ORIGINAL RESEARCH

Effect of Open Flap Debridement with and without LLLT in Patients with Periodontitis on Wound Healing, GCF ALP Levels, and Clinical Parameters

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Abstract

Aim: The tenet of the study is to evaluate the efficacy of low-level laser therapy (LLLT) as an adjunct to surgical periodontal therapy [open flap debridement (OFD)] on clinical parameters, gingival crevicular fluid (GCF) alkaline phosphatase (ALP) levels in GCF and wound healing.

Materials and methods: Thirty subjects afflicted with chronic periodontitis showing evidence of horizontal bone loss on the radiograph, pocket probing depth (PPD) between 4 and 7 mm, and ≥20 natural teeth present in the oral cavity were included in the study. In every patient, OFD+LLLT was done in one quadrant and OFD in another was performed. The clinical parameters were assessed at baseline, 3 and 6 months visits while the GCF sample was collected at baseline visit and 6 months recall. Wound healing indices were recorded 1-week post-op surgery for each group.

Results: The results showed an evident improvement in all the clinical parameters [pocket probing depth, gingival index (GI), plaque index (PI), and CAL] from baseline–6 months values; however, no statistically significant difference was seen on the intergroup comparison. Wound healing was statistically significantly superior in the OFD + LLLT group in comparison to the OFD group, indicating a positive effect of lasers on healing. Gingival crevicular fluid ALP levels in the two groups decreased after 6 months and a statistically significant reduction in the laser group indicated an anti-inflammatory effect.

Conclusion: The results clearly indicated the efficacy of lasers in terms of acceleration of wound healing and control of inflammation.

Clinical significance: Lasers as an adjunct to surgical periodontal therapy evidently have an anti-inflammatory effect (decrease in GCF ALP levels) as well as accelerate the wound healing process.

Keywords: Accelerated wound healing, Alkaline phosphatase, Chronic periodontitis, Gingival crevicular fluid, Low-level laser therapy.

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Introduction

Periodontal disease is an inflammatory disease of the structures supporting the teeth leading to increased probing depth due to attachment and alveolar bone loss, inflammation of periodontium, bleeding on probing being its earliest sign, and worst being the loss of tooth or teeth. The treatment modalities can be both nonsurgical and surgical based on the severity and extent of the periodontal disease. Scaling and root planning being the preliminary step should be done before any intervention. Surgical therapy aims to gain access to underlying roots and bone and henceforth their debridement is done through a process known as open flap debridement (OFD)/access flap operation.

Laser as an adjunctive therapy (LLLT) to periodontal therapies has been proven as a successful treatment modality and is quite popular nowadays. The first laser apparatus was designed by T.H. Maiman in 1960.[1] It was used in dentistry by Goldman in 1964.[2]

Low-level laser therapy/laser biostimulation/soft laser therapy/biomodulation[3] is the irradiation of tissues by laser in noncontact mode and at low power. Treatment with low-intensity lasers to improve wound healing has been applied since 1967 when Mester first showed an acceleration in the healing of wounds in mice stimulated with a ruby laser.[4] It was observed that the application of 1 J/cm^2 of laser[5] resulted in the healing of the lesion. The dosage of LLLT ranges from 0.3 to 19 J/cm^2. Its principle is based on the Arndt–Schulz law, wherein a low dose of lasers stimulates physiological processes with increased production of ATP. The penetration of LLLT red or infrared in soft and hard tissue is between 3 and 15 mm. The absorption of laser light in cellular photoreceptors like in the transfer of electrons in the cytochrome c oxidase pathway of mitochondrial membrane results in their activation and oxidation of NADH, leading to enhanced ATP production, which, in turn, activates and synthesize nucleus further, resulting in driving force to the cells.

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The LLLT serves many purposes like the antibacterial and anti-inflammatory effects, reduces post-op pain and discomfort, and accelerates wound healing through stimulation of fibroblasts.

