Original Article

Efficacy of rh-PDGF-BB and Emdogain With or Without DFDBA Using M-MIST in the Treatment of Intrabony Defects

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Abstract

Background: The versatile combination of emdogain or enamel matrix derivative (EMD), recombinant human platelet-derived growth factor-BB (rhPDGF-BB), and demineralized freeze-dried bone allograft (DFDBA) has not been utilized in the treatment of intrabony defects yet. **Aim:** The present study attempted to investigate the efficacy of a combination of simple, uncomplicated nature of modified minimally invasive surgical technique (M-MIST) with EMD, rhPDGF-BB, and DFDBA in the surgical management of intrabony defects and to assess the possible favorable effects for a period of 6 months. **Patients and Methods:** Thirty healthy subjects were included in the present double-blind, randomized controlled, two-arm parallel study. The test group was treated with M-MIST by using rhPDGF-BB, EMD, and DFDBA, and the control group was treated with M-MIST by using rhPDGF-BB and EMD. **Results:** Differences between the mean values of primary clinical parameters including relative attachment level, probing depth, and gingival recession at baseline and those at 6 months after surgery were statistically significant in both groups. Inter-group comparison for clinical attachment level gain, probing depth reduction, and change in the position of gingival margin revealed no statistically significant differences. Inter-group comparison revealed significant differences in linear bone growth (LBG) and percentage bone fill (% BF) but no significant differences in the residual defect depth and change in the alveolar crest position. **Conclusion:** The additional use of DFDBA provides superior benefits in terms of LBG and % BF in intrabony defects. This improvement might be attributed to the use of an osteoinductive scaffold.

Keywords: *DFDBA, EMD, intrabony defects, M-MIST, rhPDGF-BB*

Introduction

Periodontal therapy involves two key components: eradication of bacterial plaque and elimination of the anatomic defects produced by periodontitis. Generally, two surgical methods are used to eliminate these defects, namely resective and regenerative. Regenerative therapy aids in eliminating periodontal defects by creating novel bone and periodontal ligament and relocating the gingival margin. Bone graft materials such as autogenous grafts, demineralized freeze-dried bone allograft (DFDBA), freeze-dried bone allograft (FDBA), bone xenografts, or synthetic bone substitutes have been used in the treatment of intrabony defects over years.[1]

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DFDBA has been used alone or in combination with additional materials for periodontal therapy. It is both osteoinductive and osteoconductive in nature.[2] The role of bone morphogenetic proteins (BMPs) within the DFDBA in conferring osteoinductive property to DFDBA has been challenged. Moreover, the concentration of BMPs in commercial DFDBA is perhaps too meager to achieve any substantial inductive effect.

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Growth factors are important for periodontal regeneration because they are implicated in the proliferation, chemotaxis, and differentiation of various cells such as fibroblasts and osteoblasts. Platelet-rich plasma (PRP) and platelet-rich fibrin (PRF) containing growth factors possibly enhance periodontal regeneration, and the efficacy of these sources has been well established.[3] The ability of platelet-derived growth factor to stimulate the regeneration of bone, cementum, and periodontal ligament has been demonstrated in several animal and human trials.[4] Artificially produced recombinant human PGDF-BB (rhPDGF-BB) has also been employed in recent years because it provides a greater concentration of PGDF compared with naturally obtained PRP or PRF.

Several studies have shown that emdogain (EMD) also promotes periodontal regeneration in recession and furcation defects due to its osteoinductive and osteopromotive attributes.[5] Among various factors, refinement of the surgical technique with a microsurgical approach appears to be a decisive element in successful regeneration.[6] In light of this concept, advancements have been made in periodontal flap techniques, such as papilla preservation flaps, minimally invasive surgery, minimally invasive surgical technique (MIST), and modified MIST (M-MIST), for the treatment of intrabony defects. In the MIST, a concept introduced by Harrel and Rees, trauma to the soft tissue flaps is minimized and wound stability is enhanced.[7] Moreover, the technique aids in the retention of graft material, which may have a favorable effect on periodontal regeneration. M-MIST is a further modification of the MIST approach that was designed to decrease surgical invasiveness in the treatment of intrabony defects.[8]

The synergistic effect of rhPDGF-BB and EMD is assumed to overcome the potential confines when used in conjunction with an excellent scaffold such as DFDBA. The unique combination of EMD, rhPDGF-BB, and DFDBA has not been utilized to date in the regeneration of intrabony defects. Hence, this study aimed to analyze the use of DFDBA to the combination of M-MIST, EMD, and rhPDGF-BB in the surgical management of intrabony periodontal defects and assessment of the potential beneficial effects for a period of 6 months.

Materials and Methods

Study design

The present study was a double-blind, randomized controlled, two-arm parallel study performed in the Department of Periodontics, from December 2013 to November 2014. Ethical clearance was obtained from the Institutional Ethics Committee of the institute (SSCDS/D128306016). The study was conducted to evaluate the efficacy of EMD and rhPDGF-BB with and without DFDBA during M-MIST in the treatment of human periodontal intrabony defects. All the patients were followed-up for a period of 6 months.

