RESEARCH PAPER

Comparative evaluation of efficacy of SRP alone vs PDT, LLLT after SRP in the management of diabetic patients with Chronic Periodontitis: A Clinical trial and Microbiological Assay

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ABSTRACT

Aim: To compare clinical and microbiological effects among individuals with chronic periodontitis and well-controlled type II diabetes after treatment with scaling and root planing alone, scaling and root planing associated with photodynamic therapy (PDT), or scaling and root planing in combination with low-level laser therapy (LLLT).

Objectives:

1. To assess the Modified Sulcular Bleeding Index (mSBI), Plaque Index (PI) and Probing Pocket Depth (PPD) from baseline till 45 days follow up to detect changes.
2. To quantify colony-forming units (CFU) in subgingival plaque at baseline and 45 days after treatment.

Settings and Design: Thirty patients (30–50 years old) with chronic periodontitis and type II diabetes (HbA1c 6–7%) were recruited in a parallel-arm, randomized clinical trial and microbiological study. Subjects were randomly allocated in equal numbers to three treatment groups.

Materials and Methods: After ethical clearance, participants underwent full-mouth SRP. Group II also received LLLT, group III was treated with ICG-PDT. PI, mSBI and PPD were recorded at baseline and 45 days and subgingival samples were taken for CFU. Descriptive statistics was expressed as mean ± SD. Intragroup comparisons were performed with the paired t-test and intergroup comparisons with unpaired Student's t-tests, where $P< 0.05$ was regarded as significant.

Results: There was a meaningful improvement from baseline to day 45 in all three groups, both in clinical indices and microbial counts (P <0.001). Between-group comparisons showed that adding light-based therapy to SRP significantly enhanced outcomes. The SRP+PDT group achieved the largest reductions in plaque index and bleeding index, while the SRP+LLLT group also outperformed SRP alone. Both adjunctive groups had significantly lower PPD, PI, and mSBI than the SRP-only group (P<0.05). The highest level of bacterial reduction was observed in the SRP+PDT group.

Conclusion: Adjunctive photodynamic or low-level laser therapy with SRP produced significantly greater clinical improvements than SRP alone in diabetic patients with chronic periodontitis. Both light-based treatments enhanced healing, suggesting their potential value as supplements to standard periodontal therapy

Keywords: chronic periodontitis; diabetic; photodynamic therapy; low-level laser therapy; colony-forming units

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Abbreviations: a-PDT-antimicrobial photodynamic therapy, PD-Probing depth, mSBI-modified sulcus bleeding

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index, NS-not significant, PI-Plaque Index, SRP-scaling and root planing, DM-Diabetes mellitus, ICG-Indocyanine Green, LLLT-Low Level Laser therapy

INTRODUCTION

Periodontitis is a biofilm-induced inflammatory disease of long duration that compromises the supporting structures of the teeth. Clinical signs include gingival bleeding, deep periodontal pockets, and loss of attachment. Diabetes poses a noteworthy determinant for periodontitis, as elevated blood glucose impairs immune response and wound healing, increasing susceptibility to periodontal infections.[1] Conversely, active periodontitis can worsen glycemic control. In fact, of periodontium has been occasionally described as the "sixth complication" of diabetes, reflecting the bidirectional relationship between oral and systemic health.[2] When diabetes is not well regulated, the probability of developing periodontitis, and treating periodontal disease can contribute to better blood sugar control.[3]

Periodontal care generally starts with non-surgical treatment. Scaling and root planing (SRP) with thorough oral hygiene instruction, are considered the standard initial approach. SRP mechanically removes plaque and calculus from tooth roots. However, due to intricate root anatomies and deep pockets, SRP may not eliminate all pathogenic microbes, allowing some bacteria to persist in difficult-to-reach areas.[4]

To enhance disinfection, adjunctive therapies like antimicrobial photodynamic therapy (aPDT) have been introduced. aPDT involves introducing a photosensitizing agent into the periodontal pocket, which is then illuminated with a specific light wavelength to produce an oxygen-dependent reaction. Once activated, it produces reactive oxygen species, including singlet oxygen, which selectively kill bacteria while sparing host tissues.[5] Thus, aPDT can reduce microbial loads[6] without the side effects of systemic antibiotics.