It reduces inflammation through various mechanisms like affecting the COX enzymes and hence decreases prostaglandin synthesis (PGE2 mainly), decreases inflammatory mediators (IL-1β, TNF-α, IFN-γ), inhibits the production of matrix metalloproteinases (MMP-8), stimulates the production of growth factors (PDGF, TGF, and FGF).

With its anti-inflammatory effect, LLLT contributes to accelerated wound healing by starting the inflammatory phase of wound healing sooner, stimulating fibroblasts, and hence collagenous fiber production along with the role of growth factors. It also causes vasodilation responsible for increased blood perfusion and hence enhanced cellular migration and proliferation at the wound site.

Pain reduction is another positive effect of soft laser therapy that is achieved by a direct effect on the release of endorphins and enkephalins, which help relieve pain, reduce inflammation, and enhance wound healing.

The lasers exert their antibacterial effect by directly penetrating the cell wall of bacteria and affecting the protein complexes by causing their disintegration or indirectly with the help of chemical photosensitizer making them more susceptible to killing. The numerous positive effects of LLLT make it a beneficial adjunctive treatment modality to various periodontal therapies.

Gingival crevicular fluid contains three types of mediators namely: tissue breakdown products, Host-derived enzymes and their inhibitors, inflammatory mediators, and host response modifiers. Alkaline phosphatase (ALP) is classified as a host-derived enzyme of the GCF inflammatory biomarkers. It is one of the first host-derived enzymes identified in GCF in cases of inflammation. The potentiality of ALP as an important biochemical marker of GCF was identified by Ishikawa and Cimasoni in 1970.[6]

Alkaline phosphatase is a membrane-bound glycoprotein released by various cells in and around the periodontium and gingival sulcus. It is secreted from polymorphonuclear neutrophils during inflammation, osteoblasts during the formation of bone, and periodontal ligament fibroblasts during the regeneration of periodontal tissues. Thus, it plays a dual role in the progression of inflammation of periodontium and regeneration or healing of tissues.[7]

The activity of ALP is valuable for diagnosing the activity of periodontal disease as the enzyme-related alterations occur at the GCF levels much earlier than the clinically significant changes indicating disease progression.

This study has been undertaken to assess the efficacy of low-level laser therapy (LLLT) as an adjunctive treatment modality to OFD on wound healing, GCF ALP, and clinical parameters. Since, lasers have been used an adjunctive approach for a long time and have shown promising results published in literature including reduction of inflammation, post-op pain relief, and enhanced healing potential by the effect on different cells as well as reduction in bacterial count. It is because of these number of advantages it offers the present study has incorporated its use to unleash its true potential in the best interest of the patient.

Materials and Methods

Study Design

In the present split-mouth design study, 30 subjects including both genders and in the age-group 18–50 years were selected for final analysis after excluding those lost to follow-up and sample contamination from the OPD of Periodontics Department of ITS Dental College, Greater Noida, willing to give written consent for taking part in the study (Fig. 1).

