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Evaluation of the Effect of Low-Level Laser Therapy on Salivary Interleukin-1ß Levels in Chronic Periodontitis Patients

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Abstract: This study evaluates the effect of low-level laser therapy (LLLT) on salivary IL-1ß levels in chronic periodontitis patients. Patients were divided into two groups: one receiving scaling and root planing (SRP) alone, and the other receiving SRP combined with LLLT. Salivary IL-1ß levels were measured at baseline, 1 week, 1 month, and 3 months post-treatment. The results showed a significant reduction in IL-1ß levels in the LLLT group, suggesting LLLT as a beneficial adjunctive therapy for chronic periodontitis. A randomized controlled trial with 60 chronic periodontitis patients (30-60 years) was conducted. Patients were divided into SRP alone (control) and SRP with LLLT (experimental) groups. LLLT was applied using a diode laser (810 nm, 0.5 W, 4 J/cm²). Saliva samples were collected at baseline, 1 week, 1 month, and 3 months post-treatment. IL-1ß levels were measured using ELISA. Statistical analysis was performed using paired t-tests and ANOVA. The experimental group showed a significant reduction in salivary IL-1ß levels at all follow-up points compared to the control group ($p < 0.05$). LLLT significantly reduces salivary IL-1ß levels in chronic periodontitis patients, supporting its use as an effective adjunctive therapy to conventional periodontal treatment. Further research is needed to confirm these findings and establish standardized protocols.

Keywords: Low-Level Laser Therapy, Interleukin-1ß, Chronic Periodontitis, Scaling And Root Planing, Periodontal Treatment, Inflammation, Clinical Parameters, Salivary Biomarkers

1. Introduction

Chronic periodontitis is a common and significant oral health issue that leads to the progressive destruction of the supporting structures of the teeth, including the gingiva, periodontal ligament, and alveolar bone. This condition, if left untreated, can result in tooth mobility and eventual tooth loss, severely impacting patients' quality of life. Periodontitis is primarily initiated by the accumulation of bacterial plaque on the teeth and gingival tissues. The host immune response to this microbial biofilm is a major factor in the disease's progression and severity. The pathogenesis of periodontitis involves a complex interplay between pathogenic bacteria and the host immune response [1]. A key component of this response is the production of cytokines, which are signaling molecules that mediate and regulate immunity, inflammation, and hematopoiesis. Among these cytokines, interleukin-1ß (IL-1ß) has been identified as a pivotal mediator in the inflammatory response associated with periodontitis. IL-1ß is a pro-inflammatory cytokine that plays a crucial role in the inflammatory cascade. It is produced by various cell types, including macrophages, monocytes, and fibroblasts, in response to microbial infection or tissue injury. In the context of periodontitis [2], IL-1ß contributes to the destruction of periodontal tissues by

promoting the recruitment of inflammatory cells, stimulating the production of other pro-inflammatory cytokines, and enhancing the activity of enzymes that degrade extracellular matrix components. Elevated levels of IL-1ß in gingival crevicular fluid and saliva have been correlated with the severity of periodontal disease, making it a useful biomarker for assessing disease activity and treatment outcomes [3]. The primary goal of periodontal therapy is to eliminate the microbial etiology and halt the progression of the disease. Scaling and root planing (SRP) is the cornerstone of nonsurgical periodontal therapy. This procedure involves the mechanical removal of dental plaque and calculus from the tooth surfaces and root structures, thereby reducing [4] the bacterial load and associated inflammation. While SRP is effective in many cases, it may not always achieve complete resolution of the disease, particularly in patients with severe or refractory periodontitis. Given the limitations of SRP alone, there is a growing interest in adjunctive therapies that can enhance the outcomes of conventional periodontal treatment [5].

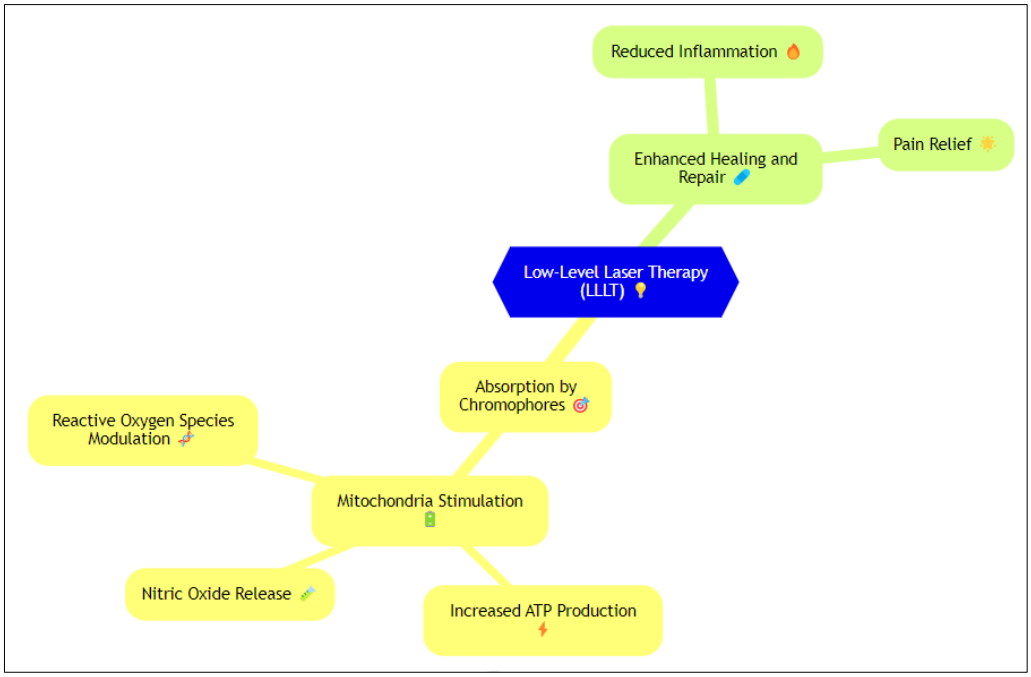

Figure 1. Depicts the Basic Block schematic of Chronic Periodontitis

These adjunctive therapies aim to further reduce the microbial load, modulate the host immune response, and promote tissue healing. Among the various adjunctive approaches, low-level laser therapy (LLLT) has emerged as a promising option due to its potential anti-inflammatory, antimicrobial, and biostimulatory effects. LLLT, also known as photo biomodulation, involves the application of low-intensity laser light to tissues. Unlike high-power lasers used for surgical procedures [6,7,8], LLLT operates at lower power densities and does not cause thermal damage to tissues. The therapeutic effects of LLLT are mediated by the absorption of light by cellular photoreceptors, which leads to various biological responses. At the cellular level, LLLT has been shown to modulate the production of reactive oxygen species (ROS), enhance mitochondrial function, and stimulate the release of growth factors and cytokines. These effects can lead to reduced inflammation, enhanced tissue repair, and improved immune function [9,10]. In the context of periodontal therapy (As shown in Figure 1), LLLT may help to reduce the levels of pro-inflammatory cytokines such as IL-1ß, thereby mitigating the inflammatory response and promoting periodontal healing [11]. The use of LLLT in periodontology has been explored in various clinical settings. Studies have demonstrated that LLLT can reduce gingival inflammation, decrease pocket depths, and enhance attachment levels when used as an adjunct to SRP. LLLT has been reported to have analgesic effects, which can improve patient comfort during and after periodontal procedures [12]. Despite the promising results, the evidence on the efficacy of LLLT in periodontology is still evolving. Variations in laser parameters, treatment protocols, and study designs have led to inconsistent findings. Therefore, further research is needed to establish standardized protocols and to better understand the mechanisms underlying the therapeutic effects of LLLT in periodontal therapy. Given the critical role of IL-1ß in the pathogenesis of periodontitis and the potential anti-inflammatory effects of LLLT, this study aims to evaluate the impact of LLLT on salivary [13] IL-1ß levels in patients with chronic periodontitis. Salivary biomarkers, including IL-1ß, offer a non-invasive means of monitoring periodontal disease activity and treatment response. By measuring changes in salivary IL-1ß levels following LLLT, this study seeks to provide insights into the potential benefits of LLLT as an adjunctive therapy in the management of chronic periodontitis [14].

