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Original Article

A Split-Mouth Study Comparing Photodynamic Therapy and Scaling and Root Planning in the Treatment of Chronic Periodontitis

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ABSTRACT

Chronic periodontitis is a complex condition with a well-established bacterial cause. The primary treatment for non-surgical periodontal therapy is mechanical debridement. However, certain areas that are difficult to access can hinder the effectiveness of this approach, prompting the exploration of adjunctive therapies to enhance the results of conventional scaling and root planning (SRP). Various alternative therapies, such as ozone therapy, probiotics, systemic and local antibiotics, and photodynamic therapy (PDT), have been investigated for the management of periodontal diseases. Antibiotics, while effective, are limited by potential systemic side effects and the risk of bacterial resistance. PDT has emerged as a modern, non-toxic, non-invasive, and highly effective antimicrobial treatment for a variety of conditions. This treatment involves the use of a photosensitizer dye, which, when exposed to low-level laser light (660-680 nm, 100 mW), produces singlet oxygen, a powerful oxidizing agent that kills bacteria. This split-mouth study aimed to evaluate the effectiveness of PDT as an adjunct to SRP compared to SRP alone in patients with chronic periodontitis. Clinical parameters were measured at baseline and ninety days after PDT application. The results of the study showed statistically significant improvements in clinical parameters for the SRP + PDT group. When used alongside SRP, PDT has demonstrated enhanced periodontal outcomes, providing a beneficial effect for patients with chronic periodontitis.

Keywords: SRP, Chronic periodontitis, Photosensitizers, Photodynamic therapy, Singlet oxygen

Introduction

The American Academy of Periodontology defines chronic periodontitis as “an infectious disease resulting in inflammation within the supporting tissues of the teeth, progressive attachment, and bone loss characterized by pocket formation and recession of the gingiva” [1]. Clinically, it manifests as the loss of the attachment apparatus around the teeth, which can ultimately result in tooth loss. The development of periodontitis is primarily driven by bacterial biofilms and host inflammatory mediators, such as pro-inflammatory cytokines [2, 3].

The primary aim of periodontal treatment is to halt the inflammatory process, prevent or slow disease progression, and promote the regeneration of lost periodontal tissues [4]. Successful treatment should lead to better periodontal comfort and function. The therapeutic approach focuses on eliminating dental plaque and calculus to reduce the overall bacterial load. Treatment options may be nonsurgical or surgical, depending on the severity of the disease [5].

Nonsurgical therapies include mechanical and chemotherapeutic approaches designed to reduce or eliminate microbial biofilm. The conventional nonsurgical treatment involves mechanical debridement, using hand and ultrasonic instruments to clean the diseased root surfaces [6]. However, thoroughly debriding deep periodontal

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pockets is challenging with nonsurgical treatments such as scaling and root planing (SRP). This limitation highlights the need for alternative treatments to enhance the outcomes of nonsurgical management of chronic periodontitis. Adjunct therapies, like systemic and local antibiotics, are sometimes used in cases where conventional treatments are ineffective. However, systemic antimicrobials can lead to undesirable side effects, including the development of resistant microorganisms and other complications with prolonged use, which limits their role as adjunct treatments [7].

Due to the complications associated with both local and systemic antibiotic use, there has been ongoing research to identify alternative treatments for chronic periodontitis. One promising non-invasive approach that has recently emerged in clinical dentistry is photodynamic therapy (PDT) [8].

PDT involves a combination of three key elements: a photosensitizer, a low-level laser to activate the photosensitizer and oxygen. When these elements are combined, they generate cytotoxic reactive oxygen species, predominantly singlet oxygen, which has lethal effects on microorganisms, providing an antimicrobial action [9]. While Oscar Raab's accidental discovery of phototherapeutics occurred in 1900, antibacterial PDT was first introduced in 1960 by Macmillan, who used toluidine blue against microbes. PDT offers several advantages, including its specificity for targeted cells, minimal collateral damage, activation only upon light exposure, and the absence of resistance development among bacteria, a common issue with the overuse of antibiotics [10].

