

Original Article

Efficacy of herbal mucoadhesive gel with extracts of *Coriandrum sativum* and curcumin as local drug delivery in the treatment of chronic periodontitis - A clinico-microbiological trial

ABSTRACT

Context: Herbal products are the recent advancement in the field of alternative medicines for the management of chronic periodontitis. They can be used as local drug delivery (LDD) agents over conventional antibiotics because of their extensive natural activity, advanced safety margin, and inferior costs. The present study evaluates the efficacy of one such indigenously prepared herbal gel containing extracts of *Coriandrum sativum* and curcumin in chronic periodontitis patients.

Subjects and Methods: A total of 18 patients diagnosed with chronic periodontitis were included in this randomized clinical trial. The selected 72 pockets were equally divided into experimental and control groups. Full mouth scaling and root planing (SRP) was done. The experimental site received indigenously prepared herbal LDD gel containing combined extracts of *C. sativum* and curcumin, and the other side received a placebo gel. The periodontal parameters assessed were plaque index, papillary bleeding index, periodontal pocket depth (PPD), and clinical attachment level (CAL) at baseline, 1 month, and 3 months. Microbiological parameters for anaerobic analysis were assessed by colony-forming units at baseline and 3 months.

Results: SPSS software analyzed all the data by repeated measure analysis of variance, paired *t*-test, and sample *t*-test with the difference of $P < 0.05$. Both clinical parameters and microbiological parameters showed a statistical reduction in the experimental group at 1 month and 3 months of evaluation. Significant better improvement was observed in the experimental group from 1 month to 3 months after the assessment in PPD and CAL.

Conclusion: Locally delivered combined extracts of *C. sativum* and curcumin gel was more effective in reducing periodontal clinical parameter when used as an adjunct to SRP in the treatment of chronic periodontitis.

Keywords: *Coriandrum sativum*, curcumin, herbal local drug delivery, local drug delivery

INTRODUCTION

Microbiological plaque and infectious bacteria are responsible for the initiation of an inflammatory response in periodontal tissues. The complex interaction in the environment with the bacterial agent and the host defense mechanism against these bacteria determines the nature of the periodontal disease.^[1] This inflammation can be arrested by mechanical periodontal nonsurgical therapy like scaling and root planing (SRP).^[2] However, due to the lack of accessibility in the deep periodontal pocket, its effectiveness is questionable.^[3] An adjunctive antiseptic and antibiotic agent is additionally required for periodontal healing against these putative

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pathogens.^[4] They are available in various forms such as gel, fibers, nanoparticles, films, vesicular systems, etc.

The main aim of this adjunctive agent is to reach to the base of the pocket wherein the sustained release would help combat the bacterial destruction to the periodontal tissues.^[5] Goodson *et al.* are the pioneer in proposing the concept of controlled drug delivery system in the treatment of periodontitis.^[6] For this, various antimicrobial and antibacterial agents have been used for management of the deep periodontal niches in the pockets.

Modern chemotherapeutics has displayed satisfactory improvement in periodontal health. However, because of its side effects and cost ineffectiveness, herbal products with immense benefits for lower socioeconomic populations around the globe are now researched and included.^[7] Moreover, with the blind overuse of these artificial antimicrobial agents, problems such as antimicrobial resistance and appearance of rare infections have been observed. Therefore, the natural phytochemicals are a reasonable substitute for them.^[8]

Herbal medications such as curcumin, coriander, neem, *Aloe vera*, Babul, Bakul, lemongrass, tea tree oil, and green tea have been used since ancient times. *Coriandrum sativum*, a widely used spice named coriander belonging to Umbelliferae family, has spasmolytic and carminative property.^[9] The extracts of the coriander seed oil are among the significant twenty essential oils in the world market.^[10] This tannin-containing natural phytochemical is known to exert antimicrobial activity.^[11]

An Indian spice – turmeric/curcumin/*Curcuma longa* – derived from rhizomes consists of three active curcuminoids – curcumin (diferuloylmethane), demethoxyl-curcumin, and bisdemethoxyl-curcumin. This member of the Zingiberaceae family is a rich source of volatile oils (atlantone, turmerone, and zingiberene), proteins, sugars, and resins. It is known to exhibit properties such as anti-inflammatory, anticarcinogenic, antioxidant, antiviral, and antimicrobial activities. Most importantly, it helps modulate the inflammatory response by inhibiting the production of inflammatory cytokines, cyclooxygenase-2, and lipoxygenase activity.^[12]

Yaghini *et al.*^[9] and Behal R *et al.*^[13] have successfully used *C. sativum* and curcumin gel as local drug delivery (LDD) in their clinical trial, respectively. This study aimed to evaluate the clinic effects of subgingival application of combined extract from *C. Sativum* and curcumin for the treatment of chronic periodontitis.