Population screening

Among the 38 patients screened from the Outpatient Department of Periodontics, 30 patients (19 men and 11 women) aged 25–45 years were included in the study. The inclusion criteria were: systemically healthy chronic periodontitis patients presenting with at least one tooth with probing depth (PD) and clinical attachment level (CAL) ≥5 mm; radiographic evidence of angular bone loss and no history of taking antibiotics, corticosteroids, nonsteroidal anti-inflammatory drugs, or periodontal treatment over the past 3 months. Vital or endodontically treated teeth were included. As a thumb rule, patients with good oral hygiene and those presenting with full-mouth plaque scores (FMPS) [O'Leary *et al*. 1972][9] and full-mouth bleeding scores (FMBS) [Cortellini *et al*. 1993][10] of ≤20% were included. Smokers and pregnant or lactating mothers were excluded from the study. Teeth with mobility greater than grade II (Miller 1943),[11] class II and class III furcation involvement (Glickman 1953),[12] with clinical signs of any acute infection at surgical site, apical pathology, root anomalies such as fracture, or irregularities were also excluded. Final eligibility was confirmed during surgery, wherein patients with a vertical defect depth >3 mm without any buccal or lingual extension were considered eligible for the analysis.

After obtaining informed consent from all the patients before the commencement of the study, initial therapy including scaling and root planing was performed, and oral hygiene instructions were provided to all the patients. Baseline measurements were documented clinically and radiographically 8 weeks after completion of the initial therapy [Figures 1 and 2].

Sample size and randomization

A sample size of 12 per treatment group was set assuming 95% confidence interval and 80% power, as reported in earlier comparable studies.[13,14] Computer-generated block randomization (four-unit block size) was performed, which produced a succession of numbers. Information about treatment allocation was sealed in numbered envelopes, and it was disclosed to the periodontist (MP) immediately before surgery. Presurgical and post-surgical assessments were accomplished by a calibrated investigator (P) who was blinded to the nature of the intervention. The patients were randomly allocated to the test group (M-MIST + EMD + rhPDGF-BB [0.3 mg/ml] gel +

DFDBA) or the control group (M-MIST + EMD + rhPDGF-BB [0.3 mg/ml] gel). The patients as well as the investigator (P) who assessed the outcomes were blinded to the allocation (a double-blind study).

Clinical parameters

All clinical parameters were recorded at the initial visits, baseline, 3 months, and 6 months after surgery. Clinical indices, namely FMPS and FMBS, were recorded. Modified gingival index (MGI) (Lobene *et al*. 1986)[15] was used to assess the gingival status. The clinical parameters included relative attachment level (RAL), PD, and gingival recession (GR), which were recorded to the nearest millimeter (at the deepest location of the selected interproximal site) by using a UNC-15 probe on a fabricated occlusal stent at baseline and at 6 months after the surgery.

PD, RAL, and GR were calculated from a fixed reference point on the stent. Although CAL is the gold standard indicator of periodontal health, RAL was considered reliable due to difficulties presented by factors such as restorations. RAL was measured as the distance from the apical border of the stent to the base of the pocket. All the parameters were clinically assessed by a single examiner (P). Calibration was considered reproducible when the measurements at baseline and those at 48 h showed a difference of ≤1 mm in 95% of the cases.

Radiographic parameters

Intraoral periapical radiographs of the studied teeth were obtained using the long-cone paralleling technique at baseline and at 6 months after surgery. The Rinn XCP film-holding paralleling device (Dentsply Ltd, Addlestone, UK) was used to position the films. The radiographs were digitized and analyzed using the AutoCAD software 2010 (Autodesk India Pvt. Ltd., Mumbai, India). The anatomical landmarks of the intrabony defect were selected on the radiographs based on the criteria established by Schei *et al*. (1959),[16] which comprised of cementoenamel junction (CEJ), alveolar crest (AC), and base of the defect (BD). The radiographic parameters included linear bone growth (LBG), percentage bone fill (% BF), and distance from the CEJ to the alveolar crest position (C-ACP).[13,17] The differences between measurements at baseline and those at 6 months were adjusted for distortion.

Surgical approach (M-MIST)

Microsurgical instruments were used to execute all surgical procedures (Salvin Dental Surgicals, Charlotte, NC, USA), aided by magnifying loupes (2.5×) (STAC Dental Instruments Inc., Brampton, Ontario, Canada). Under adequate anesthesia, bone sounding was performed to confine the extension of the defect either buccally or palatally/lingually. The defect-associated papilla was surgically treated using the M-MIST approach, as described by Cortellini and Tonetti in 2009[6] [Figures 3 and 4]. Using mini blade No. 67, the first incision was made toward the crest of the bone, extending to the line angle of the buccal aspect of the two teeth adjacent to the defect. The first incision was extended intrasulcularly until the mid-buccal portion of the adjacent teeth to permit the reflection of a triangular buccal flap until the coronal edge of the buccal AC. The second incision was made with an inclination to split the coronal part of the papilla from the apical part containing the granulation tissue. Subsequent surgical debridement of the osseous defect was achieved using mini curettes (SAS 3/4, 5/6, 11/12, 13/14; Hu-Friedy Mfg. Co., Chicago, IL, USA). Following debridement, direct measurements of the osseous defect were made using a UNC-15 periodontal probe. The vertical bone depth (from the bottom of the defect to the AC) and the number of bony walls were recorded. Final patient eligibility was confirmed if the depth of the vertical bone defect was ≥3 mm. In both the groups, root surfaces adjacent to the defects were conditioned for 2 min with 24% ethylenediaminetetraacetic acid (EDTA) solution (pH 6.7) to eliminate the smear layer. Subsequently, EMD was applied using a syringe and a blunt end cannula onto the exposed root surface, starting at the most apical bone level. The fundamental objective of applying EMD onto the root surface was not to fill the periodontal defect but to fully cover the exposed root surface to allow precipitation of amelogenins onto the exposed and conditioned root surface. After root conditioning, presuturing was performed using 6-0 polypropylene monofilament sutures (Hindustan Latex Ltd., Trivandrum, Kerala, India) [Figures 5-8].