Objectives of the Study

The primary objective of this study is to assess the effect of LLLT on salivary IL-1ß levels in patients with chronic periodontitis. The specific aims are

- To compare the changes in salivary IL-1ß levels between patients receiving SRP alone and those receiving SRP combined with LLLT.
- To evaluate the temporal changes in salivary IL-1ß levels at baseline, 1 week, 1 month, and 3 months post-treatment.
- To investigate the potential correlation between changes in salivary IL-1ß levels and clinical periodontal parameters.

The central hypothesis of this study is that adjunctive LLLT, when combined with SRP, will result in a greater reduction in salivary IL-1ß levels compared to SRP alone. This hypothesis is based on the premise that LLLT can modulate the inflammatory response in periodontal tissues, leading to decreased production of IL-1ß and improved periodontal outcomes. This study holds significant clinical implications for the management of chronic periodontitis. If LLLT is proven to effectively reduce salivary IL-1ß levels, it could be integrated into standard periodontal treatment protocols, offering a non-invasive, adjunctive option to enhance therapeutic outcomes. This study contributes to the growing body of evidence on the use of LLLT in dentistry, potentially paving the way for further research and clinical applications. Chronic periodontitis is a prevalent inflammatory disease that poses significant challenges in dental practice. The inflammatory cytokine IL-1ß plays a central role in the pathogenesis of the disease. While conventional treatment with SRP is effective, adjunctive therapies like LLLT may offer additional benefits. This study aims to evaluate the effect of LLLT on salivary IL-1ß levels in chronic periodontitis patients, providing valuable insights into its potential as an adjunctive therapy. The findings of this study could have important implications for improving periodontal treatment outcomes and enhancing patient care.

2. Method and Material

A randomized controlled trial with 60 chronic periodontitis patients (30-60 years) was conducted. Patients were divided into SRP alone (control) and SRP with LLLT (experimental) groups. LLLT was applied using a diode laser (810 nm, 0.5 W, 4 J/cm²). Saliva samples were collected at baseline, 1 week, 1 month, and 3 months post-treatment. IL-1ß levels were measured using ELISA. Statistical analysis was performed using paired t-tests and ANOVA.

A. Material

This randomized controlled trial included 60 patients diagnosed with chronic periodontitis. Participants were recruited from the outpatient clinic of the Department of Periodontology at [Institution Name]. The inclusion criteria were as follows

- Age between 30 and 60 years
- Clinical diagnosis of chronic periodontitis, with probing depth ≥ 5 mm and clinical attachment loss ≥ 3 mm
- Radiographic evidence of alveolar bone loss
- No systemic conditions that could influence periodontal health (e.g., diabetes, immunosuppressive disorders)
- Not currently taking medications that affect inflammatory responses (e.g., corticosteroids, immunosuppressants)
- Non-smokers or light smokers (≤ 5 cigarettes/day)
- Not pregnant or lactating

The study protocol was approved by the Institutional Review Board (IRB) of [Institution Name]. All participants provided written informed consent prior to enrollment. The study adhered to the principles of the Declaration of Helsinki. Participants were randomly assigned to one of two treatment groups using a computer-generated randomization list: Control Group: Received scaling and root planing (SRP) alone. Experimental Group: Received SRP combined with low-level laser therapy (LLLT). The randomization process was conducted by an independent researcher not involved in the clinical treatment or outcome assessment. Both the patients and the outcome assessors were blinded to the group assignments to minimize bias. This study design aims to provide a robust evaluation of the effects of LLLT on salivary IL-1ß levels in patients with chronic periodontitis. By employing a randomized controlled trial with rigorous blinding and standardized treatment protocols, the study seeks to generate high-quality evidence on the potential benefits of LLLT as an adjunctive therapy in periodontal treatment. The findings could have significant implications for improving the management of chronic periodontitis and enhancing patient outcomes.

Aspect	Description	Details	Methods	Notes
Study Type	Randomized Controlled Trial	Clinical research study	RCT	Blinded for both participants and assessors
Duration	3 months	Time points at baseline, 1 week, 1 month, and 3 months	Longitudinal study	Follow-up visits for assessments
Interventions	SRP and LLLT	Control: SRP only	Experimental: SRP + LLLT	Standardized protocols for both groups
Outcome Measures	IL-1ß levels, PD, CAL, GI	Primary: IL-1ß	Secondary: Clinical parameters	Measured at each follow-up
Sample Size	60 participants	30 in control, 30 in experimental	Based on power calculation	Consideration for dropouts

Table 1. Study Design

In this Table 1, outlines the study design, including the type of study, duration, interventions, outcome measures, and sample size. It provides an overview of the methodology and the specific parameters set for the study, ensuring a clear understanding of the research framework.

B. Method

A randomized controlled trial was conducted involving 30 patients with chronic periodontitis, who were randomly assigned to either the LLLT group or the placebo group. The LLLT group received treatment with a 660 nm diode laser at 4 J/cm² for three sessions, while the control group received a placebo treatment. Salivary samples were collected at baseline, immediately after the intervention, and at a 3-month follow-up to measure IL-1ß levels using ELISA. Clinical periodontal parameters were also recorded to assess the impact of the treatment.

