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Research Article

Low-Level Laser Adjunctive Use with Orthodontic Treatment of Patients with Compromised Periodontal Structure

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Abstract

Background: The analgesic and inflammatory-modulating effects of low-level laser in adjunct to orthodontic treatment for patients with compromised periodontium was assessed.

Materials & Method: A randomized controlled clinical trial through split-mouth design was done for 20 patients with chronic periodontitis underwent orthodontic treatment. One side of dental arch received Laser application (Test group), while the other side received pseudo-laser treatment (Control group). Laser application was repeated twice / week for 4 weeks following orthodontic treatment initiation and monthly thereafter until treatment termination. Subjective pain was assessed by visual analogue scale (VAS); clinical periodontal condition was assessed with periodontal parameters (GI, PI, PPD, and GR). GCF levels of IL-1β, and PGE2 were measured by ELISA.

Results: Pain intensity was markedly decreased on Laser- treated side at the all follow-up visits; with a lower peak value during first week following orthodontic treatment initiation ($P \leq 0.05$). The PI scores were slightly increased on both sides, but with fewer levels on Laser-treated side at 1-month, whilst GI scores were decreased by the third-month follow-up ($P \leq 0.05$). A marked decreased level of IL-1β and PGE2 in GCF was noted during the 1st month of the orthodontic treatment initiation ($P \leq 0.05$).

Conclusion: In view of these results, it can be postulated that LLL application exhibits beneficial value in pain relief and inflammation control, during early stage of orthodontic treatment among patients with compromised periodontium.

Keywords: *LLL application, VAS, pain associated with initial application of orthodontic appliances.*

Introduction

Periodontal disease has been considered as a multifactorial immune-inflammatory disorder involving tooth-supporting, initiated through extension of plaque biofilm bacteria into the subgingival area.[1] It is associated with marked attachment loss and alveolar bone support reduction, tooth mobility, pathologic migration, teeth extrusion and spacing as well as marginal gingival recession.[2] In many cases, it may be accompanied by deteriorated anterior dental esthetics that reflected on the facial soft tissues.[3-5] Advanced periodontal disease is associated with loss around involved teeth and ensuing their pathological migration.[6] Teeth displacement associated with compromised periodontal support requires adjunctive orthodontic treatment aimed at preserving and restoring deteriorating dentition[7,8] One of objectives of orthodontic treatment in these situation is to contribute to a better oral hygiene, correcting dental apparatus irregularities as well as to remove / minimize the occlusion trauma.[9] Orthodontic treatment can be justified as a part of periodontal therapy if it is used to reduce plaque accumulation, correct abnormal structure forms, improve aesthetics and facilitate prosthetic replacement.[10]

Dental response to orthodontic forces is slower in adults, but the teeth are moving in the same manner regardless of age. Orthodontic treatment is no longer a contraindication in the therapy of severe adult periodontal disease and the age, per se, not contraindicate orthodontic treatment. It should be kept in mind that the tissue's response to orthodontic forces, cell mobilization and conversion of collagen fibers is much slower in adults; adult bone is less reactive to orthodontic force and there is great risk of marginal bone loss and loss of attachment with mild gingival infection. [11]

Studies documented that orthodontic treatment improve the dental esthetics, and has a significant impact on the psychosocial aspect of patients' life.[12] Orthodontic treatment provides beneficial changes in bone topography since moving a tooth towards an intraosseous defect helps its elimination, and it can also intrude and reposition pathologically migrated teeth.[13] Hence, Orthodontic treatment has been recommended as corrective therapy; formation of new cementum with insertion of collagen during orthodontic intrusion were observed. [14] However, tooth movement with compromised periodontium poses great challenges to orthodontists.[15] The first challenge is the patient's complain from pain and discomfort during orthodontic treatment, leading to weakened masticatory function and poorer oral health.[16,17] The second challenge is to control gingival inflammation, to avoid the detrimental effect upon periodontal health and tooth movement, possibly result in gingival recession, attachment loss, bone / root resorption.[8,18] Additionally, fixed orthodontic appliances may aggravate plaque biofilm accumulation, especially with insufficient oral hygiene maintaining because of pain and discomfort complaint.[17] Thus, practicing orthodontics should think to apply approaches facilitating pain management and able to control gingival inflammation with establishing strict oral hygiene measures to ensure safe and efficient tooth movement among patients with compromised periodontium.

