Efficacy of Platelet-rich Fibrin vs. Enamel Matrix Derivative in the Treatment of Periodontal Intrabony Defects: A Clinical and Cone Beam Computed Tomography Study

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Abstract

Objective: To evaluate and compare the efficacy of platelet-rich fibrin (PRF) with enamel matrix derivative (EMD; Emdogain®) in the treatment of periodontal intrabony defects in patients with chronic periodontitis, six months after surgery.

Methods: Forty-four (44) intrabony defects in 30 patients (15 males) were randomly allocated into two treatment groups: EMD (n = 22) and PRF (n = 22). Measurement of the defects was done using clinical and cone beam computed tomography at baseline and 6 months. Clinical and radiographic parameters such as probing depth, clinical attachment level, intrabony defect depth and defect angle, were recorded at baseline and 6 months post-operatively. Within group change was evaluated using the Wilcoxon signed rank test. Intergroup comparisons were made using the Mann-Whitney U test.

Results: Postsurgical measurements revealed that there was an equal reduction in probing depth and a greater but statistically non-significant attachment gain for the Emdogain® group when compared to the platelet-rich fibrin group. The Emdogain® group presented with significantly greater percentage defect resolution (43.07% ± 12.21) than did the platelet-rich fibrin group (32.41% ± 14.61). Post-operatively the changes in defect width and defect angle were significant in both groups, but upon intergroup comparison they were found to be statistically non-significantly different.

Conclusion: Both Emdogain® and platelet-rich fibrin were effective in the regeneration of intrabony defects. Emdogain® was significantly superior in terms of percentage defect resolution.

Key words: Platelet-rich fibrin, Emdogain®, intrabony defects, computed tomography

Introduction

Intrabony defects with deep pockets occur frequently in periodontitis and represent sites that, if left untreated, are at increased risk for disease progression, as shown by persisting residual deep pockets (Papapanou and Wennstrom, 1991; Lang and Tonetti, 2003; Matuliene *et al.,* 2008, 2010)**.** A variety of treatment approaches to the restoration of interproximal intrabony defects have been suggested, including the use of different types of bone grafts, guided tissue regeneration, growth factors and a combination of these (Becker and Becker, 1999; Rosen *et al.,* 2000; Cortelleni and Tonetti, 2000). Among different materials used in the regeneration of the periodontal intrabony defects, enamel matrix derivative (EMD) has gained a special place (Heijl *et al.*, 1997) for the treatment of intrabony defects since its inception and has set a very high standard for periodontal regeneration. Different clinical studies (Heijl *et al.*, 1997; Heden *et al.*, 1999; Sculean *et al.*, 2002; Crea *et al.*, 2008; Leknes *et al.*, 2009) have indicated that topical application of commercially available enamel matrix derivative (Emdogain®) on the diseased root surface during access flap surgery promoted clinically significant gains of attachment and bone in intrabony defects.

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Autologous platelet concentrations have attracted the attention of researchers and clinicians as a way to accelerate and enhance wound healing in surgical wounds in both dentistry and medicine (Gupta *et al*., 2011). Platelet-rich plasma (PRP), the first generation of platelet concentrate, contains autologous thrombocyte growth factors and has shown promise for acceleration of dento-alveolar bone regeneration (Weibrich *et al.,* 2002). But the limitation of using PRP is that its properties can vary depending on the concentration of platelets, amount of leukocytes, the type of activator used and time of placement of fibrin scaffold after clotting (Sanchej *et al.,* 2003). Platelet-rich fibrin (PRF), developed in France by Choukroun (Choukroun *et al*., 2001) for specific use in oral and maxillofacial surgery, is believed to release polypeptide growth factors, such as transforming growth factor-β1, platelet-derived growth factor, vascular endothelial growth factor and matrix glycoproteins, into the surgical wound in a sustained fashion (Dohan *et al.,* 2006) and exerts an antibacterial effect in the wound, helping in angiogenesis (Choukroun *et al.,* 2006) Overall, PRF has physical and biochemical attributes that make it attractive for application in periodontal wound healing (Dohan *et al*., 2006)

Radiographic assessments of intrabony defects have traditionally relied upon periapical radiography using paralleling extension cone methods. Unfortunately, periapical radiography inherently poses a limitation, such as two-dimensional presentation of the defects, along with increased radiation dosage. To overcome such issues cone beam computed tomography (CBCT) has been introduced for head and neck applications (Mozzo *et al*., 1998). Contrary to conventional radiographic methods, CBCT offers certain advantages in terms of low radiation dosage and precision in the measurement, along with the advantage of allowing observance of periodontal defects in all directions (Mohan *et al*., 2011). Studies conducted by Mengel *et al*. (2005) and Misch *et al*. (2006) suggested that CBCT is an accurate measurement tool for periodontal defects.

To the best of our knowledge, a comparison between the two regenerative materials (PRF vs EMD) with CBCT has not been reported yet. Hence, the present study was carried out as a single-center randomized clinical trial to compare the effectiveness of PRF with EMD in treating interproximal intrabony defects.

Materials and methods

The study was conducted in the Department of Periodontology, Saraswati Dental College and Hospital, Lucknow (UP), India from December 2012 to November 2013. Ethical clearance was obtained from Saraswati Dental College's Human Research Ethical Committee (SDCHREC). Adult patients with generalized moderate to severe chronic periodontitis (Carranza, 2002) were consecutively enrolled from amongst the patients visiting the Department of Periodontology for the present randomized clinical study. A case report form was designed, so as to have a systematic and methodical recording of all the observations and information. It included a detailed case history, clinical examination, indices and written consent of the patient.