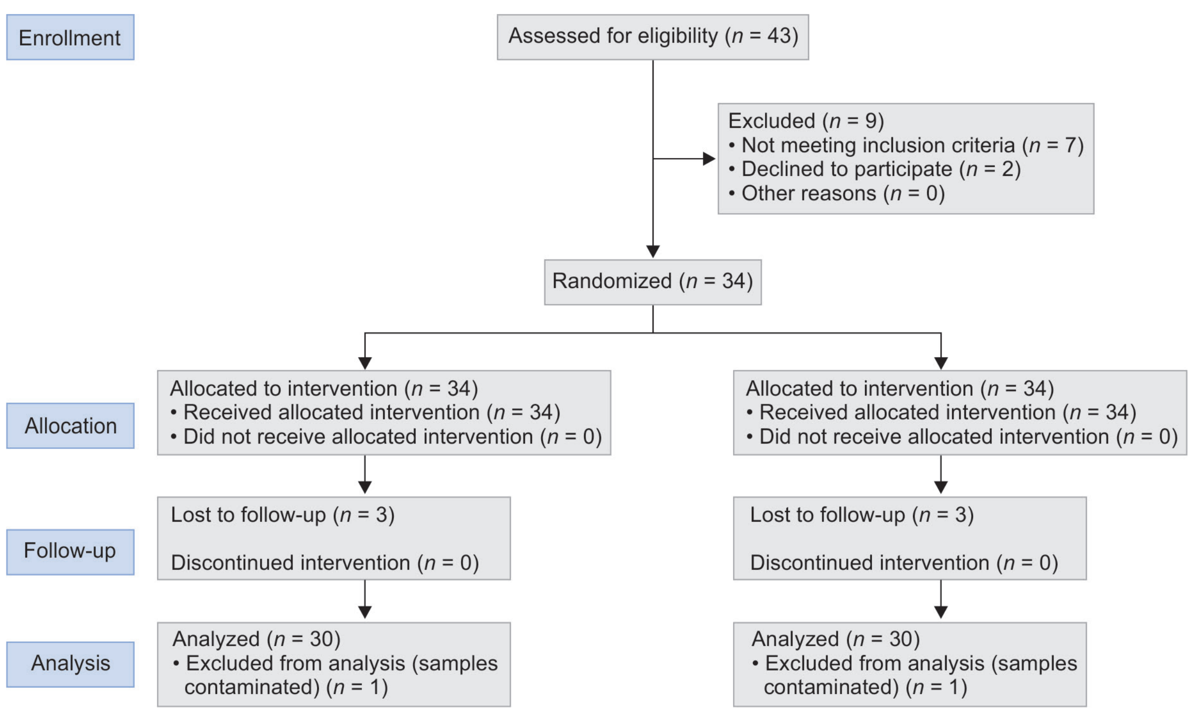

Fig. 1: Study design CONSORT flow diagram

Sample Size Calculation

Level of significance = 5%, Power = 80%, Type of test = two-sided

The formula for calculating sample size is: Sample size for a clinical trial (outcome variable on a ratio scale and testing null hypothesis

$$n = 2\,\frac{S^2(Z1+Z2)^2}{(M1-M2)^2}$$

t tests - Means: Difference between two independent means (two groups)

Analysis: *a priori*: Compute the required sample size
Input: Tail(s) = Two
Effect size d = 0.74
α err prob = 0.05
Power (1-β err prob) = 0.80
Allocation ratio N2/N1 = 1
Output: Noncentrality parameter δ = 2.866
Critical t = 2.001
Df = 58
Sample size group I = 30
Sample size group II = 30
Actual power = 0.841

A power analysis was established by G*Power version 3.0.1 (Franz Faul Universität, Kiel, Germany). A total calculated sample size of 30 subjects for split-mouth study design to adjust for attrition/loss to follow-up (30 subjects – Group I, same 30 subjects – Group II) would yield 80% power to detect significant differences, with an effect size of 0.74 and significance level at 0.05.

Data Collection

The study was duly approved by the Institutional Ethics Committee (IEC) Reference No. IEC/PERIO/2/21. The study was undertaken in July 2022 and completed in August 2023. The two groups are as follows: the test group with 34 patients where bio-stimulation with a diode laser (Biolase, Epic X, USA) with OFD was used on one side of the mouth (OFD+LLLT group), control group with the same 34 patients underwent OFD on the other side (OFD group).

Inclusion Criteria

- Patients afflicted with periodontitis showing evidence of horizontal bone loss on radiographs,
- Probing depth more than equal to 4 and less than or equal to 7,
- Presence of at least 20 natural teeth in the mouth.

Exclusion Criteria

- Patients who were smokers,
- Pregnant and lactating females,
- Those with a history of diabetes, hypertension, and other systemic-related diseases affecting the periodontium,
- Having an allergy to medications,
- Who have received surgical or non-surgical treatment 6 months prior.

Surgical Procedure

The OFD technique used was as described by – By Kirkland in 1931 known as Kirkland flap/Modified flap operation.

