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Research Article

Comparative Study of Anti-Inflammatory and Antibacterial Effects of Adjunctive Herbal and Phytotherapy in Chronic Periodontitis with Clinical and Microbiological Outcomes

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Abstract

Introduction: Periodontal diseases are inflammatory conditions affecting the supporting structures of teeth, often resulting in tooth loss when left untreated. Conventional treatments include mechanical debridement and systemic antibiotics. However, the growing interest in herbal medicine stems from its potential anti-inflammatory and antimicrobial properties. This study evaluated the effects of adjunctive herbal therapy on clinical parameters and microbiological outcomes in patients with periodontal disease.

Materials and Methods: This prospective observational study was jointly conducted at the Department of Periodontology, Lahore Medical and Dental College and Fatima Memorial College of Medicine and Dentistry, Lahore, from January to December 2022. A total of 120 systemically healthy participants with clinically diagnosed moderate to severe chronic periodontitis were enrolled. Participants were equally divided into two groups: Group A (n = 60), who received adjunctive herbal and phytomedicine-based therapy in addition to mechanical debridement through scaling and root planing (SRP), and Group B (n = 60), who received only mechanical debridement (SRP alone). Clinical assessments—including Plaque Index (PI), Gingival Index (GI), Probing Pocket Depth (PPD), and Clinical Attachment Level (CAL)—were recorded at baseline, 6-month, and 12-month follow-up visits. Microbiological evaluations involved quantification of subgingival bacterial load expressed as colony-forming units per milliliter (CFU/mL) using quantitative polymerase chain reaction (qPCR). Inflammatory status was assessed via enzyme-linked immunosorbent assay (ELISA) of interleukin-6 (IL-6) and tumor necrosis factor-alpha (TNF-α) levels in gingival crevicular fluid (GCF) collected from standardized index sites using sterile PerioPaper® strips. Data were statistically analyzed using SPSS version 26, employing paired and independent t-tests, with a p-value < 0.05 considered statistically

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significant.

Results: At 12 months, the herbal therapy group demonstrated significant enhancements to clinical indicators: Plaque Index (1.4 ± 0.3 vs. 1.9 ± 0.5, $p < 0.001$), Gingival Index (1.2 ± 0.3 vs. 1.6 ± 0.4, $p < 0.001$), Probing Pocket Depth (4.2 ± 0.9 mm vs. 4.9 ± 1.0 mm, $p = 0.002$), and Clinical Attachment Level (4.8 ± 1.0 mm vs. 5.3 ± 1.1 mm, $p = 0.027$). Bacterial load significantly reduced in the herbal group (2.4 × 10^5 ± 5.3 × 10^4 CFU/mL vs. 1.1 × 10^6 ± 2.5 × 10^5 CFU/mL, $p < 0.001$).

Conclusion: Herbal therapy, when used as an adjunct to mechanical debridement, significantly improved both clinical and microbiological outcomes in patients with periodontal disease. These findings highlight the therapeutic potential of phytotherapy in periodontal care. Further controlled trials are recommended to validate these results.

Introduction

Periodontal diseases, including gingivitis and periodontitis, are considered the most common oral health conditions globally, impacting millions of people and causing systemic health issues and tooth loss [1]. These conditions are primarily caused by microbial dysbiosis and an exaggerated host inflammatory response, leading to the destruction of periodontal tissues [2]. Conventional periodontal therapy primarily relies on mechanical debridement, antimicrobial agents, and adjunctive anti-inflammatory medications [3]. However, the limitations associated with these approaches, such as antibiotic resistance, adverse effects, and recurrence of disease, have driven interest in alternative therapeutic strategies.

Because of its strong anti-inflammatory, antimicrobial, and wound-healing qualities, herbal medicine and phytotherapy have been used extensively in many traditional medical systems, such as Ayurveda, Traditional Chinese Medicine, and Unani medicine [4]. Over the years, the integration of herbal and phytomedicine-based therapies into modern dentistry has gained significant attention due to their natural origin, biocompatibility, and minimal side effects [5]. Various plant-derived bioactive compounds, including flavonoids, alkaloids, tannins, terpenoids, and polyphenols, have demonstrated promising therapeutic effects in managing periodontal diseases [6]. These compounds exhibit antibacterial activity against key periodontal pathogens such as *Porphyromonas gingivalis*, *Aggregatibacter actinomycetemcomitans*, and *Fusobacterium nucleatum*, while also modulating inflammatory pathways to reduce gingival inflammation and tissue destruction [7].