Patient selection and inclusion criteria

The patients were selected based on the following inclusion criteria: Patients of both sexes with an age range of 30-65 years having at least one intrabony defect with pocket probing depth (PPD) ≥ 5mm; clinical attachment loss (CAL) ≤ PPD and radiographic defect depth on an intra-oral periapical apical x-ray of ≥ 3 mm; predominantly three-wall interproximal intrabony defect as assessed from bone sounding one month after scaling and root planing, compliant patients with full mouth plaque score (Silness and Löe, 1964) of 0.1 - 0.9 and gingival index (Löe and Silness, 1963) score of 0.1 - 1.0 (good oral hygiene during phase 1 therapy).

Smoking, pregnancy and lactation, history of periodontal surgery within 6 months, third molars, teeth with furcation involvement, greater than two degrees mobility and inadequate endodontic treatment/restoration were the exclusion criteria.

Materials

Enamel matrix derivative was procured from Straumann AG (Basel, Switzerland) as the commercially marketed Emdogain®.

Platelet-rich fibrin was prepared according to the protocol developed by Choukroun *et al*., 2001 using a REMI Laboratories (India) tabletop centrifuge. Intravenous blood (by venipuncture of the antecubital vein) was collected in 10 ml tubes without anticoagulant and immediately centrifuged at 3000 rpm for 12 minutes. Blood centrifugation immediately after collection allowed for the composition of a structured fibrin clot in the middle of the tube, just between the red corpuscles at the bottom and acellular plasma. The PRF was easily separated from the red blood corpuscles base (preserving a small layer of RBC) using tweezers and scissors. The centrifuge machine was placed close to the operatory and all efforts were made to minimize the time between the preparation of PRF and its placement in the defect so as to retain maximum regenerative potential.

Study design

For this randomized clinical study, a total of 44 sites in 30 patients (15 males) meeting the selection criteria were chosen and equally divided into two groups (n = 22). Initial phase I therapy consisted of full mouth scaling and root planing under local anesthesia. Four weeks later, a periodontal reevaluation was performed

to confirm the suitability of the sites for this periodontal surgical study, and a preoperative periapical radiograph was taken. After completion of phase 1 therapy, patients were randomly assigned by the toss of a coin (made by a neutral person not involved in the study) to receive either Emdogain® or PRF. Customized acrylic occlusal stents were prepared to provide reproducible testing points and insertion axes. Before surgery a CBCT image was taken as baseline radiographic assessment.

CBCT imaging

For our study, a high resolution Cone Beam CT (Newtom 3G Cone Beam X-ray Technology QR DVT 9000 SRL, AFP Imaging Company, Verona, Italy) equipped with a three-dimensional image reconstruction software package, NNT (version 2.499, QR SRL, Verona Italy), was used for CT scanning and image reconstruction. Data were captured in high resolution at 0.4 mm voxel size with an exposure time of 20 sec (110 KvP, 2.6 mA and 13.6 mA sec) scanning sagittal sections with a constant slice thickness of 1 mm.

Standardization of radiographic technique

A single trained technician took all pre- and post-surgery CBCT scans. A calibration exercise was performed to obtain intra-examiner consistency in CBCT measurements. The occlusal plane of the jawbone was positioned horizontally to the scan plane and the mid-sagittal plane was centered. The beam height at the surface of the image receptor was adjustable and set to visualize the entire jaws between approximately 20 mm and 60 mm beam height. Measurements were made using sagittal sections. The voltage, current, exposure time and detection field were kept constant for each patient at both times of exposure. The reference chosen to standardize the axial and sagittal planes was the bi-spinal line, coinciding with the vertical and horizontal planes, respectively. Axial and sagittal sections were obtained six months after reconstruction using the same reference as baseline. Duplicate measurements were made and the mean was recorded as the final value.

Radiographic measurement

The following landmarks were considered for each defect (*Figure 1*): The cementoenamel junction (CEJ) of the tooth involved in the intrabony defect (C1) was identified as the difference between the radiopacity of the enamel and the cementum. The most apical extension of an interproximal restoration, when present, was used instead of the CEJ. The most apical extension of the intrabony destruction where the periodontal ligament still retained its normal width was considered as the bottom of the defect (B1). The most coronal position of the alveolar crest of the intrabony defect where it touches the root surface of the adjacent tooth was noted as A1. An auxiliary line perpendicular to the tooth axis was drawn from A1 to C1B1; the point of intersection of this line on C1B1 was noted as R.

