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ORIGINAL ARTICLE

Evaluating the effect of low-level laser therapy on pain induced by orthodontic separation: a randomized split-mouth clinical trial

Seema Gupta[1] · Sachin Ahuja[1] · Eenal Bhambri[1] · Surbhi Sharma[1] · Rohini Sharma[1] · Himanshu Kalia[1]

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Abstract

Introduction Pain is the most common sequela reported by patients undergoing orthodontic treatment. It is a prime concern as despite the desire, the orthodontic treatment is refuted by most patients because of the associated pain and discomfort. Recently, there is an abundance of research going on in the field of orthodontics regarding the causes of orthodontic pain and the measures that could efficiently reduce it. One such method is the administration of lasers to reduce the intensity of pain. Therefore, the aim of this study was to assess the effect of low-level laser therapy on spontaneous pain and pain on chewing caused by elastomeric separators.

Method Forty patients were randomly selected for this single-blind, split-mouth study. Elastomeric separators were placed mesial and distal to the permanent first molars in all the four quadrants. The arches were divided into experimental and control sides. The experimental side was treated with low-level laser therapy on two points on the buccal and lingual mucosa for 20 s each, with a 940-nm gallium-aluminum-arsenic diode laser on continuous mode and power set at 200 mW. The other side received placebo laser therapy without turning on the laser. A visual analogue scale was used to assess the intensity of spontaneous pain and pain on chewing, and the subjects were asked to mark the pain scores in a questionnaire given to them at different time intervals. The independent samples *t* test and analysis of variance with the post hoc Tukey test was used to analyze the results.

Results The subjects reported less intensity of pain on chewing as well as spontaneous pain at the sites which were given low-level laser therapy as compared to the placebo side. The difference between the pain intensity on the low-level laser therapy side and placebo side was found to be statistically significant ($p \leq 0.05$).

Conclusion A single dose of low-level laser therapy is an effective modality in significantly reducing the intensity of both spontaneous and pain on chewing caused after the placement of elastomeric separators.

Keywords LLLT · Pain · Orthodontic separation

✉ Surbhi Sharma
sharma.surbhi1924@gmail.com

Seema Gupta
mdsseema31@yahoo.com

Sachin Ahuja
drsachinahuja@hotmail.com

Eenal Bhambri
dreenal700@gmail.com

Rohini Sharma
dr.rohini_ortho@yahoo.com

Himanshu Kalia
himanshu1228549@gmail.com

[1] Department of Orthodontics and Dentofacial Orthopaedics, Surendra Dental College and Research Institute, Sri Ganganagar, Rajasthan 335001, India

Introduction

The International Association for the Study of Pain taxonomy defines pain as "an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage." Pain is a subjective response and is dependent on innumerable factors such as age, gender, individual pain threshold, psychological condition, emotional status and stress, cultural differences, and previous pain experiences [1, 2]. Dental procedures are often associated with pain and apprehension [2, 3]. Pain is a subjective experience and a common clinical symptom in orthodontic patients. There is abundance of research which shows that as many as 95% of orthodontic patients feel pain and 8–30% of patients discontinue treatment because of pain [4, 5]. There are various orthodontic operations that can cause pain [4, 5]. It has