Indocyanine green (ICG) is a clinically approved photosensitizer with strong near-infrared absorption. Originally developed for medical imaging procedures such as measuring cardiac output, assessing retinal vasculature, analyzing liver blood flow, and evaluating burn depth, ICG offers favorable properties for PDT. It has rapid hepatic clearance and strong absorption peaks in the 800–830 nm range,[7] making it suitable for activation with diode lasers used in dentistry. These characteristics allow ICG-based PDT to target deep-seated periodontal pathogens effectively.

The investigation was designed to determine whether supplementing SRP with either ICG-mediated PDT or low-level laser therapy would yield superior periodontal outcomes in individuals with controlled type II diabetes, when compared with SRP as a standalone therapy. We hypothesized that the adjunctive therapies would enhance clinical outcomes beyond those achieved with SRP alone.

MATERIALS AND METHODS:

Thirty clinically confirmed cases of chronic periodontitis, ranging in age from 30 to 50 years, and having well-controlled type II diabetes (HbA1c between 6 and 7%), were enrolled from the outpatient periodontics clinic at Panineeya Mahavidyalaya Institute of Dental Sciences, Hyderabad. The study protocol received approval from the Institutional Ethics Committee, and all participants gave their written informed consent. Expectant mothers, or breastfeeding individuals, smokers, those with recent infections or taking antibiotics/medications that could affect periodontal status, or had been treated for periodontal disease within the last six months.[8]

Participants were randomly assigned to three groups (10 subjects each):

- Group A: SRP alone.
- Group B: SRP + Low-Level Laser Therapy (LLLT).
- Group C: SRP + Photodynamic Therapy (PDT) using ICG.

Clinical measurements included:

- Plaque Index (PI): quantified dental plaque.
- Modified Sulcular Bleeding Index (mSBI): assessed the presence of gingival bleeding.
- Probing Pocket Depth (PPD): recorded using a standardized periodontal probe.

These were recorded at baseline (prior to treatment) and again at 45 days post-treatment by an examiner blinded to group assignment.

At baseline and 45 days later, subgingival plaque was collected from the site with the greatest pocket depth (≥5 mm). Blood agar plates were used to culture these samples that were placed in thioglycollate broth and transported to the lab. Bacterial load at each time point was determined by counting colony-forming units (CFUs).

STATISTICAL ANALYSIS:

Using the primary outcome as a reference, a sample size of 10 patients in 1 group was calculated to achieve 95% power with a 5% significance level. Continuous data were presented as mean ± standard deviation. Paired t-tests compared changes within each group (baseline vs. 45 days), and Student's t-tests compared differences between groups. A P value of less than 0.05 was considered statistically significant.

RESULTS:

The study groups demonstrated notable improvements in clinical and microbiological parameters from study onset to the 45-day follow-up (Tables 1-3; $P<0.0001$ for within-group changes). In Group A (SRP alone), mean PI, mSBI, and PD scores all decreased significantly, and CFU counts dropped, indicating effective periodontal therapy.

Between-group comparisons revealed that the adjunctive therapy groups achieved greater benefits than SRP alone. Group B (SRP+LLLT) showed significantly lower mSBI at 45 days (Table 4) compared to Group A ($P<0.05$). Group C (SRP+PDT) had the largest improvements (Table 5): it exhibited significantly lower PI than Group B ($P<0.05$). Specifically, the reduction in plaque accumulation and bleeding was greatest in the SRP+PDT group.

Additionally, the PD and mSBI in Group C was significantly smaller than in Group A (Table 6) at 45 days (P<0.05).

Table 1: Intragroup comparison in Group A (Scaling and Root plaining alone) at baseline and after 45 days.

Parameters	Group A	n	Mean±SD	*P*-Value
PI	Baseline	10	2.34±0.326	*P*<0.0001**
	After 45 days	10	0.65±0.265	
PD	Baseline	10	6.5±0.67	*P*<0.0001**
	After 45 days	10	3±0.77	
mSBI	Baseline	10	2.5±0.67	*P*<0.0001**
	After 45 days	10	0.667±0.489	
CFU	Baseline	10	4.6±0.516	*P*<0.0001**
	After 45 days	10	2.3±0.483	

Table 2: Intragroup comparison in the Group B (SRP+LLLT) at baseline and after 45 days.

