpecker - model- I LED) emitting blue light. Light Emitting Diode exposure is started, immediately after attaching the coil springs. It is repeated on days 3, 7 and 14. LED exposure is done intraorally on the buccal and palatal side on the cervical third of root, middle and apical third of root for 5 minutes. On the 30th day, final impression is made to compare the amount of tooth movement. Vertical lines were drawn on the cast over the palatal surface of the canine from the centre of the incisal edge to the centre of the cervical line. At 3 points: incisal, middle, and cervical thirds of the crowns, the distance between the canine and the lateral incisor was assessed before and after canine retraction. All cast measurements were made using a digital vernier calliper (Aerospace). The difference between the measurements obtained from the two casts gives the amount of tooth movement.

RESULTS

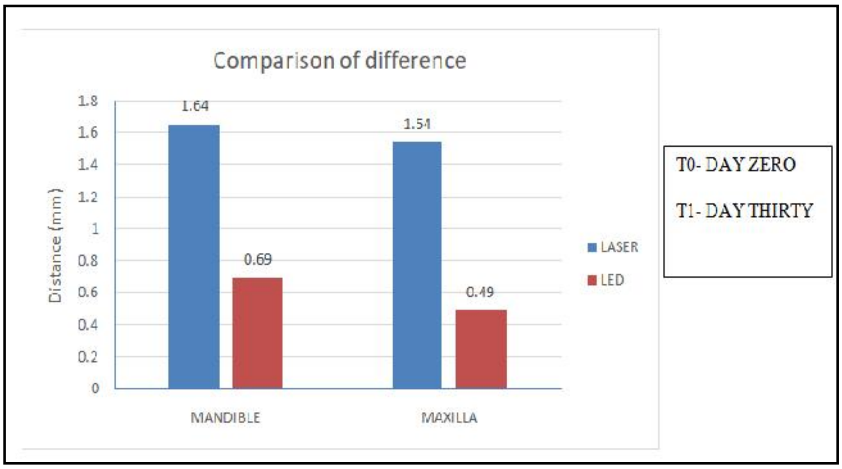
Independent Sample student's t test is used to compare the tooth movement between Light Emitting Diode and Low Level Laser therapy. Results were tabulated on MS EXCEL and statistical evaluation was done. The statistical calculations were performed using the software SPSS for Windows (Statistical Presentation System Software, SPSS Inc. 1999, New York) version 19.0. The mean tooth movement obtained in the group treated with LLLT was 1.54 mm (SD =0.23) in maxilla and 1.64 (SD = 0.26) in mandible. The mean tooth movement obtained in the group treated with LED was 0.49 mm (SD =0.62) in maxilla and 0.69 (SD = 0.30) in mandible. The result obtained in this study shows LLLT is much more efficient in accelerating tooth movement compared to the LED diode. LLLT increased the rate of tooth movement by 28.2% in mandible and 21.6% in maxilla. LED diode showed a tooth movement of 11.8% in mandible and 6.7% in maxilla which is within the normal range. Rate of tooth movement is more in mandible compared to maxilla, but the difference is not statistically significant.

DISCUSSION

In the current scenario, a variety of treatment modalities are available for accelerating tooth movement. Photobiomodulation is one such option that is used to increase the rate of orthodontic tooth movement. Photobiomodulation includes use of low level laser therapy and LED. Though LLLT and LED are categorised under photobiomodulation therapy, they differ in many ways. Lasers are monochromatic and coherent whereas, LEDs are incoherent and much safer compared to LASER[8]. Numerous theories have been put forward to explain the molecular mechanism of photobiomodulation. Near Infra Red radiation and monochromatic visible light is absorbed by Cytochrome C oxidase molecule, which acts as the primary photoreceptor. Activation of Cytochrome C oxidase results in increased production of ATP, which in turn increases cellular metabolism[9,10]. Cytochrome C oxidase complex consists of two hemes, cytochrome a and cytochrome a3. Cytochrome a molecule absorbs light in the wavelength 605-630 nm and cytochrome a3 in the range 445-460 nm[11]. The LED diode that is routinely used in orthodontic practice emits blue light in the wavelength 450-480 nm. Hence, theoretically blue light has the potential to stimulate Cytochrome C oxidase, thereby accelerating OTM.