Fig. 2: Placement of intracrevicular incisions

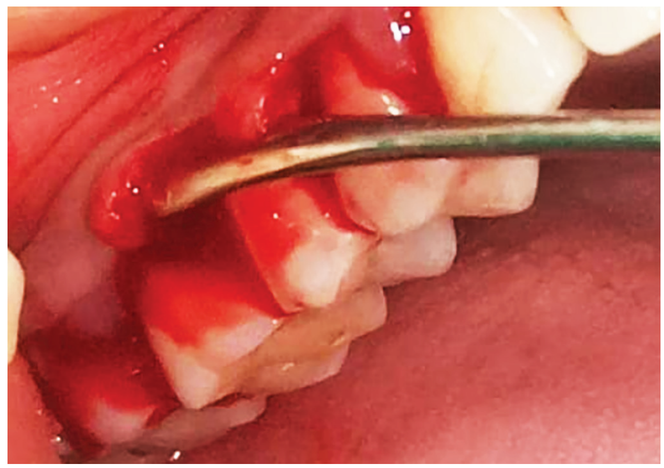

Fig. 3: Flap reflection

Control group—The procedure is as follows:

- Step I: Administration of 2% lignocaine hydrochloride solution with adrenaline (1:80,000).
- Step II: The intracrevicular incisions were placed using #15 blade (Fig. 2).
- Step III: The buccal and lingual/palatal flaps were reflected (Fig. 3).
- Step IV: The tooth roots were meticulously cleaned by scaling and thorough root planning, and complete debridement was done to eliminate all the granulation tissue (Fig. 4).
- Step V: Both the flaps were approximated by placing sutures (simply interrupted) (Fig. 5).

Test group—Steps 1–4 were performed the same as the control group.

After that, the patient and staff of the operating room were made to wear safety laser glasses. LLLT was performed by movements in a sweeping motion with the tip of the diode laser (Biolase, Epic X, USA) in apical to coronal (vertically) and mesial to distal (horizontally) directions (Fig. 6) on four surfaces (Mesio-buccal, mid buccal, disto-buccal, and lingual/palatal) and the inner surface of flap using horizontal strokes. This was performed for a

Fig. 4: Complete debridement of root surfaces and granulation tissue removed

Fig. 5: Sutures placed

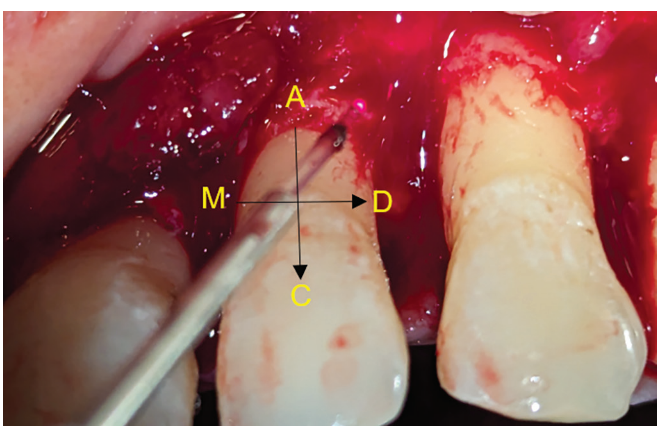

Fig. 6: Low-level laser therapy done on the test site in apico (A)-coronal (C) and Mesio (M)-distal (D) direction in sweeping motion on buccal surface being performed

time period of 10 seconds in non-contact mode on each surface with a power of 1.0 watts. Finally, flaps were approximated in the same manner as the control group.

Outcome Analysis

At the baseline visit, the assessment of the following clinical parameters were as follows: pocket probing depth (PPD), plaque index, GI, and clinical attachment level was done, and a GCF sample was collected. After a 1-week recall visit, wound healing indices were clinically evaluated using the early wound healing score by Wachtel et al.,[8] the Landry index[9] was recorded for both groups. The early wound healing score is assigned between 0 and 10 based on clinical signs of inflammation, re-epithelialization, and hemostasis. Here, 0 indicates worst while 10 indicates ideal healing. The healing index (HI) by Landry et al.[9] designates a score between 1 and 5 to assess the healing based on tissue color, granulation tissue, bleeding on palpation, suppuration, and epithelialization on incision margin, one designates very poor healing and five indicates excellent healing of the tissues. The better the healing the higher the score. The clinical variables: pocket probing depth (PPD), plaque index (PI) – Silness and Loe, GI – Loe and Silness, clinical attachment level (CAL) were estimated at 3 and 6 months recall after treatment. While GCF ALP levels were assessed at baseline and recall of 6 months. An enzyme-linked immuno-sorbent assay (ELISA) kit (Biospes, China) was used to assess the levels of inflammatory mediators.

