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EFFICACY OF PHOTODYNAMIC THERAPY COMBINED WITH SCALING AND ROOT PLANNING IN THE TREATMENT OF CHRONIC PERIODONTITIS: A SYSTEMATIC LITERATURE REVIEW

KAREN MICHELLE HERRERA PULLAS1, WELLINGTON ANDRÉS SÁNCHEZ ROCHA2, KENNY NOÉ ORTEGA MONCAYO3, GENESIS NICOLE NÚÑEZ MEDINA4, ALISSON MICAELA MIÑO MESTANZA5, JENNIFER CECILIA ZAMBONINO ESQUIVEL6

1Dentist, Universidad Central del Ecuador.
2Dentist, Independent Investigator.
3Dentist, Universidad Tecnológica Equinoccial De Quito.
4Dentist, Independent Investigator.
5Dentist, Universidad Tecnológica Equinoccial De Quito.
6Dentist, Universidad de las Américas.

ABSTRACT

Chronic periodontitis (CP) is a prevalent inflammatory disease-causing tooth loss, significantly impacting physical and mental health. A significant contributor to the development of CP and the resulting severe periodontal tissue destruction is dental plaque biofilm. Scaling and root planing (SRP) and antibiotics are standard treatments, although they have drawbacks and may lead to bacterial resistance. Using SRP in conjunction with photodynamic treatment (PDT) to treat cerebral palsy (CP) was evaluated in this integrative review. PDT, SRP, and CP-related search phrases were utilised in Scopus, Google Scholar, and PubMed to find papers published between 2019 and 2024. English-language research using human subjects that assessed PDT using SRP met the inclusion requirements. Research that lacked validity or significance were excluded. Probing pocket depth, clinical attachment levels, bleeding on probing, and plaque ratings were all significantly improved with PDT+SRP, according to clinical data from main investigations. Beneficial bacteria increased but periodontopathogens decreased in the microbial makeup. Although the long-term advantages of PDT+SRP were less evident, meta-analyses supported its effectiveness, especially in the short term. PDT therefore shows significant short-term benefits in microbial profiles and clinical outcomes in CP patients when used as an adjuvant to SRP. To verify long-term advantages and improve treatment regimens, further investigation is required.

INTRODUCTION

Chronic periodontitis (CP), one of the most prevalent periodontal diseases, is the main factor in tooth loss in people, which has a detrimental impact on both physical and mental health. Dental plaque biofilm

plays a key role in the development of periodontitis, an inflammatory disease that severely damages the supporting tissue of the periodontal region [1]. Inflammation throughout the body may result from it [2]. The annual cost of severe periodontitis is estimated to be 54 billion US dollars worldwide [3]. The most significant pathogens that because periodontal disease are complex microorganisms like Porphyromonas gingivalis, T. denticola, aggregative bacteria actinomycetes, and so on [4]. Reducing germs and controlling tooth plaque are the primary objectives of periodontal therapy. Antibiotic medication and mechanical debridement are part of the standard of treatment [5]. Antibiotics help lessen the pathogen that causes periodontal disease, but regular use of them can cause bacterial drug resistance [6]. The most popular CP therapies include scaling and root planing (SRP), subgingival curettage, and cleaning; nonetheless, there are several drawbacks. The intricate anatomical structure of the root bifurcation, the depth of the periodontal pocket, and the degradation of deep gingival tissues by bacteria make periodontium difficult to remove. Finding a more efficient supplementary treatment is thus crucial for CP patients taking SRP [7].