Parameters	Group B	n	Mean±SD	*P*-Value
PI	Baseline	10	2.49±0.415	*P*<0.0001**
	After 45 days	10	0.47±0.214	
PD	Baseline	10	6.5±0.67	*P*<0.0001**
	After 45 days	10	2.5±0.5	
mSBI	Baseline	10	2.5±0.67	*P*<0.0001**
	After 45 days	10	0.2±0.4	
CFU	Baseline	10	4.7±0.483	*P*<0.0001**
	After 45 days	10	2.3±0.483	

Table 3: Intragroup comparison in the Group C (SRP + PDT) at baseline and after 45 days.

Parameters	Group C	n	Mean±SD	*P*-Value
PI	Baseline	10	2.33±0.319	*P*<0.0001**
	After 45 days	10	0800±0.156	
PD	Baseline	10	6.3±0.45	*P*<0.0001**
	After 45 days	10	2.2±0.6	
mSBI	Baseline	10	2.4±0.663	*P*<0.0001**
	After 45 days	10	0.1±0.3	
CFU	Baseline	10	4.7±0.483	*P*<0.0001**
	After 45 days	10	2.1±0.316	

Table 4: Intergroup comparison between the Group A and Group B

Parameters after 45 days	Groups	n	Mean±SD	*P*-Value
PI	Group A	10	0.65±0.265	*P*>0.05 NS
	Group B	10	0.47±0.214	
PD	Group A	10	3±0.77	*P*>0.05 NS
	Group B	10	2.5±0.5	
mSBI	Group A	10	0.667±0.489	*P*<0.05*
	Group B	10	0.2±0.4	
CFU	Group A	10	2.3±0.483	*P*>0.05 NS
	Group B	10	2.3±0.493	

Table 5: Intergroup comparison between the Group B and Group C

Parameters after 45 days	Groups	n	Mean±SD	*P*-Value
PI	Group B	10	0.47±0.214	*P*<0.05*
	Group C	10	0.80±0.156	
PD	Group B	10	2.5±0.5	*P*>0.05 NS
	Group C	10	2.2±0.6	
mSBI	Group B	10	0.2±0.4	*P*>0.05 NS
	Group C	10	0.1±0.3	
CFU	Group B	10	2.3±0.483	*P*>0.05 NS
	Group C	10	2.1±0.316	

Table 6: Intergroup comparison between the Group A and Group C

Parameters after 45 days	Groups	N	Mean±SD	*P*-Value
PI	Group A	10	0.65±0.265	*P*>0.05 NS
	Group C	10	0.80±0.156	
PD	Group A	10	3±0.77	*P*<0.05*
	Group C	10	2.2±0.6	
mSBI	Group A	10	0.667±0.489	*P*<0.05*

	Group C	10	0.1±0.3	
CFU	Group A	10	2.3±0.483	*P*>0.05 NS
	Group C	10	2.1±0.316	

The following abbreviations are used throughout the results: PI, Plaque Index; PD, Probing Depth; mSBI, Modified Sulcular Bleeding Index; CFU, Colony-Forming Units; P, Probability value; NS, Not significant; SD, Standard Deviation; and n, sample size. Continuous data are presented as mean ± SD, and a P-value less than 0.05 was considered statistically significant.

DISCUSSION:

Photodynamic therapy (PDT) is known for its capacity to target a wide range of periodontal pathogens, even those not responsive to standard antimicrobial agents.[8] Several clinical trials have evaluated PDT combined with conventional periodontal therapy and have reported favorable changes in clinical and microbiological markers, such as reduced plaque accumulation, decreased probing pocket depths, and diminished bleeding upon probing.[9]

This randomized clinical investigation compared the clinical and microbial responses of patients with chronic periodontitis and well-controlled type II diabetes undergoing SRP alone versus SRP together with either PDT or low-level laser therapy. Evaluations performed after 45 days showed that the groups receiving adjunctive therapies achieved stronger clinical improvements, including lower PI, reduced PD, and a greater decline in mSBI. Furthermore, a significant reduction in bacterial CFU counts was evident relative to control group.