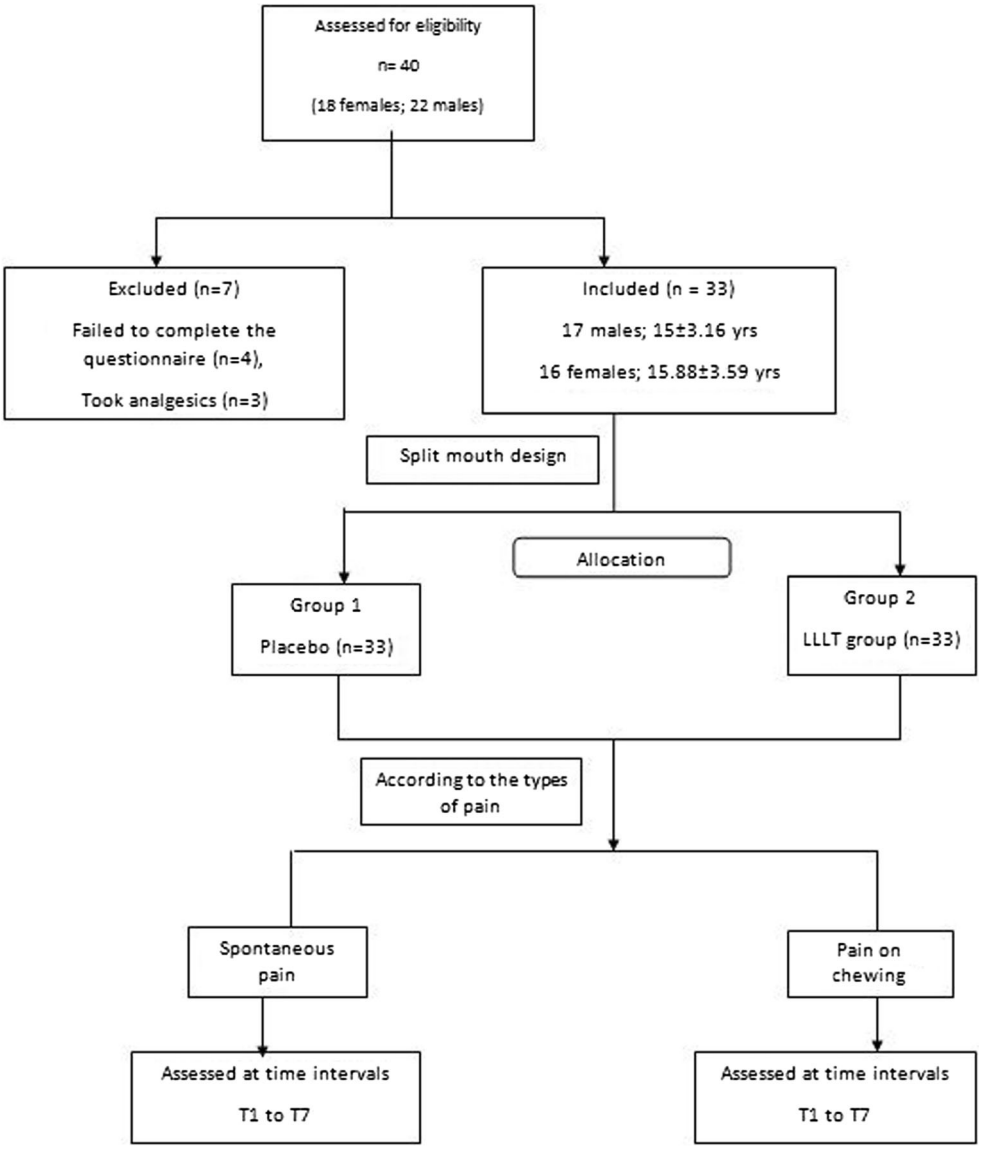

Fig. 1 Consort flow diagram. Different time intervals at which pain was assessed: T1 = 0 h, T = 4 h, T3 = 6 h, T4 = 12 h, T5 = 24 h, T6 = 36 h, T7 = 48 h

been reported that more than 90% of orthodontic patients experience varying degrees of pain after the placement of elastomeric separators, initial wire insertions, and activations [6, 7].

Pain usually begins within 4 h after the procedure, peaks at 24 h approximately, and dissipates by day 7 [7, 8]. The intensity of the pain is sometimes perceived as even greater than the pain related to extractions and thereby becomes a major deterrent to treatment or a reason for premature discontinuation of orthodontic treatment [6]. As a common and necessary operation, placement of separators to create enough space for bands is believed to cause mild to moderate pain. It is generally understood that when the periodontal ligament is under pressure, the mediators of inflammation, such as prostaglandins, histamine, and substance P, which cause sensitivity of free nerve terminations and pain or discomfort after placement of archwires or separators, are released [4]. Mester [9] discovered laser biostimulation in 1967; since then, this approach has been used in various medical fields to regenerate tissue and reduce inflammation, and also as an analgesic. Low-level laser therapy (LLLT) is used in dentistry after third molar surgery, craniomandibular disorders, dentin hyperesthesia, sensory disturbances of the inferior alveolar nerve, and chemotherapy-induced mucositis. Studies have been done to understand its effect as an accelerator of tooth movement and as an analgesic in the field of orthodontics as well [10].

The assertion that implementation of a low-level laser can reduce pain in orthodontic patients would make it a viable alternative to the drug regimens that are usually recommended. Furthermore, if the efficacy of LLLT is confirmed, then one could avoid use of NSAIDs, which are believed to slow down tooth movement. Some investigators have reported significant results in pain reduction after applying multiple and frequent doses of LLLT [3, 6, 11]. Considering the

convenience of patients, some researchers have attempted a single dose of LLLT and found significant results [1, 6, 12, 13]. Lim et al. [14] applied a single dose of LLLT to reduce separation pain with the split-mouth design, but they only recorded postoperative spontaneous pain for 5 days, and no consideration was given to pain on chewing. Only few studies [6] have been conducted to observe the effects of LLLT on the reduction of pain on chewing caused by separator placement. Therefore, the purpose of this research was to evaluate the effect of a single dose of LLLT on not only spontaneous pain but also pain on chewing caused by the placement of separators.