In the test group, the required quantities of DFDBA and rhPDGF-BB were mixed together into a workable consistency and placed into the osseous defect. In the control group, rhPDGF-BB was administered directly into the defect by using a syringe and a blunt end cannula. The presutured mucoperiosteal buccal flaps were repositioned at the defect-associated inter-dental area and held together with modified internal cross-mattress suture.

Post-surgical care

After surgery, antibiotics including 500 mg amoxicillin three times daily for 5 days and analgesics including ibuprofen (400 mg) + paracetamol (500 mg) three times daily (for the first day after the surgery) were prescribed. Post-operative instructions were provided to all the patients. All the patients were administered a regimen of rinsing with 0.2% chlorhexidine twice a daily until they could achieve regular mechanical plaque control.

Suture removal was performed 1 week after surgery. The patients were reinstructed about appropriate oral hygiene and examined 15 days after surgery. They were further re-evaluated at 1, 3, and 6-month intervals [Figure 9-11]. Supportive periodontal care was provided every 3 months for 1 year.

Outcome measures

Primary outcome measures included mean CAL gain (CAL-G) and LBG. Secondary outcome measures included PD reduction (PD-R), change in the position of gingival margin (c-GMP), % BF, residual defect depth (RDD), C-ACP, FMBS, FMPS, and MGI.

Statistical analysis

Before performing the statistical analyses, the assigned codes were revealed. A biostatistician performed all the statistical analyses by using SPSS version 14 (SPSS Inc., Chicago, IL, USA). Subsequent statistical tests were used to analyze the clinical and radiographic parameters. The intragroup analysis for RAL, PD, GR, CEJ-BD, RDD, and C-ACP was performed using Student's paired t-test, whereas the inter-group analysis for CAL-G, PD-R, C-GMP, LBG, C-ACP, % BF, RDD, FMPS, FMBS, and MGI was performed using Student's independent t-test. The intragroup analysis for FMPS, FMBS, and MGI was performed using the repeated measure analysis of variance.

Results

Patient and defect characteristics

Thirty patients (19 men and 11 women) aged 25–45 years were enrolled in this study and were randomly assigned to the test group or to the control group [Table 1]. Among the 30 patients, 26 patients completed the 6-month follow-up. Four patients (two from the test group and two from the control group) were lost to follow-up; of these, two patients migrated to distant places, and the remaining two patients were reluctant to visit for the post-operative follow-up visits for reasons not related to the study. Each of the patient who had at least one infrabony defect was selected and allocated in both the groups. Mean age of the patients from the test and the control groups was 33.08 ± 7.70 years and 35.23 ± 6.47 years, respectively. Baseline clinical and radiographic defect characteristics were not significantly different between the groups, indicating that the groups were evenly matched. Altogether, 26 patients (13 patients from the test group and 13 patients from the control group, with 13 defects in each group) completed the 6-month follow-up.

Clinical outcomes

Healing was uneventful in both the groups, and no systemic or local adverse effects were observed [Table 2]. Intragroup comparison revealed a statistically significant increase in the mean FMPS and mean FMBS scores from baseline to 3 months in the test group. Intragroup comparison of the mean