SUBJECTS AND METHODS

Patients diagnosed with chronic periodontitis referred to the Department of Periodontics, Late Yashwantrao Chavan Medical Memorial and Rural Development Foundation's Dental College and Hospital, Ahmednagar, were selected for this randomized controlled clinical trial. Institutional ethical approval from the committee and written informed consent from all the patients were obtained regarding the protocol of the study.

A total of 18 systemically healthy controls (25–45 years) with no history of substance abuse, antibiotic or periodontal therapy, drug allergy, or ongoing orthodontic treatment were included. Pregnant and lactating female individuals were excluded, and the teeth were having an average periodontal pocket depth (PPD) of 4–6 mm. In the same appointment, study sites were determined and to standardize the recording of clinical parameters along with the fabrication of custom acrylic stent.

Clinical parameters such as plaque index (PI),^[14] papillary bleeding index (PBI),^[15] PPD,^[16] and clinical attachment level (CAL)^[17] were recorded. All the clinical and microbiological measurements were performed by a single calibrated examiner.

Complete oral prophylaxis, including SRP, was performed using ultrasonic scaler (Woodpecker, UDS-N1, Guilin, China) and hand instruments (Hu-Friedy, Chicago, IL, USA) along with oral hygiene reinforcements. Instructions included were brushing by the modified bass method and flossing. Participants were refrained from using any mouth rinse post-SRP. Two weeks later, the participants were reevaluated, and the local herbal drug was delivered in a persistent pocket.

A total of 72 pockets were randomly divided into two equal groups among 18 patients. The experimental group ($n = 36$) received indigenously prepared herbal LDD gel containing combined extracts of *C. sativum* and curcumin while the control group ($n = 36$) received a placebo gel. The gel application was made with the help of a blunt cannula [Figure 1], and the periodontal pack was placed.

In vitro preparation of herbal gel

In an *in vitro* study, using four bio-adhesive polymers of mucoadhesive gels, i.e., Carbopol 940, sodium carboxymethyl cellulose (CMC), curcumin 1 g, and *C. sativum* 1 g, three different Formulations (F) as F1, F2, and F3 having a varying concentration [Table 1] of 0.5 g, 1 g, and 1.5 g were tested. Their physicochemical tests, mucoadhesive strength, drug release, and antibacterial activity against *Porphyromonas gingivalis* and *Aggregatibacter actinomycetemcomitans* (Gram-negative, facultative anaerobe) were evaluated. Since

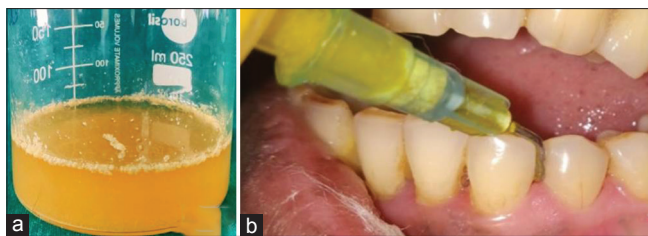


Figure 1: (a) Indigenously prepared herbal gel containing the extracts of *Coriandrum sativum* and curcumin, (b) the gel loaded in a syringe with blunt cannula for ease of delivery in to the periodontal pocket

Formulation 2 (F2) showed better results, it was selected for further clinical evaluation [Figure 1a].

Commercially available curcumin and coriander extract oil were taken for preparation of gel. Methylparaben (0.18 g) and propylparaben (0.02 g) were dissolved in water 80°C.^[18] Accurately weighed quantity of gelling agent Carbopol 940 (1 g) and sodium CMC (3 g) was dispersed in water separately and mixed well. The extracts were dissolved in polyethylene glycol 400 (13 g) and added to the gel base and mixed well.^[9,19] The ingredients were obtained from the Department of Pharmaceutics, Padmashree Vithalrao Vikhe Patil Foundation's College of Pharmacy, Ahmednagar.