The introduction of various treatment modalities that may aid in the elimination or modification of the causal elements is the fundamental idea of the disease control approach. Scaling and root planning (SRP) is the gold standard treatment technique for periodontal disease. It has been shown that SRP effectively lowers periodontal disease (PD), improves periodontal disease (CAL), and alleviates related inflammatory disorders. SRP is not without limits, however. In deep pockets that are difficult to reach, root furcation, and concavities, SRP may not be a practical therapeutic option [8]. Health care providers and academics have been collaborating to develop treatment plans that are simple to implement and available to the general public in an effort to enhance the results. In recent years, many additional treatments have been suggested to enhance the therapeutic impact of SRP, including as laser therapy, antibiotics, and comprehensive host management. Laser treatment is a non-invasive, stimulating, and anti-infective auxiliary therapy as compared to other auxiliary approaches. Additionally, CP patients have increasingly received laser treatment [9] [10]. PDT stands out among the various other laser therapy techniques. PDT, a locally non-invasive therapeutic approach, has been used in medicine since the early 1900s and is well-known for its superior tumour treatment efficacy [11]. According to Allison et al, the presence of three elements—light, photosensitizer, and oxygen—is necessary for PDT to work. When light with a certain wavelength activates sick tissue cells, photosensitizer joins with those cells in a selective manner [12]. After that, it combines with the oxygen in the environment to create compounds that are reactive to oxygen, such singlet oxygen and oxygen-free radicals. Bacteria cannot survive these compounds' cytotoxicity [13]. Since there is no set standard for the kind of light source utilized in PDT, diode or semiconductor lasers are often used. Patients are more likely to embrace PDT because of its safety, lack of side effects, and non-surgical approach to therapy. Additionally, studies on animals and in vitro have shown that PDT successfully suppresses the bacterium that causes periodontal disease [14].

PDT is used in addition to SRP because it is a non-invasive, safe therapy with negligible side effects that may improve clinical results and is more well-tolerated by patients than surgical procedures. Using PDT in addition to SRP has been proven in many trials to increase pocket depth (PD), clinical attachment loss (CAL), and bleeding on probing (BOP) [15]. Different treatment methods, including variations in wavelength, power, irradiation duration, energy density, etc., might be blamed for these disputes. The research aims to assess the most current evidence about the effectiveness of PDT plus SRP in treating chronic periodontitis.

METHODOLOGY

An integrative approach was utilized to systematically review the efficacy of photodynamic therapy (PDT) combined with scaling and root planning (SRP) in treating chronic periodontitis. Comprehensive searches were conducted in Scopus, Google Scholar, and PubMed for studies published between 2014 and 2024, using key terms such as "photodynamic therapy," "scaling and root planning," "chronic periodontitis," and "periodontal treatment." Boolean operators refined these search queries to ensure a thorough examination of the topic.

Inclusion and exclusion criteria

The review's included studies had to fulfil specific criteria, such as being published in English within the allotted time frame, examining the clinical application of PDT in conjunction with SRP for chronic periodontitis, involving human participants, and offering noteworthy contributions to the diagnosis, prognosis, or treatment of the ailment. Research that did not fit these parameters, lacked scientific rigour, or did not make a substantial contribution to our knowledge of the uses of PDT in periodontal treatment were disregarded. Every chosen research was carefully assessed for its applicability and relevance to the goals of the review.

Categorization and analysis

The chosen studies' therapeutic uses and important discoveries about PDT and SRP in chronic periodontitis were the basis for categorization and analysis. Changes in microbial composition (shifts in subgingival microbial profiles, reduction in periodontopathogen bacteria, and increase in beneficial bacteria), impact on inflammatory markers (changes in cytokine levels such as IL-1β and IL-6), and patient-specific factors (effects in different populations like smokers versus non-smokers, and the influence of treatment frequency and duration) were among the categories. Clinical outcomes included improvements in probing pocket depth, clinical attachment level, and reductions in bleeding on probing and plaque scores. A thorough evaluation of PDT's function as an adjuvant treatment to SRP was made possible by the data synthesis within each category, which improved knowledge of PDT's efficacy and its uses in periodontal care.