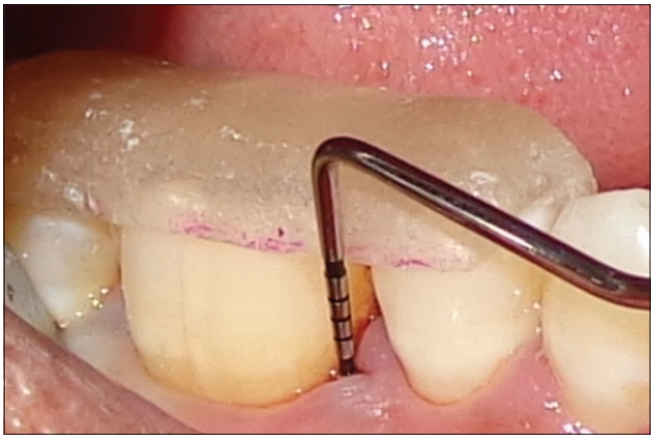

Figure 1: Preoperative view showing probing depth with stent in position

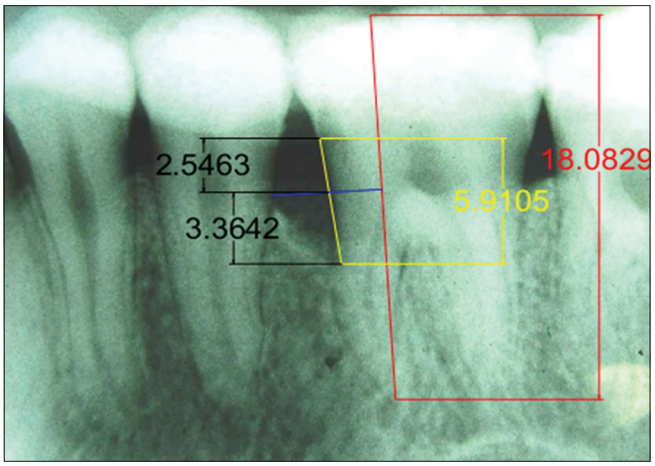

Figure 2: Radiograph at baseline

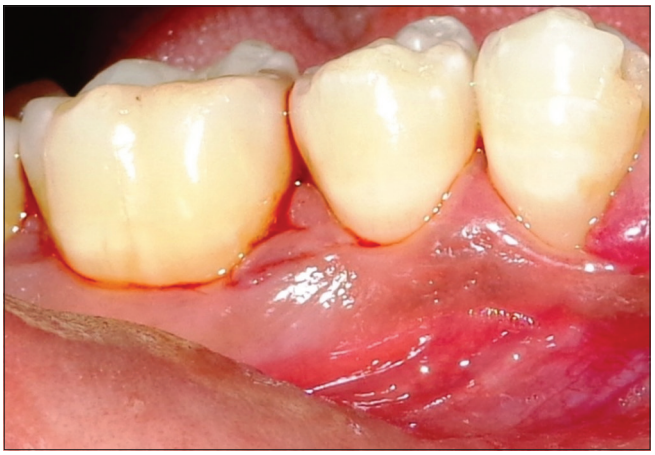

Figure 3: Horizontal incision given on the inter-dental papilla

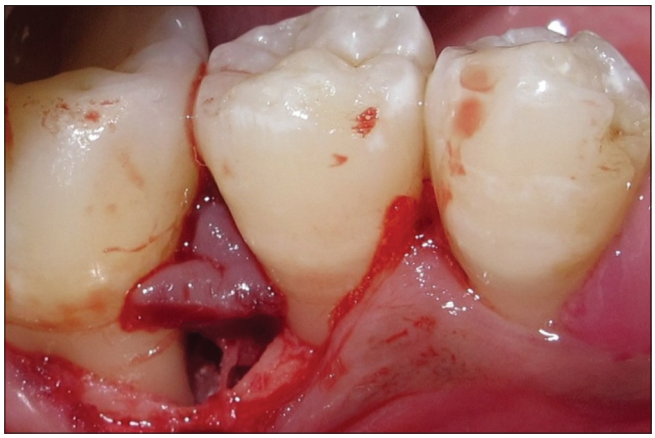

Figure 4: Defect area after debridement

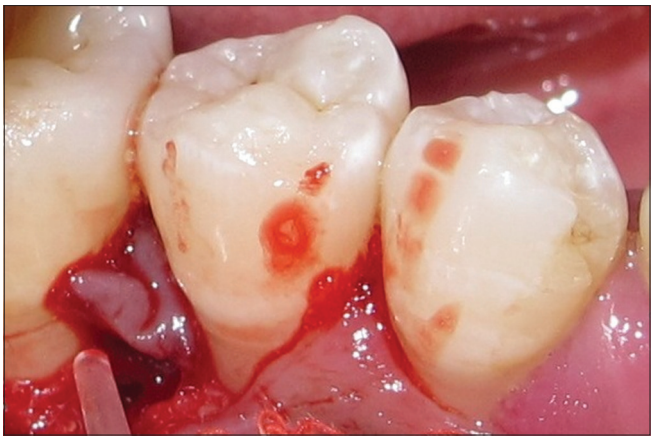

Figure 5: Application of 24% EDTA gel on the root surface

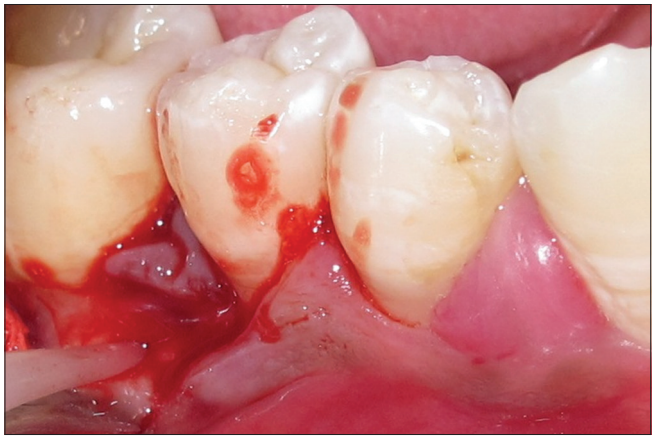

Figure 6: Application of EMD gel on the root surface

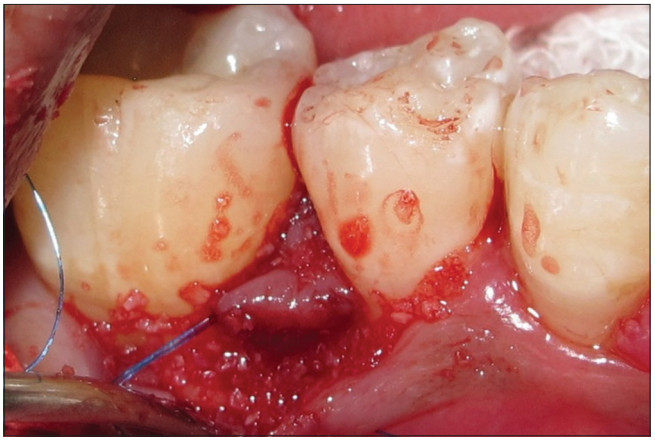

Figure 7: Application of mixture of rh-PDGF-BB and DFDBA into the defect

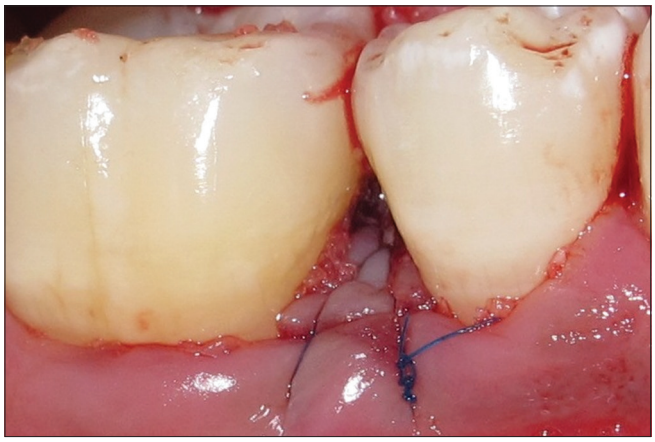

Figure 8: Modified internal cross-mattress suture in position

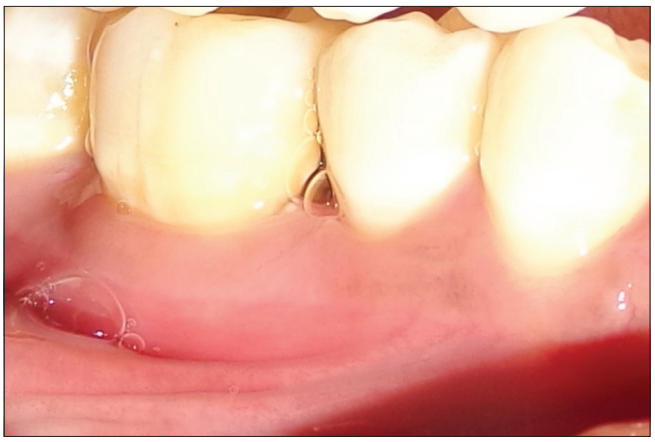

Figure 9: Clinical view at 6 months post-operative

FMPS and mean FMBS scores at baseline, 3 months, and 6 months revealed no significant changes in the control group. Intragroup comparison of the mean MGI scores revealed significant reduction from baseline to 6 months post-operatively in both the groups. Inter-group comparison of the mean FMPS, FMBS, and MGI scores at baseline, 3 months, and 6 months after surgery revealed no significant differences.

Intragroup comparison of mean RAL from baseline to 6 months after surgery indicated statistically significant ($p < 0.001$) changes in both the groups. Inter-group comparison of mean CAL-G indicated no significant difference. Intragroup comparison of mean PD from baseline to 6 months after surgery showed significant changes in both the groups ($p < 0.001$).

Table 1: Baseline, clinical, and radiographic defect characteristics between test and control groups

Baseline parameters	Test group (*n*=13)	Control group (*n*=13)	*P*
Mean age	33.08±7.70	35.23±6.47	0.447 (NS)
FMPS (%)	17.35±3.44	18.56±2.18	0.62 (NS)
FMBS (%)	17.19±3.24	19.07±2.18	0.987 (NS)
MGI	0.25±0.07	0.25±0.06	0.951 (NS)
