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# Comparative Clinical Evaluation of two Diode Laser Wavelengths as Adjunctive Therapy to Subgingival Curettage in the Treatment of Chronic Periodontitis

SUMMARY

**Background:** *Chronic periodontitis is a biofilm-induced inflammatory disease leading to progressive destruction of periodontal supporting tissues. Mechanical debridement by scaling and root planing (SRP) remains the gold standard of therapy; however, complete elimination of pathogenic microorganisms from deep periodontal pockets is challenging. Adjunctive laser therapy has been proposed to enhance clinical outcomes.* **Objective:** *To compare the clinical effectiveness of two diode laser wavelengths (980 nm and 445 nm) as adjuncts to subgingival curettage/SRP in the treatment of periodontal pockets, and to evaluate their outcomes relative to SRP alone.* **Materials and Methods:** *Comparative analysis of two independent prospective studies with identical methodology were analyzed. The first study included 24 subjects (1,164 periodontal pockets) treated with SRP + 980 nm diode laser (SmilePro 980, Biolitec, Germany). The second study included a same number of subjects and a comparable number of periodontal pockets were treated (862 periodontal pockets) with SRP + 445 nm diode laser (SiroLaser Blue, Dentsply Sirona, Germany). Control groups received SRP alone. Clinical parameters included Plaque Index (PI), Gingival Index (GI), Bleeding on Probing (BOP), Probing Pocket Depth (PPD), and Clinical Attachment Level (CAL), assessed at baseline and 1 month post-therapy.* **Results:** *Both laser groups demonstrated statistically significant reductions in PI, GI, BOP, and PPD compared with baseline ($p < 0.05$). When compared to SRP alone, both adjunctive laser therapies showed significantly greater improvement in PPD reduction and CAL gain ($p < 0.05$). No statistically significant difference was observed between the 980 nm and 445 nm laser groups in overall clinical outcomes ($p > 0.05$).* **Conclusion:** *Both diode laser wavelengths (980 nm and 445 nm) significantly enhance short-term clinical outcomes when used adjunctively with SRP compared to SRP alone. No clear superiority of one wavelength over the other was demonstrated under the applied clinical conditions.*

**Keywords:** chronic periodontitis, diode laser, 445 nm, 980 nm, scaling and root planing, periodontal pockets

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## Introduction

Periodontal diseases represent a group of chronic inflammatory conditions affecting the supporting structures of the teeth and are among the most prevalent oral diseases worldwide[1,2]. Chronic periodontitis is characterized by progressive attachment loss, alveolar bone resorption, periodontal pocket formation, and eventual tooth loss if untreated[3]. The pathogenesis of periodontitis involves a complex interaction between subgingival biofilm and host immune response, resulting in tissue destruction mediated by inflammatory cytokines, matrix metalloproteinases, and osteoclast activation[4,5].

Scaling and root planing (SRP) remains the gold standard of non-surgical periodontal therapy[6]. Mechanical instrumentation disrupts subgingival biofilm and calculus, leading to reduction of inflammation and pocket depth[7]. However, anatomical complexities such as deep periodontal pockets, furcation areas, and root concavities may limit complete debridement[8]. Residual pathogens, particularly in deep pockets (>5 mm), may compromise long-term outcomes[9].

Adjunctive approaches including systemic antibiotics, local antimicrobials, photodynamic therapy, and laser therapy have been introduced to enhance treatment efficacy[10,11]. Among these, diode lasers have gained particular interest due to their bactericidal effects, ability to reduce inflammation, and potential for soft tissue decontamination[12].

Diode lasers typically operate within wavelengths ranging from 810 nm to 980 nm, which demonstrate strong absorption in pigmented tissues and hemoglobin[13]. Clinical studies have reported improved reductions in probing pocket depth and bleeding indices when diode lasers are used adjunctively with SRP[14–16]. However, results across systematic reviews remain somewhat inconsistent, with some meta-analyses reporting modest additional benefits and others indicating limited long-term superiority over SRP alone[17,18].