LASER (an ellipsis for "light amplification by stimulated emission of radiation), is a device that emits light in spatially coherent and collimated pattern; a laser beam can endure in narrow fashion over a long distance, and it can also be tightly focused. Laser light is a man-made single photon wave length, and it is a type of electromagnetic wave producing heat and converting electromagnetic energy into thermal energy.[19] Low-level laser irradiation (LLLI) is a type of laser therapy with low-energy outputs to keep temperature of treated tissue slightly below normal body temperature.[20-22] Owing to its non-thermal bio-stimulatory effects, LLLI showed adjunct efficacy to nonsurgical periodontal treatment toward controlling of inflammation in patients with chronic periodontitis.[23] Lasers use in periodontal therapy showed potent inhibition of bacteremia, [18] pocket epithelium excavation, efficient subgingival calculus removal[19] and improvement of periodontal regeneration without damaging the adjoining bone and pulp tissues.[20-22]

An interest in LLL application in modern orthodontics have been grown as less pain and marked efficient tooth movement can be anticipated.[24,25] It showed beneficial effect in inducing remodeling processes in the soft and hard oral tis- sues, healing through its photo-bio-stimulatory effects.[26,27] LLL use during orthodontic teeth movement was effectively able to reduce associated pain, accelerate orthodontic tooth movement, and inhibit release of pain mediators.[28,29] LLL bio -stimulation can be attributed to cellular absorption of laser light by the target tissue causing activation of intracellular sig- naling cascades, which increases cellular metabolism, and anti-inflammatory changes involving both soft and hard oral tissues.[27] This process can induce, in the long term, a better tooth movement and osteoclast formation on compression side during experimental tooth movement, determining and enhancing the time/ rate of orthodontic tooth movement. [30]

It is of worthy to mention that, the application of LLL as part of a joint orthodontic-periodontal treatment has not been extensively studied. In view of these, it was felt that investigating the effects of LLL with orthodontic treatment of patients exhibiting periodontitis on subjective pain and gingival inflammation over a period of a year would be of interest. To avoid the bias, it was hypothesized that pain perceptions and gingival tissue inflammation did not differ between patients receiving orthodontic treatment in conjunction with LLL and those receiving orthodontic treatment with no adjunctive. Hence, double blind split mouth design was applied in the present study.

Materials and Method

Study design and Patients Selection

This study was designed as a double-blind randomized controlled trial applying a split-mouth design. Pairs of displaced single-rooted teeth with periodontitis located on both sides of the jaws were randomly assigned to either Laser group (*Test group*) or Pseudo-laser treatment group (*Placebo group*). Randomization was prepared by a statistician and sealed in sequentially numbered, dark envelopes to protect patient's allocation system. Patients were informed about the nature of the study and about the actual irradiation use, but not about their allocation settings of LLL and pseudo laser. Both operator and assistant doing the laser therapy and recording the parameters for each treatment were blinded. The outcome assessor person was not included in randomization process, patient's inclusion as well as in clinical treatment performing.

Twenty patients were included from those attending at outpatient clinics, Faculty of Dental Medicine, Al-Azhar University, Cairo, Egypt; according to following criteria: Adult patients of both genders with age between 30 - 40 years, systemically healthy, not taking antibiotic and/or anti-inflammatory drugs within last six weeks, exhibiting moderate periodontitis with at least two pairs of clinically matched displaced single rooted teeth on both sides of the jaw with pocket depth of 4 - 5 mm. Patients with Aggressive periodontitis, with smoking habit, pregnant women, previous orthodontic treatment, and previously treated teeth with periodontal surgery were not included.

Orthodontic Treatment

The required orthodontic treatment for all included patients was performed by the same clinical operator. Pre-adjusted appliances with 0.018 inch brackets#/ buccal tubes# were applied on maxillary and/or mandibular arches, with 0.014-inch thermal nickel-titanium (NiTi) as initial arch wire for the first 2 months followed by 0.016-inch thermal NiTi for the third month. They were scheduled on periodic visits every 4 weeks for needed intervention and follow up. All included patients completed the planned treatment and follow up period.

