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Photodynamic Therapy with Curcumin and Chitosan as an Adjunct to Scaling and Root Planing in the Treatment of Chronic Periodontitis: A Clinical Study

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Abstract:

Background:*Chronic periodontitis is an inflammatory condition leading to progressive attachment loss and alveolar bone destruction. Scaling and root planing (SRP) remains the standard non-surgical treatment; however, adjunctive therapies may enhance clinical outcomes. Curcumin and chitosan possess antimicrobial, anti-inflammatory, and wound-healing properties, and photodynamic activation may potentiate their effects.* ***Aim:*** *To evaluate the clinical efficacy of photodynamic therapy (PDT) with curcumin–chitosan gel as an adjunct to SRP in patients with mild to moderate chronic periodontitis.* ***Materials and Methods:*** *A randomized controlled clinical trial was conducted involving 24 patients diagnosed with mild to moderate chronic periodontitis. Participants were randomly assigned into two groups: Group A received SRP alone, and Group B received SRP followed by subgingival application of curcumin–chitosan gel with subsequent blue LED photoactivation. Clinical parameters—gingival index (GI), plaque index (PI), probing pocket depth (PPD), clinical attachment level (CAL), and bleeding on probing (BOP)—were recorded at baseline, 15 days, 1 month, 3 months, and 6 months. Statistical analysis was performed using paired and unpaired t-tests, with $p<0.05$ considered significant.* ***Results:*** *Both groups showed significant improvement in all clinical parameters compared to baseline ($p<0.05$). Group B demonstrated greater reductions in GI, PI, PPD, and BOP, and greater CAL gain than Group A at all follow-up intervals. At 6 months, Group B showed a mean PPD reduction of 1.01 mm ($p<0.001$), CAL gain of 0.98 mm ($p<0.001$), GI reduction of 0.81 ($p<0.001$), PI reduction of 0.57 ($p<0.001$), and BOP reduction of 77.08% ($p<0.001$) from baseline.* ***Conclusion:*** *PDT with curcumin–chitosan gel as an adjunct to SRP resulted in superior improvements in periodontal health compared to SRP alone. This combination therapy offers a promising, minimally invasive approach for managing chronic periodontitis.*

Keywords: *chronic periodontitis, photodynamic therapy, curcumin, chitosan, scaling and root planing, local drug delivery*

INTRODUCTION

Chronic periodontitis is a prevalent inflammatory disease affecting the supporting structures of teeth, characterized by progressive loss of connective tissue attachment and alveolar bone [1]. It is initiated by microbial biofilm accumulation and modified by the host's immune-inflammatory response, leading to tissue destruction [2]. The global prevalence of severe periodontitis affects approximately 11.2% of the world's population, making it a significant public health concern [3].

Conventional periodontal therapy primarily involves mechanical debridement through scaling and root planing (SRP) to remove subgingival biofilm and calculus [4]. While SRP remains the gold standard for non-surgical periodontal treatment, it has limitations including incomplete removal of pathogens from inaccessible areas, limited efficacy in deep pockets, and rapid bacterial recolonization [5]. These limitations have led to the development of adjunctive therapies to enhance treatment outcomes.

Local drug delivery (LDD) systems have emerged as promising adjunctive treatments, allowing targeted delivery of antimicrobial agents directly into periodontal pockets [6]. Among these, natural compounds have gained attention due to their favorable safety profiles and multiple biological activities. Curcumin,

the principal bioactive component of turmeric (Curcuma longa), exhibits potent anti-inflammatory, antioxidant, and antimicrobial properties [7]. Studies have demonstrated its effectiveness against periodontal pathogens such as Porphyromonasgingivalis and Aggregatibacteractinomycetemcomitans [8]. Chitosan, a natural polysaccharide derived from chitin, possesses unique properties including biocompatibility, biodegradability, mucoadhesion, and antimicrobial activity [9]. Its ability to form gels makes it an excellent vehicle for drug delivery in periodontal pockets [10]. When combined with photodynamic therapy (PDT), which utilizes light-activated photosensitizers to produce reactive oxygen species that destroy microbial cells, these natural compounds may offer enhanced therapeutic effects [11]. Photodynamic therapy involves the administration of a non-toxic photosensitizer followed by illumination with light of appropriate wavelength, leading to the destruction of target cells [12]. PDT has shown promise as an adjunct to SRP in periodontal treatment, with studies reporting improvements in clinical parameters and reductions in periodontal pathogens [13]. The combination of curcumin as a photosensitizer with chitosan as a delivery vehicle may provide synergistic benefits for periodontal therapy. Despite the growing interest in natural compounds and PDT for periodontal treatment, limited clinical studies have evaluated the combination of curcumin and chitosan with photodynamic therapy as an adjunct to SRP. Most existing studies have focused on either curcumin or chitosan alone or in combination with conventional antimicrobials [14,15]. Therefore, this study aimed to clinically evaluate the efficacy of photodynamic therapy with curcumin and chitosan gel as an adjunct to SRP in the treatment of chronic periodontitis.

