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ORIGINAL ARTICLE

Effect of Low-Level Laser Therapy (Lllt) on Pain Perception Using Single Vs Multiple Irradiations During Maxillary Canine Retraction: A Randomized Split-Mouth Clinical Trial

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ABSTRACT

To evaluate the outcome of low-level laser treatment (LLLT) on pain management during maxillary canine distalization. Forty patients (15-25years age) with Angle's Class II division 1 malocclusion needing bilateral extraction of maxillary first premolar were included. Patients were randomly divided into two experimental groups - Group A – laser irradiated on day 0 (on day of canine retraction), 3 & 7 and Group B – laser irradiated on day 0 only. Split mouth approach of the maxillary arch was employed and randomly assigned by lottery method into experimental (Group A - LT and Group B - LT) and placebo (Group A - PB and Group B - PB). Extraction of maxillary 1st premolar was followed with levelling and alignment. Upon completion of levelling and alignment, distalization of maxillary canine was initiated with closed coil NiTi springs delivering a force of 150 g on 0.019x0.025 in stainless steel (SS) arch wires. Laser irradiation was then carried out for each intervention group. Patients of both groups were handed a feedback form based on numeric rating scale (NRS) to record the pain intensity at 24 hours (T_1), fourth day (T_2) and 8th day (T_3) during canine distalization. A significant reduction in pain was discerned at T_1, T_2, and T_3 in both experimental groups (Group A – LT and Group B – LT) compared to the PB groups. Single dose irradiation showed significant reduction in pain intensity at 24 hours (T_1) vs multiple irradiations Low-level laser therapy can be used as a valuable auxiliary method during orthodontic treatment to alleviate the pain non pharmacologically.

Keywords*: low-level laser therapy (LLLT), dentistry, lasers, Pain perception, orthodontic tooth movement, canine retraction.*

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INTRODUCTION

Pain occurring during orthodontic treatment discourages many individuals to undergo the procedure and has been the main reason for discontinuation of treatment [1, 2]. Response to pain varies from subject to

subject and depends on various factors like age, gender, pain threshold, amount of force applied, previous pain experience and emotional stability of the individual.[1,3]Multiple factors cause pain during active orthodontic treatment like pressure, ischemia, inflammation and edema related to tooth movement.[4] Pain usually begins within 4 hours, increases over the next 24 hours and has been found to decrease within 7 days.[4] Both pharmacological and non-pharmacological methods have been employed to control pain during orthodontic tooth movement (OTM). NSAIDs have been found to hinder tooth movement and increases the likelihood of root resorption.[4] Non pharmacological methods include use of magnets and ultrasounds, LLLT, bite wafers and chewing gum, vibratory stimulation, transcutaneous electrical nerve stimulation (TENS), application of ice/cryotherapy and acupuncture/acupressure. These are generally preferred over pharmacological methods due to the negative effects of NSAIDs on tooth movement. Low-level laser therapy has shown anti-inflammatory effects and propensity to cause peripheral nerve blockage, making LLLT a promising tool for pain management and healing of tissues.[5] Multiple researchers have included LLLT as an adjunct in pain management during various stages of orthodontic treatment[6–8].Majority of the studies recorded its analgesic effect as a secondary outcome leading to contrasting results and ultimately speckled outcomes. To our knowledge there is limited research on change in pain perception and the role of multiple irradiation vs single dose of LLLT. This research was therefore directed to evaluate the analgesic effect of LLLT as a primary outcome during OTM comparing two different irradiation protocols. The null hypothesis was that there would be no difference in pain perception during canine retraction either with single or multiple irradiations during orthodontic tooth movement using LLLT.

MATERIAL AND METHODS

This randomized controlled clinical research was performed in the Department of Orthodontics and Department of Periodontics, Teerthanker Mahaveer Dental College and Research Centre, Teerthanker Mahaveer University, Moradabad. Forty patients with the age range from 15-25 years having healthy medical and dental status with no history of prior orthodontic treatment were recruited in the study. Inclusion and exclusion criteria are given in Table 1. Approval from the ethical body of the institute was obtained and patients were screened for participation in the study. A thorough verbal explanation of the procedure was done with consent forms duly signed from patients and legal guardians (for minors). Diagnostic orthodontic records were procured.