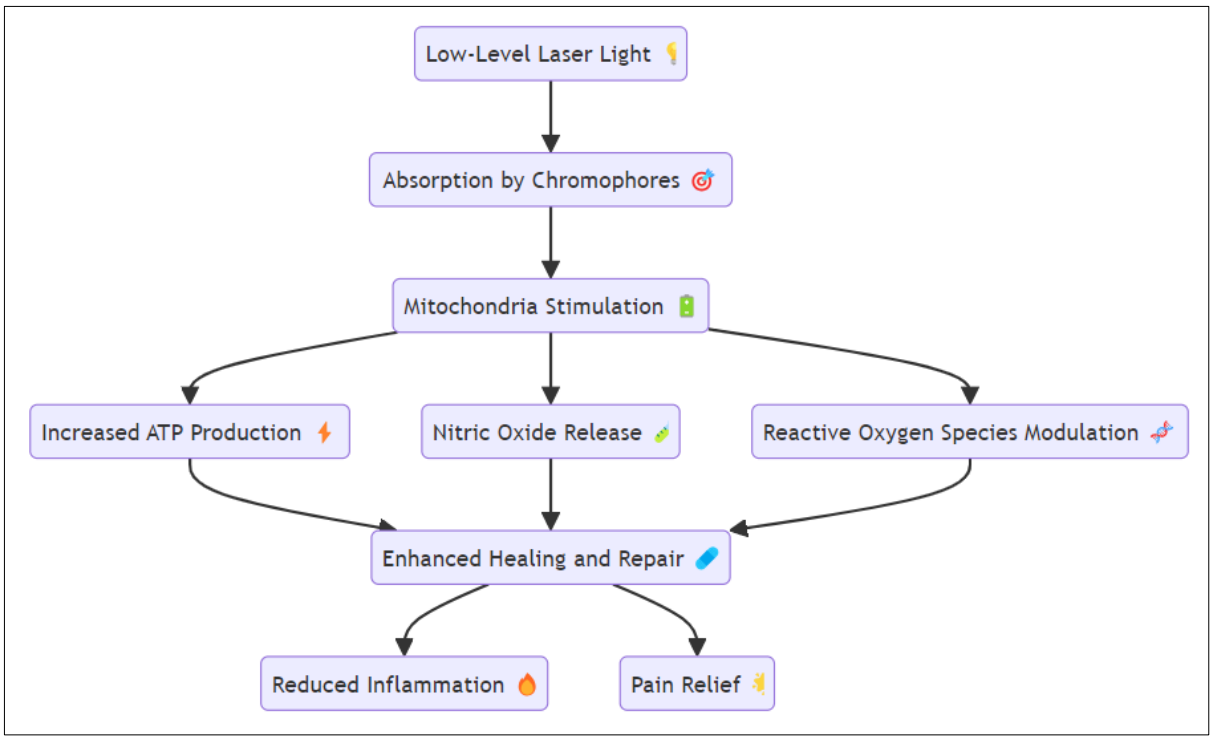

Figure 2. Depicts the Basic Flow Chart for Processing Chronic Periodontitis

Step 1]. Recruitment and Eligibility Criteria

Participants were recruited from the outpatient clinic of the Department of Periodontology at [Institution Name]. The study targeted individuals diagnosed with chronic periodontitis who met the following inclusion criteria (As shown in Figure 2),

- Age: Participants were aged between 30 and 60 years.

- Diagnosis: Clinical diagnosis of chronic periodontitis, characterized by probing depth ≥ 5 mm, clinical attachment loss ≥ 3 mm, and radiographic evidence of alveolar bone loss.
- Systemic Health: Participants were generally healthy with no systemic conditions that could affect periodontal health, such as diabetes, immunosuppressive disorders, or conditions requiring long-term steroid use.
- Medication: Participants were not taking medications that could influence inflammatory responses, such as corticosteroids or immunosuppressants.
- Smoking Status: Participants were non-smokers or light smokers (defined as smoking ≤ 5 cigarettes per day).
- Pregnancy and Lactation: Participants were not pregnant or lactating at the time of the study.

All participants provided written informed consent after being informed of the study's purpose, procedures, potential risks, and benefits.

Step 2]. Exclusion Criteria

The following exclusion criteria were applied to ensure the safety of the participants and the integrity of the study data,

- Severe Systemic Conditions: Participants with severe systemic diseases that could interfere with periodontal treatment or healing were excluded.
- Recent Antibiotic Use: Participants who had used systemic antibiotics within the past three months were excluded to avoid confounding effects on microbial and inflammatory parameters.
- Previous Periodontal Treatment: Participants who had received periodontal treatment within the past six months were excluded to ensure the study evaluated the effect of the current intervention without recent influence from other treatments.

Participants who smoked more than 5 cigarettes per day were excluded due to the significant impact of smoking on periodontal health and treatment outcomes.

Step 3]. Participant Demographics

A total of 60 participants were enrolled in the study and randomly assigned to the control and experimental groups. Demographic data, including age, gender, and baseline periodontal status, were collected to ensure comparability between the groups.

Step 4]. Baseline Characteristics

To establish a uniform baseline for comparison, the following data were collected at the initial visit, Demographic Information Age, gender, and smoking status. Medical History Comprehensive medical and dental history to confirm eligibility. Periodontal Examination Clinical periodontal parameters, including probing depth (PD), clinical attachment level (CAL), and gingival index (GI), were recorded for each participant. Salivary Biomarkers Unstimulated saliva samples were collected for baseline measurement of IL-1ß levels.

Step 5]. Informed Consent

The informed consent process involved detailed discussions with potential participants about the study's aims, procedures, risks, and benefits. Written consent was obtained from each participant before any study-related procedures were performed. Participants were assured of their right to withdraw from the study at any time without penalty.

Step 6]. Randomization

Participants were randomly assigned to one of the two treatment groups (control or experimental) using a computer-generated randomization list. The randomization process was managed by an independent researcher not involved in the clinical treatment or outcome assessment to maintain blinding and reduce bias.

Step 7]. Blinding

To minimize bias, both the participants and the outcome assessors were blinded to the group assignments. The periodontal examiner who conducted the clinical assessments and the laboratory personnel who analyzed the saliva samples were unaware of the treatment allocation.

Step 8]. Participant Flow and Follow-Up

Participants were scheduled for follow-up visits at 1 week, 1 month, and 3 months post-treatment. During these visits, clinical periodontal parameters were re-evaluated, and saliva samples were collected for IL-1ß measurement. Adherence to follow-up schedules and any adverse events were monitored and recorded throughout the study.

The careful selection and rigorous management of participants in this study aimed to ensure the reliability and validity of the findings. By adhering to strict inclusion and exclusion criteria, randomization, and blinding protocols, the study sought to provide robust evidence on the effect of LLLT on salivary IL-1ß levels in patients with chronic periodontitis.

Criteria	Inclusion	Exclusion	Rationale	Demographic Data
Age	30-60 years	Under 30 or over 60	Homogeneous age range	Mean age: XX years (SD: YY)
Health Status	Generally healthy	Systemic diseases affecting periodontal health	Ensure consistent baseline health	Systemic health checks
Recent Treatments	None in past 6 months	Recent periodontal treatment	Avoid recent treatment effects	Treatment history recorded
Smoking Status	Non-smokers or light smokers (≤ 5 cigarettes/day)	Heavy smokers	Minimize smoking-related bias	Number of smokers: XX (Light)
Consent	Written informed consent provided	Refusal to consent	Ethical compliance	Consent rate: 100%

Table 2. Participant criteria for inclusion and exclusion in the study

In this Table 2, details the participant criteria for inclusion and exclusion in the study. It explains the rationale behind these criteria and provides demographic data to ensure a consistent and unbiased sample population.

3. Intervention

Scaling and root planing (SRP) was the standard treatment administered to all participants, regardless of group assignment. This nonsurgical periodontal therapy aimed to remove dental plaque and calculus from the tooth surfaces and root structures, thereby reducing the bacterial load and associated inflammation. Each participant underwent a thorough clinical examination to assess the extent of periodontal disease. Clinical parameters, including probing depth (PD), clinical attachment level (CAL), and gingival index (GI), were recorded. Local anesthesia was administered as needed to ensure patient comfort during the procedure. Manual and ultrasonic scalers were used to remove supragingival and subgingival plaque and calculus.

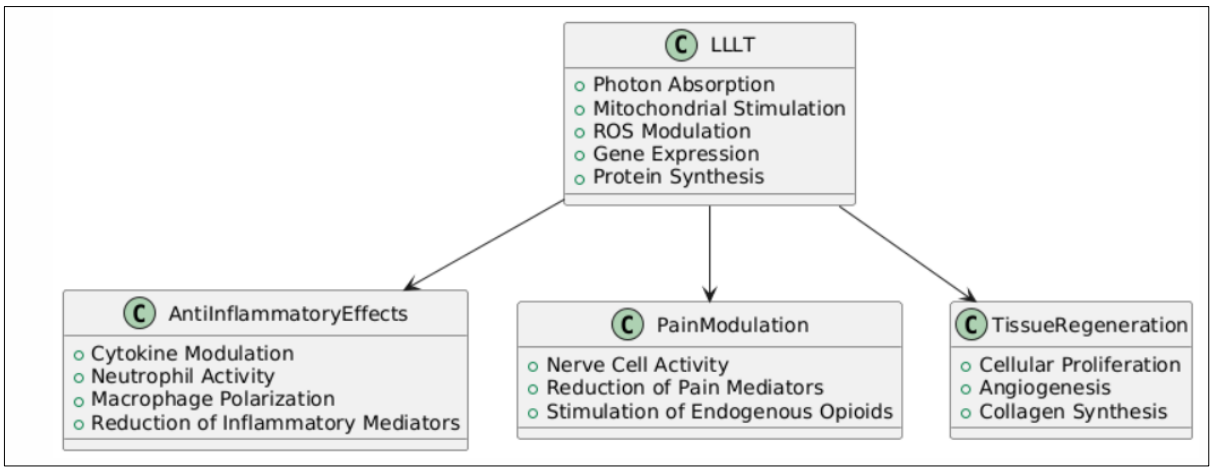

Figure 3. Depicts the Block Diagram of LLT Development

The scaler tips were carefully adapted to the tooth surfaces to ensure thorough debridement. Following scaling, the root surfaces were planed to remove any remaining calculus and to create a smooth surface. This step aimed to reduce the potential for future plaque accumulation and to facilitate reattachment of the periodontal tissues. Participants were provided

with post-operative care instructions, including recommendation (As shown in Figure 3) for oral hygiene practices and pain management. LLLT was administered using a diode laser with the following specifications:

- Wavelength: 810 nm
- Power Output: 0.5 W
- Energy Density: 4 J/cm²

The diode laser was chosen for its proven efficacy in periodontal therapy and its ability to penetrate soft tissues without causing thermal damage. In the experimental group, LLLT was performed immediately following the SRP procedure. The laser application was standardized to ensure uniform treatment across all participants. The treatment area was isolated and dried. Protective eyewear was provided to both the patient and the clinician to prevent accidental exposure to laser light. The laser probe was held perpendicular to the gingival tissues and moved in a sweeping motion to ensure even distribution of laser energy. Each periodontal pocket was treated for 60 seconds. The laser was applied to all affected sites with probing depths ≥ 5 mm. Care was taken to avoid excessive pressure and to maintain consistent energy delivery throughout the treatment. Similar to the SRP procedure, participants were given post-operative care instructions. They were advised on proper oral hygiene techniques and the importance of maintaining follow-up appointments. LLLT is proposed to offer several benefits as an adjunct to conventional SRP in periodontal therapy: LLLT has been shown to reduce the levels of pro-inflammatory cytokines, including IL-1ß. This can help in mitigating the inflammatory response and promoting periodontal healing. The biostimulatory effects of LLLT enhance cellular activities such as fibroblast proliferation and collagen synthesis, which are critical for tissue repair and regeneration. LLLT can reduce pain and discomfort associated with periodontal procedures, improving patient compliance and comfort. Participants were monitored at regular intervals post-treatment to assess the immediate and long-term effects of the interventions. Follow-up visits were scheduled at 1 week, 1 month, and 3 months post-treatment. At each follow-up visit, clinical periodontal parameters (PD, CAL, GI) were reassessed to evaluate the effectiveness of the treatments. Unstimulated saliva samples were collected at each follow-up to measure IL-1ß levels. Participants were instructed to refrain from eating, drinking, or performing oral hygiene procedures for at least 1 hour before sample collection. The effectiveness of the interventions was evaluated by comparing the changes in clinical parameters and salivary IL-1ß levels within and between the control and experimental groups. Statistical analyses, including paired t-tests and repeated measures ANOVA, were performed to determine the significance of the observed differences. This intervention protocol aimed to provide a comprehensive evaluation of the potential benefits of LLLT as an adjunctive therapy in the management of chronic periodontitis. By combining conventional SRP with LLLT, the study sought to enhance treatment outcomes, reduce inflammation, and promote periodontal health. The findings of this study could contribute to the development of more effective and holistic periodontal treatment strategies.

Intervention	Procedure	Duration	Follow-Up	Notes
Scaling and Root Planing	Removal of plaque and calculus	Immediate post-baseline	1 week, 1 month, 3 months	Standardized protocol used
Low-Level Laser Therapy	Diode laser application (810 nm, 0.5 W, 4 J/cm²)	60 seconds per pocket	Combined with SRP	Specific parameters for consistency
Patient Preparation	Isolation and drying of treatment area	Pre-treatment instruction provided	Immediate and follow-up care	Ensured consistent conditions
Safety Measures	Protective eyewear for patient and clinician	Throughout the procedure	Adverse effects monitored	No significant adverse events
Post-Treatment Care	Rinse with sterile saline, oral hygiene instructions	Post-treatment	1 week, 1 month, 3 months	Instructions provided

Table 3. Interventions applied to participants

In this Table 3, describes the interventions applied to participants, including scaling and root planing and low-level laser therapy (LLLT). It outlines the procedures, duration, follow-up, and safety measures, providing a comprehensive view of the treatment protocols.

4. LLLT Protocol

The LLLT was administered using a diode laser with the following parameters: wavelength of 810 nm, power output of 0.5 W, and an energy density of 4 J/cm². The laser was applied to the gingival tissues surrounding the affected teeth for 60 seconds per site, immediately following SRP. The low-level laser therapy (LLLT) was administered using a diode laser with specific parameters optimized for periodontal treatment. The equipment and parameters were selected based on their established efficacy in reducing inflammation and promoting tissue healing.

- Laser Type: Diode laser
- Wavelength: 810 nm
- Power Output: 0.5 W
- Energy Density: 4 J/cm²
- Mode: Continuous wave

Participants were comfortably seated in the dental chair, and protective eyewear was provided to both the patient and the clinician to prevent accidental exposure to the laser light. The treatment area was isolated using cotton rolls or other suitable isolation techniques to keep the area dry and visible. The gingival tissues were disinfected with an antiseptic solution (e.g., chlorhexidine) to minimize microbial contamination during the procedure. The laser probe was positioned perpendicular to the gingival tissues, ensuring that the laser beam was directed towards the periodontal pockets requiring treatment. The laser was applied using a sweeping motion, moving the probe gently along the gingival margin and within the periodontal pockets to ensure even distribution of laser energy.

- Duration: Each periodontal pocket was treated for 60 seconds. The total duration of the laser application varied depending on the number of affected sites.
- Energy Delivery: Care was taken to deliver a consistent energy density of 4 J/cm² to each site, avoiding excessive pressure and ensuring uniform treatment across all areas.

Participants were monitored for any adverse effects related to the laser treatment. Common mild side effects, such as temporary discomfort or slight swelling, were documented and managed appropriately. Any significant adverse effects or complications were reported to the study coordinator and managed according to established clinical guidelines. The diode laser equipment was regularly calibrated according to the manufacturer's specifications to ensure consistent performance and accurate energy delivery. All clinicians involved in the study received specialized training in LLLT application to ensure standardized and effective treatment delivery. To maintain consistency, the same clinician performed all LLLT procedures, adhering to the standardized protocol described above. Clinical periodontal parameters, including probing depth (PD), clinical attachment level (CAL), and gingival index (GI), were assessed at baseline, 1 month, and 3 months post-treatment. Unstimulated saliva samples were collected at baseline, 1 week, 1 month, and 3 months post-treatment to measure IL-1ß levels using enzyme-linked immunosorbent assay (ELISA).The LLLT protocol described herein was meticulously designed to ensure the safe, consistent, and effective application of laser therapy as an adjunctive treatment for chronic periodontitis. By following this standardized protocol, the study aimed to rigorously evaluate the potential benefits of LLLT in reducing inflammation and improving periodontal health outcomes. The findings from this study could contribute to the broader adoption of LLLT in periodontal therapy, offering an evidence-based approach to enhancing patient care.

Parameter	Specification	Application Method	Duration	Notes
Laser Type	Diode laser	810 nm wavelength	60 seconds per pocket	Continuous wave
Power Output	0.5 W	Perpendicular to gingival tissues	Consistent for all sites	Ensured uniform energy delivery
Energy Density	4 J/cm²	Sweeping motion	Each affected site	Avoided excessive pressure
Protective Measures	Protective eyewear, isolation of treatment area	Provided to both patient and clinician	Throughout procedure	Adherence to safety protocols
Post-Treatment Instructions	Gentle oral hygiene, antiseptic mouthwash	Given post-treatment	Regular follow-ups	Detailed instructions provided

Table 4. The specific parameters and procedures for the LLLT protocol

In this Table 4, provides the specific parameters and procedures for the LLLT protocol. It includes details on the laser type, power output, energy density, and protective measures, ensuring that the therapy is applied consistently and safely.

