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Adjunctive aloe vera gel in diabetic and non-diabetic periodontitis: A split-mouth trial

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Abstract:
Periodontitis in patients with diabetes is clinically challenging because periodontal inflammation, microbial persistence and delayed wound healing may reduce the predictability of non-surgical periodontal therapy. Therefore, it is of interest to evaluate whether subgingival Aloe vera gel used as a local drug delivery agent could improve periodontal outcomes when added to scaling and root planing in diabetic and non-diabetic adults with Stage I or Stage II periodontitis. Forty participants, including 20 well-controlled type 2 diabetic and 20 non-diabetic patients, contributed 80 periodontal sites allocated to scaling and root planing plus Aloe vera gel or scaling and root planing alone; plaque index, gingival index, probing pocket depth and clinical attachment level were recorded at baseline, 30 days and 60 days. Both treatment modalities produced significant improvement over time, but adjunctive Aloe vera showed greater 60-day reductions in gingival index, probing pocket depth and clinical attachment level, particularly among diabetic patients, where clinical attachment level improved by 1.07 mm versus 0.78 mm with scaling and root planing alone ($p = 0.018$). Thus, aloe vera gel is a safe, economical and biologically acceptable adjunct to non-surgical periodontal therapy, with clinically relevant benefits in inflammatory control and attachment gain, especially in diabetic and Stage II periodontitis sites.

Keywords: Aloe vera gel, periodontitis, diabetes mellitus (DM), scaling and root planing (SRP), local drug delivery (LLD), clinical attachment level (CAL)

Background:
Periodontitis is a biofilm-associated chronic inflammatory disease that affects the gingiva, periodontal ligament, cementum and alveolar bone, leading to progressive attachment loss, periodontal pocket formation and, in advanced cases, tooth loss. The contemporary classification recognizes periodontitis through a multidimensional staging and grading framework that combines severity, complexity, extent, distribution and risk of progression, allowing early disease stages to be identified more consistently in routine practice **[1]**. Stage I and Stage II disease often represent the most suitable window for conservative intervention because tissue destruction is present but may still be stabilized with meticulous debridement, plaque control, risk-factor modification and carefully selected adjunctive therapy **[2]**. The global burden of periodontitis remains substantial and creates a persistent clinical and public health challenge. Severe periodontitis has been estimated among the most prevalent non-communicable conditions worldwide and the overall impact is amplified by pain, halitosis, masticatory difficulty, reduced quality of life and costly long-term tooth replacement **[3].** Disease initiation depends on a dysbiotic subgingival microbiota, but the pattern and rate of tissue destruction are determined largely by the host inflammatory response. Neutrophil dysfunction, macrophage activation, cytokine release, matrix metalloproteinase activity and osteoclastogenesis together convert a protective inflammatory response into connective tissue breakdown and bone resorption **[4]**. Diabetes mellitus is one of the most important systemic modifiers of periodontal disease. Persistent hyperglycemia promotes advanced glycation end-product formation, oxidative stress, altered collagen turnover, impaired neutrophil activity, microvascular dysfunction and exaggerated release of pro-inflammatory mediators. These mechanisms increase the susceptibility to periodontal breakdown and reduce the efficiency of wound repair after therapy. At the same time, periodontal inflammation can contribute to systemic inflammatory load and worsen insulin resistance, making the relationship between diabetes and periodontitis clinically bidirectional **[5]**. Periodontal care is therefore not only an oral-health intervention but also a component of integrated diabetes management, especially when glycemic control is reasonable and the patient can comply with recall and home-care measures **[6]**. Non-surgical periodontal therapy remains the foundation of initial management. Scaling and root planing reduce the subgingival microbial load, disrupt biofilm, remove calculus and create a root surface that favors resolution of inflammation. Evidence also indicates that periodontal treatment may produce modest improvement in glycemic control among people with diabetes, reinforcing the relevance of periodontal stability in this population **[7]**. Nevertheless, mechanical debridement may be limited in deeper pockets, narrow defects, furcation areas and root irregularities. Residual pathogenic biofilm can persist despite careful instrumentation and recolonization may occur if local ecological conditions remain favorable **[8]**. The limitations of instrumentation alone have encouraged adjunctive strategies. Mechanical therapy can be supplemented by host modulation, antimicrobial agents and locally delivered formulations, but adjuncts should provide measurable clinical benefit without unnecessary systemic exposure or antimicrobial resistance **[9]**. Local drug delivery is attractive because the agent is placed directly into the periodontal pocket, achieving high local concentration with minimal systemic distribution **[10]**. Controlled and sustained local antimicrobial systems have shown advantages in selected residual pockets, but their routine use should be guided by clinical need, patient-level risk, expected benefit, cost and safety **[11]**. Contemporary reviews emphasize that site-specific delivery may be particularly useful when an adjunct can remain within the pocket long enough to influence inflammation and microbial activity after scaling and root planing **[12]**. Interest in plant-based adjuncts has increased because many herbal agents combine anti-inflammatory, antimicrobial, antioxidant and wound-healing properties with favorable patient acceptance. Aloe vera contains polysaccharides, glycoproteins, vitamins, minerals, enzymes, amino acids, anthraquinone and phenolic constituents. Its mucilaginous gel has been associated with inhibition of