Extractions of the maxillary first premolars were performed prior to leveling and alignment. MBT (Mclaughlin Bennet and Trevisi) prescription brackets of 0.022 slot were bonded and leveling and alignment phase was commenced with 0.016 in heat activated NiTi wire followed by 0.017x0.025 in NiTi, 0.019x0.025 in NiTi and 0.019x0.025 in SS as the final working wire. Individual canine retraction was initiated after 21 days of placement of 0.019x0.025 stainless steel wire with 9 mm closed coil NiTi spring delivering a force of 150 g measured with an orthodontic dynamometer (Morelli dynamometer 50-500gms, Brazil)) and secured with a ligature tie between the power arms of the canine bracket and 1st molar band.

Patients were divided into two groups (n=20 each) by randomization through a computer-generated list of random numbers. Split mouth design was chosen by lottery method and randomly assigned one side of the maxillary arch as the experimental side (Group A – LT and Group B – LT) and the other side as placebo (Group A- PB and Group B - PB). For Group A – LT: diode laser irradiation was carried out on 3 points on the canine root on days 0 (T_1 - day of placement of closed coil spring), 3 and 7. Similar laser protocol was followed for Group B – LT but irradiated only once (day 0). Specifications for the laser irradiation is tabulated in Table 2. For the PB group the laser was held in place with the unit turned off to simulate LLLT and remove bias in patient reported pain perception.

The analgesic effect and change in pain perception via LLLT was evaluated by a feedback form based on an 11 point (0 to 10) numeric rating scale (NRS) with 0 indicating no pain and 10 worst imaginable pain. The form was handed over to the patients of both groups to record the pain intensity (PI) after 24 hours, on 4th and 8th from day of activation of the NiTi spring. The PI score for right and left sides of the jaw were recorded separately and patients returned the feedback forms after completion of scoring. Call reminders were made to all patients to fill the feedback forms. All patients were advised to avoid the use of NSAIDs during the study period.

Statistical analysis: Data obtained was analyzed using the SPSS version 20.0 software. The Mann-Whitney U test was performed to compare PI between experimental and control groups with two different laser irradiation protocol. The Wilcoxon Ranked Test was applied to compare the PI between the experimental groups (Group A – LT and Group B – LT).

Table-1: Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
Orthodontic patients requiring first upper premolars extraction and two-step retraction technique	History of long-term medication with nonsteroidal antiinflammatory
No previous orthodontic treatment	Periodontally compromised patients
Complete permanent dentition (except third molars)	Impacted canines and canines with dilacerated roots
Healthy patients without systemic diseases that can affect bone and tooth movement	
Good oral hygiene and healthy periodontium which will be evaluated clinically (probing depth ≤3 mm), with no radiographic evidence of bone loss, plaque and gingival index ≤1 according to Loe and Silness	

Table2: Laser parameters

Group A – LT (irradiated on Day 0, 3 and 7 after initiation of canine retraction) and Group B – LT (irradiated on day 0)

	Group A - LT	Group B - LT
Type	GaAlAs diode laser	GaAlAs diode laser
Wavelength	810 nm	810 nm
Power	100 mW	100 mW
Irradiation time	6 s per point	15 s (cervical and apical); 20 s (middle)
Anatomical points	3 points along the centre of root – apical, middle and cervical (buccal & palatally)	3 points along the centre of root – apical, middle and cervical (buccal & palatally)
Pulse parameter	Continuous mode, in contact	Continuous mode, in contact
Days of irradiation	Day 0 (day of placement of closed coil spring), 3 and 7	Day 0 (day of placement of closed coil spring)
Total energy density /fluence	10 J/cm^2	10 J/cm^2

RESULTS

The highest value of PI was experienced by most patients at 24 hours of spring activation (Table3 &4). A significant reduction in PI was observed in both experimental groups at all time points – T_1, T_2 and T_3 as the level of pain was significantly higher in the control side. Highest pain score was recorded in the control group at T_1. When the Group A – LT and Group B – LT were compared statistically significant difference in PI was noted in Group B – LT at T_1 and in Group A – LT at T_2. However no significant difference was observed at T_3 for both experimental groups.

