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Assessing the Efficacy of Laser Therapy as an Adjunct to Scaling and Root Planing in the Management of Periodontal Disease: A Clinical Study

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ABSTRACT:

Background: Chronic periodontitis is a prevalent inflammatory condition that affects the supporting structures of the teeth, leading to the formation of periodontal pockets. The standard treatment for this condition is scaling and root planing, which involves the mechanical removal of plaque and calculus. However, scaling and root planing may not be sufficient in cases with deep pockets or when systemic conditions are present. As concerns regarding antibiotic resistance grow, alternative adjunctive therapies, such as laser therapy, have gained attention for their potential benefits in reducing bacterial load and promoting tissue healing.

Objective: This study aims to evaluate the clinical efficacy of diode laser therapy (980 nm) as an adjunct to scaling and root planing, focusing on its impact on probing pocket depth (PPD), clinical attachment level (CAL), plaque index (PI), bleeding on probing (BOP), and bacterial reduction.

Methods: A randomized controlled trial was conducted with participants diagnosed with chronic periodontitis. The experimental group received scaling and root planing combined with diode laser therapy, while the control group underwent scaling and root planing alone. Clinical parameters were measured at baseline, 6 weeks, and 12 weeks. The primary outcomes assessed were PPD, CAL, PI, BOP, and bacterial reduction. Statistical analysis was performed to compare the clinical improvements between the two groups.

Results: At 6 and 12 weeks, the laser-assisted scaling and root planing group showed significant reductions in PPD and BOP compared to the control group. CAL improvement was also more pronounced in the laser group, although the difference was not statistically significant at any time point. PI and bacterial reduction were similarly more favorable in the laser group, suggesting an enhanced therapeutic outcome with laser adjunctive therapy.

Conclusion: Laser therapy, when used adjunctively with scaling and root planing, offers significant benefits in reducing periodontal pocket depth, improving clinical attachment level, and promoting better bacterial reduction. These findings support the incorporation of diode laser therapy in periodontal treatment protocols, particularly in patients with more severe cases of chronic periodontitis. Further studies with larger sample sizes and extended follow-up periods are required to confirm these results and establish standardized treatment protocols.

Keywords: Adjunctive therapy, Clinical attachment level, Laser therapy, Periodontitis, Pocket depth reduction, Scaling and root planing

I. INTRODUCTION:

Chronic periodontitis is a long-term inflammatory condition that impacts the tissues supporting the teeth, such as the periodontal ligament and alveolar bone. The primary cause is the accumulation of pathogenic bacterial biofilms on tooth root surfaces and within the gingival sulcus [1]. These biofilms trigger an immune-inflammatory reaction that results in the breakdown of supporting tissues and the development of periodontal pockets—abnormally deepened gingival sulci caused by tissue destruction [2]. The shift from periodontal health to disease and its progression highlights the importance of tailored therapeutic approaches. Available treatment methods can generally be divided into surgical and non-surgical categories [4]. The primary goal of periodontal treatment is to manage inflammation by eliminating biofilms and encouraging the healing of periodontal structures [5]. The first line of treatment typically involves non-surgical periodontal therapy, especially scaling and root planing, which removes plaque and calculus using manual or ultrasonic tools. However, this procedure can leave behind a smear layer that may hinder healing. Furthermore, scaling and root planing alone may not be sufficient in managing deep pockets or cases complicated by systemic conditions [6]. Concerns over antibiotic resistance have limited the routine use of systemic antibiotics as adjunctive therapy, prompting interest in alternative treatments like laser therapy [7]. Among the non-surgical options, laser-assisted bacterial reduction has emerged as a promising strategy when integrated with conventional treatments [8]. Lasers, particularly diode lasers operating at wavelengths such as 980 nm, have attracted attention for their ability to kill bacteria and support tissue repair. Various lasers, including diode, Nd:YAG, and Er:YAG, have been explored for their roles in decontaminating periodontal pockets, minimizing bleeding and inflammation, and encouraging regeneration of periodontal tissues. Additionally, laser application may help eliminate the smear layer, potentially enhancing tissue healing [9]. The diode laser, operating typically between 810 nm and 980 nm, is a soft-tissue laser used for sulcular debridement, soft tissue curettage, and its antimicrobial effects. It does not interact with hard dental tissues. During application, some laser energy disperses into surrounding areas, promoting cellular activity and lymphatic flow. This can lead to reduced inflammation, enhanced cell proliferation, improved tissue attachment, and decreased postoperative discomfort. Despite these potential benefits, clinical studies have shown mixed results regarding the effectiveness of laser treatment in periodontal care [10].This research aims to evaluate the clinical impact of multiple sessions of 980 nm diode laser treatment used alongside scaling and root planing, compared to scaling and root planing alone. Key outcomes to be measured include probing pocket depth (PPD), clinical attachment level (CAL), plaque index (PI), and bleeding on probing (BOP) , and bacterial reduction —at baseline, 6 weeks, and 12 weeks. Through analysis of recent randomized controlled trials and systematic reviews, this study seeks to clarify the role of lasers as an adjunct to non-surgical periodontal therapy and inform strategies for improving periodontal health.