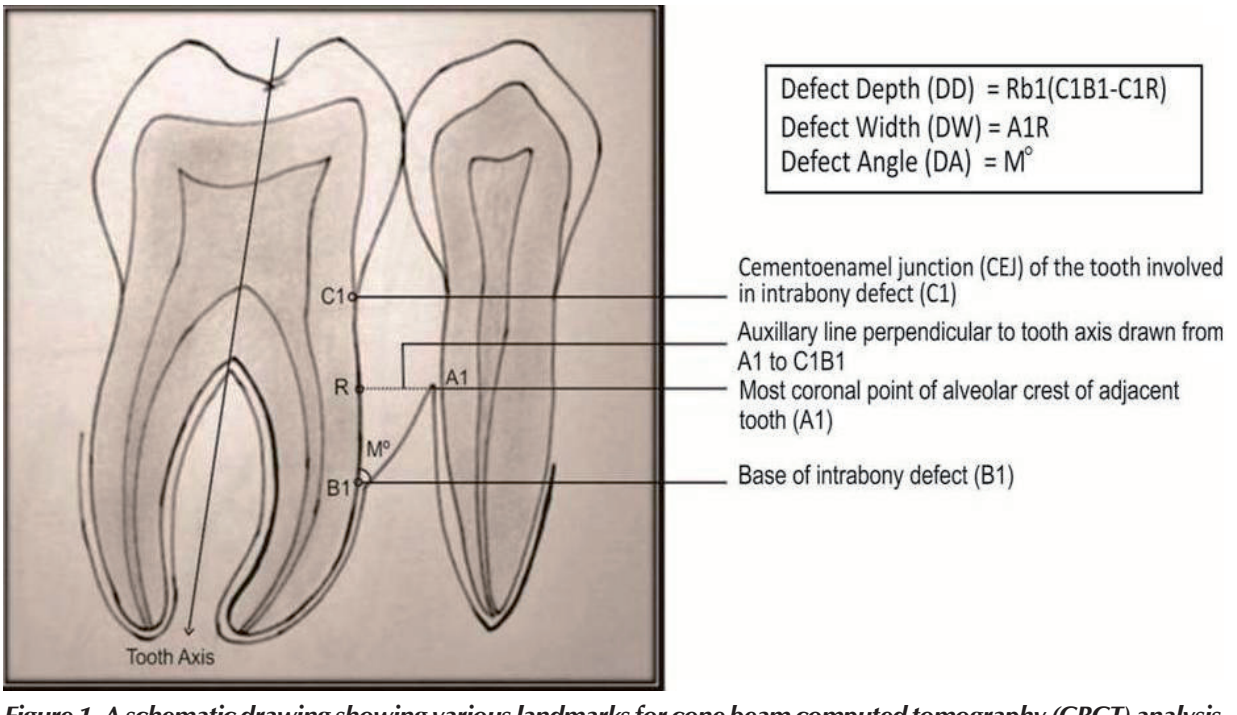

Figure 1. A schematic drawing showing various landmarks for cone beam computed tomography (CBCT) analysis.

The following measurements were made at baseline and 6 months post-surgery (*Figures 2, 3)*: 1) Defect depth - calculated as the difference of the distance from C1B1 minus C1R, or DD = (C1B1-C1R). 2) Defect width - drawn perpendicular to the tooth axis and measured as the distance from the alveolar crest to the point of intersection on line C1B1 denoted as R, or DW = A1R. 3. Defect angle - measured between a line drawn from the CEJ to the base of the defect (BD), and one drawn from the BD to the lateral margin of the intrabony defect, or DA= A1B1C1.

Clinical parameters

Along with plaque index and gingival index the clinical parameters probing pocket depth (PPD) and clinical attachment level (CAL) were recorded for each surgical site before surgery, (baseline) and 6 months post-surgery (*Figures 4,5*) using a University of North Carolina (UNC-15) probe. The apical end of the vertical groove of the stent was used as a fixed reference point (FRP) for measuring the above-mentioned parameters.

Surgical procedure

Extra-oral antisepsis was performed with 5% povidone iodine solution and 0.2% chlorhexidine digluconate rinse. All surgical procedures were performed under local anesthesia (2% lidocaine with 1:80000 epinephrine). Intracrevicular incisions were made in an attempt to preserve as much tissue as possible and full thickness mucoperiosteal flaps were reflected. The flaps were extended one tooth mesially and distally to the defect to provide full visibility and access to the denuded root surface and associated defect. However, extensive surgical approaches were avoided, and localized and minimized access flaps were used as much as possible. All granulation tissue was removed and the roots were scaled and