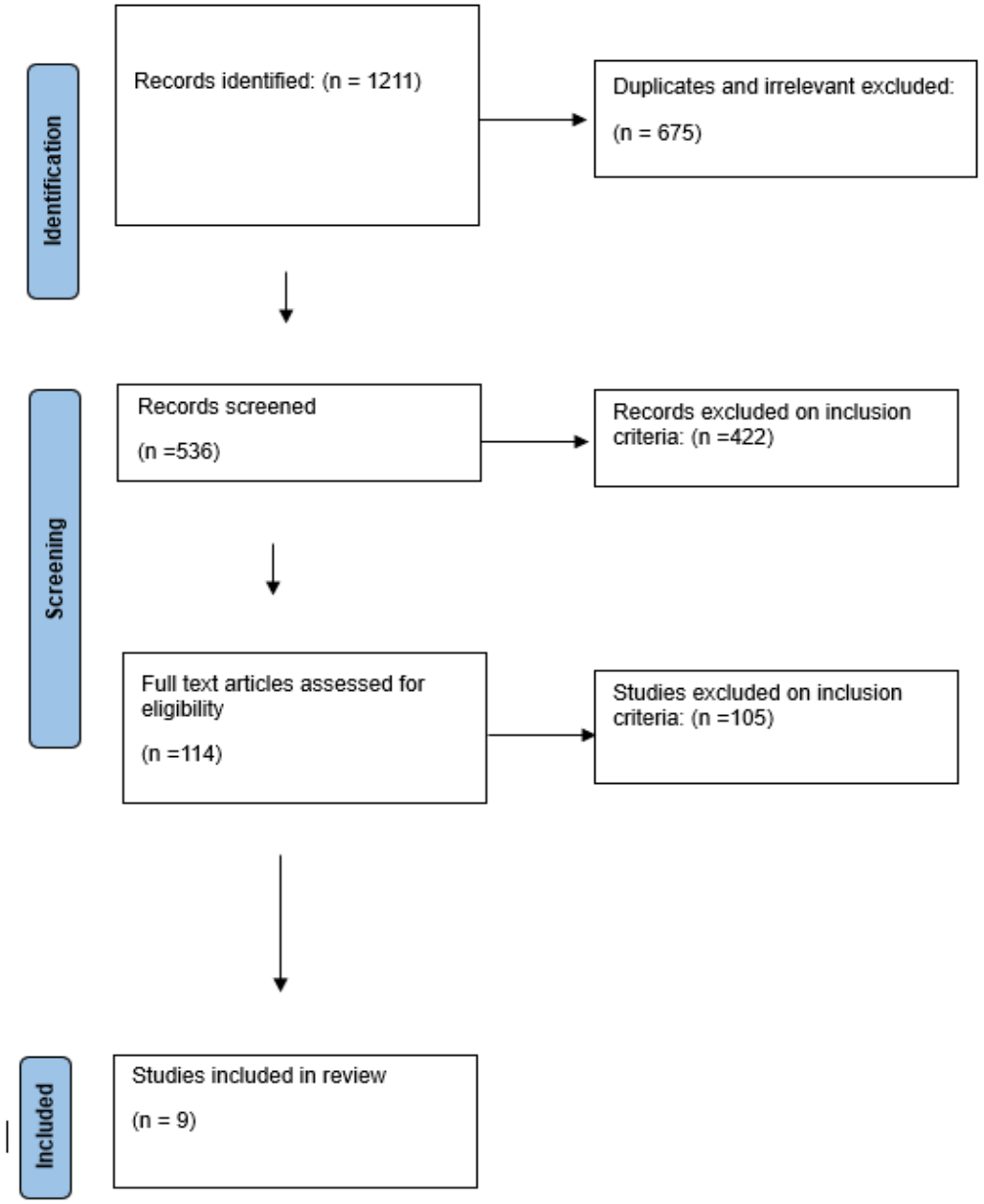

Figure 1 *(Prisma Flow Diagram.)*

RESULTS

Clinical evidence by primary studies

To determine if photodynamic therapy (PDT) is as effective as scaling and root planing (SRP) in treating chronic periodontitis, Min Nie carried out research. This split-mouth randomised clinical experiment had seventeen participants [16]. Three groups were randomly assigned: one group had a single PDT treatment immediately after SRP, one group received three repeated PDT applications one week after SRP, and the control group consisted of sites with bleeding on probing in distinct quadrants and probing pocket depth (PPD) ≥5 mm. At baseline, Week 2, and Week 8, the subgingival plaque was collected for 16S rRNA gene sequencing. During this 8-week follow-up, 17 patients with 60 sites finished it, and

sequencing of 157 subgingival plaques was effective. Two main outcomes, PPD at Week 8 and subgingival microbial composition, showed significant improvements. In comparison to the control group, the repeated-PDT group had significant improvements in PPD and significant changes in the microbial profile at Week 2, including a decrease in α-diversity and anaerobic bacteria and an increase in aerobic bacteria. At Week 8, there was further improvement in secondary outcomes, including clinical attachment level and sulcus bleeding index. In addition, between baseline and the single- and repeated-PDT groups, there was a reduction in periodontopathogens and an increase in beneficial bacteria. As a result, PDT encourages modifications in the subgingival plaque of patients with periodontitis that are beneficial to periodontal health, making recurrent PDT a viable adjuvant therapy for periodontal therapy.