The current body of literature presents varying opinions on the effectiveness of photodynamic therapy. In light of these discrepancies, the present study aims to contribute to the existing scientific knowledge and further support the evidence on the efficacy of PDT.

Materials and Methods

Study design and population

This prospective interventional split-mouth study was carried out at the Department of Periodontology in a tertiary care institution, adhering to ethical standards, including the principles outlined in the World Medical Association Declaration of Helsinki. A total of 12 participants (7 males and 5 females), aged between 18 and 65 years, were recruited from the outpatient department. All participants provided informed consent after being fully briefed on the trial details.

Sample size calculation

The sample size was determined based on the primary outcome of pocket probing depth, using a 5% significance level and 80% statistical power. According to the sample size calculation for this split-mouth study, 12 subjects were included.

Inclusion and exclusion criteria

The following criteria were used for participant inclusion: 1) patients in good general health, 2) a minimum of 20 teeth present, and 3) generalized moderate to severe chronic periodontitis with probing depth of ≥ 4 mm in at least two posterior and two anterior teeth in each quadrant. Exclusion criteria were: 1) smokers, 2) individuals who had received periodontal treatment within the past six months, 3) those needing antibiotic prophylaxis for routine dental procedures, 4) pregnant or lactating women, and 5) individuals allergic to the photosensitizer dye.

Clinical parameters

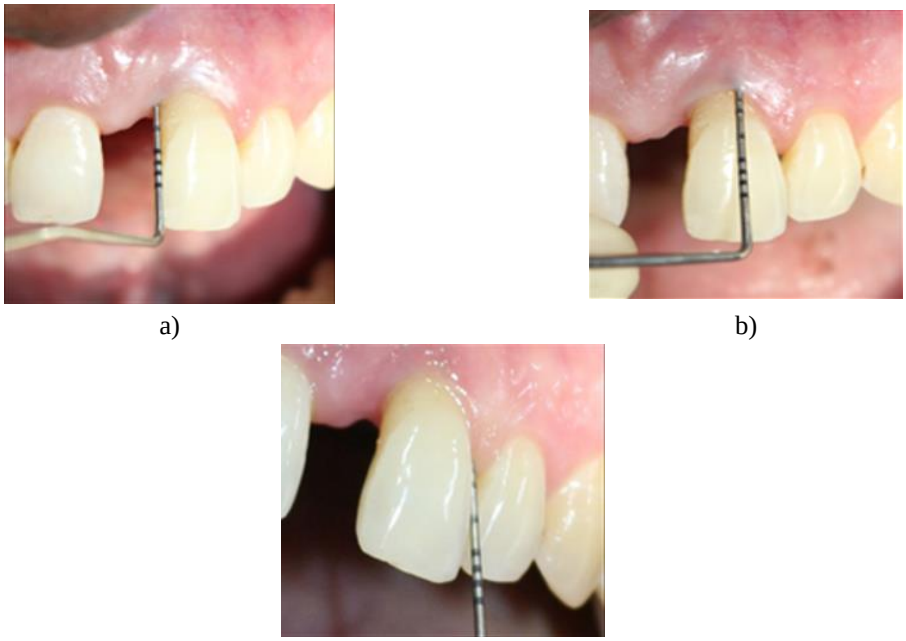
The clinical parameters assessed in this study included plaque index, gingival index, bleeding on probing, and pocket probing depth. These parameters were recorded at three-time points: baseline, one month, and three months. Measurements were taken at six sites per tooth using a Williams periodontal probe (Hu-Friedy Mfg. Co., Chicago, IL).

Patient allocation

In this split-mouth design, each patient's mouth was divided into 2 halves: one half included the lower and upper quadrants on the right side, while the other half included the lower and upper quadrants on the left side. The allocation of these halves into the treatment groups (group A for the test and group B for control) was randomized using the coin toss method.