PDT offers distinct advantage in periodontal management because it disrupts microbial cells through photochemical reactions without encouraging resistance development. Thus, PDT is particularly advantageous for patients with systemic risk factors that may impair standard treatment outcomes.[8] In the present study, the improvement in PI and inflammatory parameters suggests that combining PDT with SRP enhances periodontal healing mechanisms more effectively than mechanical debridement alone. Although SRP contributed to clinical improvements across all groups, the test groups demonstrated noticeably greater benefits at the 45-day evaluation.[9]

Azarpazhooh et al.[10] noted that while PDT alone showed limited therapeutic benefit, its use in conjunction with SRP enhances clinical recovery, though the advantages may not always be significantly different from SRP therapy by itself. Khader and colleagues[11] in their meta-analysis further suggested that co-therapy with PDT could reduce the need for invasive periodontal surgery, particularly in diabetic individuals showing more severe periodontal breakdown.

aPDT induces microbial cell death through the interplay of a triad; light activation, a photosensitizing agent, and molecular oxygen. Once photosensitizing agent is excited, cytotoxic reactive oxygen species are generated, resulting in the destruction of periodontal microorganisms while leaving host tissue unharmed.[12] Unlike common dyes, ICG exhibits selective bacterial affinity and reduces the potential for inadvertent tissue damage. ICG is also compatible with diode lasers commonly used in practice (810 nm), ensuring a cost-efficient and clinically feasible application.[13]

Karmakar et al.[14] demonstrated that PDT activated with ICG effectively targets periodontopathogenic bacteria, including *P. gingivalis, T. denticola, and T. forsythia.* Additionally, Oktawati et al.[15] observed reductions in PD, BOP, and CAL following PDT intervention. These findings reinforce the results of our study, showcasing improved inflammatory outcomes among patients treated with SRP + PDT.

Statistical outcomes in the present study revealed a considerable drop in PD and mSBI in the test categories at various time intervals, in line with earlier randomized trials validating the merits of adjunctive aPDT in periodontal therapy.[16] While some research suggests that PDT may not always provide major additional gains, a larger body of literature confirms that PDT, when combined with SRP, yields superior improvements in periodontal health when compared with SRP alone.[17]

Microbial assessments further confirmed a pronounced decrease in bacterial viability in both SRP-only and adjunctive therapy groups, with the greatest reduction observed in patients treated with PDT ($P < 0.001$). These microbiological improvements corroborate prior findings by Wadhwa et al.[18] and Srikanth et al.,[19] who reported significant elimination of bacterial species in deep periodontal pockets following aPDT with ICG. Although studies evaluating ICG-mediated aPDT are still limited, evidence consistently indicates meaningful clinical and microbial benefits associated with this approach.[20]

Recent systematic reviews and meta-analyses emphasize that aPDT enhances nonsurgical periodontal outcomes particularly in shallow to moderate pocket depths and offers clear advantages among diabetic individuals, supporting the present findings.[21] However, some contrasting results have been noted; Polansky et al.[22] reported no significant variation between aPDT-assisted intervention compared with standard SRP. A more contemporary meta-analysis study by Pardo and co-authors[23] reinforced the positive role of PDT in periodontal wound healing and microbial suppression.

Overall, within the limits of this clinical trial, all therapeutic strategies led to notable positive changes in the measured clinical outcomes. However, SRP combined with either PDT or LLLT demonstrated superior clinical and microbial responses compared to standard SRP, highlighting the capability of adjunctive light-based therapies in addressing periodontal ailments in patients in type II diabetic patients.

CONCLUSIONS:

All three treatment approaches led to significant periodontal improvement, but the greatest benefits were seen when photodynamic or laser therapy supplemented SRP. Both SRP+PDT and SRP+LLLT groups achieved significantly better clinical outcomes (greater reductions in probing depths, plaque, bleeding, and microbial counts)

compared to SRP alone. This suggests that incorporating these adjunctive therapies into periodontal treatment protocols could enhance outcomes for diabetic patients.

LIMITATIONS:

This clinical trial was restricted by both its modest sample size and the short follow-up interval. Only one concentration of ICG and a single treatment session were used, which may not represent optimal conditions. Future studies should include larger randomized trials with longer monitoring, multiple treatment sessions, and varying ICG dosages. Standardizing photodynamic therapy protocols and assessing outcomes in peri-implant cases would also help validate the clinical utility of these adjunctive treatments

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