The objective of M.F. ELSADEK and M.F. FARAHAT was to investigate the effectiveness of photodynamic therapy (PDT) in conjunction with scaling and root planning (SRP) for the management of chronic periodontitis in elderly individuals.60 elderly adults with severe periodontitis (Stage III/Grade C) were evaluated for this clinical research [8]. Both Group A (SRP + PDT; test group) and Group B (SRP alone) were assigned to participants at random. Clinical attachment level (CAL), probing depth (PD), bleeding on probing (BOP), and plaque scores (PS) were among the clinical periodontal indicators assessed. Using the Enzyme Linked Immunosorbent Assay (ELISA), the levels of interleukin (IL)-1β and IL-6 in cerebrospinal fluid were measured. At baseline, three months, and six months, respectively, all measures were carried out. To examine the mean values and create intergroup comparisons, the Mann-Whitney test was used. Outcomes: The included patients' ages varied from 65.4 to 67.1 years old on average. When comparing Group, A patients to Group B patients at the three-month follow-up, there was a statistically significant decrease in PS and BOP ($p<0.001$) on the intergroup comparison. Both groups had a decrease in probing depth and CAL. The inter-group comparison did, however, reveal decreased PD at the three- and six-month follow-ups (p0.05). At three months, IL-6 showed the similar pattern. But the IL-6 was still reduced for six months after that, when it was reassessed. In elderly individuals with diseased periodontal pockets, PDT assisted in lowering the clinical and pro-inflammatory burden.

A split-mouth, randomised controlled clinical study was carried out by Kaveri Kranti Gandhi et al. to assess the effectiveness of photodynamic therapy (PDT) and low-level laser therapy (LLLT) in addition to scaling and root planning (SRP) for the treatment of chronic periodontitis [17]. Test groups 1 (SRP + PDT), 2 (SRP + LLLT), and control group (SRP alone; two quadrants per patient) were assigned to each quadrant. At the 1-, 3-, 6-, and 9-month follow-ups, the test groups demonstrated substantially greater decreases in the Gingival Index, probing depth, and clinical attachment level as well as in the counts of Prohormones gingival is and Aggregatibacter actinomycetemcomitans in comparison to the control group.

An investigation was carried out by Karuna Joshi et al. to evaluate the photosensitizer indocyanine green (ICG), which has a lower toxicity and superior tissue absorption, as an adjuvant to scale and root planning (SRP) in aPDT [6]. A total of 29 individuals with chronic generalised periodontitis were recruited in the current split-mouth clinical research. The test group got adjunctive treatment in the form of ICG, mediated aPDT in addition to SRP, whereas the control quadrant received scaling and root planning alone. The test and control quadrants were randomly assigned. Clinical indicators were measured at baseline and after three months, including plaque index (PI), modified sulcular bleeding index (mSBI), periodontal probing depth (PPD), and clinical attachment level (CAL). Although the

intergroup comparison for both measures produced a non-significant result, it was noted that there was a substantial decrease in PI and mSBI from baseline to three months in both groups. In contrast, the intergroup comparison between the test and control groups from baseline to three months showed a substantial improvement in PPD and CAL in the ICG group. Within the constraints of the current investigation, it can be said that the use of ICG-mediated PDT as an adjuvant increased SRP's efficacy.

In order to treat chronic periodontitis (CP) in cigarette smokers and never-smokers, Fatemeh AlAhmari et al. evaluated the effectiveness of scaling and root planning (SRP) with and without adjunct antibiotic photodynamic therapy (aPDT) [18]. Group 1 consisted of cigarette smokers, whereas Group 2 consisted of never-smokers with CP. Regarding treatment, these patients were split into two groups: (a) SRP alone, and (b) SRP with adjunct aPDT. The following periodontal parameters were measured: probing pocket depth ≥4 mm [PD], clinical attachment loss [AL], bleeding on probing [BOP], plaque index [PI], and follow-up at one month and three months. The Kruskall-Wallis test was used for group comparisons. Eighty-three male CP patients were involved (42 smokers in Group 1 and 41 never smokers in Group 2). In group 1, the mean history of cigarette smoking was 11.7 ± 0.3 and 12.5 ± 0.4 pack years for those who got SRP alone and SRP with adjunct aPDT, respectively. All members of groups 1 and 2 had similar baseline values for PI, BOP, PD, and clinical AL. PI ($P < 0.05$), PD ($P < 0.05$), and clinical AL ($P < 0.05$) were all greater in group-1 at the one-month and three-month follow-ups than in group-2. At the one-month and three-month follow-ups, PI, BOP, PD, and clinical AL were similar in Group 2. As a result, the effectiveness of SRP for the treatment of CP in smokers is impaired, whether or not aPDT is used. The effects of SRP with or without aPDT are similar in never-smokers with CP.