Table-3:NPar Tests- Descriptive Statistics

Technique (LLLT)		N	Mean NRS Score	Std. Deviation	Minimum Score	Maximum score	Percentiles		
							25th	50th (Median)	75th
Group-A	24 HOURS Exp	20	7.65	.671	7	9	7.00	8.00	8.00
	4 DAY Exp	20	5.75	.550	5	7	5.00	6.00	6.00
	8 DAY Exp	20	1.70	1.031	0	3	1.00	2.00	2.75
	24 HOURS Pb	20	9.45	.605	8	10	9.00	9.50	10.00
	4 DAY Pb	20	7.50	.688	6	9	7.00	7.50	8.00
	8 DAY Pb	20	1.95	.686	1	3	1.25	2.00	2.00
	Technique	20	1.00	.000	1	1	1.00	1.00	1.00
Group-B	24 HOURS Exp	20	8.70	1.031	7	10	8.00	9.00	9.75
	4 DAY Exp	20	4.75	.716	4	6	4.00	5.00	5.00
	8 DAY Exp	20	1.65	.587	1	3	1.00	2.00	2.00
	24 HOURS Pb	20	9.55	.510	9	10	9.00	10.00	10.00
	4 DAY Pb	20	6.80	.951	5	8	6.00	7.00	7.75
	8 DAY Pb	20	2.10	.718	1	3	2.00	2.00	3.00
	Technique	20	2.00	.000	2	2	2.00	2.00	2.00

Exp-Experimental, Pb-Placebo

Table-4 :Test Statistics [a]

	24 HOURS Exp	4 DAY Exp	8 DAY Exp	24 HOURS Pb	4 DAY Pb	8 DAY Pb
Mann-Whitney U	86.000	64.500	188.000	185.500	119.000	177.000
Wilcoxon W	296.000	274.500	398.000	395.500	329.000	387.000
Z	-3.220	-3.917	-.348	-.449	-2.339	-.683
Asymp. Sig. (2-tailed)	.001**	<.001**	.728	.654	.019*	.494
Exact Sig. [2*(1-tailed Sig.)]	.002[b]	.000[b]	.758[b]	.698[b]	.028[b]	.547[b]

Exp-Experimental, Pb-Placebo a. Grouping Variable: Technique
b. Not corrected for ties.

DISCUSSION

This study was implemented to assess the ability of LLLT as an auxiliary tool for pain management during OTM. An 810 nm GaAlAs diode laser was used for this purpose following two different irradiation regimens. Laser irradiation protocol differs among researchers. Some follow multiple applications in a month while a few have tried single monthly irradiation that corresponds with orthodontic appointment and hence convenient for the patient. In the present study, for Group A – LT, laser irradiation was carried out on days 0 (day of canine retraction), 3 and 7 (multiple). For Group B – LT, irradiation was performed only on day 0 (single). This study was conducted to determine if multiple or single laser irradiation was efficient to reduce pain during OTM. Statistically significant results were obtained for both interventions when compared to controls at T_1, T_2 and T_3. Studies by various authors have also found the multiple [7, 9, 10] and single [6, 11] visit recalls beneficial in alleviating pain during canine retraction.

A split mouth design was utilized since it efficiently decreases the sample size and inter-subject variability [12]. To reduce the chances of carry-across effects of a split mouth arrangement, a plastic shield having wavelength close to the diode laser (810 nm) was positioned over the placebo side during irradiation of the experimental canine. All safety precautions given by the manufacturer were followed including use of protective glasses by operator and patient. The entire protocol was performed in a separate room. Air pods were provided for each patient during laser irradiation to annul the beep sound of the laser unit during irradiation protocol.

Pain levels were assessed after 24 hours, 4 and 8 days of initiation of canine retraction. A feedback form was designed with an 11-point NRS with 0 indicating “no pain” and 10 -“worst imaginable pain”. This is in contrast to various researchers who used the Visual Analogue Scale (VAS). The accuracy and feasibility of NRS makes its use patient friendly irrespective of age or educational background. It is easy to understand, illustrating also good sensitivity even when there are small changes and has good reproducibility [13].

Pain is subjective, being influenced by multiple factors like age, gender, emotional stability & pain threshold of the individual, magnitude of force applied and anatomic variations.[1,3] Diode lasers having wavelength of 810 nm lies close to the “optical window” which provides a greater depth and causes inhibition of COX and PGE_2 leading to less pain [14]. LLLT also decreases the reactive oxygen species and mRNA expression of phospholipase A_2 levels [15]. Reduction of TNF-α, an inflammatory mediator has also been suggested.[16]

Two different mechanisms have been suggested for pain control with the use of LLLT. The first involves the release of β-endorphin [17], which is natural mediator that controls pain by inhibition of arachidonic acid[18] released from injured cells giving rise to metabolites that interact with pain receptors. The second mechanism is subdued conduction in the peripheral nerves by effecting sodium-potassium pump leading to impaired local pain transmission [19].