Several herbal extracts and phytochemicals, such as curcumin, green tea catechins, aloe vera, propolis, neem, and chamomile, have been extensively studied for their role in periodontal health [8]. Curcumin, a polyphenolic compound from *Curcuma longa*, has been reported to prevent the signalling of nuclear factor kappa B (NF-κB), thus lowering the generation of pro-inflammatory cytokines in periodontal tissues [9]. Catechins found in green tea, especially epigallocatechin gallate (EGCG), have shown antibacterial and anti-inflammatory qualities, making them a potential adjunctive therapy for periodontitis [10]. Similarly, neem (*Azadirachta indica*) and propolis, a bee-derived resin, have been shown to exert antibacterial effects against periodontal pathogens while promoting tissue healing [11].

Despite increasing amount of data demonstrating the efficacy of herbal and phytomedicine-based remedies in periodontal disease management, significant gaps remain in their clinical application, formulation standardization, and sustained effectiveness. The objective of this review is to comprehensively analyze the anti-inflammatory and antibacterial efficacy of herbal and phytomedicine-based periodontal therapies while identifying potential areas for further research and clinical translation.

Materials and Methods

Study Design and Setting

This prospective observational study was conducted collaboratively at the Department of Periodontology, Lahore Medical and Dental College, and Fatima Memorial College of Medicine and Dentistry, Lahore, Pakistan. The study spanned a 12-month period from January to December 2022. Its primary objective was to assess the real-world clinical and microbiological effectiveness of herbal and phytomedicine-based periodontal therapy in comparison to conventional nonsurgical periodontal treatment. Specifically, the study aimed to investigate the anti-inflammatory and antibacterial impact of herbal therapy on periodontal disease outcomes.

Sample Size Calculation

The sample size was determined using the formula for observational studies comparing periodontal inflammation and bacterial load in different treatment groups. The formula used was: $n = (Z_{\alpha/2})^2 \times p(1-p)/d^2$

Where $Z_{\alpha/2}$ was 1.96 for a 95% confidence interval, p (expected proportion of individuals showing improvement) was 0.65, and d (margin of error) was 0.1. The initial calculation yielded 108 participants. Because the follow-up period was 12 months, we added a 10 % safety margin for potential drop-outs (loss to follow-up), inflating the target by 12 participants to a final sample size of 120.

Participant Selection and Grouping

Participants with moderate to severe persistent periodontal disease were recruited from the outpatient department of the hospital. Participants have to be between the ages of 25 and 60 in order to meet the requirements of inclusion criteria, having moderate to severe case of chronic periodontitis confirmed, characterized by clinical attachment loss ≥ 4 mm, probing pocket depth ≥ 5 mm, and bleeding on probing ≥ 30%. Only systemically healthy individuals were included. The exclusion criteria encompassed people whose periodontal health is impacted by systemic disorders, such as diabetes mellitus, individuals receiving immunosuppressive therapy, smokers, pregnant or lactating women, and those having history of periodontal treatment during the past one year.

Participants were allocated non-randomly into two groups. Assignment was guided by (i) each patient's preference regarding herbal therapy and (ii) the attending periodontist's clinical judgement about suitability and safety. Patients in Group A received herbal treatments as well as phytomedicine in addition to standard scaling and root planning (SRP) procedures. Patients who received SRP as their sole periodontal treatment without herbal therapy formed the Group B (Control Group). A total of 120 participants were enrolled and all completed the study (Group A = 60, Group B = 60), preserving numerical balance between groups at baseline and across all follow-up intervals.

Data Collection and Outcome Measures

All four clinical parameters (Plaque Index, Gingival Index, Probing Pocket Depth and Clinical Attachment Level) were recorded at three predefined time points baseline, 6 months, and 12 months for every participant. Quantitative polymerase chain reaction (qPCR) was used to evaluate bacterial loads from subgingival plaque samples that researchers collected during each evaluation time. Subgingival GCF was collected from the deepest point of the index site in each quadrant using sterile paper strips (PerioPaper®, OraFlow Inc.) inserted for 30 seconds. Strips visibly contaminated with blood were discarded. Samples were placed in 1.5 mL microcentrifuge tubes, immediately stored on dry ice, and transferred within 1 hour to a –80 °C freezer until batch ELISA analysis. The researchers obtained Gingival crevicular fluid (GCF) for inflammatory marker evaluation through enzyme-linked immunosorbent assay (ELISA) of interleukin-6 (IL-6) and tumor necrosis factor-alpha (TNF-α).