Low-Level Laser (LLL) Application

One side of the jaw was randomly allocated to test side and received LLL using a diode laser operating at 980 nm (Wiser Laser Doctor Smile, Lambda, Italy) with a wavelength of 810 nm (1 W of output power, a continuous wave of 66,7 J/cm2) and 0.6 mm optic with fiber. Laser probe was targeted at level of bracket and buccal gingival margin first, and then shifted into level of buccal alveolar mucosa covering root area; both at 1 cm. Each area was irradiated for 15 seconds. LLL was repeated twice times weekly for 4 weeks following bracket bonding and monthly thereafter until orthodontic treatment termination. Protective eyewear was used to protect patients and operators throughout the irradiation process to avoid the development of any harmful effects.

Pain Assessment

The pain experienced by the patient was assessed by the criteria of visual analogue scale (VAS); at baseline, each patient was asked to record the pain using (VAS).[31] They were carefully instructed regarding how to complete VAS and were asked to mark on the linear scale to record daily pain intensity separately on each jaw side for first 2 weeks following orthodontic treatment initiation, then weekly for next 6 weeks (two months following treatment initiation). A score of 0 represented the absence of any pain/discomfort while a score of 10 intended any pain considered to be intolerable. They were advised to avoid analgesics during the study period, but they were asked to notify the clinical operator in case of unconveyable pain that necessitate analgesic taking and a decision was made not to consider their recorded data into the same results, but as category of severe pain associated with treatment needs analgesics.

Assessment of Clinical Periodontal Condition

All included patients were subjected to complete initial periodontal therapy including thorough scaling, root planning and polishing prior to the orthodontic treatment initiation. Then periodontal clinical condition was assessed (Baseline) with the following parameters: Plaque index (PlI)[32], Gingival index (GI) [33], Probing pocket depth (PPD) using graduated periodontal probe, and Gingival recession (GR).[34] These parameters were recorded during the orthodontic treatment at 1-moth, 2- month, 6-month, and termination of orthodontic treatment.

Measurement of GCF levels of IL-1ß and PGE2

The GCF samples were collected from all target teeth in both groups with prefabricated paper strips, inserted into pockets until resistance was felt and held in place for 30 seconds. Paper strips were immediately transferred to separate micro centrifuge tubes containing phosphate-buffered saline solution. Collection of the GCF samples was carried out initially (baseline), one week, 1-month, and 2-month after orthodontic treatment initiation. Levels of interleukin 1β (IL1ß) and prostaglandin E2 (PGE2) was measured by ELISA, according to previously mentioned method35, using commercially available ELISA kits (R&D Systems Inc., Minneapolis, USA); recorded level of each biomarker was expressed in pg/µg of total protein in GCF.

Statistical Analysis

Numerical data were expressed by Mean +SD, while categorical variables were expressed as number and percentage. The data were compared by two-sample t-tests, and ANOVA was used in analysis of differences in post-therapy pain levels. All statistical analyses were performed using SPSS software version 23.0 (SPSS Inc., Chicago, IL, USA), and significance level was set at p value < 0.05.

Results

Bio-Demographic data

Twenty patients (12 females and 8 males, ranging in age between 30 and 40 years with a mean of 35+ 4.8 years) with controlled chronic periodontitis were included in the present study. They had a total of 128 single rooted and displaced target teeth, and they exhibited mild to moderate crowding or spacing; no adverse events were reported during the study period. No significant differences were found between Laser-treated group and Placebo group for any assessment, indicating that the two sides were comparable at the baseline (Table 1). They co-operated well and showed complete compliance with desire to have the correction of teeth crowding, spacing, and periodontal problems. All patients completed the planned treatment and all assessments were performed.