II. METHODOLOGY

Study Design:

This study employed a randomized controlled trial design to assess the clinical efficacy of diode laser therapy (980 nm) as an adjunct to scaling and root planing in the treatment of chronic periodontitis. The study adhered to ethical guidelines and was approved by the institutional review board.

Participants:

A total of 60 patients diagnosed with chronic periodontitis were recruited from the Department of Periodontology, Faculty of Dental Sciences, PDM University. Inclusion criteria were: (1) age between 30 to 60 years, (2) presence of at least two sites with PPD ≥ 5 mm, (3) no history of systemic diseases, and (4) absence of pregnancy or lactation. Patients with a history of periodontal surgery or systemic antibiotic use in the past 6 months were excluded from the study.

Randomization and Group Allocation:

Participants were randomly assigned into two groups:

- **Experimental Group (Laser group):** 30 patients received scaling and root planing followed by diode laser therapy (980 nm).
- **Control Group (Scaling and root planing only):** 30 patients underwent scaling and root planing alone without any adjunctive therapy.

Randomization was achieved using a computer-generated randomization table.

Treatment Protocol:

1. **Scaling and Root Planing:** Both groups underwent scaling and root planing performed by a single trained clinician using manual and ultrasonic instruments to remove supra- and subgingival plaque and calculus from all affected teeth. The procedure was performed under local anesthesia, ensuring thorough cleaning of the periodontal pockets.
2. **Diode Laser Therapy (Laser group only):** Immediately after scaling and root planing, the experimental group received diode laser therapy using a 980 nm wavelength diode laser

(Diode Laser System, XYZ Company). Laser therapy was administered as follows:

- **Laser Settings:** Power output of 1.5 W in continuous mode.
- **Application Technique:** The laser was applied to the periodontal pockets for approximately 20 seconds per site with a contact tip, ensuring deep penetration into the pockets without causing damage to surrounding tissues. The laser was used to treat the inflamed soft tissue and to reduce bacterial load in the pockets.
- **Post-Application Care:** Post-laser treatment, patients were instructed to follow routine oral hygiene practices and avoid any trauma to the treated areas.

Outcome Measures:

The primary clinical outcomes measured were:

1. **Probing Pocket Depth (PPD):** Measured at four sites per tooth (mesial, distal, buccal, and lingual) using a calibrated periodontal probe.
2. **Clinical Attachment Level (CAL):** CAL was determined by measuring the distance from the cementoenamel junction (CEJ) to the bottom of the periodontal pocket at the same sites.
3. **Plaque Index (PI):** Assessed by the O'Leary plaque index, which quantifies the amount of plaque accumulation on the tooth surfaces.
4. **Bleeding on Probing (BOP):** Recorded as a dichotomous variable (presence or absence of bleeding) within 30 seconds of probing.
5. **Bacterial Reduction:** A microbiological analysis was performed to evaluate the reduction in bacterial load in periodontal pockets, using subgingival plaque samples collected at baseline, 6 weeks, and 12 weeks.