Statistical Analysis

An analysis of the data took place using SPSS version 26. Continuous data were subjected to descriptive statistics, such as mean ± standard deviation, though categorical factors were represented by percentages and frequencies. Independent t-tests were performed to contrast clinical and bacterial outcomes among the two parties, while paired t-tests were used to assess shifts within the group over time (baseline vs. six months vs. 12 months). P-values less than 0.05 were regarded as statistically significant.

Ethical approval

The study was approved by the Institutional Review Boards of both Lahore Medical and Dental College and Fatima Memorial College of Medicine and Dentistry. Written informed consent was obtained from all participants following full disclosure of the study objectives and procedures.

Results

The study had 120 people in total, 60 in each of the two groups (Group A: Herbal Therapy and Group B: Control). Between the two groups, the individuals' demographic traits were comparable. The average age of Group A participants was 42.6 ± 8.4 years, while in Group B, it was 43.2 ± 7.9 years, with no discernible difference among the groups (p = 0.675). Gender-wise, Group B had 34 males (56.7%) and 26 females (43.3%), whereas Group A had 32 males (53.3%) and 28 females (46.7%). The distribution of genders among the groups did not differ considerably (p = 0.576). In terms of smoking status, 15% (n = 9) of participants in Group A were smokers, compared to 12% (n = 7) in Group B, without any remarkable difference in smoking rates between the groups (p = 0.528). Overall, the demographic data suggest a comparable composition of participants in both groups (figure 1).