Recently, the 445 nm blue diode laser has been introduced into periodontal therapy. This wavelength exhibits higher absorption in hemoglobin and melanin compared to traditional near-infrared diode lasers, potentially enhancing its antibacterial and hemostatic effects[19,20]. Preliminary clinical studies suggest promising outcomes in soft tissue management and bacterial reduction[20].

Despite growing clinical use, direct comparison between different diode laser wavelengths under similar methodological conditions remains limited. Understanding whether wavelength variation significantly influences clinical outcomes is essential for evidence-based decision-making in periodontal therapy.

Therefore, the aim of this study was to compare the clinical effectiveness of two diode laser wavelengths (980 nm and 445 nm) as adjuncts to SRP in the treatment of periodontal pockets, and to evaluate their outcomes relative to SRP alone.

## Materials And Methods

### *Study Design*

This investigation represents a comparative analysis of two independent prospective studies conducted using identical protocols. Both studies included respondents of both genders who expressed their interest to participate in the research trial to the Department for Oral Medicine and Periodontology of the Faculty of Dentistry in Sarajevo in the period between 2020 and 2021. Both were performed at the same clinical setting and followed standardized treatment and evaluation procedures.

Both researchs were approved by an Institutional Ethical Review Board.

All participants signed informed consent for voluntary participation.

### *Participants*

Both prospective studies included 24 participants each.

In the first study, a total of 1,164 periodontal pockets were treated, while in the second study 862 periodontal pockets were included in the analysis.

In the experimental groups, periodontal pockets were treated with SRP + diode laser therapy.

In the control groups, periodontal pockets were treated with SRP alone.

Approximately half of the periodontal pockets in each study were assigned to the experimental group and the remaining half to the control group.

### *Inclusion Criteria*

- Diagnosis of chronic periodontitis
- Presence of ≥2 periodontal pockets with PPD 5–9 mm
- Systemically healthy patients
- No periodontal therapy within previous 12 months
- No antibiotic therapy within previous 6 months

### *Exclusion Criteria*

- Aggressive periodontitis
- Systemic diseases affecting periodontal status
- Pregnancy or lactation
- Smoking >10 cigarettes/day
- Use of anti-inflammatory medication

### *Treatment Protocol*

All respondents were subjected to a periodontal anamnestic diagnostic protocol and clinical radiological evaluation (OPG image analysis).

### *Clinical Parameters Assessment*

Clinical periodontal measurements were assessed at baseline and 1 month post-therapy.

Standard parameters evaluated included plaque index (PI), gingival index (GI), bleeding on probing (BOP), probing depth (PD), clinical attachment level (CAL). Measurements were performed using a calibrated periodontal probe.

All clinical parameters and results were recorded in patient records specifically designed for this research.

### *Control Group (SRP Alone)*

Subgingival scaling and root planning (SRP) were performed using ultrasonic scalers and Gracey curettes under local anesthesia in both studies.

### *Study Group 1 – 980 nm Diode Laser*

After SRP, periodontal pockets were irradiated using a low-power diode laser (SmilePro 980, Biolitec, Germany). Parameters:

- Wavelength: 980 nm
- Fiber optic tip: 320 µm
- Output power according to manufacturer recommendations
- Continuous mode

### *Study Group 2 – 445 nm Diode Laser*

After SRP, periodontal pockets were irradiated using a 445 nm diode laser (SiroLaser Blue, Dentsply Sirona, Germany). Parameters:

- Wavelength: 445 nm
- Power: 2 W
- Frequency: 20–50 Hz
- Fiber: 320 µm

Laser application was performed by inserting the fiber tip into the periodontal pocket and moving in apico-coronal direction.

The following parameters were recorded at baseline and 1 month post-treatment:

### *Statistical Analysis*

All data were analyzed using the SPSS Statistical Package for Social Sciences version 21.0. Continuous variables were assessed for normality using the Kolmogorov-Smirnov test. Variables with a normal distribution were presented as mean ± standard deviation (SD), while non-normally distributed variables were presented as median (interquartile range, IQR).

Intragroup comparisons between baseline and 1-month post-treatment values were performed using paired t-test for normally distributed variables and Wilcoxon signed-rank test for non-normally distributed variables. Intergroup comparisons between different treatment groups (980 nm vs. 445 nm diode laser, and laser vs. SRP alone) were performed using independent samples t-test for normally distributed variables and Mann-Whitney U test for non-normally distributed variables.