Material and methodology

The present prospective, single-blind, placebo-controlled, split-mouth study is comprised of 40 patients (18 females and 22 males, age range 14–25 years) who reported to the Department for orthodontic treatment. A sample size of at least 26 was calculated to be necessary for the detection of a mean difference of 2 units for the pain perception with a test power of 90% ($p = 0.05$ significance level). Therefore, 40 patients were randomly selected and exposed to laser irradiation. The enrollment of subjects and design of the study are explained in the consort diagram (Fig. 1). The study was approved by the institutional ethical committee.

The inclusion criteria were patients with no history of orthodontic treatment, healthy and complete dentition including permanent second molars, presence of tight proximal contacts around the first molars on both sides, and patients with healthy permanent molars without any active periodontal lesion. Patients on pharmacological therapy with NSAIDs, patients contraindicated for LLLT, patients suffering from chronic pain disorders, patients with history of neurological and psychological disorders, patients with multiple fillings and root canal treatments, patients with multiple missing teeth, and patients with spacing between molars and premolars were excluded from the study. The complete procedure was explained

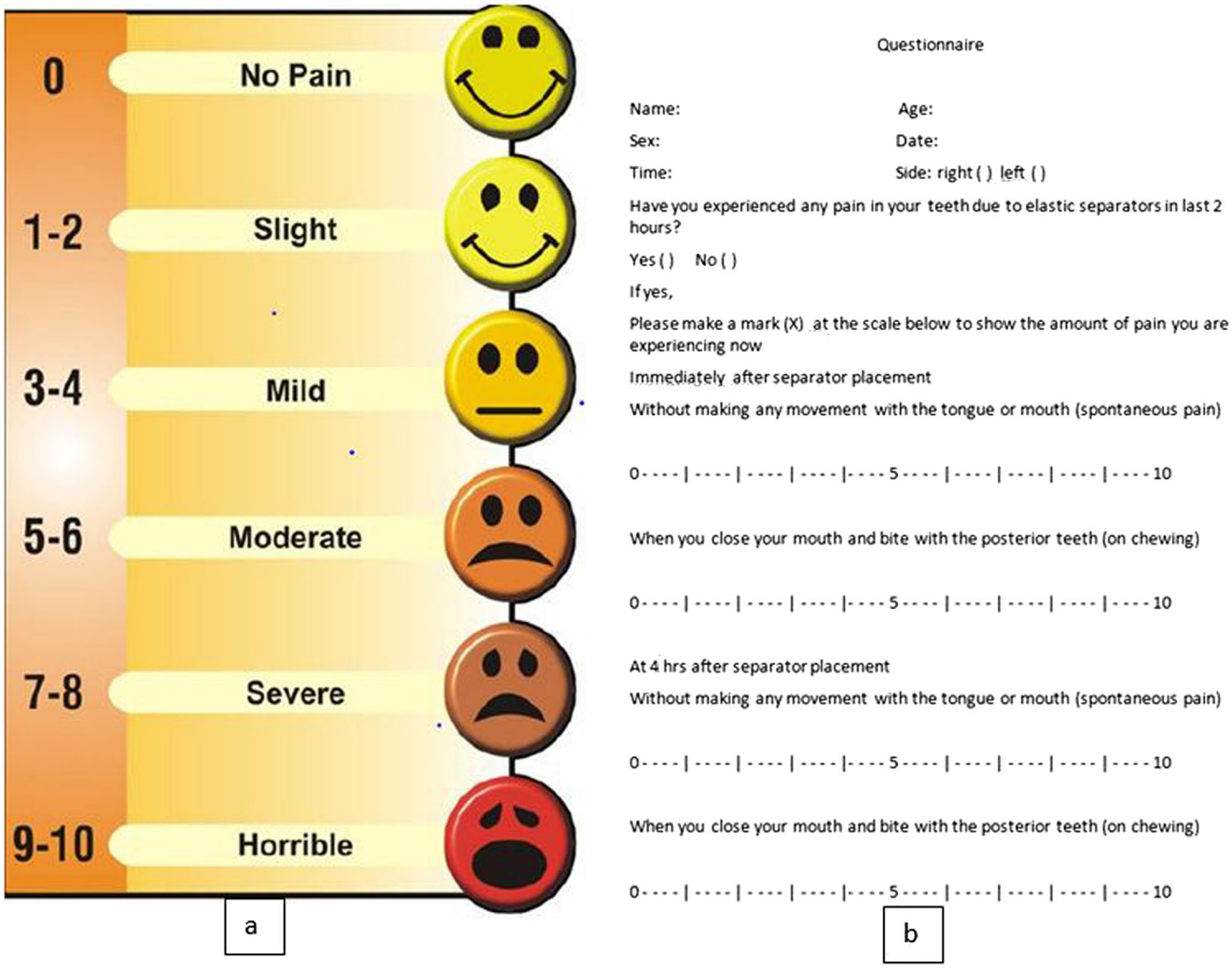

Fig. 2 Visual analogue scale (VAS) (**a**) and visual analogue scale (VAS) scorecard (**b**)

verbally to the patients and voluntary participation was ensured by obtaining their signatures on the consent form.

In all selected patients, elastomeric separators (3M Unitek, Monrovia, CA) were placed using separator-placing pliers interproximally across the permanent first molars (both mesially and distally) in all quadrants. Both arches in each patient were divided into experimental and placebo sides (groups) randomly by lottery method. Immediately after placement of the separators, LLLT was applied on the experimental side using a 940-nm gallium-aluminum-arsenic diode laser (EzLase; BIOLASE® Technology, Inc., 4 Cromwell, Irvine, CA) on continuous mode with power set at 200 mW [6]. The laser was applied buccally and lingually on two points: mucosa adjacent to the mesial and distal contact points of the permanent first molar, for 20 s each. The energy dose (0.2 W × 20 s) was 4 J at each point and 16 J on the whole. It was ensured that while working on the intervention side, the emitted light does not affect the placebo side. On the placebo side, the laser was not turned on but held in the same way and for the same duration. The operator, assistant, and patient all wore protective glasses.