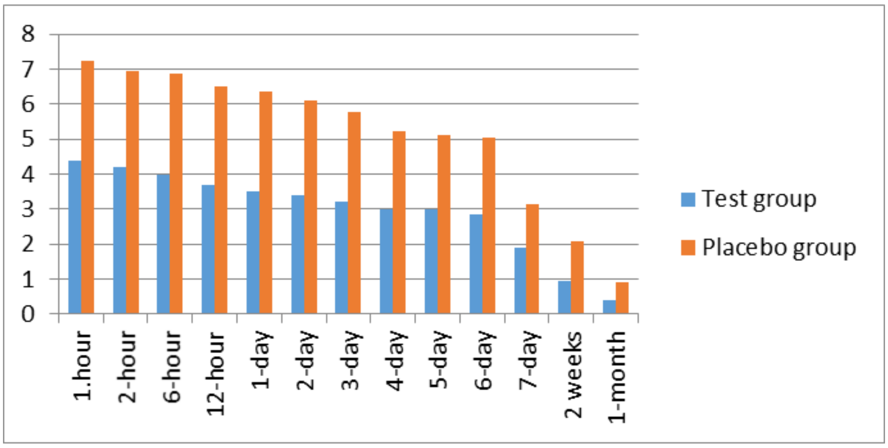
Table 1: Bio-demographic data recorded initially prior to initiation of orthodontic treatment of patients exhibiting mild/moderate periodontitis, applying laser on one side (Test group) and Pseudo-laser on the other side in conjunction with orthodontic tooth movement.

Group	N	Age		Number of affected teeth		Side with Teeth crowding	Side with Teeth spacing
	M F T	*M+SD*	*Range*	Maxilla	Mandible		
Laser group	8 12 20	35+ 4.8	30- 40	34	30	10	10
Placebo group	*8 12 20*	35 +4.8	30-40	32	32	9	11

Results of Subjective Pain Perception

Pain intensity increased from 1 hour after brackets placement and peaked at 24 hours, and then it gradually decreased to the baseline level in the both groups *(P < 0.01)*. A higher score was recorded on the pseudo laser treated (placebo) side at both 6-hour and 24-hour intervals. Patients felt significantly greater maximum pain intensity on the placebo side over 10 days. Laser-treated (Test) side showed significant reduction in dental pain due to orthodontic treatment after first Laser application *(p< 0.001)*.The pain subsided 1 day earlier on Laser-treated (Test) side after the orthodontic treatment initiation. Significantly less pain was reported on Laser-treated side at day one *(P < 0.05)* and one week after brackets placement *(P < 0.05)*. There was no significant difference between the two groups regarding pain complaint at 1-month and 2-moth. At a further 12-month follow-up period, none of enrolled patients were presented with any clinical periodontal damage, as gingivitis or increased depth of probing pocket depth (Figure 1).

Figure 1: The mean of recorded VAS at different time starting following orthodontic treatment initiation up to one month, in the two studied groups.



Results of Teeth Alignment

Laser-treated *(Test)* side recorded a higher levelling and alignment improvement percentage (65.36 _ 11.39%) compared to Pseudo laser-treated *(Control)* side at T1 time (44.39 _ 15.51%, p = 0.003), and at T2 (89.42 _ 7.16%) compared to the control side (68.66 _ 15.12%, p < 0.001) (Table 2).

Table 2: Leveling and alignment improvement % (days); results are expressed as mean _ SD. Compared to the control side, the test side showed a significant reduced overall time needed for space closure (p < 0.001). P < 0.05 was considered statistically significant.

	T1		T2	
	Mean + SD	**Range**	**Mean + SD**	**Range**
Test side	65.36 _ 11.39	59.9 – 67.4	89.42 _ 7.16	78.2–95.2
Control side	44.39 _ 15.51	41.3 – 48.7	68.66 _ 15.12	62.1–71.3

Results of Clinical Periodontal Assessment

Periodontal status was assessed during follow up period (Figure 2a, b, c, d). The Pseudo-laser treated (Placebo) group showed increased accumulation of plaque biofilm than Laser treated group; difference was statistically significant only at one-month (p<0.05), and non-significant thereafter visits (P> 0.05). Regarding the GI score, the change level from baseline value showed non-significant difference the 1-month follow-up visit (P> 0.05), but intergroup decrease was significant at the 3-month follow-up visit (P< 0.05). There were non- significant differences regarding PPD or GR either intragroup or intergroup were noted at any follow up visit (p>0.05). (Table 3).