Statistical Analysis

- Statistical Product and Service Solution (SPSS) version 21 for Windows (Armonk, NY: IBM Corp) software was used to calculate the data.
- An unpaired t-test was used to find significant differences between both groups for parametric distribution data.
- Paired t-test to find a level of significance within each group for parametric distribution data was used.
- The chi-square test was taken to find statistically significant differences for intergroup comparison for percentage/proportion data.

Results

After screening for OPD according to exclusion and inclusion criteria a total of 34 patients remained on which intervention was performed out of which three lost to follow-up and 1 was excluded for other reasons. Therefore, in the current study, a sum total of 224 sites from 30 systemically healthy patients afflicted with periodontitis were incorporated for final evaluation, of which 118 sites were in the OFD + LLLT group and 106 sites were in the OFD group. The participants enrolled were 14 males and 16 females. Open flap surgery with and without the application of lasers in both groups, respectively, was performed. The clinical variables, GCF sample for ALP, and wound healing indices were evaluated at different follow-up visits.

On intragroup comparison, the Plaque index decreased from 1.84 ± 0.53 at baseline to 0.8 ± 0.30 and 0.59 ± 0.2 at 3 and 6 months for the test group and from 1.8 ± 0.63 at baseline to 0.81 ± 0.36 and 0.59 ± 0.21 at 3 and 6 months for the control group. On intergroup comparison at any interval, no statistically evident difference was seen *p*-values 0.92 and 0.99 at 3 and 6 months (Table 1).

For GI intragroup comparison at baseline, 3 and 6 months interval reduction for the test group are 1.74 ± 0.45, 1.11 ± 0.38, and 0.756 ± 0.36, and control group are 1.76 ± 0.54, 1.09 ± 0.48, and 0.758 ± 0.42 with no statistically significant difference between the control and test group at 3 months (*p*-value 0.895) and 6 months (*p*-value 0.990) (Table 1).

Table 1: Intergroup comparison of various clinical parameters at baseline 3- and 6-month intervals

		Test group	*Control group*	*Intergroup comparison*
Clinical parameters	*Time Interval*	*Mean ± SD*	*Mean ± SD*	*p-value*
Plaque index (PI)	At baseline	1.84 ± 0.53	1.8 ± 0.63	0.798
	3 months	0.8 ± 0.3	0.81 ± 0.36	0.921
	6 months	0.59 ± 0.2	0.59 ± 0.21	0.990
Gingival index (GI)	At baseline	1.74 ± 0.45	1.76 ± 0.54	0.875
	3 months	1.11 ± 0.38	1.09 ± 0.48	0.895
	6 months	0.756 ± 0.36	0.758 ± 0.42	0.990
Pocket probing depth (PPD)	At baseline	5.83 ± 0.69	5.86 ± 0.77	0.862
	3 months	3.43 ± 0.5	3.5 ± 0.75	0.634
	6 months	3.23 ± 0.43	3.23 ± 0.43	1.000
Clinical attachment level (CAL)	At baseline	2.14 ± 0.39	2.32 ± 0.32	0.056
	3 months	1.42 ± 0.35	1.54 ± 0.72	0.220
	6 months	1.25 ± 0.42	1.41 ± 0.63	0.120

Table 2: Intergroup comparison of GCF ALP levels at baseline and 6-month interval