The study sites were isolated with a cotton roll for baseline microbiological sampling. With the help of a sterile curette, subgingival plaque samples were collected and transferred into 5 ml of thioglycollate broth (0.1 ml) in a blood agar plate containing protein source (e.g., tryptone), soyabean protein digest, sodium chloride, agar, and 5% sheep blood. This setup is recommended for cultivation of aerobic, microaerophilic, and anaerobic microorganism.^[20] L-shaped spreader is useful in evenly spreading the sample. This was now transferred to an anaerobic gas-pack container that absorbs oxygen and generates carbon dioxide. The methylene blue indicator in the gas-pack container is an indicator of the anaerobic condition. After 72 h of incubation at 37°C,^[21] colony-forming units (CFUs) were assessed by summing by the grids [Figure 2a and b]. Likewise, the procedure was repeated after 3 months [Figure 2c and d].

SPSS version 17 software (SPSS Inc., Chicago, IL, USA) analyzed all the data. We were using repeated measure analysis of variance, paired *t*-test, and sample *t*-test with the difference of *P* < 0.05.

RESULTS

In this randomized controlled clinical trial, an analysis of 72 samples (36 experimental sites and 36 control sites) was determined. Proper compliance was noted among all the study participants. The experimental group showed

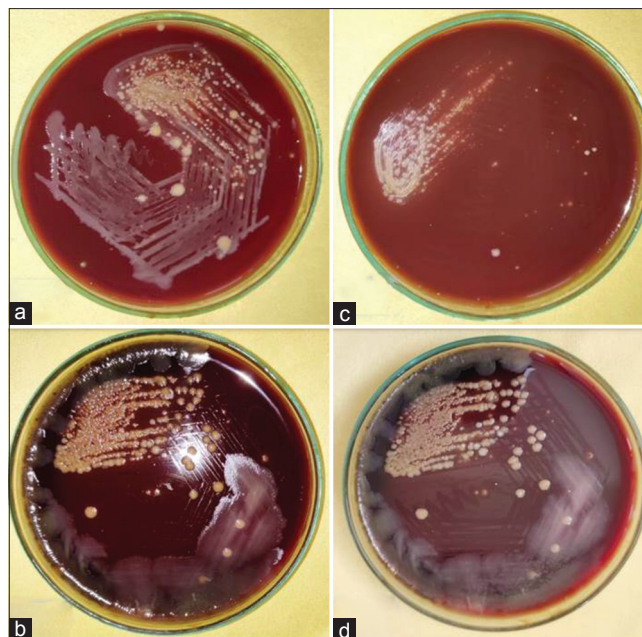


Figure 2: Microbiologic evaluation by colony-forming units. (a and b) Baseline photographs of experimental and control groups, respectively. Similarly, (c and d) 3 months postoperative re-evaluation photographs

Table 1: *In vitro* formulation of three gel

Ingredients (g)	F1	F2	F3
Carbopol 940	1	1	0.5
Na-CMC	3	-	3
Curcumin	0.5	1	1.5
<i>C. sativum</i> extract	0.5	1	1.5
PEG 400	13	13	13
Methyl paraben	0.18	0.18	0.18
Propyl paraben	0.02	0.02	0.02
Triethanolamine	Qs.	-	-
Water Q.S. to	100	100	100

uneventful healing with no signs of allergy, swelling, or inflammation. This ensures that the material is biocompatible and well tolerated by the patients.

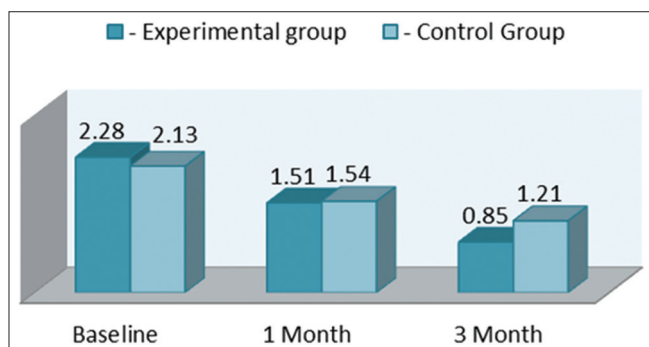
The mean reduction in PI from 2.28 to 0.85 and 2.13 to 1.21 was noted in the experimental and control groups, respectively [Graph 1]. Similarly, Graph 2 shows the mean difference in PBI. The experimental group (2.21–0.76) comparatively showed better reduction than the control group (2.17–1.29). Table 2 demonstrates the intragroup values obtained using the paired *t*-test. *P* < 0.001 was found to be statistically significant at 1 month and 3 months in all the groups. Remarkable improvement was noted from baseline to 3 months in all the groups.