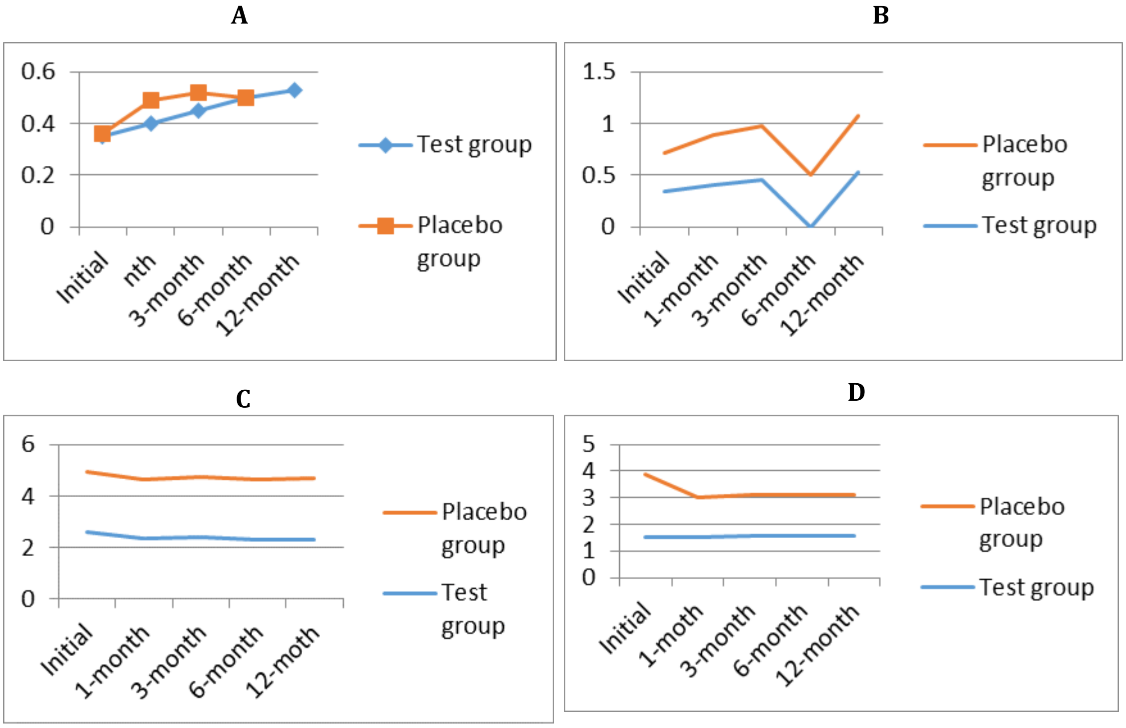


Figure 2: Clinical assessment of periodontal condition among the two groups, recorded as the mean of Gingival Index (A), Plaque Index (B), Probing Pocket depth (C), and Gingival recession (D).

Table 3: Comparison between the two groups according to recorded clinical parameters at various follow up visits up to one month following treatment the initiation of orthodontic.

	Laser-treated side (Test Group)					No Laser treated side (Control Group)					*P*
Clinical Asses-ment	**Initial**	**1-month**	**3-month**	**6-month**	**12-month**	**Initial**	**1-month**	**3-month**	**6-month**	**12-month**	
GI MSD	0.50 0.28	0.52 0.30	0.54 0.30	0.55 0.28	0.58 0.30	0.51 0.27	0.65 0.35	0.68 0.36	0.76 0.36	0.79 0.38	*ns*
PlI MSD	0.35 0.20	0.40 0.25	0.45 0.22	0.50 0.26	0.53 0.31	0.36 0.22	0.49 0.25	0.52 0.30	0.50 0.22	0.55 0.33	*ns*
PPD MSD	2.26 0.46	2.37 0.45	2.39 0.45	2.29 0.55	2.32 0.33	2.30 0.43	2.25 0.44	2.35 0.47	2.33 0.37	2.37 0.39	*ns*
GR MSD	1.50 1.10	1.51 1.08	1.55 1.12	1.55 1.10	1.56 1.15	1.49 1.15	1.52 1.18	1.56 1.20	1.57 1.25	1.57 1.28	*ns*