		Test group	*Control group*	*Intergroup comparison*
Biomarkers	*Time Interval*	*Mean ± SD*	*Mean ± SD*	*p-value*
Alkaline phosphatase (ALP)	At baseline	20.7 ± 3.04	20.46 ± 2.81	0.757
	6 months	11.71 ± 2.27	14.41 ± 2.85	<0.001[aa]

[aa]Highly statistically significant

The CAL gain occurred in the test group from baseline (2.14 ± 0.39) to 3 months (1.42 ± 0.35) and 6 months (1.25 ± 0.42) as well as the control group from baseline (2.32 ± 0.32) to 3 and 6 months (1.54 ± 0.72, 1.41 ± 0.63), but intergroup comparison showed no difference at 3 months (0.220) and 6 months (0.120) (Table 1).

There was a significant reduction in pocket depth in the test group (5.83 ± 0.69, 3.43 ± 0.5, 3.23 ± 0.43) and control group (5.86 ± 0.77, 3.5 ± 0.75, 3.23 ± 0.43) from baseline to 3 and 6 months but no difference between the two groups at 3 months (0.634) and 6 months (1.000) (Table 1).

The results show a marked decrease in ALP levels in GCF from baseline to that after 6 months in the test (20.7 ± 3.04 to 11.71 ± 2.27) and control groups (20.46 ± 2.81 to 14.41 ± 2.85) with a statistically significant more reduction in the test group at 6 months (p-value < 0.001) on the intergroup comparison (Table 2, Fig. 7).

The wound healing indices were recorded after 1 week to assess the surgical site healing and it was found that both the indices indicate superior healing in the OFD + LLLT group as compared to the OFD group with p-value < 0.008 for early wound healing score and < 0.011 for HI, which shows the difference is statistically significant between the two groups (Table 3 and Fig. 8).

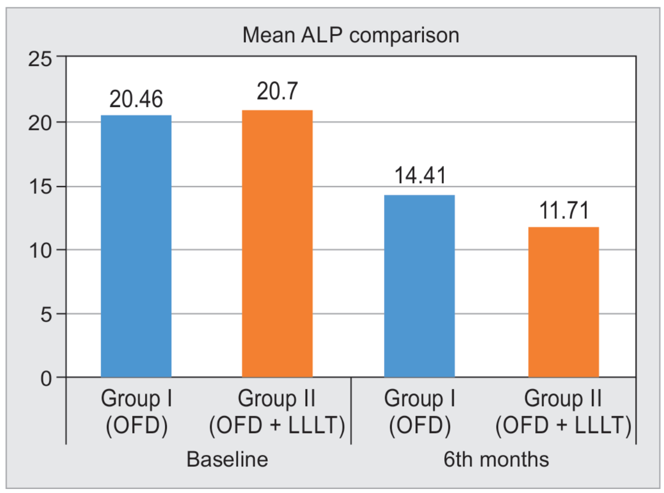

Fig. 7: Alkaline phosphatase level in GCF at baseline and 6 months

Discussion

Periodontal diseases are inflammatory diseases causing damage to the tooth and its supporting structures in which dental plaque is the main etiologic agent,[10] leading to its progression while other factors play a secondary role. Hence, it is of utmost importance to remove it completely for the success of periodontal therapies.

This study was done on 30 patients with periodontitis to assess the efficacy of LLLT as an adjunctive treatment approach to OFD on clinical and biochemical parameters along with the healing of wounds on surgical sites.

The clinical parameters evaluated in this study are PI, GI, PPD, and CAL, where PI – Silness and Loe[11] reflects the oral hygiene status of the individual and shows a tendency towards progressively improving it, whereas in the GI, Loe and Silness[12] assess the inflammation of gingiva. The PPD and CAL are indicative of the extent and severity of the destruction of both soft and hard tissues caused by the disease progression.