PPD [Figure 3] and CAL differences, as appreciated in Graphs 3 and 4, respectively, show a comparatively equal reduction from baseline to 1 month. However, the control

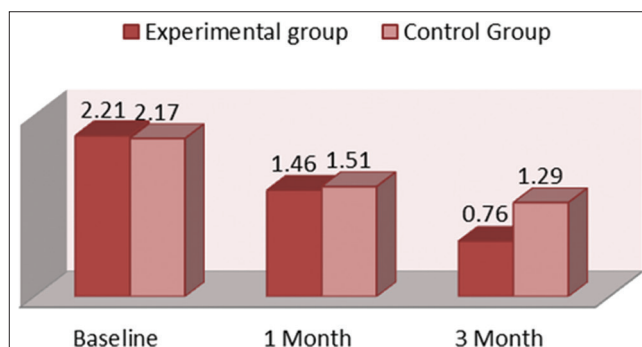
Table 2: Intragroup evaluation of PI - Plaque Index, PBI - Papillary Bleeding Index, PPD - Probing Pocket Depth, CAL - Clinical Attachment Level and MCFC - Mean Colony Forming Cells

Dependent variable	TIME Interval	Mean±Standard deviation				
		PI	PBI	PPD	CAL	MCFC
Experimental group	Baseline	2.28±0.41	2.21±0.39	5.1±0.86	5.2±0.89	3459.4±385.39
	1 month	1.51±0.22*	1.46±0.30*	3.7±0.71*	4.1±0.64*	-
	3 month	0.85±0.09*	0.76±0.19*	2.4±0.51*	2.9±0.88*	2877.8±413.12*
Control group	Baseline	2.13±0.47	2.17±0.24	4.9±0.99	5.1±0.91	3428.5±504.85
	1 month	1.54±0.53*	1.51±0.45*	3.94±0.89*	4.1±0.98*	-
	3 month	1.21±0.45*	1.29±0.51*	3.6±0.91*	3.69±1.20*	3265.2±501.69*

* $P < 0.0001$ P value was obtained is statistically significance among all time intervals



Graph 1: The mean reduction in plaque index as observed in the experimental and control groups at baseline, 1 month, and 3 months



Graph 2: The mean reduction in papillary bleeding index as observed in experimental and control groups at baseline, 1 month, and 3 months

group did not show any improvement in comparison from 1 month to 3 months' values. Similarly, Graph 5 represents that the mean colony-forming cells showed improvement in the experimental group only, which is appreciable in Figure 3.

There was no statistical difference observed from baseline to 1 month in intragroup comparison in all four clinical parameters, as seen in Table 3. However, the P value obtained between baseline and 3 months showed a statistical difference, i.e., $P \leq 0.05$ was observed. The results obtained from both intra- and intergroup comparisons imply that the experiment group showed considerable improvement even after 1 month, proving the sustained release of drugs helpful in combating the bacterial load at sites.

DISCUSSION

Periodontal disease is believed to have multifactorial etiology. Pathologic bacterial residing in deep niches on pockets is considered to be the primary etiology.^[13] The rationale of planning adjunctive local application to SRP therapy is to target specific broad-spectrum bacterial agents and its toxic products. Various drug delivery systems such as irrigational, injectable systems, gels, strips and compacts, fibers, film, vesicular systems, microparticle system, and nanoparticle system are available for the treatment of chronic periodontitis.^[22] The most

commonly used irrigation systems are ineffective in terms of inaccessibility and rapid clearance of the drug from subgingival environment.^[23]

In this study, the mucoadhesive gel was used. The mucoadhesiveness^[24] of the gel was predetermined in an *in vitro* study. Carbopols used for gel formulations have high molecular weight. It swells water up to 1000 times more, increasing the large adhesive surface area with the mucin to provide good mucoadhesiveness. This also prolongs the contact time with mucosa, thus delaying the residence time. This could be the reason for the favorable results obtained in experimental sites.