A questionnaire was formulated using the visual analogue scale scorecard (Fig. 2) which was given to all the patients to record their pain daily at different time intervals for 2 days. The patients were advised that 0 indicated no pain and 10 indicated unbearable pain. The patients were asked to record spontaneous pain as well as pain on chewing at every point of time mentioned in the questionnaire for 2 days. Analgesics were discouraged, but if the subjects take them, they were asked to note it. Each subject was reminded to make their daily entry via a reminder phone call. The statistical analysis was carried out using SPSS software (version 23; IBM, Armonk, NY). Independent samples *t* tests were applied to compare the mean pain scores between the experimental and the placebo sides for spontaneous and pain on chewing. Analysis of variance was used to evaluate the differences in the levels of pain during the time interval under study. Tukey honestly significant difference (HSD) post hoc analysis was done to compare the mean scores of both the spontaneous and pain on chewing at different time intervals in both the LLLT and the placebo groups.

Results

A total number of 40 patients who met the inclusion criteria were initially selected, but 4 of them were dropped from the study as they failed to complete the questionnaire and 3 subjects were dropped as they took pharmacological analgesics to relieve pain caused by separators, thus making a total sample size of 33 subjects. Both spontaneous pain and pain on chewing were evaluated in each subject. Of the 33 subjects included, there were 16 females (48.5%) and 17 males (51.5%) in the LLLT group as well as in the placebo group. The mean age distribution was 15 ± 3.59 years for the males and 15.88 ± 3.59 years for the females in both the placebo and LLLT groups.

Regarding gender, on evaluation using Student's paired *t* test, no significant differences were found between the male and female subjects in terms of perception of both spontaneous pain and pain on chewing ($p > 0.05$). No significant differences were found in the mean pain scores in the maxillary and mandibular arches in both the LLLT and the placebo groups for both spontaneous and pain on chewing (Tables 1 and 2 ($p > 0.05$); hence, further evaluation was done on pooled data.