Treatment procedure

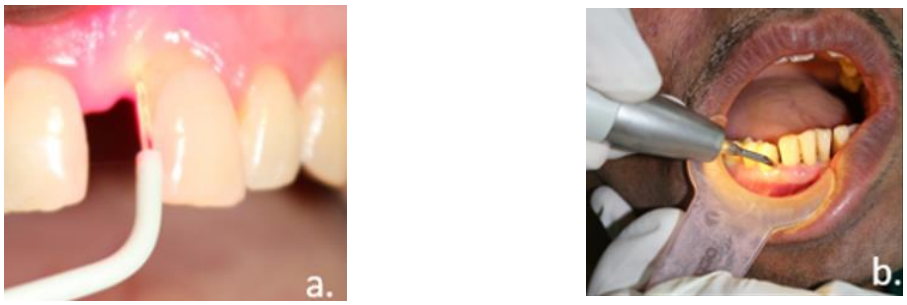
Conventional non-surgical periodontal therapy was provided to all patients diagnosed with chronic periodontitis who met the inclusion and exclusion criteria. The procedure included scaling and root planing, which was carried out using ultrasonic scalers and periodontal hand instruments like Gracey curettes **(Figures 1 and 2)**.



a) b)

c)

Figure 1. Group A (SRP+PDT) PRE-OP pocket probing depth (PPD) baseline; a) 4 mm at Mesiofacial, b) 2 mm at midfacial, c) distofacial 3mm surface of 12



a) b)

Figure 2. a) group A with PDT in addition to SRP, b) group B sites for SRP

Group A – In this group, one-half of the patient's mouth underwent photodynamic therapy following scaling and root planing. The procedure utilized the HELBO TheraLite (Bredent medical™) diode laser (Six hundred sixty nanometers) with a power output of 100 milliwatts, delivered through the HELBO® 3D Pocket Probe at a power density of sixty mW/cm². Each of the 6 surfaces of the treated tooth received an energy fluence of 3.53 J/cm² over a 10-second irradiation period. The photosensitizer used was HELBO blue (1% methylene blue solution with an absorbance peak at Six hundred seventy nanometers, concentration of 10 mg/mL), which exhibited antibacterial effects upon laser activation. The photosensitizer was introduced into the periodontal pocket using a viscoelastic cannula and left in place for 60 seconds to allow bacterial adsorption. Any excess dye was then rinsed out to prevent interference with laser penetration. The diode laser was applied for one minute per tooth, with 10 seconds of exposure at each site. The singlet oxygen generated during the process led to targeted bacterial destruction.
Group B – In this group, the corresponding halves of the patient's mouth received only scaling and root planing, without any additional treatment.

Statistical analyses

Statistical analysis was performed using the Statistical Package for Social Sciences version 26, with data initially compiled in an Excel sheet. A P-value < 0.05 was considered statistically significant when comparing the two