Results of GCF levels of PGE-2 and IL-1b

The measured levels of PGE2 in GCF in both treated sides were increase at 1- day following treatment initiation ($P < 0.01$) and were markedly decline (Fig 3). Laser treated group showed less increased levels of IL-1β in GCF than placebo group at 1 day ($P < 0.01$), 1-week, and 1 month ($P < 0.03$) following orthodontic initiation. Levels of PGE2 in GCF showed less increase among Laser-treated group compared to pseudo-laser treated (placebo) group at the 1-day ($P < 0.02$) and 1-week ($P < 0.01$) intervals. Increased GCF levels showed better control in Laser treated group at the 1-day interval ($P < 0.01$) (Figure 4).

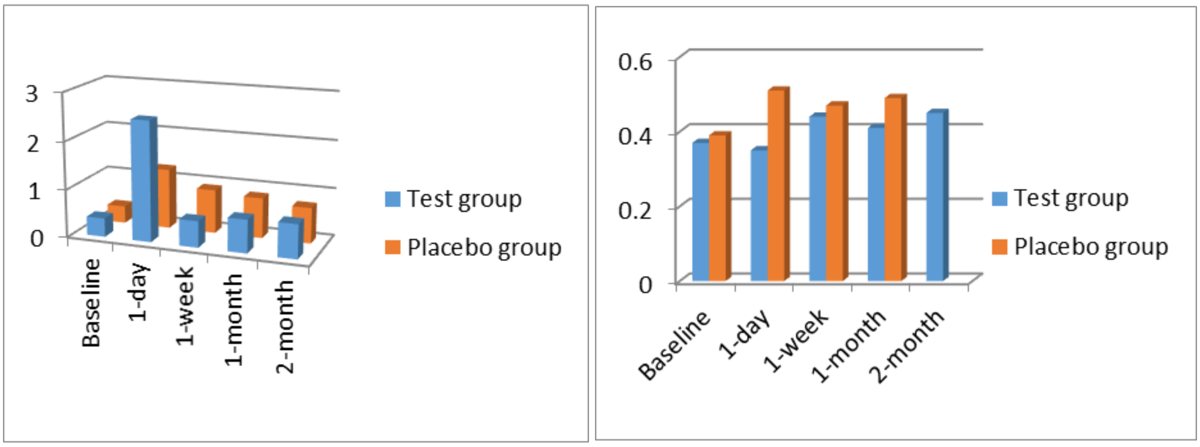


Figure 3: Measured levels of PGE in GCF. Figure 4: Measured levels of IL-1b in GCF.

Discussion

The adjunctive effect of Laser on management of orthodontic pain and periodontal inflammation during undertaking orthodontic treatment for subjects with compromised periodontium received attention. In this respect, periodontal clinical status assessment, and GCF biomarkers analysis were done to verify the possible modulatory effects of the Laser therapy on periodontal inflammation. Benefits of Laser in periodontal therapy have been described in previous studies, in terms of greater reduction of periodontal pocket depth, gingival bleeding and inflammation, decreased levels of IL-1b in the GCF.[21-23] Studies highlighting that, soft tissue and bone treated with LLL showed accelerated tissue repair process with increased orthodontic tooth movement speed.[36] Orthodontic tooth movement can result in quantitative and qualitative changes in periodontal tissues.[6-8] These changes in periodontal tissues are modulated by growth factors, bone metabolism, and mediators as interleukins-1ß and some enzymes are increased in response to orthodontic mechanical stress during tooth movement.[35, 37] LLL therapy provide an effective tool for tissue repair and bone reformation through tissue bio-stimulation; induced by laser therapy at bone neo-apposition level which had direct proportional relationship with dose and time of Laser application.[38, 39]