The mean pain scores for both spontaneous pain and pain on chewing were found to be the lowest at T1, gradually increased at T6, with a slight decline at T7. To assess whether there was any statistically significant difference occurring in the level of both types of pain at different time intervals in the

Table 1 Comparison between pain perception in the maxillary and mandibular arches in the control group

Time interval	Variable	Spontaneous pain	Pain on chewing
T1	Maxilla	0.35 ± 0.702	0.53 ± 1.18
	Mandible	0.19 ± 0.4	0.25 ± 0.77
	t test	0.99	1.93
	p value	0.33	0.07
T2	Maxilla	2.29 ± 1.23	4.41 ± 2.57
	Mandible	2.94 ± 1.14	4.5 ± 2.61
	t test	1.94	0.12
	p value	0.06	0.86
T3	Maxilla	2.82 ± 2.56	4.94 ± 2.3
	Mandible	3.19 ± 2.07	5.13 ± 2.13
	t test	0.56	0.24
	p value	0.58	0.77
T4	Maxilla	3.59 ± 2.62	5.53 ± 2.095
	Mandible	3.81 ± 2.29	5.19 ± 1.91
	t test	0.32	0.51
	p value	0.75	0.54
T5	Maxilla	3.29 ± 1.83	5.82 ± 2.0
	Mandible	4.06 ± 1.84	5.56 ± 1.86
	t test	1.48	0.30
	p value	0.14	0.79
T6	Maxilla	3.76 ± 2.71	5.65 ± 1.94
	Mandible	4.25 ± 2.65	5.5 ± 1.86
	t test	0.65	0.11
	p value	0.52	0.91
T7	Maxilla	2.82 ± 1.78	5.35 ± 1.49
	Mandible	3.31 ± 1.96	5.25 ± 1.92
	t test	0.93	0.09
	p value	0.36	0.89

$p \leq 0.05$ considered significant

Table 2 Comparison between pain perception in the maxillary and mandibular arches in the experimental (LLLT) group

Time interval	Variable	Spontaneous pain	Pain on chewing
T1	Maxilla	0.23 ± 0.431	0.29 ± 0.99
	Mandible	0.19 ± 0.4	0.25 ± 0.78
	t test	0.34	0.28
	p value	0.73	0.76
T2	Maxilla	1.53 ± 1.31	2.94 ± 2.93
	Mandible	2 ± 1.17	2.87 ± 2.55
	t test	1.31	0.08
	p value	0.16	0.92
T3	Maxilla	1.59 ± 1.87	3.06 ± 1.78
	Mandible	1.56 ± 1.32	3 ± 1.86
	t test	0.06	0.06
	p value	0.95	0.94
T4	Maxilla	1.94 ± 2.3	2.88 ± 1.99
	Mandible	2.37 ± 1.89	3 ± 1.79
	t test	1.13	0.22
	p value	0.21	0.68
T5	Maxilla	1.88 ± 1.36	3.47 ± 2.48
	Mandible	2.56 ± 2.03	3.31 ± 2.36
	t test	1.43	0.31
	p value	0.18	0.71
T6	Maxilla	2.29 ± 2.02	3.47 ± 2.58
	Mandible	2.81 ± 2.37	3.25 ± 2.26
	t test	1.68	0.43
	p value	0.08	0.49
T7	Maxilla	1.71 ± 1.69	3.18 ± 2.29
	Mandible	2.06 ± 1.77	3 ± 2.16
	t test	1.26	0.16
	p value	0.39	0.85

$p \leq 0.05$ considered significant

placebo group as well as the LLLT group, Tukey HSD post hoc analysis was done. When the mean spontaneous pain scores at T1 were compared with those at T2–T7, significant differences were found in the level of pain for both spontaneous pain and pain on chewing in both groups ($p < 0.05$) (Tables 3 and 4). When the mean spontaneous pain scores in the control group at T2–T7 were compared with each other statistically using the Tukey HSD post hoc test, no statistically significant differences were found ($p < 0.05$).

The intensity of spontaneous pain was compared to that of pain on chewing at each interval of time in both the placebo group and the LLLT group (Tables 5 and 6). The level of pain on chewing was found to be significantly greater than that of spontaneous pain at most time points taken in both groups.

The course of spontaneous and pain on chewing was found to be the same for both groups, but with significant differences in the intensity of pain between the two sides. There were significant differences ($p < 0.05$) in scores for both spontaneous pain (Table 7, Fig. 3) and pain on chewing (Table 8, Fig. 4) for all the patients. The patients experienced significantly less pain on the LLLT side as compared to the placebo side, spontaneously as well as while chewing.