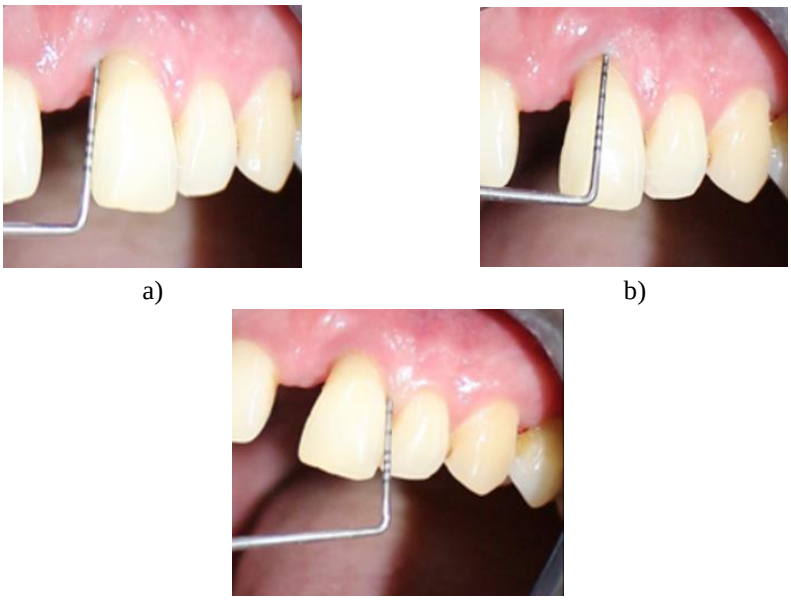
groups. Given the split-mouth study design and normal distribution of the dependent variable, intra-group and inter-group comparisons of continuous variables were conducted using paired t-tests. The t-value was obtained by comparing the mean values of both groups. Categorical variables were expressed as frequency and percentage (n, %), while continuous variables were presented as mean and standard deviation across the two study groups.

Results and Discussion

Baseline and 90-day post-treatment clinical parameters for all study participants in both the control group (group B) and test group (group A) were summarized in **Table 1**. At the initial assessment, there was no statistically significant difference between the groups in terms of % of BOP, PPD, and CAL.

The plaque index showed a decline from 2.02 ± 0.122 at baseline to 0.87 ± .214 at the 90-day follow-up. The percentage of bleeding sites in group B (SRP) was recorded at 79.47 ± 65.41 initially, which dropped to 23.15 ± 4.49 after 90 days, reflecting a mean reduction of 56.13 ± 1.92. In group A (SRP + aPDT), the baseline value was 78.71 ± 55.16, decreasing to 18.52 ± 34.15 post-treatment, with a mean reduction of 60.19 ± 2.01. Both groups demonstrated a statistically significant decline in the percentage of bleeding sites at the 90-day follow-up ($P < 0.05$) **(Table 1)**.

Regarding pocket probing depth, the mean reduction at the 90-day mark was 2.9 ± 0.17 in group A and 2.18 ± 0.24 in group B **(Table 1)**. The improvement in mean probing depth reduction was more pronounced in SRP + aPDT (group A) compared to SRP alone (group B) **(Figure 3)**.



a) b)

c)

Figure 3. Group A (SRP+PDT) POST-OP pocket probing depth (PPD) after 3 months; a) 2mm at mesiofacial, b) 1mm at midfacial, and c) 2mm at distofacial surface of 12

At the 90-day follow-up, the mean difference in clinical attachment level was recorded as 2.58 ± 0.63 in group A and 1.89 ± 0.57 in group B **(Table 1)**. A statistically significant ($P < 0.05$) improvement in mean clinical attachment level was observed in the SRP + aPDT group (group A) compared to SRP alone (group B) **(Table 1).** Furthermore, three months post-treatment, there was an overall enhancement in clinical outcomes, indicating a positive response of chronic periodontitis to non-surgical periodontal therapy. Both SRP alone and its combination with photodynamic therapy contributed to this improvement **(Figures 4-6)**.

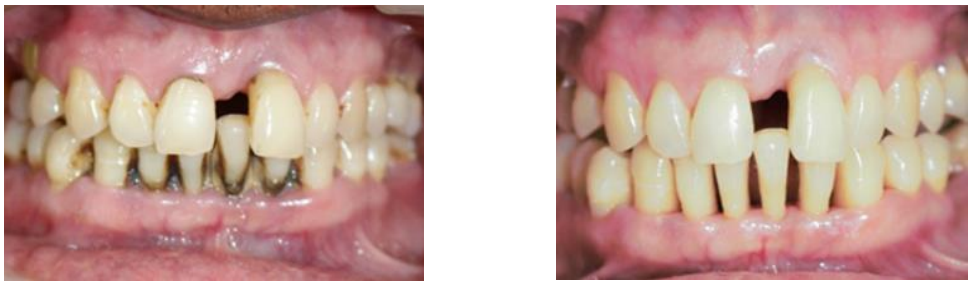


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Figure 4. A comparison between the pre-operative condition and the three-month post-operative status demonstrated an overall enhancement in clinical presentation