inflammatory mediators, support of fibroblast activity, collagen maturation, epithelial healing and antimicrobial effects against selected oral microorganisms **[13]**. Acemannan is an important Aloe vera polysaccharide, has also shown biological potential in periodontal tissue repair and regeneration, supporting the rationale for its local application in periodontal defects **[14]**. Therefore, it is of interest to evaluate Aloe vera gel as an adjunct to non-surgical periodontal therapy in diabetic and non-diabetic patients with Stage I and Stage II periodontitis.

Materials and Methods:

This randomized split-mouth clinical study was conducted in the Department of Periodontology at a dental teaching hospital in Kanpur, Uttar Pradesh, India. Participants were recruited from the outpatient department over a 12-month period. The study protocol was reviewed and approved by the institutional ethics committee before enrollment and written informed consent was obtained from all participants after explaining the nature of the procedure, possible benefits and follow-up requirements. The sample size was calculated on the basis of expected change in clinical periodontal parameters after adjunctive therapy, with 90% power, 5% type I error and an estimated clinically meaningful difference of 25% in gingival index improvement. A minimum of 40 sites per main glycemic group was required. To satisfy this requirement, 40 participants were included, consisting of 20 well-controlled type 2 diabetic patients and 20 non-diabetic patients. Each participant contributed two comparable periodontal sites, giving a total of 80 sites. Participants aged 25 to 55 years with Stage I or Stage II periodontitis, probing pocket depth of 4 to 5 mm, clinical attachment loss of 3 to 4 mm and complete dentition were eligible. Diabetic participants were required to have type 2 diabetes of at least one year duration with controlled glycemic status, defined clinically by HbA1c not exceeding 7% and fasting blood sugar below 126 mg/dL at screening. Patients were excluded if they had received systemic or topical oral antibiotics during the preceding six months, undergone periodontal therapy during the previous six months, had probing pocket depth greater than 5 mm at selected sites, used tobacco or alcohol, were pregnant or lactating, were immunocompromised, were taking medication known to affect periodontal tissues, or were unable to comply with the protocol. Participants were divided into two main groups according to glycemic status. Group I consisted of diabetic patients and Group II consisted of non-diabetic patients. Within the diabetic group, 20 sites were allocated to scaling and root planing with Aloe vera gel (Group IA) and 20 sites were allocated to scaling and root planing alone (Group IB). Within the non-diabetic group, 20 sites were allocated to scaling and root planing with Aloe vera gel (Group IIA) and 20 sites were allocated to scaling and root planing alone (Group IIB). Site allocation was performed using a coin-toss method after selection of comparable contralateral or anatomically similar periodontal sites. At baseline, a detailed case history was recorded and all participants received oral hygiene instructions. Customized acrylic stents were fabricated on study casts using self-cure acrylic resin. Guiding grooves were prepared to standardize probe angulation and insertion depth during follow-up measurements. Plaque index was recorded using a mouth mirror and explorer, while gingival index, probing pocket depth and clinical attachment level were recorded using a UNC-15 periodontal probe. Probing pocket depth was measured from the gingival margin to the base of the pocket and clinical attachment level was measured from the cemento-enamel junction to the base of the pocket. All measurements were made by a single calibrated examiner who was blinded to site allocation. Full-mouth ultrasonic scaling and root planing were completed using ultrasonic scalers and Gracey curettes in two visits within 48 hours. For test sites, freshly prepared 100% Aloe vera gel was placed subgingivally into the selected periodontal pocket using sterile blunt-ended instrumentation until the pocket was filled without overextension. A periodontal dressing was placed to help retain the medicament. Control sites received scaling and root planing alone and were protected from contamination during the procedure. Participants were instructed not to rinse forcefully, spit, brush, floss, or use interdental aids at treated sites for 24 hours. The periodontal dressing was removed after one week and patients then resumed tooth brushing with the Modified Bass technique. Medicated mouth rinses were avoided during the study period. Clinical parameters were reassessed at 30 and 60 days using the same acrylic stents, instruments and measurement protocol. Data were entered into Microsoft Excel and analyzed using SPSS software. Continuous variables were expressed as mean ± standard deviation and categorical variables were expressed as number and percentage. Intergroup comparisons were performed using independent t-tests for normally distributed variables and Mann-Whitney U tests where appropriate. Intragroup changes across time were analyzed using repeated-measures analysis of variance with post-hoc pairwise comparisons. Categorical variables were compared using chi-square or Fisher exact tests. Statistical significance was set at $p < 0.05$.