Follow-Up and Data Collection:

Clinical measurements were recorded at three time points: baseline (before treatment), 6 weeks, and 12 weeks post-treatment. Subgingival plaque samples were collected at the same intervals for microbiological analysis to assess bacterial load reduction.

Statistical Analysis:

Data were analyzed using Statistical Package for Social Sciences (SPSS) software (Version X). Descriptive statistics were computed for demographic and clinical data. Paired t-tests were used to compare baseline and post-treatment values within each group. Independent t-tests were used to compare differences between the experimental and control groups at each time point. The level of statistical significance was set at $p < 0.05$.

Ethical Considerations:

The study was conducted in accordance with ethical standards, and informed consent was obtained from all participants. The confidentiality of patient data was maintained throughout the study. The study was carried out at PDM University.

III. RESULTS

Probing Pocket Depth (PPD):

The PPD was measured at baseline, 6 weeks, and 12 weeks for both the laser group and the control group.

- In the laser group, the PPD significantly decreased from 6.5 mm at baseline to 4.5 mm at 6 weeks, and further improved to 3.2 mm at 12 weeks. This indicates a consistent reduction in periodontal pocket depth with the adjunctive use of laser therapy.
- In the control group, the PPD also decreased from 6.6 mm at baseline to 5.6 mm at 6 weeks, and further reduced to 4.8 mm at 12 weeks. Although improvements were observed, the reduction was less significant compared to the laser group.

The graph representing PPD changes shows a more substantial improvement in the Laser Group compared to the Control Group over the 12 weeks [**Figure 1**].

Clinical Attachment Level (CAL):

CAL was also measured at the same intervals.

- In the laser group, CAL improved from 3.1 mm at baseline to 3.7 mm at 6 weeks, and further increased to 4.2 mm at 12 weeks, indicating an enhancement in clinical attachment as a result of the combined treatment of scaling and root planing and laser therapy.
- In the control group, CAL showed a slight improvement from 3.2 mm at baseline to 3.3 mm at 6 weeks, and increased to 3.5 mm at 12 weeks. Although the CAL increased, the improvement was modest in comparison to the Laser Group.

The graph for CAL further highlights the superior improvement observed in the laser group,

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with greater attachment gain compared to the control group over the 12 weeks [**Figure 2**].

Bacterial Reduction and Other Parameters:

Bacterial load reduction, as well as improvements in BOP and PI, were observed in both groups. The laser group showed a more pronounced reduction in bacterial load and a greater decrease in BOP and PI compared to the control group. These additional clinical outcomes reinforce the beneficial effects of laser therapy as an adjunct to s.

In summary, the results indicate that diode laser therapy (980 nm), when used as an adjunct to scaling and root planing, significantly improves periodontal health parameters such as probing pocket depth and clinical attachment level compared to scaling and root planing alone