Discussion

Pain experience caused by tooth movement represents an important concern for patients. It can induce them to quit orthodontic treatment and can negatively influence their cooperation [1, 2]. The efficacy of diode LLLT in reducing orthodontic pain [6–8] is still controversial. In the study, we evaluated

Table 3 Tukey HSD post hoc analysis for comparison of spontaneous pain in both groups at different time intervals

Time	Comparison	Control group		Experimental group	
		Mean difference	*p* value	Mean difference	*p* value
T1	T1 vs T2	2.34	0.0002*	1.55	0.01*
	T1 vs T3	2.73	< 0.01*	1.37	0.03*
	T1 vs T4	3.43	< 0.01*	1.94	0.0004*
	T1 vs T5	3.4	< 0.01*	2	0.0002*
	T1 vs T6	3.73	< 0.01*	2.34	< 0.01*
	T1 vs T7	2.79	< 0.01*	1.67	0.004*
T2	T2 vs T3	0.39	0.98	− 0.18	0.9997
	T2 vs T4	1.09	0.33	0.39	0.9756
	T2 vs T5	1.06	0.3685	0.45	0.9508
	T2 vs T6	1.39	0.0964	0.79	0.5651
	T2 vs T7	0.45	0.9748	0.12	1
T3	T3 vs T4	0.7	0.82	0.57	0.8595
	T3 vs T5	0.67	0.8447	0.63	0.7922
	T3 vs T6	1	0.4421	0.97	0.3097
	T3 vs T7	0.06	1	0.3	0.9938
T4	T4 vs T5	− 0.03	1	0.06	1
	T4 vs T6	0.3	0.9971	0.4	0.9723
	T4 vs T7	− 0.64	0.8712	− 0.27	0.9965
T5	T5 vs T6	0.33	0.9951	0.34	0.988
	T5 vs T7	− 0.61	0.8949	0.33	0.9897
T6	T6 vs T7	− 0.94	0.5198	− 0.67	0.74

*p significant at ≤ 0.05

Table 4 Tukey HSD post hoc analysis for comparison of pain on chewing in both groups at different time intervals

Time	Comparison	Control group		Experimental group	
		Mean difference	*p* value	Mean difference	*p* value
T1	T1 vs T2	4.06	< 0.01*	2.64	< 0.01*
	T1 vs T3	4.64	< 0.01*	2.76	< 0.01*
	T1 vs T4	4.97	< 0.01*	2.67	< 0.01*
	T1 vs T5	5.31	< 0.01*	3.12	< 0.01*
	T1 vs T6	5.19	< 0.01*	3.09	< 0.01*
	T1 vs T7	4.91	< 0.01*	2.82	< 0.01*
T2	T2 vs T3	0.58	0.8867	0.12	1
	T2 vs T4	0.91	0.4754	0.03	1
	T2 vs T5	1.25	0.12	0.48	0.968
	T2 vs T6	1.13	0.21	0.45	0.9769
	T2 vs T7	0.85	0.56	0.18	0.99
T3	T3 vs T4	0.33	0.99	− 0.09	1
	T3 vs T5	0.67	0.79	0.36	0.99
	T3 vs T6	0.55	0.91	0.33	0.99
	T3 vs T7	0.27	0.99	0.06	1
T4	T4 vs T5	0.34	0.99	0.45	0.9769
	T4 vs T6	0.22	0.9993	0.42	0.98
	T4 vs T7	− 0.06	1	0.15	0.99
T5	T5 vs T6	− 0.12	1	− 0.03	1
	T5 vs T7	− 0.4	0.98	− 0.3	0.99
T6	T6 vs T7	− 0.28	0.99	− 0.27	0.99

*p significant at ≤ 0.05

the effect of a single application of LLLT on postoperative pain (spontaneous and chewing) associated with the placement of orthodontic separators. This study was performed with a split-mouth design allowing for within-subject control. This method was very appropriate for the study of pain because it quashes the effect of inter-individual variation on pain perception [15]. The laser used in this study was type IV, having infrared radiation with a wavelength of 940 nm as used in the study conducted by Qamruddin et al. in 2016 [6]. LLLT with the energy dose of 4 J per point was applied on two points on the buccal side as well as on the lingual side, whereas in most studies, only the buccal side was irradiated. The current research about the mechanism of LLLT involves mitochondria and particularly cytochrome c oxidase (Cox). Cox is the primary photoacceptor in mammalian cells and quickens electron transfer reactions, causing increased production of ATP. Therefore, diode lasers of wavelengths 600–1000 nm are widely used in dentistry for pain and inflammation relief [16]. A visual analogue scale (VAS) [17] was used and the questionnaire consisted of a scorecard to mark the intensity of

Table 5 Comparison of spontaneous pain and pain on chewing in the placebo group at different time intervals