RAL (in mm)	13.46±2.07	13.23±2.01	0.775 (NS)
PD (in mm)	8.46±1.66	7.85±0.99	0.263 (NS)
GR (in mm)	0.62±0.77	0.63±0.77	>0.99 (NS)
Defect location			
Number in maxilla	4	3	
Number in mandible	9	10	
Defect-associated tooth:			
Multi-rooted teeth	11	9	
Single-rooted teeth	2	4	
Osseous defect depth (in mm)	5.24±1.45	4.52±1.10	0.165 (NS)
Osseous defect morphology			
2 walled	4	5	
3 walled	4	4	
Combination of 2 and 3 walls	5	4	

FMBS, full-mouth bleeding scores; FMPS, full-mouth plaque scores; GR, gingival recession; MGI, modified gingival index; *n*, number of patients; S, statistically significant ($P \leq 0.05$); NS, no statistical significance

Table 2: Clinical outcomes at 6 months

Parameters	Group (Mean±SD)		*P*
	Test	Control	
PD-R (mm)	3.23±2.05	2.54±1.13	0.299 (NS)
C-GMP (mm)	-0.38±0.51	-0.62±0.51	0.257 (NS)
CAL-G (mm)	2.85±1.86	1.92±0.86	0.124 (NS)

S, statistically significant ($P \leq 0.05$), NS, no statistical significance; PD-R, probing depth reduction; C-GMP, change in gingival margin position; CAL-G, clinical attachment level gain

Table 3: Radiographic outcomes at 6 months

Parameters	Group (Mean±SD)		*P*
	Test	Control	
LBG (mm)	3.44±1.72	2.17±1.39	0.049 (S)
% BF	59.55±20.20	41.04±20.30	0.029 (S)
C-ACP (mm)	0.09±0.81	0.14±0.95	0.895 (NS)
RESIDUAL DD (mm)	1.82±1.05	2.47±0.64	0.071 (NS)

S, statistically significant ($P<0.05$); NS, no statistical significance; LBG, linear bone growth; %BF, percentage bone fill; DD, defect depth; C-ACP, change in alveolar crest position

Inter-group comparison of mean PD-R indicated no significant difference. Intragroup comparison of mean GR from baseline to 6 months post-operatively revealed significant changes in both the groups. Inter-group comparison for C-GMP revealed no significant difference. Inter-group comparison of parameters at baseline and after 6 months of flap surgery revealed statistical significant differences in all the parameters except for the PD values in control group.