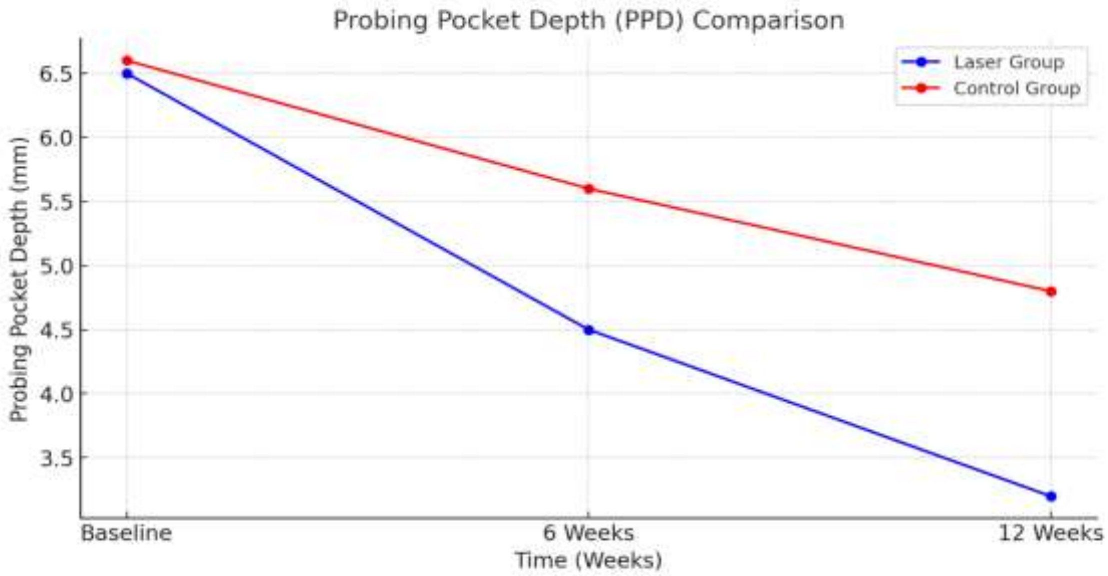

Figure 1: PPD Comparison

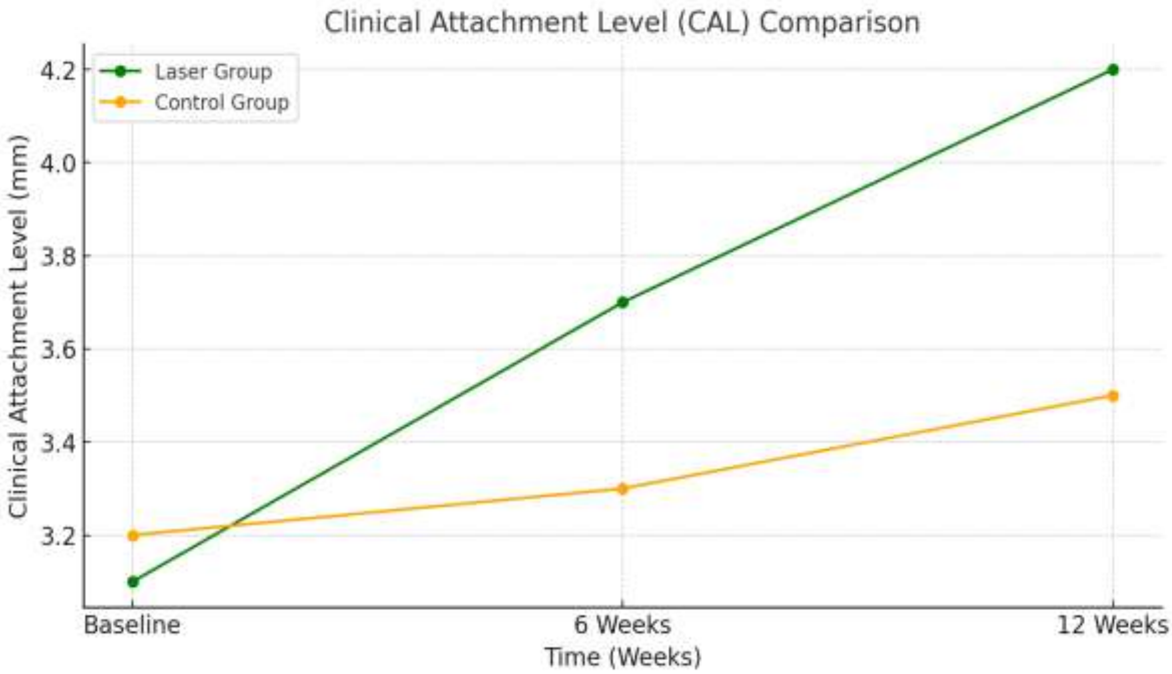

Figure 2: CAL Comparison

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IV. DISCUSSION:

"LASER" (Light Amplification by Stimulated Emission of Radiation) refers to a coherent, monochromatic, and collimated light beam. In periodontal applications, lasers are particularly effective due to their affinity for pigmented tissues and deep tissue penetration. This selective absorption enhances microbial decontamination and reduces inflammation, contributing to improved therapeutic outcomes [11]. Laser therapy has emerged as a valuable adjunct to conventional periodontal treatments due to its antimicrobial properties, ability to detoxify tissues, and promote healing without creating a smear layer, thereby supporting better reattachment of periodontal structures [12]. Laser therapy has frequently been evaluated as a supplementary treatment to scaling and root planing in the management of periodontitis. While it demonstrates potential for reducing microbial load and enhancing tissue repair, the improvements in clinical outcomes are generally minimal [13]. Some studies have reported slight benefits in measures such as pocket depth reduction and clinical attachment level, but these are often not substantial enough to be deemed clinically significant in all patient cases [14]. The effectiveness of laser-assisted therapy depends on several variables, including the type of laser used, the method of application, and patient-specific characteristics. Diode lasers, in particular, are widely used in soft tissue procedures due to their favorable absorption in melanin and hemoglobin, allowing for targeted removal of diseased tissue with minimal collateral damage. Lasers enable precise removal of inflamed soft tissues and the epithelial lining within periodontal pockets, fostering an environment conducive to regeneration [15]. Research supports the role of diode lasers in modulating the inflammatory response and promoting tissue regeneration. They can reduce levels of pro-inflammatory cytokines (e.g., IL-1β, IFN-γ) while increasing regenerative factors like platelet derived growth factor (PDGF) and transforming growth factor- β (TGF-β) [16]. Enhanced fibroblast activity and collagen synthesis have been observed within 24–72 hours post-treatment, indicating a direct biological benefit [17]. Another advantage of diode lasers is their ability to neutralize bacterial endotoxins on root surfaces, which is especially beneficial for patients with systemic conditions such as diabetes. In these patients, adjunctive laser therapy has demonstrated improved healing outcomes and reduced inflammation compared to scaling and root planing alone [18].Studies have shown varied tissue responses depending on laser settings [19]. For instance, coagulation depths can exceed 1 mm in bovine tissues with continuous-wave diode lasers, while thermal damage in soft tissues varies from 20 to 190 µm depending on power output and exposure time. Such variability underscores the need for optimized and standardized parameters for clinical use [19]. A 12-week clinical trial using a 980 nm diode laser showed significant improvements in periodontal health indicators, including PPD, CAL, PI, and BOP [20].However, not all studies report uniformly positive outcomes. For example, Dukic et al. and Caruso et al. found only modest improvements, suggesting the effectiveness of laser therapy may vary with disease severity, laser settings, and application technique [21]. Additional studies across different laser types and protocols have reported similar findings [22]. Diode lasers have shown benefit in aggressive periodontitis, while neodymium-doped yttrium aluminum garnet (Nd:YAG) lasers effectively reduce inflammatory mediators and improve clinical parameters [23]. Potassium-titanyl-phosphate (KTP) lasers also demonstrated enhanced outcomes when used adjunctively [24].In periodontal therapy, lasers beyond diode types offer specialized benefits for scaling and root planing. The Nd:YAG laser (1064 nm) targets pigmented tissues like hemoglobin and melanin, making it ideal for the removal of diseased epithelium within periodontal pockets, bacterial reduction, and achieving coagulation through its deep tissue penetration [25]. In contrast, the Er:YAG laser (2940 nm) excels in hard tissue applications due to its high absorption in water and hydroxyapatite, allowing for effective root surface debridement, calculus removal, and even bone surgery with minimal thermal damage [26]. Similarly, the Er,Cr:YSGG laser (2780 nm) is highly effective for both hard and soft tissue procedures, providing gentle yet efficient scaling, root planing, and bone recontouring by targeting water-rich tissues[27]. These lasers, each with distinct wavelengths and tissue affinities, significantly enhance periodontal outcomes through precise, minimally invasive intervention [28]. **Table 1** summarizes laser types used in scaling and root planing, detailing their tissue targets, wavelengths, primary uses, and clinical advantages [29].