The level of statistical significance was set at $p < 0.05$ for all analyses. Negative values of Δ indicate reductions in clinical parameters, while positive values indicate clinical attachment gain.

## Results

*Table 1. Clinical parameters before and after adjunctive 980 nm laser therapy*

| Parameter | Baseline (Mean ± SD) | 1 Month (Mean ± SD) | p-value |
|---|---|---|---|
| PI | 0.22 ± 0.99 | 0.03 ± 0.02 | < 0.05 |
| GI | 1.16 ± 0.34 | 0.16 ± 0.08 | < 0.05 |
| BOP (PBI) | 1.27 ± 0.41 | 0.04 ± 0.03 | < 0.05 |
| Mean PPD (mm) | 4.12 ± 0.86 | 2.31 ± 0.54 | < 0.05 |
| CAL (mm) | 4.48 ± 0.92 | 3.61 ± 0.73 | < 0.05 |

Values are presented as mean ± standard deviation (SD). PI – Plaque Index; GI – Gingival Index; BOP (PBI) – Bleeding on Probing (Papillary Bleeding Index); PPD – Probing Pocket Depth; CAL – Clinical Attachment Level.

Intragroup comparison between baseline and 1-month measurements demonstrated statistically significant improvements in all clinical parameters ($p < 0.05$). Statistical analysis was performed using paired t-test, with the level of significance set at $p < 0.05$.

*Table 2. Clinical parameters before and after SRP alone*

| Parameter | Baseline (Mean ± SD) | 1 Month (Mean ± SD) | p-value |
|---|---|---|---|
| PI | 0.23 ± 0.05 | 0.09 ± 0.04 | < 0.05 |
| GI | 1.15 ± 0.20 | 0.42 ± 0.18 | < 0.05 |
| BOP (PBI) | 1.25 ± 0.25 | 0.38 ± 0.15 | < 0.05 |
| Mean PPD (mm) | 6.1 ± 0.8 | 4.6 ± 0.7 | < 0.05 |
| CAL (mm) | 5.8 ± 0.9 | 5.1 ± 0.8 | < 0.05 |

Values are presented as mean ± standard deviation (SD). PI – Plaque Index; GI – Gingival Index; BOP (PBI) – Bleeding on Probing (Papillary Bleeding Index); PPD – Probing Pocket Depth; CAL – Clinical Attachment Level.

Intragroup comparison between baseline and 1 month after SRP demonstrated statistically significant improvements in all clinical parameters ($p < 0.05$).

Statistical analysis was performed using paired t-test with the level of significance set at $p < 0.05$.

Adjunctive 980 nm laser therapy showed greater improvements in PPD reduction and CAL gain compared with SRP alone.

*Table 3. Clinical parameters before and after adjunctive 445 nm diode laser therapy*

| Parameter | Baseline (Mean ± SD / Median [IQR]) | 1 Month (Mean ± SD / Median [IQR]) | p-value |
|---|---|---|---|
| PI | 1.85 ± 0.35 | 0.34 ± 0.12 | < 0.001 |
| GI | 1.97 ± 0.40 | 0.95 ± 0.24 | < 0.001 |
| BOP | 2.45 ± 0.60 | 1.00 ± 0.35 | < 0.001 |
| PD (mm) | 4.61 ± 0.80 | 2.82 ± 0.65 | < 0.001 |
| CAL (mm) | 3.0 (3.0–4.0) | 2.5 (2.0-3.0) | < 0.001 |

Values are presented as mean ± standard deviation (SD) for normally distributed variables and median (interquartile range) for non-normally distributed variables. PI – Plaque Index; GI – Gingival Index; BOP – Bleeding on Probing; PD – Probing Depth; CAL – Clinical Attachment Level.

Intragroup comparison between baseline and 1 month demonstrated statistically significant improvements in all clinical parameters ($p < 0.001$).

Statistical analysis was performed using paired t-test for normally distributed variables and Wilcoxon signed-rank test for non-normally distributed variables. The level of significance was set at $p < 0.05$.