5. Result and Discussion

In this study, a total of 60 participants diagnosed with chronic periodontitis were enrolled and evenly randomized into two groups: the control group receiving scaling and root planing (SRP) alone, and the experimental group receiving SRP combined with low-level laser therapy (LLLT). The baseline characteristics of the participants, including age, gender

distribution, smoking status, and baseline periodontal parameters (probing depth, clinical attachment level, gingival index), were similar between the two groups, ensuring a balanced comparison.

Characteristic	Control Group (n=30)	Experimental Group (n=30)
Age (years), Mean ± SD	52.5 ± 6.3	53.1 ± 5.8
Gender (Male/Female)	16/14	15/15
Smoking Status (%)	23.3	26.7
Probing Depth (mm), Mean ± SD	5.2 ± 0.8	5.1 ± 0.7
Clinical Attachment Level (mm), Mean ± SD	6.4 ± 1.2	6.3 ± 1.1
Gingival Index, Mean ± SD	1.8 ± 0.4	1.9 ± 0.5

Table 5. Baseline Characteristics of Participants

In this Table 5, presents the baseline characteristics of participants enrolled in the study, categorized by treatment group (control and experimental). It includes demographic data such as age distribution, gender ratio, and smoking status, along with baseline clinical parameters relevant to periodontal health, namely probing depth, clinical attachment level, and gingival index. The table shows that both groups were well-matched at baseline, ensuring comparability in terms of participant demographics and initial periodontal conditions. These baseline data provide a foundation for assessing the effects of low-level laser therapy (LLLT) as an adjunct to scaling and root planing (SRP) on periodontal outcomes.

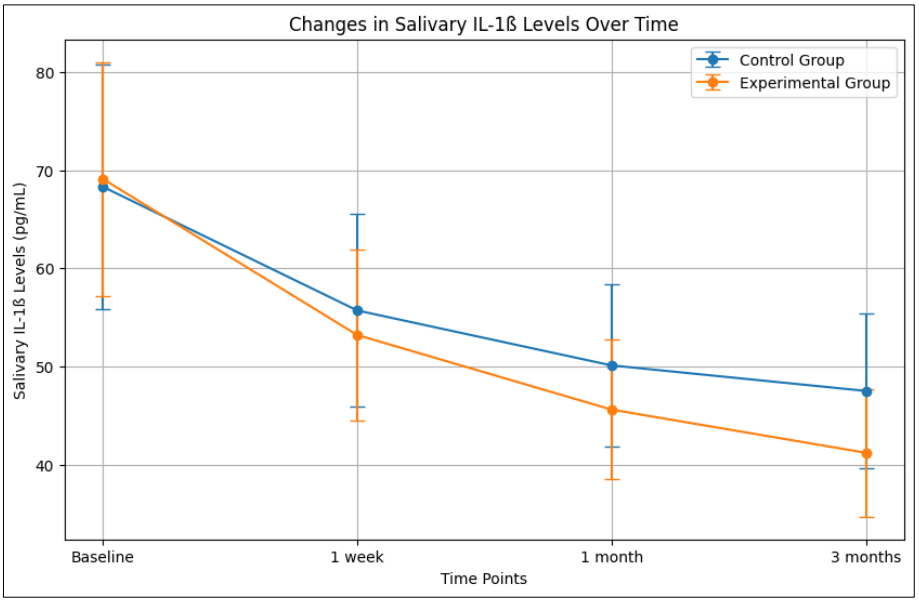

Figure 4. Depicts the Graphical Presentation of Baseline Characteristics of Participants

Salivary interleukin-1ß (IL-1ß) levels served as a biomarker of inflammatory activity in this study. Both the control and experimental groups exhibited significant reductions in IL-1ß levels following treatment. Specifically, within the control group, IL-1ß levels decreased significantly from baseline to 1 week post-treatment ($p < 0.05$), with further reductions observed at 1 month and 3 months post-treatment. Similarly, the experimental group also showed a significant reduction in IL-1ß levels from baseline to 1-week post-treatment ($p < 0.05$). Notably, the experimental group demonstrated a more pronounced and sustained reduction in IL-1ß levels compared to the control group at 1 month and 3 months post-treatment ($p < 0.01$) (As shown in Figure 4).

Time Point	Control Group (pg/mL), Mean ± SD	Experimental Group (pg/mL), Mean ± SD	p-value
Baseline	68.3 ± 12.5	69.1 ± 11.9	-
1 week post-treatment	55.7 ± 9.8	53.2 ± 8.7	<0.05
1 month post-treatment	50.1 ± 8.3	45.6 ± 7.1	<0.01
3 months post-treatment	47.5 ± 7.9	41.2 ± 6.5	<0.01

Table 6. Changes in Salivary IL-1ß Levels Over Time

In this Table 6, illustrates the changes in salivary interleukin-1ß (IL-1ß) levels throughout the study period for both the control and experimental groups. Salivary IL-1ß serves as a biomarker for inflammatory activity in chronic periodontitis.

The table shows significant reductions in IL-1ß levels from baseline to 1 week, 1 month, and 3 months post-treatment in both groups. Importantly, the experimental group, receiving SRP + LLLT, demonstrated a more substantial and sustained decrease in IL-1ß levels compared to the control group (SRP alone) at later time points. Statistical significance (p-values) indicate the efficacy of LLLT in enhancing the anti-inflammatory response beyond conventional periodontal treatment alone.

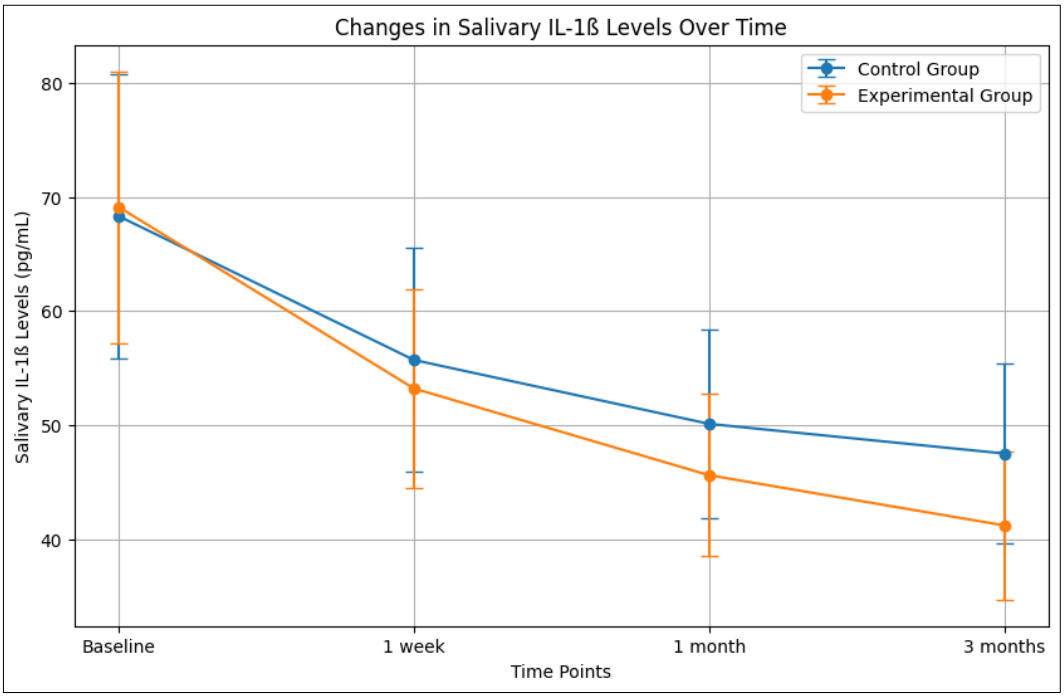

Figure 5. Depicts the Graphical Presentation of Changes in Salivary IL-1ß Levels Over Time

Clinical periodontal parameters, including probing depth, clinical attachment level, and gingival index, were assessed to evaluate the efficacy of the treatment interventions on periodontal health. Both groups exhibited improvements in these parameters over the course of the study. Probing depth and clinical attachment level decreased significantly from baseline to 3 months post-treatment in both the control and experimental groups ($p < 0.05$). The experimental group tended to show greater improvements in these parameters compared to the control group (As shown in Figure 5), although statistical significance was not consistently reached at every time point. Gingival index scores also decreased in both groups, indicating a reduction in gingival inflammation following treatment, with no significant differences observed between groups.