Time period	Groups	Mean	*p* value
T1	Spontaneous pain	0.27 ± 0.57	0.54
	Pain on chewing	0.39 ± 0.99	
T2	Spontaneous pain	2.61 ± 1.04	0.0002*
	Pain on chewing	4.45 ± 2.55	
T3	Spontaneous pain	3 ± 2.31	0.0004*
	Pain on chewing	5.03 ± 2.19	
T4	Spontaneous pain	3.70 ± 2.43	0.003*
	Pain on chewing	5.36 ± 1.98	
T5	Spontaneous pain	3.67 ± 1.85	< 0.01*
	Pain on chewing	5.70 ± 1.91	
T6	Spontaneous pain	4 ± 2.65	0.001*
	Pain on chewing	5.58 ± 1.87	
T7	Spontaneous pain	3.06 ± 1.85	< 0.01*
	Pain on chewing	5.3 ± 1.69	

*p significant at ≤ 0.05

Table 6 Comparison of spontaneous pain and pain on chewing in the LLLT group at different time intervals

Time period	Groups	Mean	*p* value
T1	Spontaneous pain	0.21 ± 0.485	0.73
	Pain on chewing	0.27 ± 0.88	
T2	Spontaneous pain	1.76 ± 1.12	0.03*
	Pain on chewing	2.91 ± 2.71	
T3	Spontaneous pain	1.58 ± 1.6	0.0008*
	Pain on chewing	3.03 ± 1.79	
T4	Spontaneous pain	2.15 ± 2.09	0.11
	Pain on chewing	2.94 ± 1.87	
T5	Spontaneous pain	2.21 ± 1.73	0.02*
	Pain on chewing	3.39 ± 2.38	
T6	Spontaneous pain	2.55 ± 2.18	0.15
	Pain on chewing	3.36 ± 2.4	
T7	Spontaneous pain	1.88 ± 1.71	0.01*
	Pain on chewing	3.09 ± 2.19	

*p significant at ≤ 0.05

Table 7 Comparison of mean spontaneous pain scores between the placebo group and the LLLT group at different time intervals after separator placement

Time interval	Group	Mean pain score	*p* value
T1	Placebo	0.27 ± 0.57	0.6532
	LLLT	0.21 ± 0.485	
T2	Placebo	2.61 ± 1.04	0.04*
	LLLT	1.76 ± 1.12	
T3	Placebo	3.00 ± 2.31	0.0058*
	LLLT	1.58 ± 1.6	
T4	Placebo	3.70 ± 2.43	0.0081*
	LLLT	2.15 ± 2.09	
T5	Placebo	3.67 ± 1.85	0.0018*
	LLLT	2.21 ± 1.73	
T6	Placebo	4.00 ± 2.65	0.0199*
	LLLT	2.55 ± 2.18	
T7	Placebo	3.06 ± 1.85	0.01*
	LLLT	1.88 ± 1.71	

*$p \leq 0.05$ considered significant

Table 8 Comparison of mean pain on chewing scores between the placebo group and the LLLT group at different time intervals after separator placement

Time interval	Group	Mean pain score	*p* value
T1	Placebo	0.39 ± 0.99	0.61
	LLLT	0.27 ± 0.88	
T2	Placebo	4.45 ± 2.55	0.0225*
	LLLT	2.91 ± 2.71	
T3	Placebo	5.03 ± 2.19	0.0002*
	LLLT	3.03 ± 1.79	
T4	Placebo	5.36 ± 1.98	0.0002*
	LLLT	2.94 ± 1.87	
T5	Placebo	5.70 ± 1.91	< 0.01*
	LLLT	3.39 ± 2.38	
T6	Placebo	5.58 ± 1.87	< 0.01*
	LLLT	3.36 ± 2.40	
T7	Placebo	5.30 ± 1.69	< 0.001*
	LLLT	3.09 ± 2.19	

*$p \leq 0.05$ considered significant

pain. The scale used a score range between 0 and 10 (0 = no pain, 10 = worst pain imaginable) for each of the quadrants. Although the VAS pain assessment is a subjective method in which there is great variability across individuals, it is one of the best methods available for pain studies [7, 18]. In this study, VAS data were collected at multiple time points: time of separator placement, as well as 4, 6, 12, 24, 36, and 48 h post irradiation. There were no significant differences in pain scores between males and females ($p > 0.05$).

There was a significant difference in the levels of both spontaneous and pain on chewing among the LLLT and the placebo groups ($p < 0.05$); this endorses the analgesic effect of LLLT on both types of pain. The patients reported maximum levels of pain 36 h after separator placements on both the placebo and LLLT sides. According to Ngan et al. [8], perceived discomfort peaked 4–24 h after insertion of separators. Pain is reportedly seen between 3 and 24 h after placement of the first arches during orthodontic treatment. Our finding of pain peaking between 6 and 48 h after the laser irradiation was consistent with these studies. Clinically, it may be necessary to recommend an analgesic regimen during the first 24 h of orthodontic treatment.