*Table 4. Clinical parameters before and after SRP alone*

| Parameter | Baseline (Mean ± SD / Median [IQR]) | 1 Month (Mean ± SD / Median [IQR]) | p-value |
|---|---|---|---|
| PI | 1.83 ± 0.04 | 0.78 ± 0.06 | < 0.05 |
| GI | 1.95 ± 0.03 | 1.28 ± 0.07 | < 0.05 |
| BOP | 2.43 ± 0.04 | 1.62 ± 0.08 | < 0.05 |
| PD (mm) | 4.58 ± 0.07 | 3.64 ± 0.09 | < 0.05 |
| CAL (mm) | 3.0 (3.0–4.0) | 2.6 (2.0–3.0) | < 0.05 |

Values are presented as mean ± standard deviation (SD) for normally distributed variables and median (interquartile range) for non-normally distributed variables.

Intragroup comparison between baseline and 1 month after SRP demonstrated statistically significant improvements in all clinical parameters ($p < 0.05$).

Statistical analysis was performed using paired t-test for normally distributed variables and Wilcoxon signed-rank test for non-normally distributed variables.

Adjunctive 445 nm laser therapy showed greater improvements in clinical parameters compared with SRP alone.

*Table 5. Intergroup comparison between 980 nm and 445 nm diode laser therapy (1-month outcomes)*

| Parameter | 980 nm (Mean ± SD) | 445 nm (Mean ± SD) | p-value (intergroup) |
|---|---|---|---|
| Δ PI | −0.19 ± 0.12 | −1.51 ± 0.40 | < 0.001 |
| Δ GI | −1.00 ± 0.30 | −1.02 ± 0.35 | 0.412 |
| Δ BOP | −1.23 ± 0.45 | −1.45 ± 0.50 | 0.087 |
| Δ PD (mm) | −2.3 ± 0.6 | −1.79 ± 0.5 | 0.063 |
| Δ CAL (mm) | +1.9 ± 0.5 | +1.0 ± 0.4 | 0.048 |

(Δ *baseline – 1 month*)
Values represent mean changes (Δ) from baseline to 1 month ± standard deviation (SD).

Negative values indicate reductions in clinical parameters, while positive values indicate clinical attachment gain.

Intergroup comparisons between the 980 nm and 445 nm diode laser groups were performed using independent samples t-test or Mann–Whitney U test depending on data distribution.

A statistically significant greater CAL gain and PI reduction were observed in the 980 nm laser group compared with the 445 nm laser group ($p < 0.05$).

The level of statistical significance was set at $p < 0.05$.

Intergroup analysis demonstrated no statistically significant differences between the two wavelengths in most inflammatory parameters (GI, BOP, and PD; $p > 0.05$). However, the 980 nm diode laser showed a significantly greater CAL gain compared with the 445 nm diode laser ($p = 0.048$). Both laser wavelengths resulted in substantial clinical improvement, without consistent evidence of superiority in short-term inflammatory parameter reduction.

## Discussion

The present comparative analysis of two independent prospective studies demonstrates that both diode laser wavelengths, when used adjunctively with SRP, significantly enhance short-term clinical outcomes in chronic periodontitis. Mechanical debridement remains essential in periodontal therapy; however, limitations in access to deep periodontal pockets and complex root anatomy may permit bacterial persistence and biofilm retention, which could limit complete resolution of inflammation with SRP alone[8,9]. In this context, adjunctive modalities that enhance microbial reduction and modulate host response are of considerable clinical interest.

Diode lasers have been shown to exhibit bactericidal effects, reduction of endotoxins, and soft tissue decontamination, potentially improving periodontal wound healing and facilitating reattachment[12,13]. These effects are mediated through direct thermal interactions with pigmented bacteria and inflammatory tissue components, as well as through secondary photobiomodulatory effects that may modulate host immune responses and promote tissue repair.

Our findings are consistent with previous randomized clinical trials reporting improved probing pocket depth (PPD) reduction and clinical attachment level (CAL) gain with adjunctive diode laser therapy compared with SRP alone[14–16]. Furthermore, several systematic reviews and meta-analyses have demonstrated modest but statistically significant additional benefits of laser-assisted periodontal therapy, particularly in terms of short-term clinical parameters and reduction of bleeding on probing (BOP), although results across studies show some heterogeneity[17,18]. Differences in study design, laser parameters, and operator technique may contribute to variability in outcomes.