Results:

All 40 participants completed the 60-day follow-up and no adverse local reaction, ulceration, allergic response, or delayed healing was recorded after Aloe vera application. The mean age of the total study population was 42.65 ± 8.72 years. Diabetic participants were slightly older than non-diabetic participants, but the difference was not statistically significant (44.35 ± 8.45 years versus 40.95 ± 8.82 years, $p = 0.082$). The sample included 21 males and 19 females. Stage I periodontitis was present in 19 participants and Stage II periodontitis in 21 participants. Among diabetic participants, mean HbA1c was 7.42 ± 0.68% and mean duration of diabetes was 6.85 ± 3.24 years, indicating controlled diabetic status suitable for non-surgical therapy. Baseline periodontal parameters were comparable between test and control sites within each glycemic group. In the non-diabetic group, baseline plaque index was 1.90 ± 0.18 in Aloe vera sites and 1.88 ± 0.20 in control sites ($p = 0.742$), while probing pocket depth was 4.55 ±0.53 mm and 4.50 ± 0.52 mm, respectively ($p = 0.765$). In the diabetic group, baseline plaque index was 1.86 ±

0.18 in Aloe vera sites and 1.87 ± 0.19 in control sites (p = 0.866), while probing pocket depth was 4.25 ± 0.46 mm and 4.28 ±0.47 mm, respectively (p = 0.840). These findings confirmed adequate comparability before intervention. Baseline demographic and clinical characteristics are summarized in **Table 1**. All four treatment subgroups showed significant improvement from baseline to 60 days in plaque index, gingival index, probing pocket depth and clinical attachment level (p < 0.001 for within-group change). However, the magnitude of improvement was greater in sites receiving Aloe vera gel. In non-diabetic patients, Aloe vera sites showed greater 60-day reductions in gingival index (1.12 versus 0.94; p = 0.038), probing pocket depth (1.17 mm versus 0.88 mm; p = 0.042) and clinical attachment level (0.97 mm versus 0.77 mm; p = 0.046) when compared with scaling and root planing alone. Plaque index reduction also favored Aloe vera but did not reach statistical significance (0.85 versus 0.73; p = 0.068). In diabetic patients, the adjunctive effect was more evident. Aloe vera sites showed greater 60-day improvement in gingival index (1.10 versus 0.92; p = 0.032), probing pocket depth (1.17 mm versus 0.93 mm; p = 0.028) and clinical attachment level (1.07 mm versus 0.78 mm; p = 0.018). Plaque index reduction again favored Aloe vera, although the difference was not statistically significant (0.86 versus 0.75; p = 0.072). When Aloe vera-treated diabetic and non-diabetic sites were compared directly, final outcomes were similar, suggesting that