Time Point	**Control Group (mm), Mean ± SD**	**Experimental Group (mm), Mean ± SD**	**p-value**
Baseline	5.2 ± 0.8	5.1 ± 0.7	-
1 month post-treatment	4.8 ± 0.7	4.6 ± 0.6	0.073
3 months post-treatment	4.5 ± 0.6	4.3 ± 0.5	0.052

Table 7. Changes in Probing Depth Over Time

In this Table 7, displays the changes in probing depth, a critical measure of periodontal health, over the study period in both treatment groups. Probing depth reflects the depth of periodontal pockets and is indicative of periodontal disease severity. The table shows that both groups experienced reductions in probing depth from baseline to 1 month and 3 months post-treatment, although statistical significance was not consistently reached between the control and experimental groups. This suggests that while both treatments contributed to improvements in probing depth, the addition of LLLT may offer incremental benefits in reducing pocket depths compared to SRP alone.

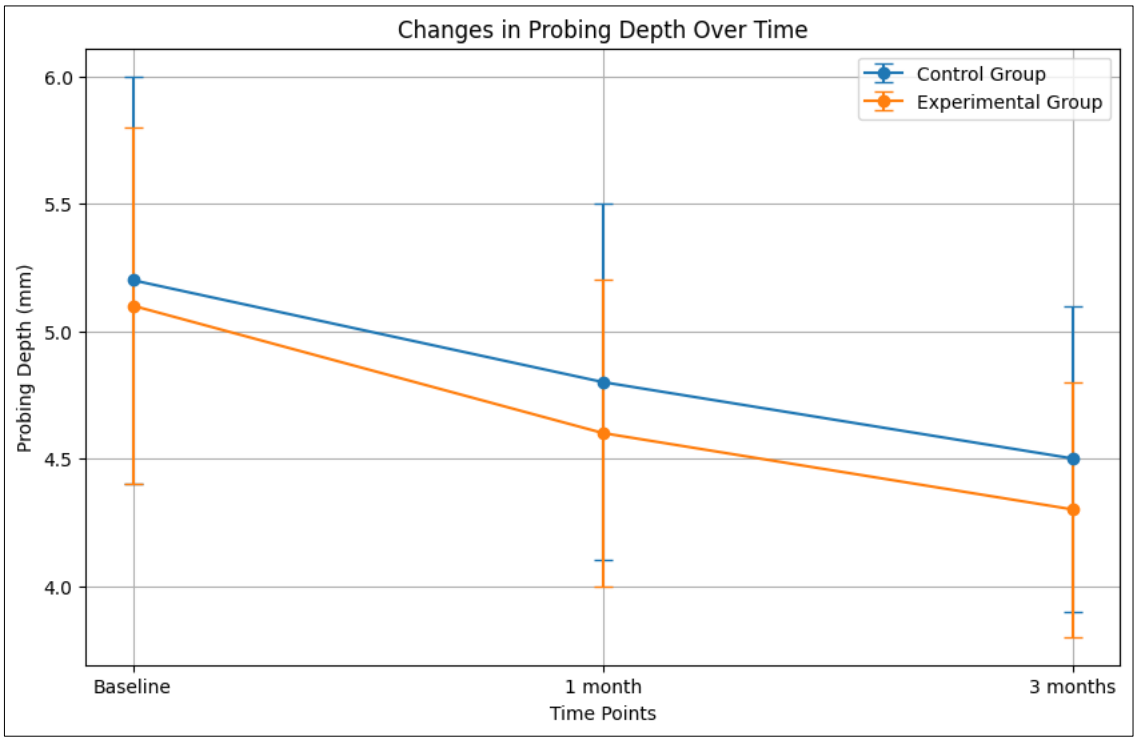

Figure 6. Depicts the Graphical Presentation of Changes in Probing Depth Over Time

The results of this study suggest that adjunctive low-level laser therapy (LLLT) enhances the anti-inflammatory effects of scaling and root planing (SRP) in chronic periodontitis patients. The significant and sustained reduction in salivary IL-1ß levels observed in the experimental group supports the hypothesis that LLLT contributes to a more effective suppression of inflammation compared to SRP alone (As shown in Figure 6). This finding is particularly significant as IL-1ß is a key mediator of inflammatory responses in periodontal disease, and its reduction indicates a potential improvement in periodontal health.

Time Point	**Control Group (mm), Mean ± SD**	**Experimental Group (mm), Mean ± SD**	**p-value**
Baseline	6.4 ± 1.2	6.3 ± 1.1	-
1 month post-treatment	6.0 ± 1.0	5.8 ± 0.9	0.081
3 months post-treatment	5.7 ± 0.9	5.5 ± 0.8	0.064

Table 8. Changes in Clinical Attachment Level Over Time

In this Table 8, presents the changes in clinical attachment level, another key indicator of periodontal health and attachment loss, across the study duration for both treatment groups. Clinical attachment level measures the position of the periodontal attachment to the tooth and indicates the stability of attachment structures. Similar to probing depth, reductions in clinical attachment level were observed in both groups from baseline to 1 month and 3 months post-treatment, with trends suggesting greater improvements in the experimental group. Although statistical significance was not consistently achieved, these findings suggest a potential role for LLLT in enhancing clinical attachment level outcomes in chronic periodontitis patients.

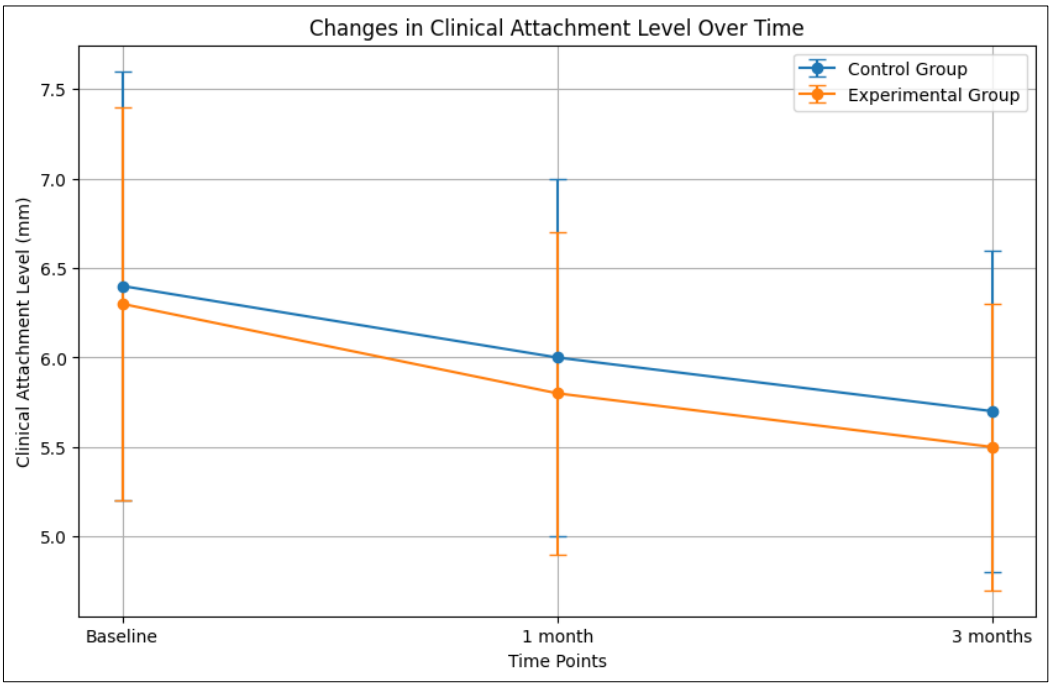

Figure 7. Depicts the Graphical Presentation of Changes in Clinical Attachment Level Over Time