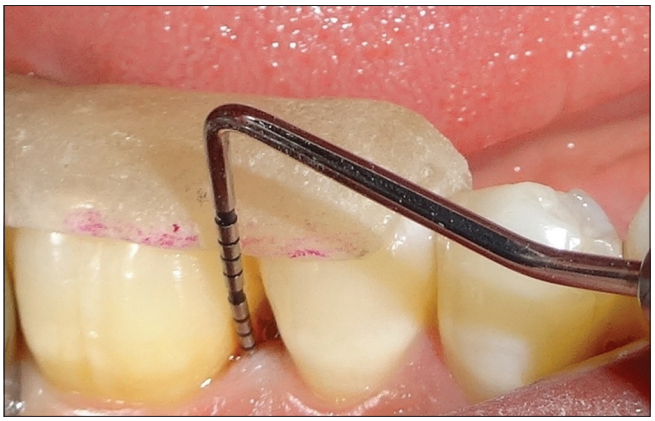

Figure 10: 6 months post-operative view showing probing depth with stent in position

Radiographic outcomes

Intragroup comparison of mean CEJ-BD and RDD from baseline to 6 months post-operatively indicated significant changes in both groups ($p < 0.001$) [Table 3]. Intragroup comparison of mean C-ACP from baseline to 6 months showed no significant changes ($p > 0.05$) in both the groups. Inter-group comparison of mean LBG [3.44 ± 1.72 and 2.17 ± 1.39 in test and control group respectively] and %BF [59.55 ± 20.20 and 41.04 ± 20.30 in test and control group respectively] revealed significant differences ($p < 0.05$), while that of RDD and C-ACP revealed no significant differences ($p > 0.05$) [Table 4]. Significant differences in the hard tissue parameters such as LBG and %

Table 4: Inter-group comparison of parameters at baseline and 6 months after surgery

Parameters	Group (Mean±SD)					
	Test			Control		
	Baseline	After 6 months	*P*	Baseline	After 6 months	*P*
FMPS (%)	17.35±3.44	8.23±2.03	0.039 (S)	18.56±2.18	9.17±1.29	0.09 (S)
FMBS (%)	17.19±3.24	9.43±1.01	0.029 (S)	19.07±2.18	8.04±0.30	0.029 (S)
RAL (in mm)	13.46±2.07	7.82±0.97	0.023 (S)	13.23±2.01	8.01±0.54	0.017 (S)
PD (in mm)	8.46±1.66	5.23±1.05	0.019 (S)	7.85±0.99	5.68+0.56	0.082 (NS)

S, statistically significant ($P<0.05$); NS, no statistical significance

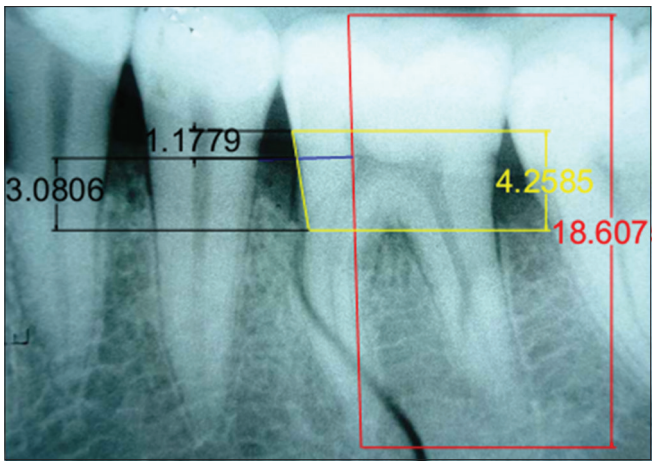

Figure 11: Radiograph at 6 months post-operative

BF between the groups can be attributed to the osteoinductive property of the graft material. Moreover, DFDBA might have potentiated the collective effect of growth factors such as EMD and rhPDGF-BB by affecting the release kinetics and maintaining the action of these materials at the site of interest, leading to a significant increase in LBG and % BF.

Intragroup comparison of the mean CEJ-BD and mean RDD from baseline to 6 months after surgery revealed significant changes ($p < 0.05$) in both the groups. Inter-group comparison of mean C-ACP from baseline to 6 months after surgery indicated no significant difference ($p > 0.05$).

Discussion

The present study was a neoteric study to assess the efficacy of a unique blend of emdogain and rhPDGF-BB with or without DFDBA during M-MIST. Mishra *et al*.[13] assessed the distinct regenerative capacity of rhPDGF-BB along with M-MIST and suggested that a combination therapy would yield superior results. Because each of these materials has its peculiar characteristics and purposes, their combination might have led to periodontal regeneration.

In the present study, 0.3 mg/mL of rhPDGF-BB gel was used as an implant material, which has been confirmed to be a therapeutic dose in the treatment of intrabony defects.[18-20] Among the graft materials, DFDBA has distinct properties of its own, serving both osteoconductive and osteoinductive roles. DFDBA was used in the present study because it has been used as a carrier for both emdogain and rhPDGF-BB in many studies.[5] The concept of root conditioning has been contentious. A contemporary systematic review demonstrated that root conditioning provides no additional benefits in regenerative procedures.[21]

In a study by Howell *et al*.,[14] a blend of rhPDGF and insulin-like growth factor-1 was used, which led to a substantial increase in LBG and % BF. The present study also utilized a blend of growth factors, which led to similar improvements in the hard tissue parameters.