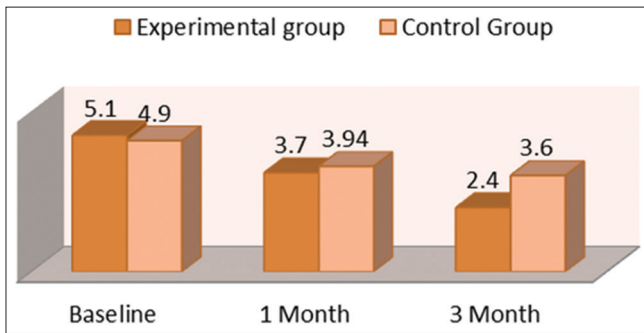
Individual clinical trials for *C. sativum*^[18] and curcumin^[12,13] can be found in the literature. The natural phytochemicals in herbal medicines are highly effective and reasonable substitutes to antibiotics.^[25] The combination of these two drugs in equal proportion showed no adverse reaction. Rather than the combined different phytochemicals of both these herbal medicines could have proven to be efficacious in this study.

A considerably sound reduction in plaque and the papillary bleeding score was obtained in the experimental group. PPD and CAL were found to be significant in intragroup. The intergroup results showed better improvement post-

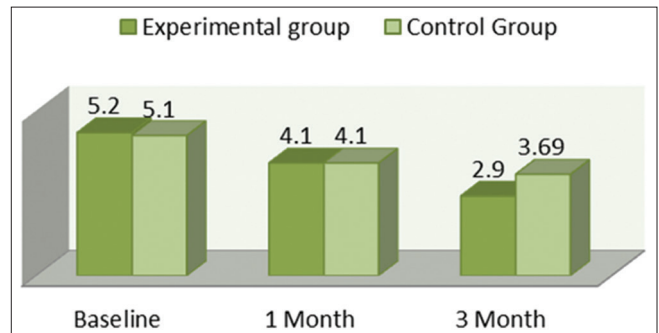
Table 3: Intergroup evaluation of PI - Plaque Index, PBI - Papillary Bleeding Index, PPD - Probing Pocket Depth, CAL - Clinical Attachment Level and MCFC - Mean Colony Forming Cells

Parameters	PI		PBI		PPD		CAL		MFCC	
	Mean ± SD	P	Mean± SD	P	Mean ± SD	P	Mean ± SD	P	Mean ± SD	P
Baseline to 1 month	-0.03 ± 0.09	0.98	-0.08 ± 0.14	0.76	-0.04 ± 0.27	0.97	-0.11 ± 0.24	0.91		
Baseline to 3 months	-0.30 ± 0.11	0.01*	-0.41 ± 0.10	0.001*	-0.71 ± 0.24	0.017*	-0.74 ± 0.21	0.005*	-392.51 ± 142.11	0.021*

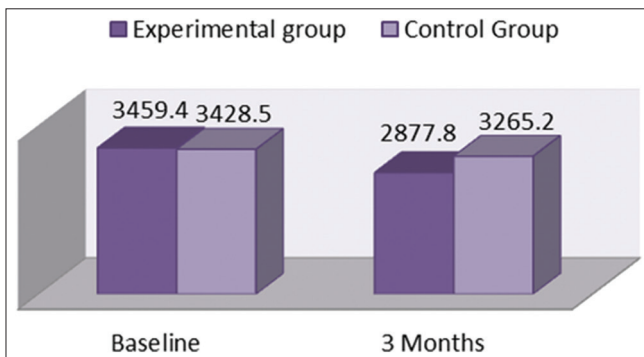
**Denotes statistical significance obtained $\leq 0.05^*$



Graph 3: The mean reduction in periodontal pocket depth as observed in experimental and control groups at baseline, 1 month, and 3 months



Graph 4: The mean reduction in clinical attachment level as observed in experimental and control groups at baseline, 1 month, and 3 months



Graph 5: The mean reduction in colony-forming unit as observed in experimental and control groups at baseline and 3 months

1–3 months, indicating excellent antibacterial and anti-inflammatory effects. This result is not in accordance with Yaghini *et al.* where a different herbal combination of oak and *C. sativum* was used.^[9]

Anaerobic culturing for a microbiological parameter was performed wherein the CFUs were determined. The “gas-pack” anaerobic chamber was used for the same. This gas-pack is cost-effective, readily available, and provides the appropriate anaerobic environment. In addition, the methylene blue indicator helps in identifying the error. The experimental group showed a significant reduction ($P < 0.05$) from 3459.4 ± 385.39 to 2877.8 ± 413.12 from baseline to 3 months. This might be due to the antibacterial property of both the herbal extracts. This is in accordance with the study performed by Silva *et al.*,^[26] who