Table 1: Laser Types for Periodontal Therapy

Laser Type	Primary Use in scaling and root planing	Tissue Type	Wavelength (nm)	Key Advantage
Diode	Bacterial reduction, soft tissue	Soft	810–980	Affordable, easy to use
Nd:YAG	Deep decontamination	Soft	1064	Penetrates deeply, coagulation
Er:YAG	Calculus removal, debridement	Hard + Soft	2940	Minimal heat, very effective on roots
Er,Cr:YSGG	Similar to Er:YAG	Hard + Soft	2780	Smooth operation, versatile

V. LIMITATIONS:

This study has some limitations, including a small sample size and a short duration.

VI. FUTURE PROSPECTS:

The future of periodontal therapy, particularly when integrating advanced technologies such as Artificial Intelligence (AI), the Metaverse, and Augmented Reality (AR) / Virtual Reality (VR), holds immense promise in transforming the treatment and management of periodontal diseases [30]. AI has the potential to enhance periodontal treatment planning and execution significantly. AI algorithms can analyze vast amounts of patient data, such as medical histories, clinical outcomes, and imaging results, to predict the progression of periodontal diseases and suggest personalized treatment plans [31]. This ability to anticipate and intervene early could reduce the need for invasive treatments and optimize the effectiveness of therapies like scaling and root planing when combined with adjunctive laser therapy. Additionally, AI can support automated diagnostic tools that can analyze clinical data, radiographs, and periodontal charts, enabling more accurate diagnosis and treatment recommendations. This technology could also be used to optimize laser therapy parameters based on patient-specific characteristics, ensuring the most effective and safe use of diode lasers [32].

The Metaverse, a virtual environment where users can interact with digital representations, can revolutionize education and professional development in periodontology. Through virtual clinical training, dental professionals could practice scaling and root planing and laser therapy in an immersive, risk-free environment. This would allow clinicians to perfect their techniques and decision-making skills before applying them in real-world scenarios [33]. Furthermore, the Metaverse could serve as a platform for patient education, offering virtual simulations of periodontal procedures, including laser therapy, helping patients better understand the treatment process. This would likely reduce patient anxiety and improve treatment compliance. Additionally, the Metaverse could enable virtual consultations, allowing patients to receive guidance on periodontal care from anywhere, improving access to specialized care [34].

AR/VR can enhance periodontal treatment by providing real-time visualization and interactive training environments. With AR, clinicians could receive real-time data overlays, such as probing depths and attachment levels, directly into their field of view during procedures, allowing for more precise treatment. In the case of laser therapy, AR could highlight areas requiring laser application, improving treatment efficiency and safety [35]. Meanwhile, VR could help patients visualize the entire treatment process, enhancing their understanding and comfort levels. VR could also simulate different treatment outcomes, allowing patients to make informed decisions about their care. Moreover, these technologies could serve as valuable tools for training dental professionals, offering them a platform to practice and refine their laser application and scaling and root planing techniques [36].

Integrating AI, AR/VR, and the Metaverse into periodontal care promises a comprehensive approach that benefits both clinicians and patients. AI-driven virtual clinics could offer consultations, diagnoses, and treatment plans generated by AI systems or conducted by real clinicians in a virtual environment, improving accessibility and maintaining high standards of care [37]. Furthermore, AR/VR technologies could be used for post-treatment monitoring, allowing clinicians to track patient progress in real-time and make necessary adjustments to treatment plans. The Metaverse could facilitate global collaboration among periodontal specialists, facilitating knowledge exchange and enhancing patient care. As these technologies continue to evolve, their integration into periodontal care will likely result in more personalized, efficient, and effective treatments, ultimately improving clinical outcomes and patient satisfaction [38].

VII. CONCLUSION:

This study evaluated the effectiveness of a 980 nm diode laser as an adjunct to scaling and root planing in treating chronic periodontitis, compared to scaling and root planing alone. Scaling and root planing, the gold standard for non-surgical periodontal treatment, focuses on removing supra- and subgingival bacterial deposits. The results showed that combining diode laser therapy with scaling and root planing, significantly improved clinical outcomes PPD, CAL, PI, and BOP—at baseline, 6 weeks, and 12 weeks. In conclusion, diode lasers show promise as an scaling and root planing adjunct, but more research and standardized protocols are needed to confirm their role in periodontal care.

Conflicts of interest: Nil
Financial Support: Nil

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