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Effect of Low-Level Laser Therapy on Periodontal Healing During Orthodontic Tooth Movement: A Randomized Clinical Study

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ABSTRACT

Background: Orthodontic tooth movement is commonly associated with periodontal inflammation, discomfort, and tissue remodeling. Maintaining periodontal health during orthodontic treatment is essential for successful outcomes. Low-Level Laser Therapy (LLLT) is a non-invasive adjunctive modality with anti-inflammatory and analgesic effects that may enhance periodontal healing during orthodontic therapy.

Aim: To evaluate the effect of Low-Level Laser Therapy on periodontal healing and pain perception during orthodontic tooth movement.

Materials and Methods: This randomized clinical study was conducted over six months in the Department of Orthodontics in collaboration with the Department of Periodontology. Thirty patients requiring bilateral maxillary canine retraction after premolar extraction were randomly divided into two groups of 15 each. Group A received conventional orthodontic treatment, while Group B received adjunctive Low-Level Laser Therapy (810 nm diode laser, 100 mW) during orthodontic activation. Fixed orthodontic treatment was carried out using MBT brackets and nickel-titanium closed coil springs. Periodontal parameters including Plaque Index (PI), Gingival Index (GI), Bleeding on Probing (BOP), and Probing Pocket Depth (PPD) were assessed at baseline, 1 month, and 3 months. Pain perception was evaluated using the Visual Analog Scale (VAS), and the rate of tooth movement was measured.

Results: Both groups demonstrated mild increases in periodontal parameters during orthodontic treatment; however, the LLLT group showed significantly lower Gingival Index and Bleeding on Probing scores compared to the control group at 1 month and 3 months ($p < 0.05$). Patients treated with LLLT reported significantly lower pain scores following orthodontic activation. The rate of orthodontic tooth movement was slightly higher in the laser group, although the difference was not statistically significant.

Conclusion: Adjunctive Low-Level Laser Therapy may positively influence periodontal healing during orthodontic tooth movement by reducing gingival inflammation and patient discomfort. LLLT appears to be a promising supportive modality for improving periodontal outcomes during orthodontic treatment.

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Introduction

Orthodontic treatment aims to achieve optimal esthetics, functional occlusion, and long-term stability through controlled tooth movement.[1] Orthodontic tooth movement is a biologic process that occurs due to remodeling of the periodontal ligament and alveolar bone in response to applied mechanical forces.[2] Although this process is essential for successful orthodontic therapy, it is often accompanied by transient inflammatory reactions, discomfort, and alterations in periodontal tissues. Fixed orthodontic appliances may also promote plaque accumulation and compromise oral hygiene maintenance, thereby increasing the risk of gingival inflammation and periodontal problems.[3]

Maintenance of periodontal health during active orthodontic treatment is considered a critical factor for successful treatment outcomes. Inflammatory changes such as gingivitis, bleeding on probing, and increased probing depth are commonly observed in orthodontic patients, particularly in those with inadequate oral hygiene practices. Therefore, several adjunctive methods have been investigated to minimize periodontal inflammation, reduce pain, and enhance tissue healing during orthodontic therapy.[4]

Low-Level Laser Therapy, also referred to as photobiomodulation therapy, has emerged as a promising non-invasive therapeutic modality in dentistry. LLLT utilizes low-intensity laser energy to stimulate cellular activity without producing thermal damage to tissues. It has been reported to possess anti-inflammatory, analgesic, and biostimulatory effects by enhancing microcirculation, collagen synthesis, cellular proliferation, and tissue repair. In orthodontics, LLLT has been investigated for its potential role in accelerating tooth movement, reducing orthodontic pain, and improving periodontal tissue response.[5,6]

Previous studies have demonstrated that Low-Level Laser Therapy may decrease inflammatory mediators and promote faster healing of periodontal tissues during orthodontic force application. However, the available literature regarding its influence on periodontal healing during orthodontic tooth movement remains limited and inconclusive. Hence, the present study was undertaken to evaluate the effect of Low-Level Laser Therapy on periodontal healing and pain perception during orthodontic tooth movement.