Table 1. A comparison of the mean differences in clinical parameters between the test and control groups was conducted 90 days after the intervention

	Group A (SRP+ PDT) difference between before and after intervention (Mean ± SD	**Group B (SRP) difference between before and after intervention (Mean ± SD)**	**Remarks**
% of Bleeding Sites	60.19 ± 2.01	56.13 ± 1.92	Significant
PPD (in mm)	2.9 ± 0.17	2.18 ± 0.24	Significant
CAL (in mm)	2.58 ± 0.63	1.89 ± 0.57	Significant

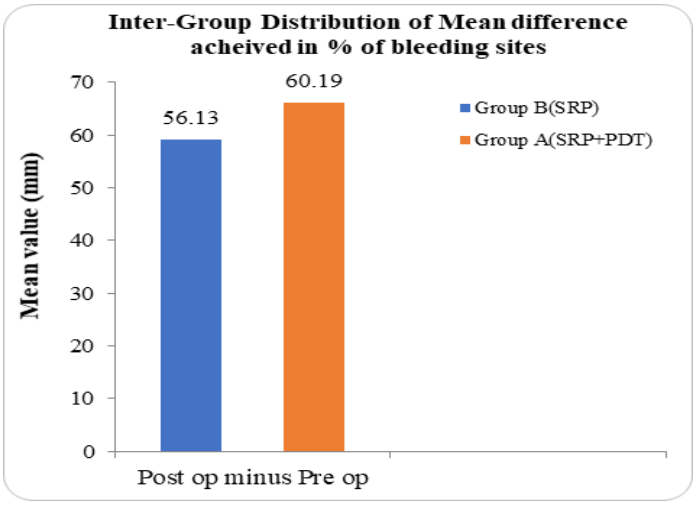

Figure 5. Comparison between groups of the mean differences in the percentage of bleeding sites.

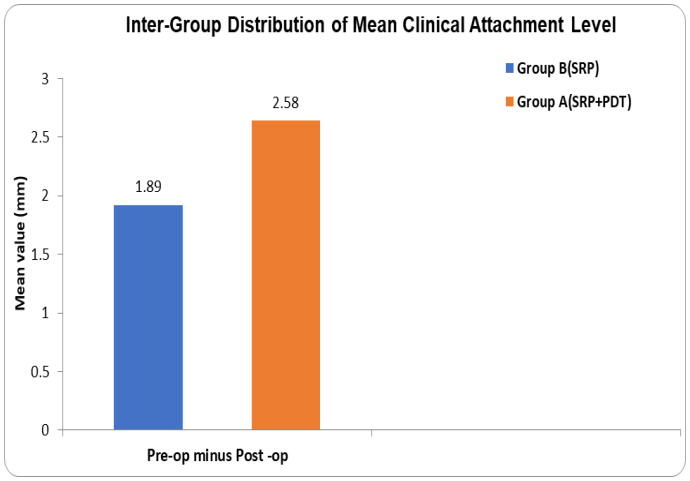

Figure 6. Comparison of mean differences in clinical attachment level between the two groups.

The primary goal of non-surgical periodontal therapy is to reduce microbial presence at sites affected by periodontal disease, thus alleviating the inflammation. This treatment approach includes supragingival scaling, subgingival scaling, and root planing. However, there are challenges in accessing difficult areas such as furcation regions, deep pockets, and root concavities that have prompted the exploration of additional therapies like locally applied antibiotics, probiotics, photodynamic therapy, and ozone therapy [11]. While antibiotics are linked to the development of bacterial resistance and systemic side effects, probiotics and ozone therapy have shown mixed results in clinical trials for periodontitis. On the other hand, photodynamic therapy (PDT), although still in its early stages, has shown great promise as an innovative treatment in both the medical and dental fields.