Graph 1. Comparison of LLLT and LED



Graph 2. Comparison of tooth movement in maxilla and mandible

Table 1. Comparison of lllt and led (mandible)

MANDIBLE		N	Distance (mm)		Difference		% of increase	Paired t test	
			Mean	Sd	Mean	sd		T	P*
LLLT	T0	32	5.83	0.54	1.64	0.26	28.2	35.77	<0.001
	T1	32	7.47	0.64					
LED	T0	32	5.81	0.60	0.69	0.30	11.8	13.19	<0.001
	T1	32	6.50	0.55					

*****P-value significant at the 0.05 level

Table II. Comparison of LLLT And Led (Maxilla)

MAXILLA		N	Distance (mm)		Difference		% of increase	Paired t test	
			Mean	Sd	Mean	Sd		T	P*
LLLT	T0	32	7.14	0.71	1.54	0.23	21.6	-8.42	<0.001
	T1	32	8.68	0.73					
LED	T0	32	7.22	1.01	0.49	0.62	6.7	4.45	<0.001
	T1	32	7.71	1.13					

*****P-value-significant at the 0.05 level

In the present study, the effectiveness of blue light in the wavelength 450-480 nm in accelerating OTM is evaluated. Compared to infrared light, the blue light has a higher energy density, but scatters more easily and has a shorter wavelength. There are only a few clinical studies evaluating the efficiency of LEDs in accelerating tooth movement. In the majority of these studies extraoral Biolex LED device, with a wavelength of 618-850 nm is used. Chung *et al*[12] found no positive biostimulatory effect on the OTM by using extra- oral Biolex LED device. However, studies conducted by Shaughnessy *et al*[14], Ekizer *et al*[14], Kau *et al*[13] using Biolex LED device showed a substantial increase in the velocity of orthodontic tooth movement. But the Biolex LED device is not routinely used in orthodontic practice, because of the increased cost, low availability and insufficient evidence supporting its effect on the rate of tooth movement. LED device emitting blue light is cost-effective, easily available and frequently used in dental practice. In the present study, blue light was unable to bring about any notable changes in orthodontic tooth movement. This could be because of the low penetration efficiency of blue light when compared to red light. The longer the wavelength, the more will be penetration efficiency. The penetration depth is less than 1 mm at 400 nm, 1 to 6 mm at 630 nm, and maximal at 700 to 900 nm[17]. According to Ramesh *et al*[18], the mean thickness of the palatal gingiva is found to be 1.7 mm at the canine region.

According to Kolte *et al*, in the mandibular arch, the mean thickness of attached gingiva was found to be 1.70 mm and in the maxillary arch it was 1.60 mm (16-24 years) and for the patient's aged 25-39 years it was 0.86 mm in the maxilla and 0.91 mm in mandible[19]. Therefore, the blue light used in the present study had less penetration capacity, which was inadequate to penetrate the buccal and palatal gingiva. In the present study a semiconductor (Ga-Al-As) diode laser of wavelength 810 nm, with a power output of 0.2 mW and an exposure time of 30 seconds was used in a continuous wave mode[20,21,22]. Higher dosages of LASER irradiation showed bio-inhibitory effects, and lower dosage showed no significant effects on the rate of tooth movement[16]. A Ga-Al-As diode laser of wavelength 810 nm has low absorbance in haemoglobin and water and thus provides enough penetration depth to affect the periodontal tissues and alveolar bone.[23] LLLT increased the rate of orthodontic tooth movement by 28.2% in mandible and 21.6% in maxilla, as represented in Table I and Table II. In the present study, laser irradiation was deemed more efficient in the mandible than maxilla; this can be because the periodontal ligament of the maxillary canines are farther from the site of irradiation on the palatal side[7]. Esnouf*et al*[24] showed a significant reduction in intensity in the first millimetre of penetration: i.e., up to 66%. The clinical implication will be that more energy density should be used on the palatal surfaces of the maxillary teeth for better penetration. This finding is in concordance with the research carried out by Doshi*et al*[7] who reported to have an increase of 58% accelerated tooth movement in maxilla and 54% in mandible in the laser irradiated side. The rate of tooth movement achieved by LED is 11.8% in the mandible and 6.7% in the maxilla, which is within the normal range and is represented in Graph II. This shows that LLLT produces more tooth movement than LED in both maxilla and mandible. Further research and studies at the histochemical level should be conducted to find out the exact cause of the increased tooth movement with LLLT. The effect of LASER irradiation reported in different studies shows conflicting results. Further long-term studies are warranted to determine the optimal dose, frequency, power output and duration of laser irradiation to accelerate orthodontic tooth movement.

Conclusion

This study concludes that

- LLLT produces more tooth movement than LED. Thus LLLT is more effective in accelerating tooth movement and thereby reducing the treatment duration.
- The tooth movement is slightly more in mandible compared to maxilla.

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