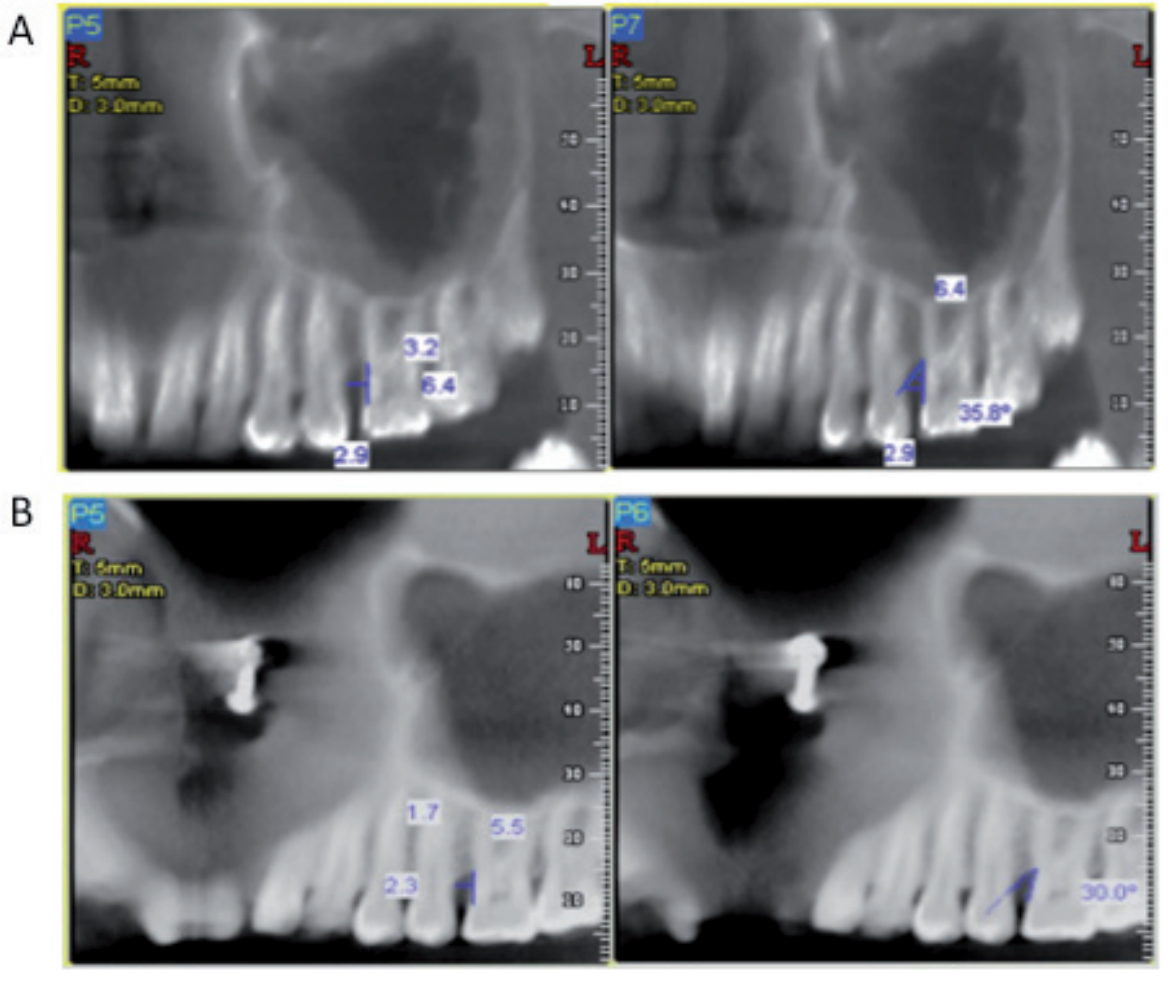

Figure 2. A) Baseline cone beam computed tomography (CBCT; sagittal section) of a case in the enamel matrix derivative (EMD) group showing various measurements. Defect depth - 3.2 mm; defect width - 2.9 mm; defect angle - 35.8°; cementoenamel junction (base of defect) - 6.4 mm. B) CBCT of the same case at 6 months. Defect depth - 1.7 mm; defect width - 2.3 mm; defect angle - 30.0°; cementoenamel junction (base of defect) - 5.5 mm.

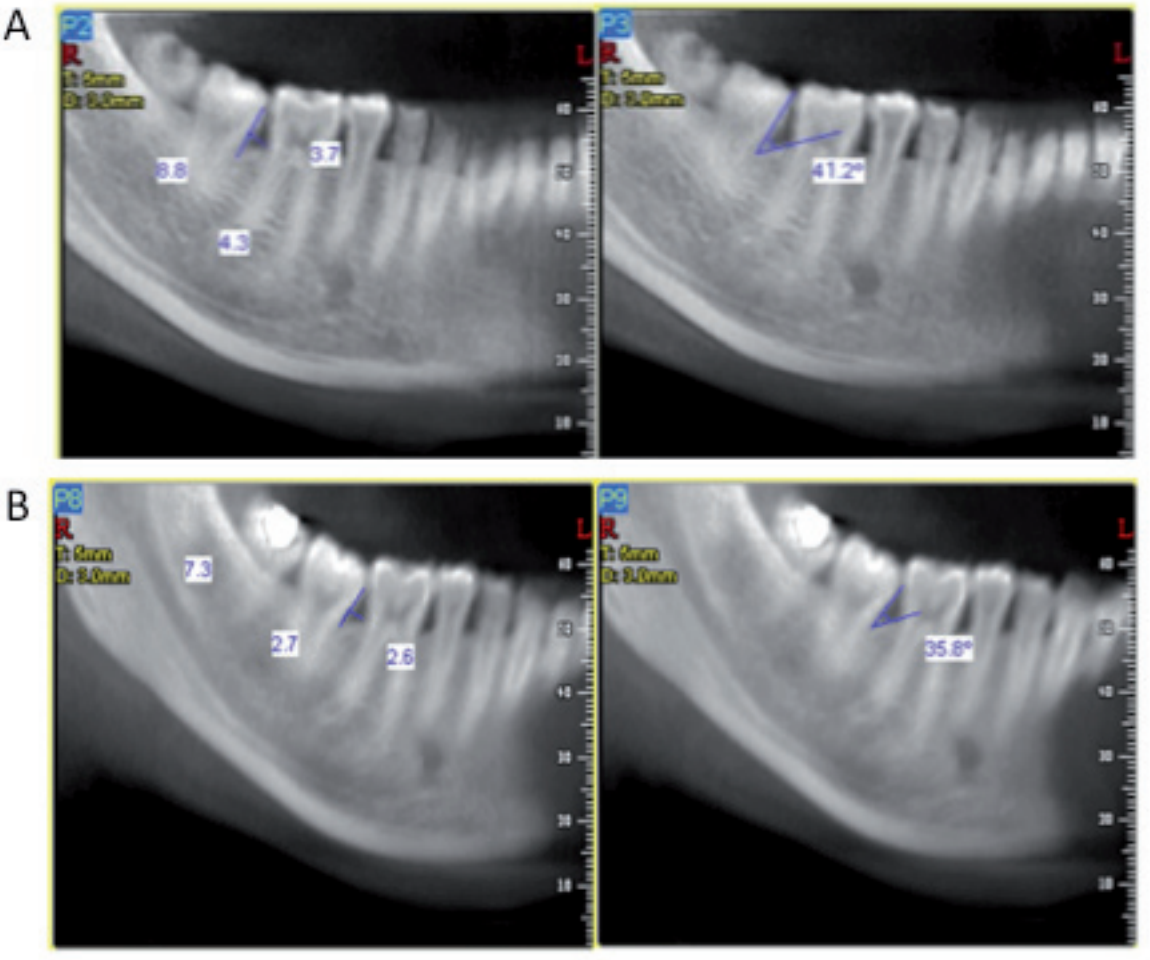

Figure 3. A) Baseline CBCT (sagittal section) of a case in the platelet-rich fibrin (PRF) group showing various measurements. Defect depth - 4.3 mm; defect width - 3.7 mm; defect angle - 41.2°; cementoenamel junction (base of defect) - 8.8 mm. B) CBCT of the same case at 6 months. Defect depth - 2.7 mm; defect width - 2.6 mm; defect angle - 35.8°; cementoenamel junction (base of defect) - 7.3 mm.