The result analysis of the study shows a significant decrease in all the clinical parameters from the start of the study to 3 and 6-month interval, but on the intergroup comparison, no statistically evident difference between the groups was noted. This can be explained by the fact that effective OFD contributed to better oral hygiene maintenance by the subjects as periodontal pockets act as a niche

Table 3: Intergroup comparison of wound healing indices post 1-week surgical therapy

		Test group	*Control group*	*Intergroup comparison*
Wound healing index	*Time Interval*	*Mean ± SD*	*Mean ± SD*	*p-value*
Early wound healing score	After 1 week	8.16 ± 0.83	7.5 ± 1.04	0.008[a]
Healing index	After 1 week	4.33 ± 0.6	3.9 ± 0.66	0.011[a]

[a]Statistically significant

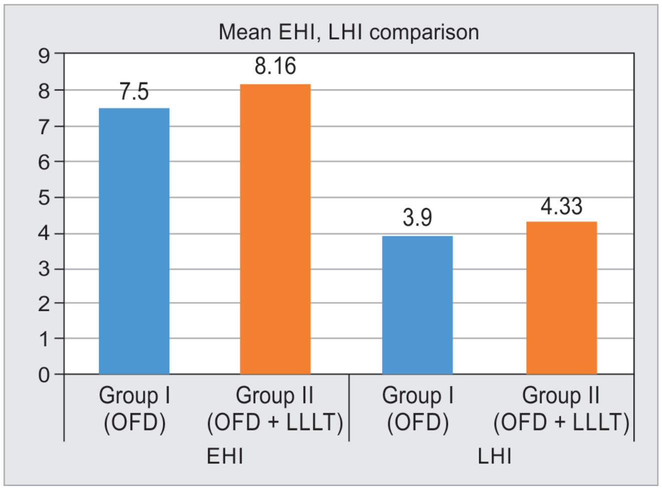

Fig. 8: Wound healing indices comparison between the control and test groups

for further plaque accumulation and attachment loss. Also, the local irritating factors (plaque and calculus) along with pocket lining have been removed reducing the overall inflammation. The results are in accordance with the study done by Al Shbool et al.[13] and Misra P et al.,[14] stated in their study that LLLT adjunctive to periodontal flap surgery serves no additional benefits. Contradictory to the results of this study, Karthikeyan J et al.[15] reported that diode laser provides additional benefits along with Kirkland flap surgery in improving the clinical variables.

Low-level laser therapy as an adjunctive treatment approach provides numerous benefits like reducing inflammation and reducing or inhibiting some of the mediators of inflammation thereafter.[16]

Low-level laser therapy mechanism of action is based on the bio-stimulation of cells where exposure to specific wavelength results in alteration in cellular metabolism and enhances its stimulation and proliferation. Through intracellular metabolic changes, it speeds up matrix formation, fibroblast migration, and cell division leading to the acceleration of the wound-healing process.[17] Low-level laser therapy boosts the chemotactic activity of leukocytes and aids in hemostasis. It also leads to accelerated epithelialization of wounds by enhancing phagocytic activity leading to fibrin breakdown. The direct inhibitory effect on various inflammatory mediators along with enhanced cellular activity contributes to its anti-inflammatory effect.

The inflammatory biomarkers act as potential determinants to assess the biochemical changes in the periodontal pocket, therefore the GCF ALP levels were analyzed to assess the prognosis and resultant outcome of periodontal treatment with low-dose laser therapy.

Alkaline phosphatase was first among the host enzymes to be identified in the GCF and its levels are three times more in GCF than in serum.[7] A significant correlation between ALP concentration in GCF and pocket depth was found by Cimasoni in 1970.[6] An increase in the activity of ALP is shown by histochemical methods in gingival inflammation, both in humans and in ferrets.[18]

The results revealed that laser has an adjunctive role to OFD in decreasing the ALP levels in chronic periodontitis patients from 0 to 6 months. Although there has been a significant decrease in ALP levels in the two groups from the start to 6 months after treatment, but the reduction was more statistically significant in the laser group in comparison to the OFD group. This can be explained by the fact that ALP is found in large amounts in granulation tissue of the lateral wall and the bottom of the periodontal pocket and that the PMNLs are among the greatest sources of ALP.[19] Therefore, after OFD and the combined anti-inflammatory action of lasers, the ALP levels in crevicular fluid decreased significantly with an overall resolution of inflammation.