MATERIALS AND METHODS

Study Design

This randomized controlled clinical trial was conducted at the Department of Periodontics and Oral Implantology, Triveni Institute of Dental Sciences, Hospital and Research Centre, Bilaspur, Chhattisgarh, India.

Sample Size and Patient Selection

A total of 24 patients with mild to moderate chronic periodontitis were selected for the study. The sample size was determined based on a power analysis with an alpha error of 0.05 and a power of 80%, assuming a clinically significant difference of 1 mm in probing pocket depth reduction between the groups.

Inclusion criteria:

1. Patients aged 18 years or older
2. Diagnosis of mild to moderate chronic periodontitis with mean probing depth ≥5 mm
3. Presence of at least 20 natural teeth
4. Good general health without systemic diseases that could affect periodontal treatment

Exclusion criteria:

1. Current smokers or those who smoked regularly within the past 12 months
2. Patients with anemia
3. Use of antibiotics within the previous 6 months
4. Use of anti-inflammatory drugs within the previous 6 months
5. Pregnancy or lactation
6. Patients undergoing orthodontic treatment
7. History of periodontal treatment in the past 6 months

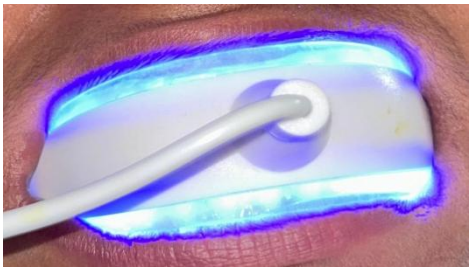
Study Groups and Intervention

After obtaining informed consent, patients were randomly assigned to one of two groups using a computer-generated randomization sequence:

Group A (Control): Received scaling and root planing (SRP) alone

Group B (Test): Received SRP plus curcumin-chitosan gel followed by photoactivation using blue LED light

GROUP A (CONTROL GROUP)



GROUP B (TEST GROUP)

Clinical Procedures

Baseline Examination

At the screening visit (15 days before baseline), complete medical and dental histories were recorded, and a full-mouth periodontal examination was performed. Supragingival scaling was performed using a piezoelectric ultrasonic scaler. Alginate impressions were made to fabricate customized acrylic stents, which served as reference guides for recording probing pocket depths and clinical attachment levels.

Baseline Measurements

At baseline, the following clinical parameters were recorded at all study sites by a calibrated examiner (intra-examiner reliability >0.85):

1. Gingival Index (GI) according to Loe and Silness (1963)
2. Plaque Index (PI) according to Silness and Loe (1964)
3. Probing Pocket Depth (PPD) using a University of North Carolina (UNC) 15 probe
4. Clinical Attachment Level (CAL) measured from the cementoenamel junction to the base of the pocket
5. Bleeding on Probing (BOP) recorded as the percentage of sites that bled within 30 seconds after probing

Treatment Protocol

All patients received full-mouth supragingival and subgingival scaling and root planing using ultrasonic scalers and Gracey curettes under local anesthesia. For Group B, after SRP, the selected sites were isolated and dried with compressed air. Curcumin-chitosan gel was delivered into the periodontal pockets using a sterile blunt tip attached to a syringe until resistance was felt. The gel was then photoactivated using a blue LED light source (wavelength 465-485 nm) for 2-3 minutes. Patients were instructed not to rinse or drink water for 30 minutes after the procedure.

Follow-up Examinations

Clinical parameters were reassessed at 15 days, 1 month, 3 months, and 6 months after treatment. At each follow-up visit, oral hygiene instructions were reinforced, and patients received supragingival prophylaxis if necessary.

Statistical Analysis

Data were analyzed using SPSS version 24.0 (IBM Corp., Armonk, NY, USA). Continuous variables were

presented as mean ± standard deviation (SD), while categorical variables were presented as frequencies and percentages. Independent t-tests were used for intergroup comparisons, and paired t-tests were used for intragroup comparisons. A p-value ≤0.05 was considered statistically significant.

Results

Demographic Characteristics

The study included 24 patients (12 in each group) with a mean age of 30.67±8.25 years in Group A and 32.92±9.33 years in Group B. Both groups had similar gender distributions, with 4 males and 8 females each. There were no statistically significant differences in demographic characteristics between the groups ($p>0.05$).

Comparison of Clinical Parameters Between Groups

Table 1 shows the comparison of gingival index (GI) and plaque index (PI) between the two groups at different time points. At baseline, there were no significant differences in GI and PI between the groups. However, at 15 days and 1 month, Group A showed significantly lower GI scores compared to Group B ($p<0.05$). At 6 months, Group B demonstrated significantly lower PI scores compared to Group A ($p=0.044$).