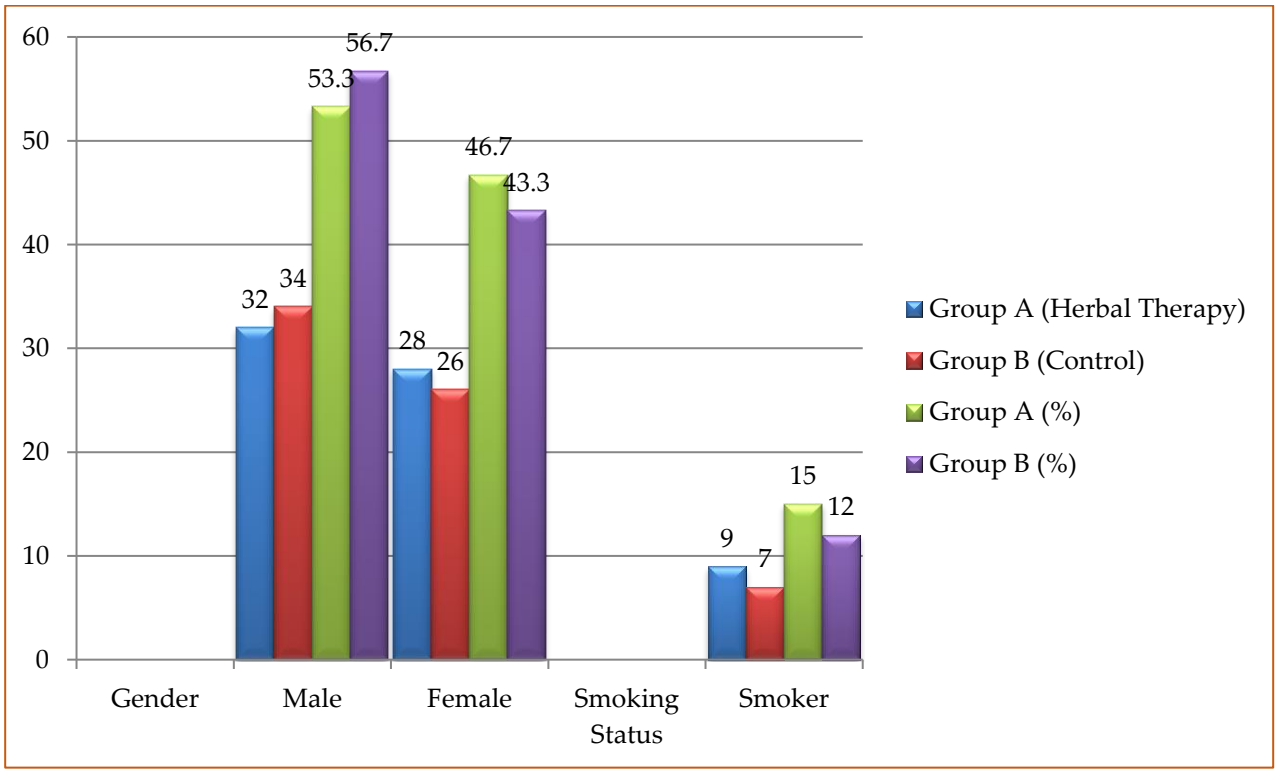

Figure 1: Demographic and Baseline Characteristics of Participants

At baseline, both groups exhibited similar periodontal clinical parameters, confirming the comparability between the groups at the beginning of research. The mean Plaque Index (PI) was 2.3 ± 0.5 for Group A and 2.4 ± 0.6 for Group B, with no remarkable difference observed (p = 0.396). The baseline mean Gingival Index (GI) was 2.0 ± 0.4 for Group A and 2.1 ± 0.5 for Group B, also showing no significant difference (p = 0.418). Regarding Probing Pocket Depth (PPD), the baseline mean for Group A was 5.4 ± 1.2 mm and 5.5 ± 1.1 mm for Group B, with no significant difference (p = 0.751). Lastly, the baseline mean Clinical Attachment Level (CAL) was 6.1 ± 1.3 mm for Group A and 6.2 ± 1.4 mm for Group B, again with no significant difference (p = 0.671). These results show that at the beginning of the trial, the groups were similar in terms of periodontal clinical indicators (table 1).

Table 1: Baseline Clinical Parameters of Participants

Clinical Parameter	Group A (Herbal Therapy)	Group B (Control)	p-value
Plaque Index (PI)	2.3 ± 0.5	2.4 ± 0.6	0.396
Gingival Index (GI)	2.0 ± 0.4	2.1 ± 0.5	0.418
Probing Pocket Depth (PPD)	5.4 ± 1.2 mm	5.5 ± 1.1 mm	0.751
Clinical Attachment Level (CAL)	6.1 ± 1.3 mm	6.2 ± 1.4 mm	0.671

At the six-month follow-up, significant changes were observed in both groups, with Group A (Herbal Therapy) indicating greater improvement compared to Group B (Control). The mean Plaque Index (PI) in Group A decreased to 1.8 ± 0.4 from 2.3 ± 0.5 at baseline ($p < 0.001$), while Group B's PI reduced to 2.2 ± 0.5 ($p < 0.001$), with a notable distinction between the groups ($p = 0.004$). Regarding the Gingival Index (GI), Group A demonstrated a notable decrease to 1.5 ± 0.3 ($p < 0.001$), compared to a smaller reduction to 1.8 ± 0.4 in Group B ($p < 0.001$), with a notable distinction between the groups ($p = 0.002$). For Probing Pocket Depth (PPD), Group A saw a reduction to 4.6 ± 1.0 mm ($p < 0.001$), while Group B had a slight reduction to 5.2 ± 1.1 mm ($p < 0.001$), with a notable distinction between groups ($p = 0.001$). Group A achieved a 5.2 ± 1.1 mm Clinical Attachment Level (CAL) improvement ($p < 0.001$) while Group B achieved 5.7 ± 1.2 mm ($p < 0.001$). The groups demonstrated a statistical difference in this outcome ($p = 0.027$). The data shows that Group A achieved superior changes in periodontal measurements compared to Group B (table 2).

Table 2: Clinical Parameters at 6-Month Follow-Up

Clinical Parameter	Group A (Herbal Therapy)	Group B (Control)	p-value
PI	1.8 ± 0.4	2.2 ± 0.5	0.004
GI	1.5 ± 0.3	1.8 ± 0.4	0.002
PPD (mm)	4.6 ± 1.0	5.2 ± 1.1	0.001
CAL (mm)	5.2 ± 1.1	5.7 ± 1.2	0.027

Plaque Index (PI), Gingival Index (GI), Probing Pocket Depth (PPD), Clinical Attachment Level (CAL).