planed using hand and ultrasonic instrumentation. No osseous recontouring was carried out. The inner side of the flap was curetted in order to remove granulation tissue and epithelium and the surgical areas were carefully rinsed with sterile saline. In the Emdogain® group the root surfaces were conditioned for 2 min with 24% EDTA gel (pH 6.7; Straumann Pref Gel, Straumann, Basel, Switzerland) to remove the smear layer. The defects and the adjacent soft tissue were thoroughly rinsed with sterile saline in order to remove any EDTA residue. Following root conditioning, EMD was applied on the root surfaces and then into the defects with a sterile syringe. In the PRF group, PRF was placed into the intrabony defect and filled up to the level of the alveolar crest. The mucoperiosteal flaps were repositioned and secured using 4-0 silk sutures. Interrupted direct loop sutures were placed to gain primary closure of the interdental papilla and the area was protected by non-eugenol dressing (CoePak®, GC America, Chicago, IL, USA).

Post-operative care

Use of antimicrobials and antibiotics was followed as a standard post-operative regimen in patients of both groups. (Slots *et al*, 2000). Amoxicillin 500 mg thrice daily for controlling post-operative bacterial contamination and paracetamol 500 mg two times a day for control of pain and post-operative inflammation for 5 days was prescribed, along with chlorhexidine digluconate rinses (0.2%) rinses twice a day for 4 weeks. Periodontal dressings and sutures were removed 2 weeks post-operatively. Surgical wounds were gently cleansed with 0.2% of chlorhexidine digluconate and patients were instructed in gentle brushing with a soft toothbrush. Patients were re-instructed regarding proper oral hygiene measures post-operatively, examined weekly up to 1 month after surgery, and then at 3 and 6 months. Supragingival scaling was done but no subgingival instrumentation was attempted at any of these appointments.

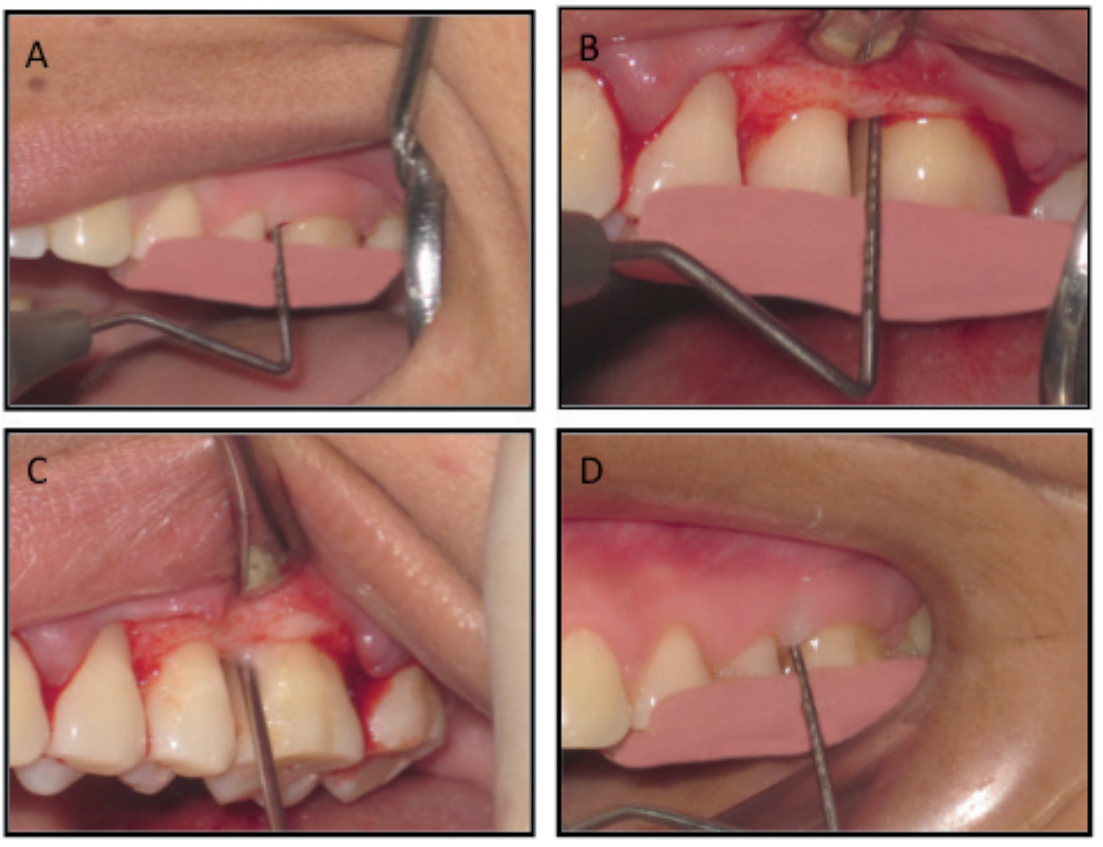

Figure 4. Emdogain® group: A) Baseline probing depth; B) Intrabony defect depth after flap reflection; C) Application of EMD; D) Post-operative probing depth.