In the study by Sanikop et al., to evaluate the ALP levels in GCF samples of three groups including healthy individuals, patients diagnosed with gingivitis, and chronic periodontitis, the outcome of the study indicated an evident relationship between ALP levels and periodontal disease and also designated ALP as a biomarker to diagnose the periodontal disease progression.[18]

The findings of the study are in accordance with the study conducted by Teymouri et al. in 2016, who found a decrease in the inflammatory mediators (IL-1β and IL-17) following diode laser application with periodontal therapy.[20]

Riya et al., in their study, found similar observations with the reduction in IL-1 Beta levels, which is a pro-inflammatory mediator using LLLT as an adjunct to periodontal therapy.[21]

The analysis of the previous studies is in conjunction with our study stating that ALP is a key biomarker in assessing the severity and progression of periodontal diseases. It is seen to be increased in deep pockets and therefore has a direct correlation with probing depth as more probing depth means increased ALP level.

Healing of wounds is a dynamic process involving four phases: hemostasis, inflammation, cell proliferation, and wound remodeling and maturation. It also involves various cells, cytokines, extracellular matrix, and growth factors.[22] In the present study, wound healing indices (by Wachtel et al. and Landry et al.) have shown superior healing in the OFD + LLLT group in comparison to the OFD group, which is consistent with the study done by Kolamala et al., who found better wound healing with lasers as a supplement at the third and seventh day postsurgery.[23] The improved wound healing is because of the action of lasers on the stimulation of fibroblast production and maturation, increases the release of fibroblast growth factor, moderates the inflammatory reactions, and starts the proliferative phase sooner, thereby increasing the collagenous fibers. It causes vasodilation, which is responsible for blood perfusion and also increases cell migration to the tissues, hence speeding up the repair process.[16]

These findings can be supported by the findings of Kohale et al., who found better healing outcomes using low-level laser application after scalpel gingivectomy as compared to scalpel gingivectomy alone.[24]

Silviya et al. found accelerated wound healing following the application of low-level therapy as an adjunct to single-flap periodontal surgery for the treatment of intrabony periodontal defects.[25]

The findings of this study are in contrast with the study by Jonnalagadda et al., who did not find any benefits of lasers in the healing of wounds.[26]

In a systematic review by Walsh et al. combining various studies, it has been observed that in most of the studies, LLLT has proved to be beneficial for the healing of wounds, action on immune cells as well as anti-inflammation effect.[27]

This study has found the benefits of lasers for anti-inflammatory effects and acceleration of the healing process, but no benefits on clinical parameters were observed. The study presents some limitations like a small sample size and short follow-up periods also, evaluation of GCF ALP levels were evaluated only at baseline and 6 months, and no in-between analysis was performed. The variety in results reported in various studies proves that inflammatory mediators released in GCF are site-specific and differ between individuals. They are also influenced by different environmental and genetic factors also vary according to the method of sample collection, processing, and analysis during which unintentional errors can occur. Within the limitations of the study, lasers have shown to be a beneficial adjunctive approach to periodontal surgical therapy.

Conclusion

The results of this study stated the anti-inflammatory effect of the laser by reducing the ALP level in GCF more in the test group in comparison to the control group which is statistically evident from baseline to 6 months. Also, superior healing outcomes were observed following the application of LLLT. The study did not show any additional benefits of laser application on clinical parameters while an overall improvement has been observed in both the groups. This study establishes the anti-inflammatory effect and effectiveness of lasers in improving and enhancing the healing of wounds. It also acts as a foundation for its implementation as an innovative treatment in periodontology for better outcomes for the utmost benefit and comfort of the patient.

Clinical Significance

The current literature provides evidence regarding the benefits of lasers as an adjunctive treatment approach to periodontal surgical therapy. It has numerous benefits like anti-inflammatory, angiogenesis, and hence superior healing, to enlist a few. Lasers should hence be incorporated as an adjunctive treatment modality to periodontal therapy by the clinicians as it has minimal side effects and maximum advantages as well as provides good patient comfort and satisfaction.

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