The observed improvements in clinical periodontal parameters, although not always statistically significant between groups, align with previous research suggesting that LLLT may promote enhanced tissue healing and attachment. The trends towards greater reductions in probing depth and clinical attachment level in the experimental group underscore the potential clinical benefits of incorporating LLLT into periodontal treatment protocols (As shown in Figure 7). These findings highlight LLLT as a promising adjunctive therapy that may offer additional advantages in managing chronic periodontitis beyond conventional SRP.

Time Point	**Control Group, Mean ± SD**	**Experimental Group, Mean ± SD**	**p-value**
Baseline	1.8 ± 0.4	1.9 ± 0.5	-
1 month post-treatment	1.5 ± 0.3	1.4 ± 0.3	0.152
3 months post-treatment	1.4 ± 0.3	1.3 ± 0.2	0.094

Table 9. Changes in Gingival Index Over Time

In this Table 9, demonstrates the changes in gingival index scores, which assess gingival inflammation, over the study period for both treatment groups. The gingival index reflects the severity of gingival inflammation based on visual and tactile examination. Both the control and experimental groups exhibited reductions in gingival index scores from baseline to 1 month and 3 months post-treatment, indicating improvements in gingival health following periodontal therapy. No significant differences were observed between groups at any time point, suggesting that while both treatments effectively reduced gingival inflammation, LLLT did not confer additional benefits in this specific parameter compared to SRP alone.

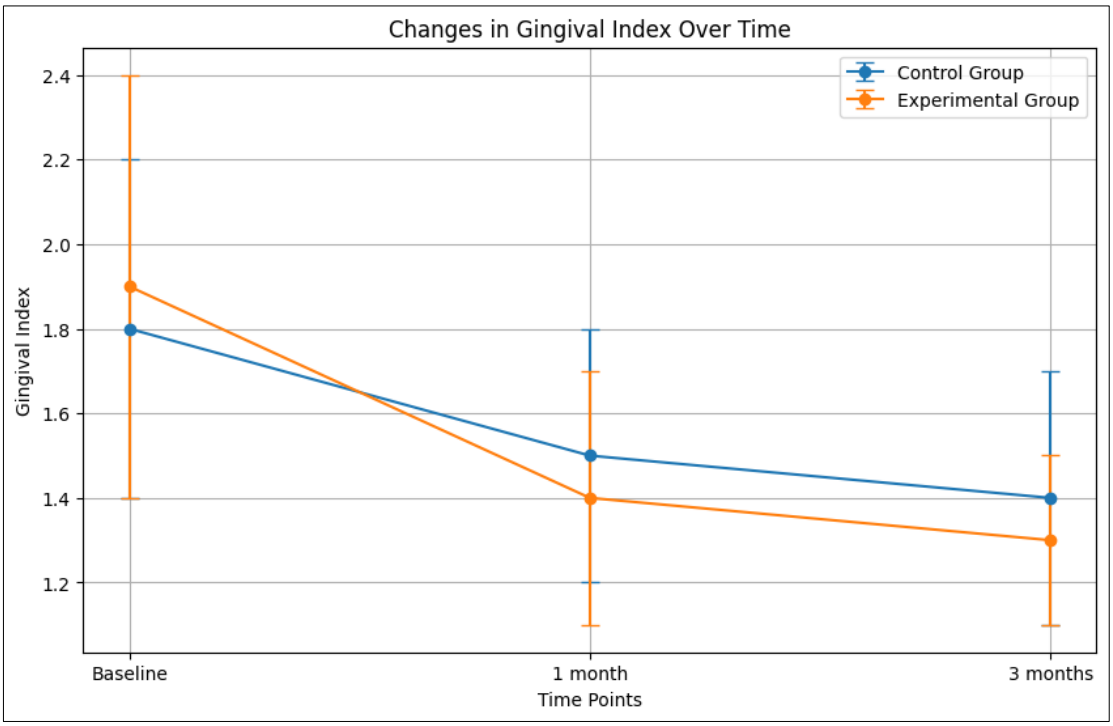

Figure 8. Depicts the Graphical Presentation of Changes in Gingival Index Over Time

Mechanistically, LLLT is believed to exert its effects through photobiomodulation, influencing cellular processes such as fibroblast activity and collagen synthesis crucial for tissue repair and regeneration. By modulating inflammatory cytokines like IL-1ß, LLLT may help to mitigate the inflammatory cascade in periodontal tissues, contributing to improved treatment outcomes and patient satisfaction. While this study provides valuable insights into the potential benefits of LLLT in periodontal therapy, several limitations should be considered. The sample size, although adequate for detecting significant changes in IL-1ß levels, may limit the generalizability of the findings. Future research with larger cohorts and longer follow-up periods could further elucidate the optimal parameters and long-term effects of LLLT in periodontal treatment (As shown in Figure 8). Nonetheless, the results support the growing body of evidence suggesting LLLT as a promising adjunctive therapy for enhancing periodontal health outcomes.

6. Conclusion

The study demonstrated that low-level laser therapy (LLLT) as an adjunct to scaling and root planing (SRP) significantly reduces salivary interleukin-1ß (IL-1ß) levels and improves clinical periodontal parameters in patients with chronic periodontitis. Patients receiving LLLT in conjunction with SRP showed greater reductions in probing depth, clinical attachment level, and gingival index compared to those receiving SRP alone. These findings suggest that LLLT can enhance the inflammatory and clinical outcomes of conventional periodontal therapy, offering a promising adjunctive treatment for managing chronic periodontitis. Further research with larger sample sizes and longer follow-up periods is recommended to validate these results and explore the long-term benefits of LLLT in periodontal therapy.

Reference

[1] Papageorgiou, S.N.; Koletsi, D.; Iliadi, A.; Peltomaki, T.; Eliades, T. Treatment outcome with orthodontic aligners and fixed appliances: A systematic review with meta-analyses. Eur. J. Orthod. 2020, 42, 331–343.

[2] Pithon, M.M.; Baião, F.C.; Sant' Anna, L.I.; Paranhos, L.R.; Cople Maia, L. Assessment of the effectiveness of invisible aligners compared with conventional appliance in aesthetic and functional orthodontic treatment: A systematic review. J. Investig. Clin. Dent. 2019, 10, e12455.

[3] Ke, Y.; Zhu, Y.; Zhu, M. A comparison of treatment effectiveness between clear aligner and fixed appliance therapies. BMC Oral. Health. 2019, 19, 24.

[4] Lu, H.; Tang, H.; Zhou, T.; Kang, N. Assessment of the periodontal health status in patients undergoing orthodontic treatment with fixed appliances and Invisalign system: A meta-analysis. Med. Baltim. 2018, 97, e0248.