Table 1. Comparison of Gingival Index and Plaque Index Between Groups

Parameter	Time Point	Group A (Mean±SD)	Group B (Mean±SD)	Mean Difference	p-value
Gingival Index	Baseline	1.47±0.31	1.78±0.29	0.31	0.061
	15 days	1.19±0.19	1.57±0.30	0.38	0.001
	1 month	1.09±0.15	1.29±0.17	0.20	0.006
	3 months	1.15±0.24	1.05±0.10	0.11	0.176
	6 months	1.23±0.36	0.96±0.08	0.27	0.026
Plaque Index	Baseline	1.70±0.56	1.55±0.22	0.15	0.410
	15 days	1.11±0.17	1.28±0.48	0.17	0.267
	1 month	1.06±0.11	1.17±0.19	0.11	0.098
	3 months	1.27±0.48	1.02±0.06	0.25	0.106
	6 months	1.29±0.48	0.98±0.06	0.31	0.044

Table 2 presents the comparison of probing pocket depth (PPD) and clinical attachment level (CAL) between the groups. At baseline, there were no significant differences in PPD and CAL between the groups. However, at 3 months and 6 months, Group B showed significantly lower PPD values compared to Group A ($p<0.05$). Similarly, Group B demonstrated significantly better CAL values at all follow-up time points compared to Group A ($p<0.05$).

Table 2. Comparison of Probing Pocket Depth and Clinical Attachment Level Between Groups

Parameter	Time Point	Group A (Mean±SD)	Group B (Mean±SD)	Mean Difference	p-value
Probing Pocket Depth (mm)	Baseline	4.32±1.49	3.97±0.74	0.35	0.494
	15 days	3.98±1.41	3.71±0.75	0.27	0.580
	1 month	3.70±1.54	3.45±0.76	0.25	0.050
	3 months	3.63±1.69	3.22±0.75	0.41	0.047
	6 months	3.73±1.72	2.96±0.77	0.77	0.019
Clinical Attachment Level (mm)	Baseline	4.40±1.48	4.07±0.67	0.33	0.502
	15 days	4.10±1.36	3.80±0.70	0.30	0.049
	1 month	3.81±1.50	3.55±0.70	0.25	0.031
	3 months	3.77±1.64	3.28±0.75	0.49	0.037
	6 months	3.78±1.70	3.10±0.76	0.68	0.023

Table 3 shows the comparison of bleeding on probing (BOP) between the groups. At baseline, there were

no significant differences in BOP between the groups. However, at 15 days, Group B showed significantly lower BOP values compared to Group A (p=0.010).

Table 3. Comparison of Bleeding on Probing Between Groups

Parameter	Time Point	Group A (Mean±SD)	Group B (Mean±SD)	Mean Difference	p-value
Bleeding on Probing (%)	Baseline	81.25±26.38	91.67±12.31	10.42	0.283
	15 days	31.25±26.38	8.33±12.31	22.92	0.010
	1 month	10.42±16.71	6.25±11.31	4.17	0.559
	3 months	18.75±15.54	8.33±12.31	10.42	0.119
	6 months	20.83±14.43	14.58±12.87	6.25	0.395

Intragroup Changes in Clinical Parameters

In Group A, significant improvements were observed in all clinical parameters from baseline to 15 days and 1 month ($p<0.05$). However, these improvements were not sustained at 6 months for GI and PI.

In Group B, significant and progressive improvements were observed in all clinical parameters at all follow-up time points compared to baseline ($p<0.001$). The most pronounced improvements were observed at 6 months, with mean reductions of 0.81 in GI, 0.57 in PI, 1.01 mm in PPD, 0.98 mm in CAL, and 77.08% in BOP.

DISCUSSION

This randomized controlled clinical study evaluated the efficacy of photodynamic therapy with curcumin and chitosan gel as an adjunct to SRP in the treatment of chronic periodontitis. The results demonstrated that the combination therapy (Group B) produced significantly better clinical outcomes compared to SRP alone (Group A) over a 6-month follow-up period.

The findings of this study are consistent with previous research on the benefits of adjunctive therapies in periodontal treatment. Several studies have reported that mechanical debridement alone may not completely eliminate periodontal pathogens, particularly in deep pockets and complex root morphologies [16]. The rapid recolonization of bacteria after SRP further limits its long-term effectiveness [17]. These limitations have led to the exploration of adjunctive antimicrobial therapies to enhance treatment outcomes.