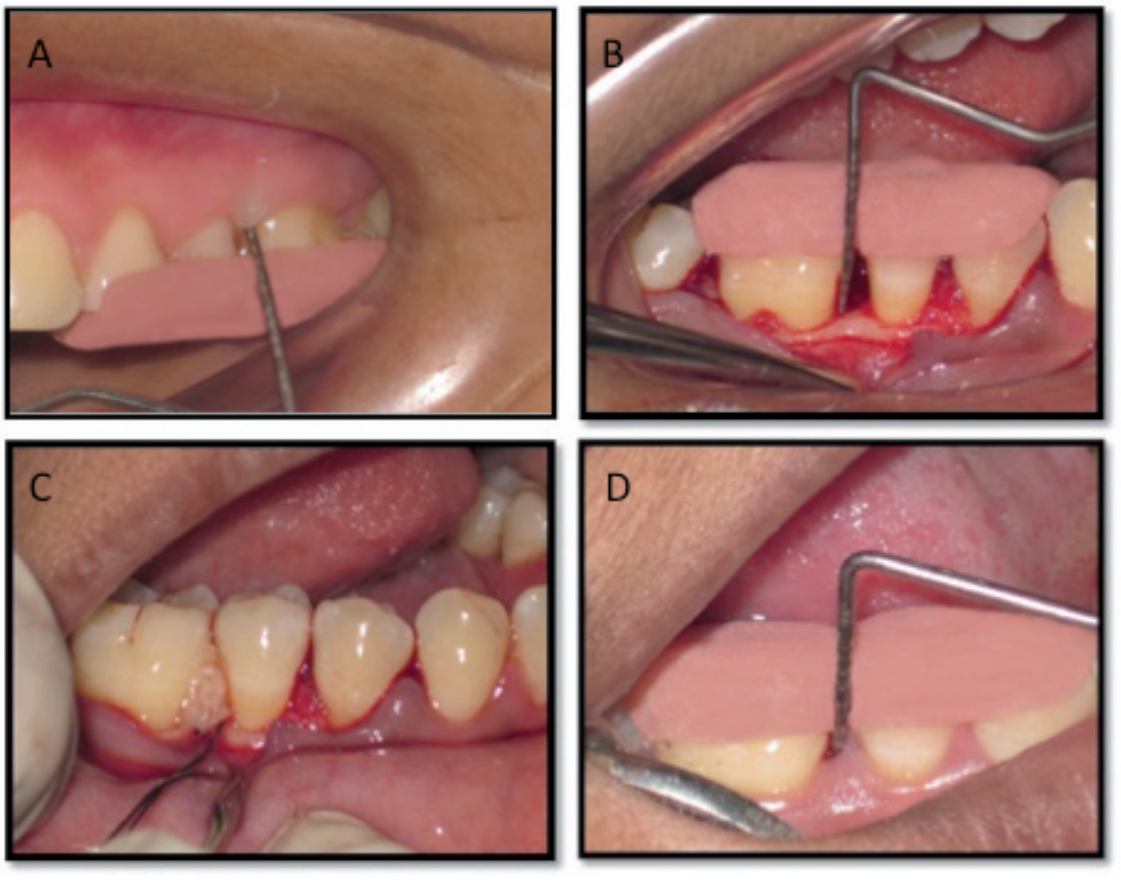

Figure 5. Platelet-rich fibrin (PRF) group: A) Baseline probing depth; B) Intrabony defect depth after flap reflection; C) Application of PRF; D) Post-operative probing depth.

Post-surgical measurements

Soft and hard tissue evaluation was performed 6 months after surgery. Soft tissue measurements were repeated with previously used acrylic stents. For obtaining hard tissue measurements of the intrabony defects, CBCT of the same study site was carried out to reassess the defects.

Statistical analysis

Data were analyzed using Statistical Package for Social Sciences Version 15.0. As the sample size was less than 30 for each group, before starting the statistical evaluation the distributions were tested for normality. It was observed that most of the distributions were not normal and symmetric; hence, a non-parametric evaluation was performed. For intergroup comparisons (Emdogain® versus PRF) a non-parametric independent samples test, *i.e.,* the Mann-Whitney U test, was used. Within-group comparisons (baseline and 6 months) were non-parametric paired data, hence the Wilcoxon signed rank test was used. The confidence level of the study was kept at 95%, and a *p* value less than 0.05 indicated a statistically significant intergroup difference.

The primary clinical outcome measures were changes in probing pocket depth and clinical attachment level. The primary radiographic outcome measure was percentage change in defect depth, i.e., percentage defect resolution. Defect angle and defect width were the secondary radiographic outcome measures.