Muzaheed et al. carried out a 6-month follow-up research to evaluate the impact on periodontopathogen bacteria in patients with periodontitis of one vs numerous sessions of photodynamic treatment (PDT) as an adjuvant to scale and root planning (SRP) [19]. There were 45 individuals with periodontitis in all. Three groups of patients were randomly assigned to them. Groups 1 (consisting of 15 patients), 2 (consisting of 15 patients), and 3 (consisting of 15 patients) had SRP with PDT at baseline, baseline and one month later, and baseline and one month and three months later. Measurements were taken at baseline and six months later for the following parameters: peri-implant plaque index (PI), bleeding on probing (BOP), probing depth (PD), clinical attachment loss (CAL), and marginal bone loss (MBL). Prohormones gingival is, Treponema denticola, Aggregatibacter Actinomycetemcomitans, Prevotella intermedia, and Fusobacterium nucleatum counts were taken before to SRP and at the 4- and 6-month follow-up. Grade-B periodontitis affected every patient. Age and gender differences were not statistically significant across all groups. After six months, individuals who had SRP once had much more periodontopathogen bacteria in their oral biofilm than those who had photo biomodulation twice or three times ($P < 0.05$). The periodontal parameters and gram-negative bacterial counts were not significantly change between individuals who got photo biomodulation twice or three times. In summary, in order to significantly lower the counts of subgingival bacteria in patients with periodontitis during a 6-month follow-up period, at least two PDT sessions after baseline

The impact of aPDT with a 660 nm diode laser and methylene blue on clinical periodontal parameters was assessed by Nahid Derikvand et al. as an addition to scaling and root planning (SRP) [15]. They evaluated aPDT as a supplement to scaling and root planning (SRP) in the treatment of chronic periodontitis in this clinical experiment. There were fifty participants in all. The case group was exposed to irradiation using a diode laser (power of 150 mW, wavelength of 660 nm) and SRP and aPDT with

methylene blue solution as photosensitizer. All the group under control got was SRP. Plaque index (PI), gingival index (GI), and probing depth (PD) are clinical indicators that were measured at baseline, six weeks, three months, and six months. When it came to baseline clinical indicators, there were no discernible variations between the subjects. PI, GI, and PD showed substantial improvements ($P < 0.05$) from the baseline. In summary, aPDT is a safe and effective method that may be used in conjunction with SRP to help patients with chronic periodontitis reduce their pocket depth.

Table 1 *(Clinical outcomes of different studies after the intervention of PTD + SRP.)*

Study	PPD Improvement	CAL Improvement	BOP Reduction	PS Reduction	Microbial Composition Changes
Min Nie	Significant	Improvement at Week 8	Not specified	Not specified	Reduction in α-diversity and anaerobic bacteria, increase in aerobic bacteria, decrease in periodontopathogens, increase in beneficial bacteria
M.F. ELSADEK and M.F. FARAHAT	Significant at 3 and 6 months	Significant at 3 and 6 months	Significant at 3 months	Significant at 3 months	Not specified
Kaveri Kranti Gandhi et al.	Significant at 1, 3, 6, and 9 months	Significant at 1, 3, 6, and 9 months	Not specified	Not specified	Reduction in Porphyromonas gingivalis and Aggregatibacter actinomycetemcomitans
Karuna Joshi et al.	Significant at 3 months	Significant at 3 months	Not specified	Significant at 3 months	Not specified
Fatemah AlAhmari et al.	Improvement in never-smokers, impaired in smokers	Improvement in never-smokers, impaired in smokers	Not specified	Improvement in never-smokers, impaired in smokers	Not specified
Muzaheed et al.	Significant with 2 or more sessions	Not specified	Not specified	Not specified	Reduction in Porphyromonas gingivalis, Treponema denticola, Aggregatibacter actinomycetemcomitans, Prevotella intermedia,

					and Fusobacterium nucleatum with 2 or more sessions
Nahid Derikvand et al.	Significant at 6 weeks, 3 months, and 6 months	Not specified	Not specified	Significant at 6 weeks, 3 months, and 6 months	Not specified