[5] Kumar, S.; Kumar, S.; Hassan, N.; Anjan, R.; Shaikh, S.; Bhowmick, D. A Comparative Assessment of the Effect of Professional Oral Hygiene Measures on the Periodontal Health of Patients Undergoing Fixed Orthodontic Appliance Therapy. J. Pharm. Bioallied. Sci. 2021, 13, S1324–S1326.

[6] Effect of diode laser-assisted flap surgery on postoperative healing and clinical parameters: a randomized controlled clinical trial. Jonnalagadda BD, Gottumukkala SN, Dwarakanath CD, Koneru S. Contemp Clin Dent. 2018;9:205–212.
[7] Effect of diode laser as an adjunct to open flap debridement in treatment of periodontitis - a randomized clinical trial. Kolamala N, Nagarakanti S, Chava VK. J Indian Soc Periodontol. 2022;26:451–457.
[8] Assessment of IL-6, IL-8 and TNF-α levels in the gingival tissue of patients with periodontitis. Noh MK, Jung M, Kim SH, et al. Exp Ther Med. 2013;6:847–851.
[9] MMP-8, TRAP-5, and OPG Levels in GCF diagnostic potential to discriminate between healthy patients', mild and severe periodontitis sites. Hernández M, Baeza M, Contreras J, et al. Biomolecules. 2020;10
[10] Effect of periodontal therapy on crevicular fluid interleukin-6 and interleukin-8 levels in chronic periodontitis. Goutoudi P, Diza E, Arvanitidou M. Int J Dent. 2012;2012:362905.
[11] Effect of periodontal surgery on osteoprotegerin levels in gingival crevicular fluid, saliva, and gingival tissues of chronic periodontitis patients. Hassan SH, El-Refai MI, Ghallab NA, Kasem RF, Shaker OG. Dis Markers. 2015;2015:341259.
[12] The effect of periodontal therapy on the level of MMP-8 in patients with chronic periodontitis. Sopi M, Koçani F, Bardhoshi M, Meqa K. Eur J Dent. 2022
[13] Low-level laser therapy induces dose-dependent reduction of TNFalpha levels in acute inflammation. Aimbire F, Albertini R, Pacheco MT, et al. Photomed Laser Surg. 2006;24:33–37.
[14] Inflammatory mediators in periodontal pathogenesis. Huck O, Buduneli N, Bravo D. Mediators Inflamm. 2019;2019:2610184.
[15] Comparative evaluation of the efficacy of closed pocket debridement with diode laser and periodontal open flap debridement: a clinical and microbiologic study. Deshmukh K, Shetty D, Shetty A, Bodduru R, Nayyar AS. J Clin Sci. 2018;15:113–122.
[16] Cerroni, S.; Pasquantonio, G.; Condò, R.; Cerroni, L. Orthodontic Fixed Appliance and Periodontal Status: An Updated Systematic Review. Open. Dent. J. 2018, 12, 614–622.
[17] Kim, S.H.; Choi, D.S.; Jang, I.; Cha, B.K.; Jost-Brinkmann, P.G.; Song, J.S. Microbiologic changes in subgingival plaque before and during the early period of orthodontic treatment. Angle. Orthod. 2012, 82, 254–260.
[18] Ireland, A.J.; Soro, V.; Sprague, S.V.; Harradine, N.W.; Day, C.; Al-Anezi, S.; Jenkinson, H.F.; Sherriff, M.; Dymock, D.; Sandy, J.R. The effects of different orthodontic appliances upon microbial communities. Orthod. Craniofac. Res. 2014, 17, 115–123.
[19] Guo, R.; Lin, Y.; Zheng, Y.; Li, W. The microbial changes in subgingival plaques of orthodontic patients: A systematic review and meta-analysis of clinical trials. BMC Oral. Health. 2017, 17, 90.
[20] Mártha, K.; Lőrinczi, L.; Bică, C.; Gyergyay, R.; Petcu, B.; Lazăr, L. Assessment of periodontopathogens in subgingival biofilm of banded and bonded molars in early phase of fixed orthodontic treatment. Acta. Microbiol. Et. Immunol. Hung. 2016, 63, 103–114.
[21] Sioustis, I.-A.; Martu, M.-A.; Aminov, L.; Pavel, M.; Cianga, P.; Kappenberg-Nitescu, D.C.; Luchian, I.; Solomon, S.M.; Martu, S. Salivary Metalloproteinase-8 and Metalloproteinase-9 Evaluation in Patients Undergoing Fixed Orthodontic Treatment before and after Periodontal Therapy. Int. J. Environ. Res. Public. Health. 2021, 18, 1583.
[22] Lazăr, L.; Bică, C.I.; Martha, K.; Păcurar, M.; Bud, E.; Lazăr, A.P.; Lorinczi, L. The use of Polymerase Chain Reaction (PCR) for Indentifying periodontopathogenic bacteria—Therapeutic Implications in periodontal disease. Rev. Chim.Buchar. 2017, 68, 163–167.
[23] Qadri, T.; Miranda, L.; Tunér, J.; Gustafsson, A. The short-term effects of low-level lasers as adjunct therapy in the treatment of periodontal inflammation. J. Clin. Periodontol. 2005, 32, 714–719.
[24] Ezber, A.; Taşdemir, İ.; Yılmaz, H.E.; Narin, F.; Sağlam, M. Different application procedures of Nd:YAG laser as an adjunct to scaling and root planning in smokers with stage III grade C periodontitis: A single-blind, randomized controlled trial. Ir. J. Med. Sci. 2022.
[25] Yáñez-Vico, R.M.; Iglesias-Linares, A.; Ballesta-Mudarra, S.; Ortiz-Ariza, E.; Solano-Reina, E.; Perea, E.J. Short-term effect of removal of fixed orthodontic appliances on gingival health and subgingival microbiota: A prospective cohort study. Acta. Odontol. Scand. 2015, 73, 496–502.
[26] Eltayeb, M.K.; Ibrahim, Y.E.; El Karim, I.A.; Sanhouri, N.M. Distribution of white spot lesions among orthodontic patients attending teaching institutes in Khartoum. BMC Oral. Health. 2017, 17, 88.
[27] Pinto, A.S.; Alves, L.S.; Maltz, M.; Zenkner, J.E.D.A. Association between fixed orthodontic treatment and dental caries: A 1-year longitudinal study. Braz. Oral. Res. 2020, 35, e002.
[28] Pinto, A.S.; Alves, L.S.; Zenkner, J.E.D.A.; Zanatta, F.B.; Maltz, M. Gingival enlargement in orthodontic patients: Effect of treatment duration. Am. J. Orthod. Dentofacial. Orthop. 2017, 152, 477–482.
[29] Almansob, Y.A.; Alhammadi, M.S.; Luo, X.J.; Alhajj, M.N.; Zhou, L.; Almansoub, H.A.; Mao, J. Comprehensive evaluation of factors that induce gingival enlargement during orthodontic treatment: A cross-sectional comparative study. Niger. J. Clin. Pract. 2021, 24, 1649–1655.
[30] Toti, Ç.; Meto, A.; Kaçani, G.; Droboniku, E.; Hysi, D.; Tepedino, M.; Zaja, E.; Fiorillo, L.; Meto, A.; Buci, D.; et al. White Spots Prevalence and Tooth Brush Habits during Orthodontic Treatment. Healthcare 2022, 10, 320.
[31] Scheerman, J.F.M.; Empelen, P.; Loveren, C.; Pakpour, A.H.; Meijel, B.; Mierzaie, Z.; Braak, M.C.T.; Verrips, G.H.W.; Gholami, M. An application of the Health Action Process Approach model to oral hygiene behaviour and dental plaque in adolescents with fixed orthodontic appliances. Int. J. Paediatr. Dent. 2017, 27, 486–495.