Results

All the patients were compliant, and healing was uneventful for both groups. Plaque index (PI) and gingival index (GI) scores showed slight decreases in both groups that were statistically significant (*Table 1*). Baseline analysis did not demonstrate any significant differences between groups for any of the assessed variables, suggesting that any final differences between treatment groups were not influenced by initial defect characteristics, thus allowing post-treatment results to be compared. *Table 1* presents statistical analysis for various soft and hard tissue parameters for the Emdogain® and PRF groups at baseline and six months as measured clinically and radiographically, whereas intergroup comparison of changes in various parameters are reported in *Table 2*. From baseline both Emdogain® and PRF treated sites presented with a significantly greater probing depth reduction as well as gain in clinical attachment level (*Table 1*), but the difference was not statistically significant (*Table 2*). Similarly, a statistically significant reduction in defect depth,

Table 1. Means and standard deviations (mm) of various clinical and radiographic parameters for the Emdogain® (EMD) group and the platelet-rich fibrin (PRF) group at baseline and 6 months

	EMD				PRF			
Clinical Parameters								
Parameter	**Baseline**	**6 months**	**Change**	***p*-value**	**Baseline**	**6 months**	**Change**	***p*-value**
PI	0.68 ± 0.11	0.61 ± 0.11	-0.07 ± 0.07	0.008*	0.69 ± 0.10	0.60 ± 0.08	-0.09 ± 0.05	0.001*
GI	1.08 ± 0.14	0.99 ± 0.11	-0.09 ± 0.06	0.001*	1.10 ± 0.14	1.00 ± 0.09	-0.10 ± 0.08	0.002*
PPD	6.87 ± 1.41	5.07 ± 1.28	-1.80 ± 0.56	<0.001*	6.2 ± 1.21	4.4 ± 1.4	-1.80 ± 0.77	0.001*
CAL	7.00 ± 1.31	5.00 ± 1.41	-2.00 ± 0.54	<0.001*	6.8 ± 1.47	4.93 ± 1.44	-1.87 ± 0.91	0.001*
Radiographic Parameters								
DD	4.73 ± 0.93	2.65 ± 0.55	-2.08 ± 0.77	0.001*	4.89 ± 1.91	3.2 ± 1.15	-1.67 ± 1.17	0.001*
DW	3.03 ± 0.43	2.39 ± 0.32	-0.64 ± 0.34	0.001*	3.44 ± 0.86	2.79 ± 0.85	-0.65 ± 0.28	0.001*
DA	27.49º ± 8.2	23.41º ± 7.7	-4.09º ± 1.8	0.001*	31.03º ± 12.8	26.73º ± 11	-4.30º ± 5.76	0.008*

*Statistically significant. PI, plaque index; GI, gingival index; PPD, probing pocket depth; CAL, clinical attachment level; DD, defect depth; DW, defect width; DA, defect angle

Table 2. Intergroup comparison of change (from baseline to six months) in clinical and radiographic parameters for the Emdogain® (EMD) and the platelet-rich fibrin (PRF) groups

Parameters	EMD Group	PRF Group	Difference	*p*-value
Clinical Parameters				
PPD	-1.8 ± 0.56	-1.8 ± 0.77	0.00 ± 0.25	0.902
CAL	-2.00 ± 0.53	-1.87 ± 0.92	-0.13 ± 0.27	0.461
Radiographic Parameters				
DR	-2.08 ± 0.78	-1.67 ± 1.17	-0.43 ± 0.36	0.126
%DR	-43.07 ± 12.21	-32.41 ± 14.61	-10.65 ± 4.92	0.019*
DW	-0.64 ± 0.34	-0.65 ± 0.28	0.013 ± 0.146	0.653
DA	-4.09º ± 1.8	-4.30º ± 5.76	0.21 ± 1.56	0.967

*Statistically significant. PPD, probing pocket depth; CAL, clinical attachment level; DR, defect resolution; %DR, percentage defect resolution; DW, defect width; DA, defect angle

defect width, and defect angle was observed in both the groups post-operatively; however, the comparison of the mean change in defect depth, i.e., mean defect resolution, defect width and defect angle was non-significant between the two groups (*Table 2*). Percentage defect resolution (% DR) was statistically higher for the EMD group (-43.07 ± 12.21) than the PRF group (-32.41 ± 14.61) at six months ($p = 0.019$).

Discussion

The goal of regenerative surgical therapy is to restore lost periodontal tissues. Teeth with deep pockets associated with deep intra bony defects have long been considered a clinical challenge (Cortellini *et al.,* 2011). However periodontal regeneration from a wide array of regenerative materials has been shown effective in the treatment of one-, two-, and three-wall intrabony defects or combinations thereof, from very deep to very shallow defects, and from very wide to very narrow ones (Murphy and Gunsolley, 2003). Data from systematic reviews have suggested that the benefits of using a regenerative graft material may indeed result in superior clinical outcomes in terms of probing depth reduction and clinical attachment gain compared with open flap debridement (Sculean *et al.,* 2008). Emdogain® has a high success rate for periodontal regeneration, and recently developed PRF has also shown promising results. A comparison of the regenerative efficacy of these two biomaterials for intrabony defects with CBCT has not been reported in the literature yet, which became the main objective for conducting this study. The primary clinical outcome measures were changes in probing pocket depth and clinical attachment level. The primary radiographic outcome measure was percentage change in defect depth, *i.e.* percentage defect resolution. Defect angle and defect width were the secondary radiographic outcome measures.