The results of the present study showed that subjective pain assessed by VAS in both two groups had similar pattern of change over a period of two weeks; a similar findings were reported.[22, 23] The comparison between Laser treated side and placebo side regarding the pain showed that patients experienced less pain on Laser-treated side than the placebo side (difference was significant at 6-hour and 24-hour, as well as at 3-day following treatment initiation). Such obvious analgesic effect of Laser therapy during the first 3 days and not thereafter has been reported.[24, 25] Laser therapy reduced the maximum pain intensity over 7 days, which lend support to other studies findings.[26, 27] The test side showed significant reduction in dental pain associated with orthodontic treatment at 3, 7, 10, 14 days following Laser application. A similar study showed that Laser therapy during orthodontic treatment was effectively tool for re- duction of dental pain associated with orthodontic traction.[40] Mechanisms responsible for the pain reduction induced by LLL during orthodontic tooth movement is still await clarification. However it has been reported that LLL possesses neural and anti-inflammatory periodontal regenerative properties determining the cell differentiation and proliferation useful for pain reduction during orthodontic tooth movement.[41]Additionally, LLL achieves its analgesic effects by attenuating the local inflammatory response, without adverse effects on periodontal tissues. Researchers reported that biting and chewing activities are negatively affected by orthodontic pain and pain serves as a modifying factor that limits the maximum bite force due to reflex mechanisms.[41]Neuromuscular adaptations to mechanical loading on the periodontal tissue may account for this finding; [42] these findings reinforce the assumption that LLL may have an analgesic effect manifested by protecting biting performance from deteriorating.[40]

The variations in levels of IL-1β and PGE2 in GCF showed an independent association with orthodontic pain.[25]Thus, PGE2 levels in GCF were peaked at the 24-hour interval in the placebo group, followed by a steady recovery over the following 2 months. The fluctuation of GCF biomarkers coincided with the change pattern of subjective pain intensity, suggests that a neuro-immune interaction occurs in the periodontal tissue during orthodontic tooth movement.[41]The GCF levels of PGE and IL-b at various time points showed less increase in Laser-treated group, especially during the first month. A study noted significantly lower level of PGE2 was reported in LLL-treated group 1 hour and 24 hours after separator placement; such inhibitory effect of LLL on the increase of pain-related cytokines in GCF, suggesting that Laser treatment had analgesic effects on periodontal patients treated by orthodontic fixed-appliances.[43-45]

Periodontal clinical assessment over 12-month follow-up period demonstrated that patients with compromised periodontal structure treated orthodontically, remained quite stable, with no significant changes in PPD, or GR and with a slight increase in PlI and GI; which has been reported previously.[4-7] The accumulated supra-gingival plaque after bracket placement can be considered as contributing factor to an increased level of gingival inflammation.

The LLL-treated side recorded less plaque accumulation, assessed with the criteria of Plaque Index [31], and gingival inflammation assessed with the criteria of Gingival Index [32], than placebo side during the first month, which coincides with its ability in controlling the upregulation of IL-1β and PGE2 in GCF. [20] This effect proved to be critical in gingival inflammation and alveolar bone resorption. [20] Such favorable effect upon the inflammation control has been reported previously.[42] LLL may have a longer-lasting effect on chronic inflammation characterized by accelerated tissue repair. When periodontal indices were compared, Laser-treated side showed more favorable results, with significantly less plaque biofilm and milder gingival inflammation at 1-month, 3-month, 6, and 12 month follow-up visits. It seems likely that, LLL is a promising adjunctive way with to mechanical debridement toward controlling of gingival inflammatory process and wound healing for patients with chronic periodontitis. [22]

In conclusion, this study provides promising findings regarding the analgesic and anti-inflammatory effects of Laser application for two months of orthodontic treatment. The null hypothesis of this study was, at least, partially rejected, as Laser use was able in reducing dental pain associated with orthodontic tooth movement among patients with compromised periodontium. However, these results were based on short and intermediate-term observations; long-term follow-up is advised to provide further verification of LLL's merits as anti-inflammatory bio-stimulation, utilizing a larger sample size are greatly recommended to validate these findings.

Conflict of Interest

The authors declare that they have no conflict of interest.

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