The assessment at 12 months showed continued improvement for both groups yet Group A maintained superior results than Group B did. Boot Camp participants in Group A achieved a notable reduction of Mean Plaque Index to 1.4 ± 0.3 ($p < 0.001$) compared to their baseline, whereas Group B decreased to 1.9 ± 0.5 but this reduction proved statistically significant from Group A ($p < 0.001$). Group A participants achieved a reduced mean Gingival Index of 1.2 ± 0.3 ($p < 0.001$) at the twelve-month follow-up although Group B participants had a mean GI of 1.6 ± 0.4 ($p < 0.001$) yet this change was not statistically significant between groups ($p < 0.001$). The Probing Pocket Depth evaluation revealed that people in Group A experienced a mean drop to 4.2 ± 0.9 mm ($p < 0.001$) but subjects from Group B showed less improvement at 4.9 ± 1.0 mm ($p < 0.001$) with a statistically significant difference between the groups ($p = 0.002$). The Clinical Attachment Level evaluation for Group A reached 4.8 ± 1.0 mm ($p < 0.001$) and Group B showed a similar improvement of 5.3 ± 1.1 mm ($p < 0.001$) although the outcome difference between groups was statistically significant ($p = 0.027$). The research data reveals Group A patients achieved superior periodontal health advances than Group B members between months 12 to 13 (table 3).

Table 3: Clinical Parameters at 12-Month Follow-Up

Clinical Parameter	Group A (Herbal Therapy)	Group B (Control)	p-value
PI	1.4 ± 0.3	1.9 ± 0.5	< 0.001
GI	1.2 ± 0.3	1.6 ± 0.4	< 0.001
PPD (mm)	4.2 ± 0.9	4.9 ± 1.0	0.002
CAL (mm)	4.8 ± 1.0	5.3 ± 1.1	0.027

Plaque Index (PI), Gingival Index (GI), Probing Pocket Depth (PPD), Clinical Attachment Level (CAL).

Subgingival plaque samples revealed a notable decrease in bacterial load in both groups, with Group A showing more pronounced bacterial reduction compared to Group B. In Group A, the bacterial load at baseline was 6.1 × 10^6 ± 1.2 × 10^6 CFU/mL, which decreased to 2.4 × 10^5 ± 5.3 × 10^4 CFU/mL at 12 months ($p < 0.001$). In Group B, the bacterial load at baseline was 6.2 × 10^6 ± 1.1 × 10^6 CFU/mL, which

reduced to 1.1 × 10^6 ± 2.5 × 10^5 CFU/mL at 12 months ($p < 0.001$). At the 12-month follow-up, the groups' differences were substantial ($p < 0.001$), indicating that Group A experienced a greater decrease in bacterial load compared to Group B (table 4).

Table 4: Bacterial Load at 12-Month Follow-Up

Group	Bacterial Load (CFU/mL)	p-value
Group A (Herbal Therapy)	$2.4 \times 10^5 \pm 5.3 \times 10^4$	< 0.001
Group B (Control)	$1.1 \times 10^6 \pm 2.5 \times 10^5$	

Inflammatory markers IL-6 and TNF-α in gingival crevicular fluid (GCF) showed a significant decrease in both groups over the 12 months, with Group A demonstrating a greater reduction compared to Group B. For IL-6, Group A's baseline level was 32.4 ± 5.1 pg/mL, which reduced to 12.5 ± 2.3 pg/mL at 12 months, representing a 61.4% reduction ($p < 0.001$). In contrast, Group B's baseline IL-6 level was 33.1 ± 4.9 pg/mL, which decreased to 18.2 ± 3.7 pg/mL, reflecting a 45.0% reduction ($p < 0.001$).

There was substantial variation between the two groups ($p < 0.001$). Regarding TNF-α, Group A's baseline level decreased at 12 months, corresponding to a 65.1% reduction ($p < 0.001$), while Group B's baseline TNF-α level was reduced, showing a 46.7% reduction ($p < 0.001$), indicating a greater reduction in both inflammatory markers in Group A compared to Group B (figure 2).

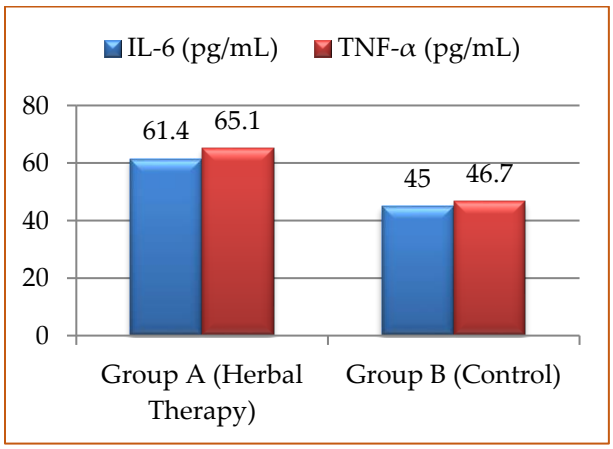

Figure 2: Inflammatory Marker Levels at 12-Month Follow-Up

Discussion

Observational study findings demonstrate that beneficiaries who received herbal treatment experienced substantially better periodontal health results compared to patients in the control group receiving no herbal therapy. The clinical parameters Plaque Index and Gingival Index along with Probing Pocket Depth and Clinical Attachment Level improved notably in the herbal therapy treated group after one year of treatment. The study demonstrates potential value in using herbal therapy among periodontal disease patients since it reduces inflammatory markers while lowering bacterial counts and generating enhanced clinical results during the treatment course.