The subjects reported less pain in the laser-treated quadrant compared to the contralateral quadrant where the placebo was applied, and this difference was greatest at 36 h after LLLT. Several prior studies in different fields have demonstrated the effectiveness of LLLT in reducing pain. Several hypotheses have been proposed regarding the mechanism by which LLLT reduces pain. In one hypothesis, LLLT is suggested to interfere with the modulation of inflammation in a manner that results in reduced levels of cytokines and COX-2 mRNA levels, which then results in reduced pain [10]. According to another hypothesis, LLLT irradiation results in an alteration in the conduction of action potentials in peripheral nerves. In support of this idea, it has been shown that 830-nm lasers can produce varicosities at the axon level [19]. These varicosities slow the velocity of fast axonal flow and decrease

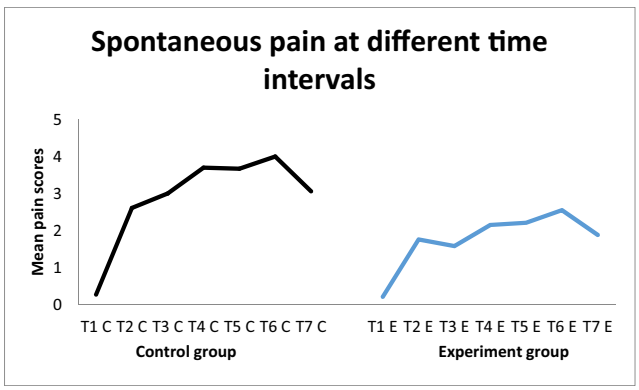

Fig. 3 Comparison of spontaneous pain scores between the placebo and LLLT groups at different time intervals

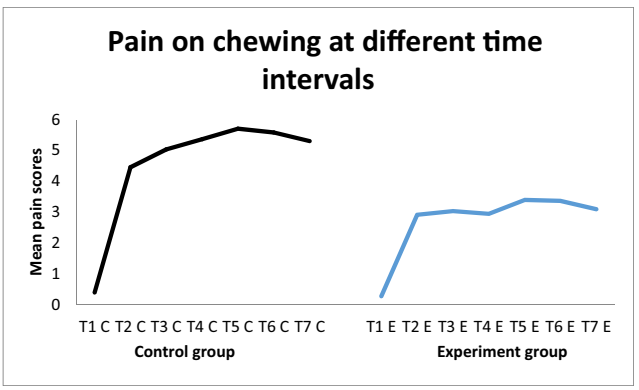

Fig. 4 Comparison of pain on chewing scores between the placebo and LLLT groups at different time intervals

mitochondrial membrane potentials, thereby resulting in a reduced availability of ATP and neurotransmission failure in nociceptive Aδ and C fibers. Finally, a third hypothesis posits that LLLT can stimulate a reduction in endogenous endorphins as described by Cabot and Laasko [20] in reports of experiments performed with a 780-nm laser at a dose of 2.5 J/cm^2.

The highest intensity of pain was associated with chewing on both placebo and experimental sides. Asiry et al. [21] and Kapoor et al. [22] also reported discomfort on eating as the most difficult activity that forces patients to change their diets to soft foods during the period of orthodontic separation.

Orthodontic patients are sometimes given NSAIDs to reduce pain, but these drugs have been shown to decline the rate of tooth movement. Use of low-power density laser treatments (i.e., phototherapy, LLLT) in orthodontic treatments can reduce pain and discomfort in a non-invasive manner, removing the need for anti-inflammatory drugs. This study explicates that a single dose of LLLT, applied immediately after the placement of elastomeric separators, has a significant analgesic effect. Further studies may be required to investigate this analgesic effect of LLLT in a larger sample size.

Conclusion

Low-level laser therapy with a 940-nm-wavelength laser light is effective in significantly reducing the intensity of pain caused by the placement of elastomeric separators.

- Low-level laser therapy significantly reduced both spontaneous pain and pain on chewing caused by elastomeric separator placement.
- There were no significant differences in the pain scores between genders.
- The mean scores of pain on chewing were found significantly greater than the mean pain scores of spontaneous pain at most time intervals assessed.

Compliance with ethical standards

The study was approved by the institutional ethical committee.

Conflict of interest No potential conflict of interest was reported by the authors.

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