Materials and Methods

This randomized clinical study was conducted in the Department of Orthodontics in collaboration with the Department of Periodontology at a tertiary dental care institution over a period of six months after obtaining approval from the Institutional Ethical Committee. The study included 30 patients requiring fixed orthodontic treatment with bilateral maxillary first premolar extraction followed by canine retraction. Patients aged between 18 and 30 years with good systemic health, healthy periodontal status, and no previous history of orthodontic treatment were selected for the study. Patients with systemic diseases affecting periodontal tissues, smokers, pregnant or lactating women, patients receiving anti-inflammatory medications, and individuals with poor oral hygiene or active periodontal disease were excluded.

After obtaining written informed consent, the participants were randomly allocated into two groups of 15 patients each using a simple randomization method. Group A served as the control group and received conventional orthodontic treatment without laser therapy, while Group B received conventional orthodontic treatment along with adjunctive Low-Level Laser Therapy (LLLT). All patients underwent fixed orthodontic treatment using 0.022-inch slot MBT prescription brackets. Initial leveling and alignment were completed using standard archwire sequences before initiation of canine retraction. Orthodontic canine retraction was performed using nickel-titanium closed coil springs delivering a standardized force of 150 g on each side.

In the experimental group, Low-Level Laser Therapy was administered using a diode laser with a wavelength of 810 nm and output power of 100 mW in continuous mode. Laser irradiation was applied at multiple points over the buccal and palatal mucosa corresponding to the canine root region immediately after orthodontic activation and subsequently on days 3, 7, and 14 during the first month of canine retraction. Each irradiation point received laser exposure for 10 seconds. Appropriate protective eyewear was provided to both the operator and the patients throughout the procedure.

Clinical periodontal parameters including Plaque Index (PI), Gingival Index (GI), Bleeding on Probing (BOP), and Probing Pocket Depth (PPD) were recorded at baseline, 1 month, and 3 months using a calibrated periodontal probe by a single trained examiner to minimize inter-examiner variability. Pain perception following orthodontic activation was evaluated using a 10-point Visual Analog Scale (VAS) at 24 hours, 48 hours, and 7 days after force application. The rate of orthodontic tooth movement was measured intraorally using a digital vernier caliper from a fixed reference point between the canine and adjacent tooth structures.

All collected data were tabulated and subjected to statistical analysis using Statistical Package for Social Sciences (SPSS) software version 25.0. Intergroup comparisons were analyzed using the independent t-test, while intragroup comparisons were assessed using paired t-test and repeated measures ANOVA. A p-value of less than 0.05 was considered statistically significant.

Result

All 30 participants completed the study successfully, with 15 patients in the control group and 15 patients in the Low-Level Laser Therapy (LLLT) group. No adverse effects related to orthodontic treatment or laser application were observed during the study period.

At baseline, there was no statistically significant difference between the two groups regarding Plaque Index (PI), Gingival Index (GI), Bleeding on Probing (BOP), and Probing Pocket Depth (PPD), indicating comparable periodontal conditions prior to intervention **(Tables 1–4)**.

The mean Plaque Index score in the control group increased from 0.82 ± 0.15 at baseline to 1.21 ± 0.18 at 1 month and 1.38 ± 0.21 at 3 months. In the LLLT group, the corresponding values were 0.80 ± 0.14, 1.09 ± 0.17, and 1.24 ± 0.19, respectively. Although the increase in plaque accumulation was lower in the laser group, the intergroup difference was not statistically significant at any interval ($p > 0.05$) (Table 1).

The Gingival Index scores increased significantly in both groups during orthodontic treatment; however, the increase was comparatively less in the LLLT group. In the control group, mean GI scores increased from 0.76 ± 0.16 at baseline to 1.43 ± 0.20 at 1 month and 1.62 ± 0.24 at 3 months. In contrast, the laser group demonstrated values of 0.74 ± 0.15, 1.08 ± 0.18, and 1.19 ± 0.21, respectively. The differences between the groups at 1 month and 3 months were statistically significant ($p = 0.003$ and $p = 0.001$, respectively) **(Table 2)**.

Bleeding on Probing scores also showed significant improvement in the laser group. The control group exhibited mean BOP scores of 8.46 ± 1.72 at baseline, 15.38 ± 2.10 at 1 month, and 17.11 ± 2.42 at 3 months. The LLLT group demonstrated comparatively lower scores of 8.21 ± 1.64, 11.64 ± 1.98, and 12.53 ± 2.06, respectively. The differences observed at 1 month and 3 months were statistically significant ($p = 0.002$ and $p = 0.001$, respectively) **(Table 3)**.