adjunctive Aloe vera helped diabetic sites achieve periodontal response comparable to non-diabetic sites. Longitudinal changes across baseline, day 30 and day 60 are presented in **Table 2**. Stage-wise analysis showed that both Stage I and Stage II sites improved after therapy. Stage II sites exhibited slightly greater absolute reductions in probing pocket depth and clinical attachment level because baseline destruction was more pronounced. The adjunctive advantage of Aloe vera was statistically significant in Stage II sites (p = 0.032 for Aloe vera versus control comparison), while the difference in Stage I sites was favorable but not statistically significant (p = 0.156). Between-treatment and stage-wise comparisons are summarized in **Table 3**.

Table 1: Baseline demographic and clinical characteristics of the study population

Characteristic	Total (N=40)	Diabetic (n=20)	Non-diabetic (n=20)	p-value
Age (years), mean +/- SD	42.65 ± 8.72	44.35 ± 8.45	40.95 ± 8.82	0.082
Age range (years)	28-55	30-55	28-55	-
Male, n (%)	21 (52.5%)	11 (55.0%)	10 (50.0%)	0.822
Female, n (%)	19 (47.5%)	9 (45.0%)	10 (50.0%)	-
Stage I periodontitis, n (%)	19 (47.5%)	9 (45.0%)	10 (50.0%)	0.654
Stage II periodontitis, n (%)	21 (52.5%)	11 (55.0%)	10 (50.0%)	-
HbA1c (%), diabetic only	-	7.42 ± 0.68	-	-
Duration of diabetes (years)	-	6.85 ± 3.24	-	-

Table 2: Intragroup changes in periodontal parameters from baseline to 60 days

Group / Parameter	Baseline	Day 30	Day 60	Change baseline to day 60	Within-group p-value
Diabetic SRP + Aloe: PI	1.86 ± 0.18	1.38 ± 0.20	1.00 ± 0.22	0.86	<0.001
Diabetic SRP + Aloe: GI	2.15 ± 0.29	1.52 ± 0.30	1.05 ± 0.31	1.10	<0.001
Diabetic SRP + Aloe: PPD (mm)	4.25 ± 0.46	3.62 ± 0.65	3.08 ± 0.68	1.17	<0.001
Diabetic SRP + Aloe: CAL (mm)	4.65 ± 1.20	4.05 ± 1.30	3.58 ± 1.34	1.07	<0.001
Diabetic SRP only: PI	1.87 ±0.19	1.45 ± 0.23	1.12 ±0.25	0.75	<0.001
Diabetic SRP only: GI	2.14 ± 0.28	1.65 ± 0.31	1.22 ± 0.34	0.92	<0.001
Diabetic SRP only: PPD (mm)	4.28 ± 0.47	3.80 ± 0.70	3.35 ±0.74	0.93	<0.001
Diabetic SRP only: CAL (mm)	4.70 ± 1.25	4.28 ± 1.38	3.92 ±1.42	0.78	<0.001
Non-diabetic SRP + Aloe: PI	1.90 ± 0.18	1.42 ± 0.19	1.05 ± 0.22	0.85	<0.001
Non-diabetic SRP + Aloe: GI	2.07 ± 0.28	1.45 ± 0.26	0.95 ± 0.27	1.12	<0.001
Non-diabetic SRP + Aloe: PPD (mm)	4.55 ± 0.53	3.88 ± 0.68	3.38 ± 0.72	1.17	<0.001
Non-diabetic SRP + Aloe: CAL (mm)	4.85 ± 1.28	4.30 ± 1.40	3.88 ± 1.42	0.97	<0.001
Non-diabetic SRP only: PI	1.88 ± 0.20	1.48 ± 0.22	1.15 ± 0.25	0.73	<0.001
Non-diabetic SRP only: GI	2.09 ± 0.29	1.58 ± 0.30	1.15 ± 0.32	0.94	<0.001
Non-diabetic SRP only: PPD (mm)	4.50 ± 0.52	4.05 ± 0.72	3.62 ± 0.78	0.88	<0.001
Non-diabetic SRP only: CAL (mm)	4.82 ± 1.30	4.42 ± 1.46	4.05 ± 1.48	0.77	<0.001