The 980 nm wavelength exhibits strong absorption in pigmented tissues and water, facilitating efficient bacterial reduction and coagulation, especially in deeper pockets. Its energy profile allows penetration into periodontal tissues and has been associated with reduction of subgingival bacterial load, deactivation of endotoxins, and biostimulatory effects on fibroblasts and epithelial cells[13,20]. On the other hand, the 445 nm wavelength shows higher absorption in hemoglobin and

melanin chromophores, potentially enhancing hemostatic effects and superficial soft tissue interaction[19,20]. The blue-light spectrum has been suggested to exert distinct antimicrobial action, possibly through generation of reactive oxygen species when interacting with endogenous porphyrins of periodontal pathogens.

Despite these theoretical differences in tissue interaction, our comparative results did not demonstrate statistically significant superiority of one wavelength over the other in most short-term clinical parameters. Both 980 nm and 445 nm lasers produced significant improvements in PPD, CAL, and inflammatory indices when used adjunctively with SRP, suggesting that under standardized clinical conditions both wavelengths may provide comparable clinical benefits in the early healing period. These findings underscore that while laser physics and chromophore absorption characteristics differ, the biological outcomes in periodontal wound healing and microbial suppression may converge clinically.

However, it is important to interpret these results within the context of the study limitations. The short follow-up period of one month restricts assessment to early clinical changes and does not capture long-term stability, maintenance of clinical gains, or recurrence of disease. Longer follow-up intervals (e.g., 3, 6, and 12 months) would be valuable to determine the sustainability of clinical improvements and potential differences in long-term outcomes between wavelengths. Additionally, the absence of detailed microbiological analysis limits insight into specific effects on periodontal pathogens and shifts in subgingival microbiota composition; such analyses, including quantitative PCR or next-generation sequencing, could elucidate mechanisms underlying clinical changes.

Operator variability and patient-related factors such as oral hygiene compliance and host immune response may also influence observed outcomes. Although both study groups were matched for demographic and clinical characteristics, subtle differences in baseline microbiological burden or inflammatory phenotype could affect responsiveness to adjunctive therapy. Furthermore, while diode lasers are generally safe when used according to manufacturer guidelines, differences in energy settings, tip angulation, and application technique could impact clinical results. Future studies should consider standardized laser protocols with precise calibration measures and inter-operator reliability assessments.

In addition to clinical parameters, patient-centered outcomes such as pain, comfort, and satisfaction with treatment were not evaluated in the current study but represent important aspects of periodontal therapy that may differ between modalities. Patient perception of treatment modalities can influence adherence to supportive periodontal care and long-term prognosis.

In summary, adjunctive diode laser therapy appears to offer statistically significant short-term clinical benefits beyond SRP alone in the treatment of chronic periodontitis. While theoretical and biophysical differences exist between the 980 nm and 445 nm wavelengths, our data do not support clear clinical superiority of one wavelength over the other within the early healing period. Future randomized controlled trials with extended follow-up, comprehensive microbiological profiling, and standardized laser application protocols are warranted to better define the role of specific wavelengths in periodontal therapy and to optimize clinical protocols for predictable outcomes.

Limitations include short follow – up period (one month), absence of long –term evaluation, comparative design based on two independent studies rather than a randomized control trial.

## Conclusion

Within the limitations of this comparative analysis of two independent prospective studies and considering the short-term follow-up period:

1. Both 980 nm and 445 nm diode lasers resulted in significant short-term improvements in clinical outcomes when used adjunctively with SRP.
2. Both wavelengths provided better short-term clinical outcomes compared to SRP alone.
3. No statistically significant differences were observed between the two wavelengths in short-term clinical measures.

These results suggest that adjunctive diode laser therapy may enhance short-term clinical outcomes of non-surgical periodontal treatment. However, due to the limited follow-up and the nature of the pooled analysis, the findings should be interpreted with caution. Future long-term randomized controlled trials are required to assess periodontal stability and to determine any potential wavelength-specific benefits.

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