Probing Pocket Depth values remained relatively stable in both groups throughout the study period. In the control group, mean PPD values were 2.18 ± 0.31 mm at baseline, 2.31 ± 0.34 mm at 1 month, and 2.39 ± 0.36 mm at 3 months. In the LLLT group, the values were 2.15 ± 0.29 mm, 2.22 ± 0.30 mm, and 2.27 ± 0.32 mm, respectively. No statistically significant difference was observed between the groups ($p > 0.05$) **(Table 4)**.

Pain perception assessed using the Visual Analog Scale (VAS) revealed significantly lower pain scores in the LLLT group following orthodontic activation. At 24 hours, the control group demonstrated a mean pain score of 6.82 ± 1.04, whereas the laser group showed a significantly lower score of 4.36 ± 0.88 ($p = 0.001$). At 48 hours, the mean pain scores were 5.11 ± 0.92 and 3.24 ± 0.76 in the control and laser groups, respectively ($p = 0.002$). By the seventh day, pain scores had reduced considerably in both groups, with no statistically significant difference observed **(Table 5)**.

The rate of orthodontic canine retraction was marginally greater in the LLLT group. At 1 month, the mean tooth movement was 0.91 ± 0.13 mm/month in the control group and 1.02 ± 0.15 mm/month in the laser group. At 3 months, the values increased to 2.68 ± 0.28 mm/month and 2.91 ± 0.31 mm/month, respectively. However, the intergroup differences were not statistically significant ($p > 0.05$) **(Table 6)**.

Overall, adjunctive Low-Level Laser Therapy demonstrated beneficial effects in reducing gingival inflammation and postoperative discomfort during orthodontic tooth movement while maintaining favorable periodontal health outcomes.

Table 1. Comparison of Mean Plaque Index (PI) Scores Between the Groups

Time Interval	Control Group (Mean ± SD)	LLLT Group (Mean ± SD)	p-value
Baseline	0.82 ± 0.15	0.80 ± 0.14	0.741
1 Month	1.21 ± 0.18	1.09 ± 0.17	0.084
3 Months	1.38 ± 0.21	1.24 ± 0.19	0.067

Table 2. Comparison of Mean Gingival Index (GI) Scores Between the Groups

Time Interval	Control Group (Mean ± SD)	LLLT Group (Mean ± SD)	p-value
Baseline	0.76 ± 0.16	0.74 ± 0.15	0.812
1 Month	1.43 ± 0.20	1.08 ± 0.18	0.003*
3 Months	1.62 ± 0.24	1.19 ± 0.21	0.001*

Table 3. Comparison of Bleeding on Probing (BOP) Scores Between the Groups

Time Interval	Control Group (Mean ± SD)	LLLT Group (Mean ± SD)	p-value
Baseline	8.46 ± 1.72	8.21 ± 1.64	0.693
1 Month	15.38 ± 2.10	11.64 ± 1.98	0.002*
3 Months	17.11 ± 2.42	12.53 ± 2.06	0.001*

Table 4. Comparison of Mean Probing Pocket Depth (PPD) Between the Groups

Time Interval	Control Group (Mean ± SD)	LLLT Group (Mean ± SD)	p-value
Baseline	2.18 ± 0.31	2.15 ± 0.29	0.784
1 Month	2.31 ± 0.34	2.22 ± 0.30	0.421
3 Months	2.39 ± 0.36	2.27 ± 0.32	0.338

Table 5. Comparison of Mean VAS Pain Scores Between the Groups

Time Interval	Control Group (Mean ± SD)	LLLT Group (Mean ± SD)	p-value
24 Hours	6.82 ± 1.04	4.36 ± 0.88	0.001*
48 Hours	5.11 ± 0.92	3.24 ± 0.76	0.002*
7 Days	1.48 ± 0.42	1.21 ± 0.36	0.117

Table 6. Comparison of Rate of Orthodontic Tooth Movement Between the Groups

Time Interval	Control Group (mm/month) Mean ± SD	LLLT Group (mm/month) Mean ± SD	p-value
1 Month	0.91 ± 0.13	1.02 ± 0.15	0.061
3 Months	2.68 ± 0.28	2.91 ± 0.31	0.074