PDT operates through two mechanisms. In the type I reaction, laser light directed at the photosensitizer generates reactive oxygen species (ROS), which damage bacterial biofilm components like polysaccharides, enzymes, and proteins. In the type II reaction, the excited photosensitizer transfers energy to oxygen molecules, converting them into highly reactive singlet oxygen. This singlet oxygen, with its potent oxidative capabilities, is beneficial in treating chronic periodontitis and peri-implantitis through its antibacterial effects when applied as antibacterial photodynamic therapy (aPDT) [12].

The study was conducted over 3 months, consistent with the duration of many other studies that have compared adjunctive therapies to standard scaling and root planing (SRP) [5, 13-16]. Our findings revealed a significant improvement in clinical parameters, including bleeding on probing, pocket depth reduction, and clinical attachment levels, following the application of photodynamic therapy (PDT) in chronic periodontitis patients. The plaque index showed a reduction from 2.02 ± 0.122 at baseline to 0.87 ± 0.214 after 3 months, suggesting that patients maintained good oral hygiene. As this was a split-mouth study, comparisons across the two groups were not made since the plaque index was calculated for the entire mouth to assess oral hygiene practices. According to Lang *et al*. [17], bleeding on probing is an early indicator of gingival inflammation and serves as a reliable predictor for future attachment loss. In our study, an important decrease in bleeding percentage was observed three months after PDT, which aligns with findings in a systematic review by Ramanauskaite *et al*. [18].

After SRP alone, there was a notable reduction in pocket probing depth (PPD) and clinical attachment levels (CAL). However, when comparing the intergroup outcomes, the SRP combined with aPDT group showed greater improvements, supporting the efficacy of PDT, as also observed in a systematic review and meta-analysis by Dalvi *et al*. [19]. A recent literature review by Sales *et al*. [20] examined the in-vitro effectiveness of PDT in reducing periodontal pathogens. In 25 studies (78.12 percent), a reduction of 3 logs CFU/mL or more was reported for microorganisms linked to periodontal disease. However, other studies, such as those by Christodoulides *et al*. [21], Polansky *et al*. [22], and Balata *et al*. [23], concluded that aPDT did not provide additional benefits in reducing PPD or improving CAL when used adjunctively with SRP in managing chronic periodontitis. The discrepancies between these findings could be attributed to differences in the techniques used, the type and concentration of photosensitizers, and the exposure time to the specific wavelength of light.

A few limitations of this research include the small sample size and the evaluation of only clinical parameters. However, despite conflicting findings regarding the effectiveness of PDT, the current study demonstrated statistically significant improvements in clinical outcomes for SRP+ aPDT (group A) when compared to SRP alone (group B). Given the benefits such as shorter treatment times, the selective action of dyes on microorganisms, the prevention of bacterial resistance, the ability to easily repeat treatments, and its relative safety, this approach holds promise for the future of periodontics.

Conclusion

Based on the results of this research, we concluded that a single application of aPDT in conjunction with SRP led to significant improvements in clinical parameters, including reductions in pocket probing depth (PPD), gains in clinical attachment level (CAL), and a notable decrease in the percentage of bleeding sites. However, limitations such as a small sample size, the focus on clinical parameters alone, and a short follow-up period hinder the ability to assess the overall benefits of PDT comprehensively. Therefore, it is recommended that future research involve larger sample sizes, include a broader range of parameters, and extend the follow-up duration.

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Conflict of Interest: None

Financial Support: None

Ethics Statement: All procedures followed the principles outlined in the Declaration of Helsinki and adhered to local statutory requirements as per departmental protocol. The study was approved by the ethical committee (letter no DYPV/EC/571/2020), and written informed consent was obtained from all participants.

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