The herbal therapy group presented a noticeably reduced bacterial load in their specimens compared to the control group making it consistent with lowered anti-inflammatory markers IL-6 and TNF-α while indicating systemic anti-inflammatory responses. The observed long-term effectiveness of herbal therapy administration at twelve months consisted of improved PI, GI, PPD scores and CAL measurements showing positive effects on tissue regeneration and periodontal tissue stabilization.

The results of this investigation align with earlier studies that have explored the efficacy of herbal therapies in managing periodontal disease [12]. Several studies have reported that herbal treatments can reduce plaque accumulation and improve gingival health, with some showing improvements in probing depth and attachment levels, which align with the results found in this study [13].

The reduced bacterial load observed in the herbal therapy group is supported by previous research indicating that various plant extracts, such as those from green tea and turmeric, possess antibacterial properties, reducing the microbial load in periodontal pockets [14].

In terms of inflammatory markers, the findings of this investigation correspond with existing literature suggesting that herbal treatments can modulate immune responses [15]. The reduction in

inflammatory cytokines, such as IL-6 and TNF-α, observed in the herbal therapy group aligns with findings from studies demonstrating that herbal compounds can down regulate pro-inflammatory mediators, thereby reducing the overall inflammatory burden in periodontal tissues [16]. Additionally, the improved clinical outcomes, such as reductions in PPD and improvements in CAL, in the herbal therapy group are consistent with studies that highlight the potential of natural therapies to promote healing of periodontal tissues by reducing inflammation and supporting tissue regeneration [17]. The study's beneficial clinical outcomes are consistent with the findings from other studies that advocate the role of herbal and phytomedicine-based therapies in periodontal disease management [18].

Limitations and Future Suggestions

This study has several limitations. The sample size, though statistically appropriate, may limit generalizability to diverse populations with varying socio-economic and health backgrounds. Because group allocation was non-random and preference-based, selection bias cannot be excluded. Future randomised controlled trials are warranted to confirm these findings. The 12-month follow-up duration represents a disadvantage because periodontal disease needs prolonged observation to evaluate treatment maintenance. The analysis did not assess any possible adverse effects of using herbal remedies which limited its exploration of safety concerns. Scientific data regarding particular periodontal pathogens were absent from the study which would have enabled enhanced understanding of how herbal medicine fights bacteria. The existing study's generalization and evaluation durations should be enhanced through research using bigger study groups from varied backgrounds and expanded observation periods longer than twelve months. Researchers should examine the bioactive substances that produce antimicrobial action and inflammatory regulation properties in their analysis. Additional microbiological testing should examine bacterial strain response to herbal therapies because it helps create targeted therapeutic methods.

Conclusion

This study concludes by showing that herbal therapy is a successful adjunctive therapy for periodontal disease, resulting in significant reductions in clinical parameters like clinical attachment level, gingival index, plaque index, and probing pocket depth. The findings also show a significant decrease in inflammatory markers and bacterial load, underscoring the potential of herbal treatments to influence immune and microbial remarks in periodontal health. Even though the results are encouraging, more studies with bigger sample sizes and longer-term monitoring are required to verify the long-term viability and security of herbal remedies for the treatment of periodontal disease.

Authors' contributions

BZ: Contributed substantially to the conception and design of the study, data acquisition, and interpretation of clinical outcomes. She was actively involved in drafting the manuscript and gave final approval of the version to be published.

NU: Played a key role in the microbiological analysis, contributed to data interpretation, and participated in critical revision of the manuscript for important intellectual content. He also provided final approval of the submitted version.

NR: Project coordination, and data integrity. She led the drafting, editing, and submission of the manuscript and approved the final version for publication.

SAN: Assisted in clinical assessments, contributed to data analysis, and was involved in drafting and reviewing the manuscript. She also gave final approval of the version to be published.

NK: Participated in the design of the study, supported literature review and analysis, and was involved in manuscript drafting and editing. She approved the final manuscript and is accountable for its accuracy and content.

Conflict of interest

Nil.

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