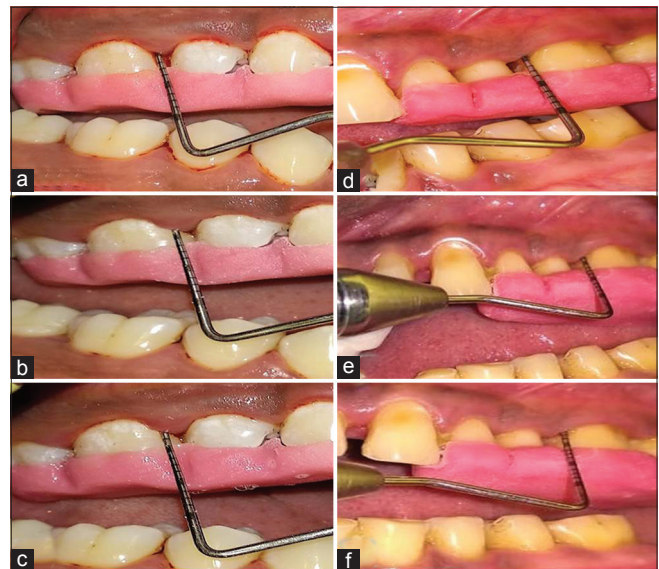


Figure 3: Periodontal pocket depth in both experimental and control groups. (a-c) Baseline 1-month and 3-month probing pocket depth evaluation of experimental group. Similarly, (d-f) baseline 1-month and 3-month probing pocket depth evaluation of control group

concluded of *C. sativum* having potent antibacterial action against the Gram-negative bacteria. Behal *et al.*^[13] in their study showed significant improvement in red complex bacterial, which is also in support of the results of CFU obtained in the study. The control group, however, showed no significant reduction. This could be attributed to the decrease in the bacterial load as a result of mechanical debridement only.

Curcumin promotes and enhances the wound healing process. The phytochemicals in it increase the fibronectin levels and encourage migration of epithelial cells by activation of growth factor-like transforming growth factor- β 1.^[27] The diverse phytochemical structure also helps in the resolution of inflammation.^[28] According to Kim, curcumin is a potent inhibitor of lipopolysaccharide-induced cytokine expression by *P. gingivalis*. It strictly suppresses the production of interleukin six at both gene transcription and translation levels.^[29]

Plant metabolites such as polyphenols on precipitation of proteins result in Tannins. Tannins prevent micro-organism growth by precipitation of microbial proteins.^[30] They increase the antioxidant level, scavenge free radicals, decrease inflammation, and help in the prevention of periodontitis by maintaining the epithelial seal.^[31] In vitro studies have shown its antibacterial property against periodontal pathogens.^[32] The extracts of *C. sativum* are a rich reservoir of tannin.

Chlorhexidine mouthwash, being the gold standard, cannot be continued after 2 weeks of its use. Its bitter taste is difficult to mask despite the manufacturer's constant efforts and the associated side effects.^[33] Comparatively, herbal products are free from side effects and provide close to equivalent result to chlorhexidine.^[34]

The result achieved by the use of herbal LDD combination in this study cannot be termed as a significant benefit as the first line of treatment. Under all conditions, the considerable role of SRP cannot be ruled out that continues to be the first-line method of periodontal therapy. There has been no study evaluating the effects of combined extracts of *C. sativum* and curcumin mucoadhesive gel in periodontitis to the best of our knowledge. However, further studies that include increased gel concentration with repeated application and long-term follow-up could be helpful in gaining clinically significant results.

CONCLUSION

The unique combination of herbal LDD containing the extracts of *C. sativum* and curcumin is effective in the nonsurgical treatment of periodontal pockets. The adjunctive LDD with mechanical debridement is recommended. It can be concluded that, when used as an adjunctive to SRP, it provides a reduction in pocket depth and gain in attachment levels and helps in reducing the bacterial load. It is a potent antibacterial, anti-inflammatory, and antiplaque gel. This herbal combination is noninvasive, easy to apply, and was well tolerated by patients with no adverse soft-tissue reactions.

However, a long-term study with a larger sample size is required to elucidate its clinical use in the future.

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Conflicts of interest

There are no conflicts of interest.

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