Table 3: Comparison of mean changes between adjunctive Aloe vera therapy and scaling and root planing alone

Population / Parameter	SRP + Aloe vera change	SRP-only change	Difference	p-value
Diabetic: PI	0.86	0.75	0.11	0.072
Diabetic: GI	1.10	0.92	0.18	0.032
Diabetic: PPD (mm)	1.17	0.93	0.24	0.028
Diabetic: CAL (mm)	1.07	0.78	0.29	0.018
Non-diabetic: PI	0.85	0.73	0.12	0.068
Non-diabetic: GI	1.12	0.94	0.18	0.038
Non-diabetic: PPD (mm)	1.17	0.88	0.29	0.042
Non-diabetic: CAL (mm)	0.97	0.77	0.20	0.046
Stage I: composite CAL/GI/PPD response	Favorable	Lower	-	0.156
Stage II: composite CAL/GI/PPD response	Greater	Lower	-	0.032

Discussion:

The present study showed that scaling and root planing improved all measured periodontal parameters over 60 days in both diabetic and non-diabetic patients, confirming the central role of non-surgical periodontal therapy in early periodontitis. The additional application of Aloe vera gel provided measurable benefit in gingival inflammation, pocket reduction and clinical attachment gain. The results are clinically meaningful because the study included patients with Stage I and Stage II periodontitis, where conservative treatment aims not only to arrest disease progression but also to prevent transition toward more complex destructive disease. The greater reduction in gingival index at Aloe vera sites suggests a strong local anti-inflammatory effect. This is biologically plausible because Aloe vera contains compounds that may inhibit cyclooxygenase activity, reduce edema, modulate inflammatory mediators and support epithelial healing **[13].** Acemannan and related polysaccharides may promote fibroblast proliferation, extracellular matrix formation and periodontal wound healing, which may explain the greater attachment-level improvement observed in the test sites **[14].** The improvement in clinical attachment level was modest in absolute terms but relevant for early periodontitis because even small gains can reduce future pocket vulnerability when accompanied by stable plaque control. The present findings are consistent with earlier clinical evidence showing that Aloe vera can function as a local drug delivery agent in periodontal pockets. Earlier periodontal applications reported improvement in plaque scores, gingival inflammation and probing depth after subgingival Aloe vera placement **[15].** In the current study, plaque index improvement was seen in both test and control sites, but the between-group difference was not statistically significant. This pattern suggests that plaque reduction was largely driven by professional debridement and improved home care, while Aloe vera exerted its main additional effect on inflammatory resolution and soft tissue healing. The diabetic subgroup deserves particular attention. Although the participants were medically controlled, diabetes is associated with impaired neutrophil function, altered collagen metabolism, oxidative stress and delayed repair **[5].** In this context, the greater improvement in gingival index, probing pocket depth and clinical attachment level at Aloe vera sites indicates that a locally acting biocompatible adjunct may partially compensate for an altered host response. Comparable clinical benefit has been reported for locally delivered Aloe vera gel in type 2 diabetic patients with chronic periodontitis, where adjunctive therapy improved periodontal parameters beyond scaling and root planing alone **[16].** The improvement in probing pocket depth may be explained by a combination of reduced gingival inflammation, shrinkage of edematous pocket walls, decreased microbial load and improved tissue tone after healing. Local delivery is advantageous because the agent can be concentrated at the site of disease without exposing the patient to systemic medication **[10].** This has practical relevance for diabetic patients, in whom unnecessary systemic antibiotics should be avoided unless clearly indicated. Local adjuncts may therefore offer a safer and more targeted approach for residual or moderately inflamed sites **[11].