Discussion

Orthodontic tooth movement is a biologic process characterized by remodeling of the periodontal ligament and alveolar bone in response to applied mechanical forces. Although fixed orthodontic appliances are highly effective in correcting malocclusion, they often create plaque-retentive areas that may predispose patients to gingival inflammation and periodontal complications.[7,8] Therefore, maintaining periodontal health during active orthodontic treatment remains a major concern in interdisciplinary dental care. The present study evaluated the effect of adjunctive Low-Level Laser Therapy (LLLT) on periodontal healing and pain perception during orthodontic tooth movement.

The findings of the present study demonstrated that patients receiving LLLT exhibited significantly lower Gingival Index and Bleeding on Probing scores compared to the control group during the follow-up period. These results suggest that Low-Level Laser Therapy may effectively reduce gingival inflammation associated with orthodontic treatment. The anti-inflammatory effect of LLLT can be attributed to its ability to enhance cellular metabolism, improve microcirculation, stimulate fibroblast proliferation, and reduce inflammatory mediator release within periodontal tissues. Laser irradiation has also been reported to accelerate tissue repair and collagen synthesis, thereby promoting improved periodontal healing.[9,10]

Although Plaque Index scores increased in both groups during orthodontic treatment, the increase was comparatively lower in the laser group. However, the difference was not statistically significant. This finding may indicate that while LLLT contributes to reducing inflammatory response, plaque accumulation remains primarily dependent on patient oral hygiene practices rather than laser application alone. Similar observations have been reported in previous studies evaluating periodontal changes during fixed orthodontic therapy.

In the present study, Probing Pocket Depth values remained relatively stable throughout the observation period in both groups, with no statistically significant intergroup difference. This finding suggests that orthodontic treatment performed under controlled conditions with adequate oral hygiene maintenance does not significantly compromise periodontal attachment levels over a short-term period. The slightly lower PPD values observed in the LLLT group may be associated with reduced inflammatory edema and enhanced tissue healing.[11]

Pain perception following orthodontic activation was significantly lower in patients receiving Low-Level Laser Therapy at 24 and 48 hours. Orthodontic pain is commonly caused by inflammatory reactions and pressure changes within the periodontal ligament after force application. The analgesic effect of LLLT may be related to modulation of nerve conduction, reduction of inflammatory mediators, increased endorphin release, and improvement in local blood circulation. The present findings are in agreement with several previous clinical studies that have demonstrated reduced orthodontic pain following laser application.[12,13]

The rate of orthodontic tooth movement was slightly greater in the laser group compared to the control group, although the difference was not statistically significant. This observation may be explained by the biostimulatory effects of LLLT on cellular activity and bone remodeling processes. Laser therapy has been suggested to stimulate osteoblastic and osteoclastic activity, thereby potentially enhancing orthodontic tooth movement.[14-16] However, variations in laser parameters, treatment protocols, and study duration may influence the overall outcome and explain the lack of significant difference in the present study.

The present study has certain limitations. The sample size was relatively small, and the follow-up duration was limited to three months. Long-term studies with larger sample sizes and advanced biomolecular assessments are recommended to further evaluate the effects of Low-Level Laser Therapy on periodontal remodeling during orthodontic treatment.

Within the limitations of the present study, adjunctive Low-Level Laser Therapy appeared to provide beneficial effects in reducing gingival inflammation and postoperative discomfort during orthodontic tooth movement while maintaining favorable periodontal health.

Conclusion

Within the limitations of the present study, adjunctive Low-Level Laser Therapy demonstrated beneficial effects on

periodontal healing during orthodontic tooth movement. Patients receiving LLLT showed significantly reduced gingival inflammation, lower bleeding on probing scores, and decreased pain perception following orthodontic activation compared to the control group. Although the rate of orthodontic tooth movement was slightly greater in the laser group, the difference was not statistically significant.

Low-Level Laser Therapy appears to be a safe, non-invasive, and effective supportive modality for improving periodontal tissue response and patient comfort during fixed orthodontic treatment. Further long-term clinical studies with larger sample sizes are recommended to validate these findings and establish standardized laser protocols for routine orthodontic-periodontal practice.

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