Pain experienced during orthodontic treatment depends on the level of compression of periodontal ligament [20]. When orthodontic tooth movement occurs, some type of pain sensitivity peaks in the first 4 days after activation [17]. In the present study, all patients experienced maximum pain during the 24-hour timeline (T_1) in both experimental and control groups followed by a gradual decrease by day 4. This pain has been suggested to be triggered by an acute inflammatory response to mechanical stimulus [21]. These periods of acute inflammation are associated with pain and a reduced masticatory function.[21,22] There was no specification on spontaneous pain or pain on mastication in the current study. However, a study by Qamruddin et al [23] evaluated the efficacy of a single application of LLLT on spontaneous pain and pain on mastication after placement of initial arch wire. A total energy density of 75 J/tooth was used and a statistically significant difference was observed in the experimental group when compared to control. LLLT was found to reduce pain felt during the day, night and on chewing.

LLLT has been found to be effective in pain alleviation during various orthodontic treatment modalities, including during separators [24, 25] and molar band placement[26] and during the initial stages of

orthodontic treatment [2,3, 8]. Most of the studies on control of pain with the help of LLLT during canine retraction assessed the amount of time required for retraction along with pain reduction [7, 9-11]. The present study primarily focused on the analgesic effect of LLLT. Two different intervention protocols were assessed – single visit irradiation and multiple visit irradiation. On completion of the study period, both protocols demonstrated reduced pain perception during canine retraction. Studies employing multiple visits for irradiation have also shown similar results [7]. Protocols with single laser irradiation application have also demonstrated positive results for decreasing pain during canine retraction [6, 11].

LLLT abridges the inflammatory process at an energy density of 8 to 12 J/cm^2 [15]. For pain reduction, however, a higher dose is needed. Reducing the pain may provide the patient some relief but in turn may prolong the inflammatory process. In this present research, the energy density was kept at 10 J/cm^2 for each intervention group, aiming at reducing the inflammation and subsequently pain. Angelieri et al [27] investigated the effect of 780 nm diode laser on pain reduction during canine retraction with an energy density of 6 J/month. Irradiations were done on days 0, 3 and 7. No statistically significant difference was observed between experimental and control groups. In our study the laser irradiation for Group A was similar as the above study (days 0, 3 and 7), however, the energy density varied (10 J) and the experimental group demonstrated significant but gradual reduction in pain from day 0 to day 7 when compared to the control. Similar studies demonstrated a statistically significant decrease in pain during canine retraction with similar protocol [7, 9].

Qamruddin et al[6] used the single irradiation protocol and found LLLT to be statistically effective in decreasing pain. Our study showed similar results when laser irradiation was implemented in a single dose for Group B - LT. However, Souza et al could not find LLLT effective enough in pain reduction with a single monthly LLLT dose [28].

With the side effects and possibilities of development of allergies, NSAIDs have also shown a possible inhibition of tooth movement as they inhibit synthesis of PGs which in turn is an important mediator for bone resorption [29-31]. LLLT when used appropriately has many advantages for the patient and orthodontist including alleviation from pain during OTM. It can be used to one's advantage and provide relief to the patient from the pain associated during tooth movement. It is non-invasive and non-ionizing that can be readily be accepted by the patient. In the present study, a single dose of low-level laser irradiation (Group B – LT) demonstrated a significant reduction in pain similar to the intervention group that received multiple irradiations (Group A – LT).

The null hypothesis that there would be no difference in pain perception during canine retraction either with single or multiple irradiations during orthodontic tooth movement using LLLT was rejected. Significant pain reduction was seen in both Group A – LT and Group B – LT at T_1, T_2 and T_3. After 24 hours, Group B – LT (single dose LLLT) was shown to reduce pain perception compared to multiple LLLT irradiations. Hence, a single monthly dose can be used as an alternative in reducing pain intensity during orthodontic tooth movement if multiple irradiations are not feasible during orthodontic treatment.

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COMPETING INTEREST

The authors declare that they have no competing interests. There was no external support or funding source associated with this review.

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