The present study did not report any healing or post-operative complications, indicating that both Emdogain® and PRF were biocompatible. The reduction in probing pocket depth (PPD) observed between baseline and six months for both groups was 1.80 mm, which was statistically significant (*Table 1*). Our results for EMD are in accordance with studies conducted by Lekovic *et al.* (2000), who did a six-month re-entry study showing a mean PPD reduction of 1.85 ± 1.38 mm on the lingual side from an initial mean probing depth of 7.16 ± 1.20 mm, and a mean reduction of 1.91 ± 1.42 mm on the buccal side from an initial mean probing depth of 7.33 ± 1.22 mm. Further, our results for PPD reduction in the EMD group fall in a range similar to those reported by various other studies (Camargo *et al.,* 2001; Jepsen *et al.*, 2008; Leknes *et al.*, 2009), with a mean PPD reduction in the range of 2.5 mm. The reduction in PPD for a PRF group as reported by Pradeep *et al.* (2012a) was 3.9 ± 1.09 mm, and was 3.35 ± 0.68 mm from an initial mean probing depth of 7.82 ± 1.10 mm according to Lekovic *et al.* (2012). The higher reduction in PPD in these studies, although they were also conducted over a six-month time period, can be attributed to the fact that they used PRF as a membrane over and above the minced PRF filling the intrabony defects. The higher reduction in PPD obtained in these studies might therefore be attributed to a guided tissue regeneration effect, which was not part of our study design and may explain the lower PPD reduction for the PRF group in our study. The mean gain in CAL observed in our study for the EMD group at the six-month follow-up visit was 2.00 ± 0.54 mm, which was statistically significant. For the PRF group a CAL gain of 1.87 ± 0.915 mm was

observed, which was also statistically significant. The intergroup comparison of CAL at six months was non-significant. Our data for CAL gain for the EMD group matches closely with data from studies by Okuda *et al.* (2000), reporting a CAL gain of 1.72 ± 1.07 mm, Crea *et al.* (2008), reporting a CAL gain of 2.5 mm, and Rosing *et al.* (2005), reporting a CAL gain of 2.01 mm. The mean CAL gain for the PRF group observed in a study by Thorat *et al.* (2011) was 3.69 ± 0.44 mm, in one by Sharma and Pradeep (2011) it was 3.31 ± 1.76 mm, and in one by Lekovic *et al.* (2012) it was 2.24 ± 0.73 mm. This higher gain in CAL in these studies, which differs from the CAL gain in our study, can be attributed to the heterogeneity of the study design (using PRF as a membrane also), as explained above for the differences in pocket depth reduction.

On analyzing the hard tissue parameters, which were assessed through CBCT, the baseline comparison of defect depth (DD) between the two groups was statistically non-significant. The width of the defect, determined radiographically in terms of defect angle (DA), at baseline for the EMD group was 27.49 ± 8.24º as compared to 31.03 ±12.82º for the PRF group. The linear measurement of the defect width (DW) for the EMD group was 3.03 ± 0.43 mm as compared to 3.44 ± 0.86 mm for the PRF group. The comparisons of DA and DW between the two groups at baseline were non-significant. Thus, at baseline the defect characteristics for two groups showed no statistically significant differences; similarly, at six months statistically non-significant differences between the two groups were observed with respect to all hard tissue parameters.

The mean defect resolution (DR), i.e., the change in the defect depth at six months for the EMD group was 2.08 ± 0.78 mm, which was statistically significant**.** The %DR of 43.07 ± 12.21% for the EMD group observed in our study corroborates well with the study done by Mueller *et al.* (2013), who from their meta-analysis concluded that a radiographic bone gain/defect resolution of up to 43.02% and 2.35 mm of mean DR can be achieved with EMD for treating periodontal intrabony defects. A defect resolution of 32.41 ± 14.61% and mean DR of 1.67 ± 1.17 mm was observed for the PRF group. Our data for %DR in the PRF group are in contrast with data from Thorat *et al.* (2011), which showed a %DR of 42.96%, and Pradeep *et al.* (2012b), who reported a %DR of 55.41 ± 11.39% in their studies. This contrast can again be attributed to the use of the intra-oral periapical (IOPA) mode of radiographic measurement in these studies and heterogeneity in their study design, wherein they have also extracted the membrane property of PRF over and above the PRF used solely as a graft material, as done in our study. Upon intergroup comparison the %DR was significantly higher ($p = 0.019$) for the EMD group. Percentage defect resolution was the only outcome variable that was statistically significantly in favor of the EMD group, highlighting the importance of use of EMD in comparison to PRF. This statement holds true because defect resolution is a better prognostic indicator than defect fill. While the defect fill takes into account only changes at the base of the defect, defect resolution takes into account changes in the alveolar crest that may occur with regenerative therapy in addition to the fill of the defect at the base.

The horizontal component of the defect can be measured linearly either as defect width or defect angle. While defect fill is the measure for vertical bone gain, defect resolution takes into account vertical plus horizontal bone gain obtained by the regeneration of bone from the lateral margins of the intrabony defect as well. A reduction in the defect angle at follow-up can occur under two circumstances: a) when there is bone fill from the lateral margins only, and b) when bone fill is from a combination of the lateral margins and the base of the defect (Klein *et al.,* 2001). In contrast, there will be an increase in the defect angle if there is bone fill solely from the base of the defect. A significant reduction in the defect angle in both groups in our study indicates the defects were filled by either of the aforementioned criteria for decrease in the defect angle. A simultaneous significant decrease in the defect width suggests that bone formation from the lateral margins of the intrabony defect might have occurred that could have produced a significant reduction in the defect angles in both groups in the present study.

In our study we opted for CBCT as the radiographic assessment tool owing to its advantages regarding accuracy, lower radiation and higher reproducibility, and also based on work done by Grimard *et al.* (2009) who compared clinical, periapical radiograph and CBCT measurement techniques for assessing bone level changes following regenerative therapy in periodontal intrabony defects, and concluded that CBCT was significantly more precise and accurate than intraoral radiographs.

Conclusion

Our results indicate that, based on CBCT analysis, EMD is statistically superior in terms of percentage defect resolution as compared to PRF in treating intrabony defects. Although PRF has also shown promising results, long-term multi-centered clinical trials along with large sample sizes are required to authenticate it as a material of choice for periodontal regeneration.

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