Clinical evidences by previous reviews

A meta-analysis on the effectiveness of additional photodynamic treatment for chronic periodontitis undergoing scaling and root planing was carried out by Jungyul Song et al [3]. They looked for randomised controlled studies that evaluated scaling and root planing (SRP) with and without PDT for chronic periodontitis in the following databases: Web of Science, Cochrane Library, Pubmed, Embase, China National Knowledge Internet, Wanfang Data, VIP, and Chinese Biomedical Literature Database. Papers released before to November 4, 2020 were included in the pooled analyses that were carried out using Stata 12.0 and Review Manager 5.3. There were found to be 18 RCTs totaling 750 periodontitis patients. Probing depth (PD) in the third month was substantially different between SRP and PDT, according to the pooled analysis [standardised mean difference (SMD), 0.22 mm; 95% CI, 0.07–0.37; P = 0.004]. At the sixth month, the PD did not significantly vary (SMD, 0.12; 95% CI, −0.10–0.33; P = 0.280). Furthermore, at the third month, there was a significant difference in the clinical attachment level (SMD, 0.24; 95% CI, 0.08–0.39; P = 0.003), while at the sixth month, there was no significant change (SMD, 0.18; 95% CI, −0.03–0.40; P = 0.090). SRP + PDT was shown to be considerably superior than SRP in terms of bleeding upon probing at the third follow-up month (SMD, 0.77; 95% CI, 0.42–1.13; P < 0.001), but not at the sixth month (SMD, 5.11; 95% CI, −2.50–12.72; P = 0.190). In the third month of follow-up, adjunctive PDT increased clinical effectiveness in terms of PD, clinical attachment level, and bleeding on probing; however, this improvement did not last into the sixth month.

When treating chronic periodontitis in cigarette smokers, Zohaib Akram et al. assess the clinical effectiveness of scaling and root planing (SRP) alone with additional photodynamic therapy (PDT) [4]. Data from randomised clinical trials (RCTs) were used to compare the effects of SRP and adjunctive PDT in each group. Gaining clinical attachment level (CAL) was one of the primary goals; probing depth (PD) decrease was one of the secondary outcomes. Random and fixed effect models were used to compute the weighted mean differences (WMD) of the outcomes and the 95% confidence intervals (CI) for each variable. Five RCTs in all were included. Three clinical studies were categorised as having a high risk of bias and two as having a moderate risk. The results of the follow-up study indicate that there was no statistically significant difference in the overall effects of CAL gain (WMD = –0.088, 95% CI = –0.40 to 0.23, p = 0.58) and PD decrease (WMD = -0.35, 95% CI = -0.87 to -0.17, p = 0.18) between the PDT and SRP groups. Given the limited strength of the existing scientific data, it is still unclear, within the confines of this investigation, whether PDT added to SRP improves clinical attachment level growth in smokers more than SRP alone.

DISCUSSION

The purpose of this systematic narrative review was to assess the effectiveness of scaling and root planning (SRP) in conjunction with photodynamic therapy (PDT) for the treatment of chronic periodontitis. The data from original research and meta-analyses point to the potential advantages of adjunctive photodynamic therapy (PDT), yet the outcomes depend on a number of variables, including study designs, patient characteristics, and application frequency.

Strong evidence for the short-term advantages of PDT, especially with repeated administrations, is shown by Min Nie's research. PDT has the ability to enhance periodontal health, as shown by the notable improvements in probing pocket depth (PPD) and alterations in subgingival microbial makeup. The microbiological influence of PDT is highlighted by the reported reduction in anaerobic bacteria and periodontopathogens, combined with a rise in aerobic and beneficial bacteria. These microbial changes are important because they improve the periodontal pockets' environment for health.