The improvements in the clinical parameters observed in the present study are similar to those observed in the pioneering studies by Cortellini and Tonetti in two consecutive years.[22,23] A few other studies that applied the combination of Emdogain and microsurgery have also reported comparable outcomes.[24,25]

In the present study, a combination of M-MIST, EMD, and rhPDGF-BB was used along with DFDBA in the test group. To date, very few studies have used this combination. Cortellini (2011) used M-MIST along with emdogain and bovine xenograft.[26] Although the improvements in clinical parameters in the aforementioned study are comparable to those in the present study, LBG was higher in the present study. This finding might be attributed to the self-resorbing capacity of DFDBA unlike bovine xenograft. Moreover, the radiopaque nature of bovine xenograft might have camouflaged the actual radiographic measurements. In the present study, the outcomes obtained in the test group were consistent with those reported in other studies that utilized a combination of emdogain and DFDBA.[27,28] Conversely, LBG and % BF in the present study were higher than those reported in a study by Hoidal *et al*.;[29] this finding might be attributed to the use of MIST and the additional use of rhPDGF-BB with DFDBA.

The combination of rhPDGF-BB and an osteoconductive scaffold such as beta-tricalcium phosphate has also been employed with a conventional flap surgery in two studies.[19,20] The results obtained in the present study are comparable to those from a study by Jayakumar *et al*.[19] The present study showed marginal improvements in the hard tissue parameters compared with those in a study by Nevins *et al*.[20] This difference can be attributed to the use of emdogain, intrinsic potential of DFDBA to serve as a osteoinductive scaffold, versatility of the surgical technique itself, or a combination of all these factors.

A close, although not entirely similar, comparison can be made with a recent study by Dori *et al*.,[30] which utilized the combination of PRP, EMD, and natural bone mineral to treat intrabony defects, showing improvements in the clinical parameters similar to those in the present study. However, no information was provided about the hard tissue parameters or defect characteristics.

In the present study, no statistically significant differences were observed in the clinical parameters between the test group and the control group, implying the role of emdogain and M-MIST in both the groups. Emdogain leads to the formation of acellular cementum and insertion of Sharpey's fibers, leading to a gain in the attachment apparatus.[5] Although it also has an effect on the bone, its predominant effect is the formation of acellular cementum, which might led to improvements in the clinical parameters in both the groups. Furthermore, the distinct characteristics of the surgical technique responsible for primary wound stability, preservation of supracrestal fiber attachment, minimization of flap reflection, and improvement of regeneration might lead to enhancement in the clinical parameters in both the groups.

Various histological studies have demonstrated that the use of rhPDGF-BB mandates the use of a scaffolding material, which potentiates the action of DFDBA, leading to robust periodontal regeneration.[31-33] Nevertheless, it is difficult to ascertain which growth factor played a leading role in new bone formation or whether the graft itself led to the improved bone fill observed in the test group. It has been concluded that the addition of DFDBA provided superior benefits in terms of LBG and % BF in the treatment of intrabony defects due to its osteoinductive nature.

One of the main limitations of the present study is the short follow-up period of 6 months. A study reported improved outcomes after a long-term follow-up period of 12 months.[34]

Conclusion

The additional use of DFDBA provides superior benefits in terms of LBG and % BF in intrabony defects. This improvement might be attributed to the use of an osteoinductive scaffold. Thus, we speculate that a long-term follow-up period might have yielded more favorable.

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Conflicts of interest

There are no conflicts of interest.

References

1. Urist MR, DeLange RJ, Finerman GA. Bone cell differentiation and growth factors. Science 1983;220:680–6.
2. Reynolds MA, Aichelman-Reidy ME, Mays GLB, Gunsolley JC. The efficacy of bone replacement grafts in the treatment of periodontal osseous defects: A Systematic review. Ann Periodontol 2003;8:227-65.
3. Plachokova AS, Nikolidakis D, Mulder J, Jansen JA, Creugers NHJ. Effect of platelet-rich plasma on bone regeneration in dentistry: A systematic review. Clin Oral Impl Res 2008;19:539–45.
4. Giannobile WV, Hernandez RA, Finkelman RD, Ryan S, Kiritsy CP, D'Andrea M, *et al*. Comparative effects of platelet-derived growth factor-BB and insulin-like growth factor-I, individually and in combination, on periodontal regeneration in Macaca fascicularis. J Periodontal Res 1996;31:301-12.
5. Venezia E, Goldstein M, Boyan BD, Schwartz Z. The use of enamel matrix derivative in the treatment of periodontal defects: A literature review and meta-analysis. Crit Rev Oral Biol Med 2004;15:382–402.
6. Cortellini P, Tonetti MS. Improved wound stability with a modified minimally invasive surgical technique in the regenerative treatment of isolated interdental intrabony defects. J Clin Periodontol 2009;36:157-63.
7. Harrel SK, Wilson TG, Nunn ME. Prospective assessment of the use of enamel matrix proteins with minimally invasive surgery. J Periodontol 2005;76:380-4.
8. Harrel SK. A minimally invasive surgical approach for periodontal regeneration: Surgical technique and observations. J Periodontol 1999;70:1547-57.
9. O'Leary TJ, Drake RB, Naylor JE. The plaque control record. J Periodontol 1972;43:38.
10. Cortellini P, Pini Prato G, Tonetti MS. Periodontal regeneration of human infrabony defects. I. Clinical measures. J Periodontol 1993;64:254-60.
11. Miller SC. Textbook of Periodontia (Oral Medicine). 2nd ed. Philadelphia: The Blakiston Co; 1943. p. 103.
12. Glickman I. Clinical Periodontology: Prevention, Diagnosis,