Curcumin, the principal bioactive compound in turmeric, has demonstrated multiple biological properties beneficial for periodontal treatment, including anti-inflammatory, antioxidant, and antimicrobial effects [18]. A systematic review by Zhang et al. reported that curcumin as an adjunct to SRP showed comparable efficacy to chlorhexidine in reducing probing depth and improving clinical attachment levels [19]. The anti-inflammatory action of curcumin is mediated through the suppression of pro-inflammatory cytokines and enzymes such as NF-κB, JAK/STAT, and MAPK [20]. Additionally, curcumin enhances wound healing by promoting collagen deposition, angiogenesis, and fibroblast density [21].

Chitosan, a natural polysaccharide, possesses unique properties that make it an ideal vehicle for drug delivery in periodontal pockets. Its mucoadhesive properties allow prolonged retention at the site of application, while its biocompatibility and biodegradability ensure safety [22]. A study by Akıncıbay et al. demonstrated that chitosan gel as an adjunct to SRP resulted in significant improvements in probing depth, clinical attachment level, and gingival inflammation compared to SRP alone [23]. The antimicrobial activity of chitosan is attributed to its polycationic nature, which interacts with negatively charged bacterial cell membranes, leading to cell lysis [24].

Photodynamic therapy has emerged as a promising adjunctive treatment for periodontitis. PDT involves the administration of a photosensitizer followed by illumination with light of appropriate wavelength, leading to the production of reactive oxygen species that destroy microbial cells [25]. A systematic review by Mahdizade Ari et al. reported that PDT as an adjunct to SRP significantly improved clinical parameters and reduced periodontal pathogens compared to SRP alone [26]. The combination of curcumin as a photosensitizer with chitosan as a delivery vehicle may provide synergistic benefits for periodontal therapy.

In the present study, Group B (SRP + curcumin-chitosan with PDT) showed significantly greater improvements in all clinical parameters compared to Group A (SRP alone). The most pronounced differences were observed at 6 months, with Group B showing a mean reduction in PPD of 1.01 mm,

CAL gain of 0.98 mm, GI reduction of 0.81, PI reduction of 0.57, and BOP reduction of 77.08% compared to baseline. These findings are consistent with previous studies on the efficacy of PDT and natural compounds in periodontal treatment.

The superior outcomes in Group B can be attributed to multiple mechanisms. The antimicrobial photodynamic therapy with curcumin likely enhanced the elimination of periodontal pathogens that were not completely removed by mechanical debridement [27]. The sustained release of curcumin from the chitosan gel may have prolonged its antimicrobial and anti-inflammatory effects, preventing rapid bacterial recolonization [28]. Additionally, the wound healing properties of both curcumin and chitosan may have contributed to the improved clinical attachment levels observed in Group B [29].

The significant reduction in bleeding on probing observed in Group B at 15 days ($p=0.010$) suggests a rapid anti-inflammatory effect of the combination therapy. This is consistent with the findings of Ivanaga et al., who reported that antimicrobial photodynamic therapy with curcumin and LED light resulted in significant reductions in gingival inflammation in diabetic patients with chronic periodontitis [30].

The progressive improvements observed in Group B over the 6-month follow-up period indicate the sustained effectiveness of the combination therapy. This is particularly important for long-term periodontal maintenance, as conventional SRP alone may not provide lasting benefits due to bacterial recolonization [31]. The use of curcumin-chitosan gel with PDT may help maintain a healthier periodontal environment by suppressing pathogenic bacteria and modulating the host inflammatory response.

It is worth noting that while both groups showed improvements in clinical parameters compared to baseline, the magnitude of improvement was significantly greater in Group B. This highlights the potential of adjunctive therapies to enhance the outcomes of conventional periodontal treatment. The findings of this study support the use of photodynamic therapy with curcumin and chitosan as an effective adjunct to SRP in the management of chronic periodontitis.

The limitations of this study include the modest sample size and the lack of microbiological analysis. Future studies with larger sample sizes and longer follow-up periods are needed to confirm these findings. Additionally, microbiological analysis would provide valuable insights into the mechanisms underlying the clinical improvements observed in this study.

CONCLUSION

This randomized controlled clinical study demonstrated that photodynamic therapy with curcumin and chitosan gel as an adjunct to scaling and root planing is significantly more effective than scaling and root planing alone in the treatment of chronic periodontitis. The combination therapy resulted in significantly greater improvements in all clinical parameters, including gingival index, plaque index, probing pocket depth, clinical attachment level, and bleeding on probing. These improvements were sustained over the 6-month follow-up period, suggesting long-term benefits of the adjunctive therapy. The use of natural compounds like curcumin and chitosan in combination with photodynamic therapy offers a promising approach for enhancing the outcomes of conventional periodontal treatment while minimizing potential side effects associated with synthetic antimicrobials. This study supports the incorporation of photodynamic therapy with curcumin and chitosan as an effective adjunctive treatment modality in the management of chronic periodontitis.

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