Similar improvements were shown in clinical measures including clinical attachment level (CAL), probing depth (PD), and plaque scores (PS) after three and six months in the research conducted by M.F. ELSADEK and M.F. FARAHAT on senior patients. The decrease in pro-inflammatory markers highlights PDT's function in reducing inflammation, which is a major contributor to the advancement of periodontal disease. These results provide credence to the idea that PDT may improve the results of traditional SRP, particularly in patients with greater inflammatory loads.

Kaveri Kranti Gandhi et al.'s research, which demonstrated consistent improvements in periodontal health indicators over nine months, lends further credence to the long-term advantages of PDT. These and other studies indicate that PDT used as an adjuvant may have long-term advantages, which makes it a useful supplement to SRP.

All trials did not, however, consistently indicate long-term advantages. For example, adjunctive PDT considerably improved PD and CAL at the three-month follow-up, but these gains did not persist at the six-month mark, according to Jungyul Song et al.'s meta-analysis. This suggests that PDT's advantages can fade with time and call for further treatments or combinations with other maintenance therapy.

The use of indocyanine green (ICG) mediated PDT as a supplement to SRP was shown to significantly enhance PPD and CAL in the short term by Karuna Joshi et al.; however, the effects in plaque index (PI) and modified sulcular bleeding index (mSBI) were not as strong. This diversity emphasises the need for further investigation to find the best PDT procedures and uncover the variables affecting their efficacy.

There are also difficulties with PDT's efficacy in smokers. The advantages of SRP, with or without concomitant PDT, were shown to be dramatically reduced in smokers, according to a research by Fatemah AlAhmari et al. This result emphasises how smoking negatively affects the results of periodontal therapy and raises the possibility that this group may need supplementary or alternative treatments. Despite its microbiological advantages, PDT's low effectiveness in smokers emphasises the intricate interactions between systemic variables and the results of periodontal therapy.

The study by Muzaheed et al. emphasises how crucial PDT session frequency is. According to their results, periodontopathogenic bacteria must be significantly reduced over the course of six months, requiring at least two PDT treatments. This is consistent with the hypothesis that recurrent PDT treatments might be essential for long-term microbiological control and therapeutic advancements.

In addition to SRP, Nahid Derikvand et al.'s research verified the safety and efficacy of aPDT using a 660 nm diode laser and methylene blue. The considerable gains in gingival index (GI), PD, and PI that were seen at different follow-up intervals provide credence to PDT's usefulness in standard periodontal treatment. The adaptability of PDT to various clinical situations and patient demands is further enhanced by the use of various photosensitizers and light sources. Based on available data, PDT is a useful complementary treatment to SRP, especially for non-smoking individuals with chronic periodontitis. Subsequent research endeavours have to concentrate on enduring results, the ideal frequency of PDT sessions, and the creation of customised treatment methodologies for heterogeneous patient cohorts.

CONCLUSION

Using photodynamic treatment (PDT) in addition to scaling and root planing (SRP) has the potential to improve chronic periodontitis (CP) patients' clinical results. Clinical research show that PDT, together with changes in the subgingival microbial composition, may dramatically increase probing pocket depth (PPD), clinical attachment level (CAL), and minimise bleeding on probing (BOP). However, the frequency of treatment and unique patient characteristics, such smoking status, might affect how effective PDT is. Though promising, PDT inclusion into regular periodontal therapy requires further validation via extensive, long-term research in order to prove its therapeutic effects and create standardised methodologies.

Numerous restrictions are noted in this assessment that may affect how broadly applicable the results are. Robust results and direct comparisons are complicated by the variety in research designs, which includes variations in PDT methods (wavelength, power, irradiation duration, and photosensitizers), patient demographics, and follow-up durations. In addition, it is difficult to evaluate the long-term safety and effectiveness of PDT as a supplement to SRP because to the very small sample sizes and brief follow-up periods in certain studies. The incoherence in disclosing microbiological and clinical results across investigations makes it even more difficult to efficiently combine data.

Further investigations using large-scale, multicentre randomised controlled trials with standardised PDT methods are needed to provide more conclusive proof of PDT's safety and effectiveness as an adjuvant treatment for CP. Long-term research is required to assess the long-term advantages and possible hazards of frequent PDT treatments. Investigating the molecular processes that underlie the effects of PDT on microbial populations and periodontal tissues may provide information about how to best customise treatment plans. Furthermore, establishing PDT's cost-effectiveness in clinical settings will be essential to its wider acceptance in periodontal treatment.

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