and Treatment of Periodontal Disease in the Practice of General Dentistry. 4th ed. Philadelphia, PA, USA: Saunders; 1972. p. 242–5.
13. Mishra A, Avula H, Pathakota KR, Avula J. Efficacy of modified minimally invasive surgical technique in the treatment of human intrabony defects with or without use of rhPDGF-BB gel – A randomized controlled trial. J Clin Periodontol 2013;40:172–9.
14. Howell TH, Fiorellini JP, Paquette DW, Offenbacher S, Giannobile WV, Lynch SE. A phase I/II clinical trial to evaluate a combination of recombinant human platelet-derived growth factor-BB and recombinant human insulin-like growth factor-I in patients with periodontal disease. J Periodontol 1997;68:1186-93.
15. Lobene RR, Weatherford T, Ross NM, Lamm RA, Menaker L. A modified gingival index for use in clinical trials. Clin Prev Dent 1986;8:3–6.
16. Schei O, Waerhaug J, Lovdal A, Arno A. Alveolar bone loss as related to oral hygiene and age. J Periodontol 1959;30:7–16.
17. Nevins M, Hanratty J, Lynch SE. Clinical results using recombinant human platelet-derived growth factor and mineralized freeze-dried bone allograft in periodontal defects. Int J Periodontics Restorative Dent 2007;27:421-7.
18. Ridgway HK, Mellonig JT, Cochran DL. Human histologic and clinical evaluation of recombinant human platelet-derived growth factor and beta-tricalcium phosphate for the treatment of periodontal intraosseous defects. Int J Periodontics Restorative Dent 2008;28:171-9.
19. Jayakumar A, Rajababu P, Rohini S, Butchibabu K, Naveen A, Reddy PK, *et al*. Multi-centre, randomized clinical trial on the efficacy and safety of recombinant human platelet-derived growth factor with β-tricalcium phosphate in human intra-osseous periodontal defects. J Clin Periodontol 2011;38:163-72.
20. Nevins M, Giannobile WV, McGuire MK, Kao RT, Mellonig JT, Hinrichs JE, *et al*. Platelet-derived growth factor stimulates bone fill and rate of attachment level gain: Results of a large multicenter randomized controlled trial. J Periodontol 2005;76:2205-15.
21. Mariotti A. Efficacy of chemical root surface modifiers in the treatment of periodontal disease-a systematic review. Ann Periodontol 2003;8:205-26.
22. Cortellini P, Tonetti MS. A minimally invasive surgical technique with an enamel matrix derivative in the regenerative treatment of intra-bony defects: A novel approach to limit morbidity. J Clin Periodontol 2007;34:87-93.
23. Cortellini P, Pini-Prato G, Nieri M, Tonetti MS. Minimally invasive surgical technique and enamel matrix derivative in intrabony defects: Factors associated with healing outcomes. Int J Periodontics Restorative Dent 2009;29:257-65.
24. Ribeiro FV, Nociti Junior FH, Sallum EA, Sallum AW, Casati MZ. Use of enamel matrix protein derivative with minimally invasive surgical approach in intra-bony periodontal defects: Clinical and patient-centered outcomes. Braz Dent J 2010;21:60-7.
25. Ribeiro FV, Casarin RCV, Francisco HN Jr, Sallum EA, Casati MZ. The role of Enamel matrix derivative protein in minimally invasive surgery in treating intrabony defects in single-rooted teeth: A randomized clinical trial. J Periodontol 2011;82:522-32.
26. Cortellini P, Tonetti MS. Clinical and radiographic outcomes of the modified minimally invasive surgical technique with and without regenerative materials: A randomized-controlled trial in intra-bony defects. J Clin Periodontol 2011;38:365-73.
27. Piemontese M, Aspriello SD, Rubini C, Ferrante L, Procaccini M. Treatment of periodontal intrabony defects with demineralized freeze-dried bone allograft in combination with platelet-rich plasma: A comparative clinical trial. J Periodontol 2008;79:802–10.
28. Gurinsky BS, Mills MP, Mellonig JT. Clinical evaluation of demineralized freeze-dried bone allograft and enamel matrix derivative versus enamel matrix derivative alone for the treatment of periodontal osseous defects in humans. J Periodontol 2004;75:1309-18.
29. Hoidal MJ, Grimard BA, Mills MP, Schoolfield JD, Mellonig JT, Mealey BL. Clinical evaluation of demineralized freeze-dried bone allograft with and without enamel matrix derivative for the treatment of periodontal osseous defects in humans. J Periodontol 2008;79:2273-80.
30. Dori F, Arweiler N, Huszar T, Gera I, Miron RJ, Sculean A. Five-year results evaluating the effects of platelet-rich plasma on the healing of intrabony defects treated with enamel matrix derivative and natural bone mineral. J Periodontol 2013;84:1546-55.
31. Nevins M, Camelo M, Nevins ML, Schenk RK, Lynch SE. Periodontalnregeneration in humans using recombinant human platelet-derived growth factor-BB (rhPDGF-BB) and allogenic bone. J Periodontol 2003;74:1282-92.
32. Nevins M, Nevins ML, Karimbux N, Kim SW, Schupbach P, Kim D. The combination of purified recombinant human platelet-derived growth factor-BB and equine particulate bone graft for periodontal regeneration. J Periodontol 2012;83:565-73.
33. Nevins M, Kao RT, McGuire MK, McClain PK, Hinrichs JE, McAllister BS. Platelet-derived growth factor promotes periodontal regeneration in localized osseous defects: 36-month extension results from a randomized, controlled, double-masked clinical trial. J Periodontol 2013;84:456-64.
34. Fickl S, Thalmair T, Kebschull M, Bohm S, Wachtel H. Microsurgical access flap in conjunction with enamel matrix derivative for the treatment of intra-bony defects: A controlled clinical trial. J Clin Periodontol 2009;36:784-90.