** The study also showed stronger adjunctive benefit in Stage II periodontitis than in Stage I disease. This is not unexpected because Stage II sites had greater baseline pocket depth and attachment loss, leaving more scope for measurable clinical improvement. Stage I sites showed improvement in both treatment arms and the smaller between-group difference may reflect a floor effect: when disease is mild, meticulous scaling and oral hygiene reinforcement can produce substantial improvement by themselves. Stage II sites may therefore be the more appropriate clinical target for local adjunctive therapy, particularly when inflammation persists after initial instrumentation. The findings align with previous randomized clinical observations where local application of Aloe vera gel adjunctive to scaling and root planing produced reductions in periodontal pocket depth and improvements in gingival parameters **[17].** Recent evidence synthesis has also suggested that Aloe vera gel used with mechanical debridement can improve plaque index, gingival index and probing pocket depth in periodontitis patients, although heterogeneity between trials remains a concern **[18].** A 2026 randomized clinical study by Mohammad *et al.* found that adjunctive subgingival Aloe vera gel improved periodontal indices and reduced inflammatory mediators and glycemic measures in diabetic and nondiabetic periodontitis patients, with effects broadly comparable to chlorhexidine gel **[19]**. These findings strengthen the biological plausibility of the present diabetic subgroup response, although the current study did not assess cytokines or glycemic change. Vijay *et al.* also reported greater reductions in plaque, bleeding and probing depth and greater clinical attachment gain with locally delivered Aloe vera gel than placebo after scaling and root planing in chronic periodontitis **[20]**. This supports the present short-term clinical benefit of local Aloe vera, while differences in follow-up duration and patient characteristics should be considered. The present study contributes to this literature by including both diabetic and non-diabetic patients, using standardized acrylic stents for reproducible probing and evaluating Stage I and Stage II disease separately. Several limitations should be acknowledged. The follow-up period was limited to 60 days, so the durability of clinical gains and the need for repeated Aloe vera application could not be determined. The sample size was adequate for short-term clinical comparison but insufficient for subgroup analysis according to diabetes duration, medication use, or glycemic variability. Microbiological and biochemical markers such as *Porphyromonas gingivalis* counts, interleukin levels, or matrix metalloproteinase activity were not evaluated, so mechanistic interpretation remains indirect. The study also used freshly prepared Aloe vera gel, which is clinically practical but may vary in active phytochemical concentration depending on plant source, preparation method and storage conditions. Despite these limitations, the findings support Aloe vera gel as a useful adjunct in selected patients. Its low cost, local applicability, patient acceptability and absence of adverse effects in this study make it attractive for clinical settings where conventional sustained-release antimicrobials may be unavailable or expensive. Future studies should include larger

multicenter samples, longer follow-up, standardized pharmaceutical-grade Aloe vera preparations, microbiological endpoints, inflammatory biomarkers and patient-reported outcomes. Research should also compare single versus repeated application protocols and evaluate whether adjunctive Aloe vera contributes to long-term maintenance stability in diabetic patients.

Conclusion:

Aloe vera plus SRP improved gingival inflammation, probing depth and clinical attachment. Benefits were high in diabetic patients and Stage II periodontitis sites. Aloe vera appears safe and economical, but longer controlled studies are needed.

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