REVIEW ARTICLE

Journal of Research in Dental and Maxillofacial Sciences

DOI: 10.52547/jrdms.7.3.181

Techniques and Materials for Treatment of Bone Loss Due to Periodontitis: A Review

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Article History
Received: 11 December 2021
Accepted: 18 February 2022

Abstract

Background and Aim: The first purpose of treatment of periodontal disease and bone loss is to regenerate the lost structures and preserve the sound residual tissues. Different techniques and materials are utilized for alveolar bone loss treatment. This review summarizes the techniques and materials utilized for treatment of alveolar bone loss due to periodontitis.

Materials and Methods: A search was performed in PubMed, Cochrane Library, and Google Scholar databases from 1990 to 2021. Totally, 133 studies were collected and reviewed, and finally, 31 studies were selected for the analysis.

Results: Of 31 papers, 13 were about intra-bony defects, and others were about furcation involvement defects. Each article suggested different techniques and materials. Clinical parameters such as plaque index, gingival index, probing pocket depth (PPD), clinical attachment loss (CAL), and gingival margin position had been measured in studies, and a few techniques showed better results than others. Treatment of furcation defects is difficult in periodontal therapy. We should note that surgical procedures do not have any superiority over non-surgical procedures.

Conclusion: In conclusion, to decide about the best technique, site of defect, severity of disease, the available materials, and the clinician's knowledge should be considered.

Key Words: Alveolar bone Loss; Furcation defects; Periodontitis; Regeneration

Cite this article as: Hassani S, Aghayan S, Hashemi Moghaddam F, Akbari Foroud S. Techniques and Materials for Treatment of Bone Loss due to Periodontitis: A Review.
J Res Dent Maxillofac Sci. 2022; 7(3):181-193.

Introduction

Periodontitis and gingivitis are among the foremost common inflammatory conditions [1,2]. Periodontitis is identified by progressive destruction of tooth-supporting structures. It is characterized by the loss of periodontal tissue support manifested by clinical attachment loss (CAL), radiographic alveolar bone loss, periodontal pocket formation, and gingival bleeding [3]. Periodontitis is classified into stages one to four based on disease severity, and grades A to C based on disease progression [4]. Periodontal bone destruction may result in vertical or horizontal bone defects, based on the direction and extent of apical propagation of plaque-induced defect [5].

The ultimate goal of periodontitis treatment and alveolar bone reconstruction is to regenerate the lost structures due to infection, trauma, or congenital anomalies [3]. The conventional treatment of periodontitis aims to inhibit the progression of disease by minimizing the pathogenic microbiota and stopping the inflammatory process [6]. Based on a guideline published by Sanz et al., [3] the treatment of periodontitis should be planned step by step to avoid unnecessary invasive treatments. The primary step to manage all stages of periodontitis is to change the patient's behavior. These behavioral changes include supragingival dental biofilm removal, improvement of oral hygiene, professional plaque removal, and risk factor control. The second step is to control the subgingival biofilm and calculus using adjunctive agents, host-modulating agents, subgingival local antimicrobial agents, and systemic antimicrobial treatment. The third step for non-responding areas is to repeat subgingival instrumentation with or without additional treatments, periodontal flap surgery, and resective and regenerative periodontal surgical procedures. Based on this guideline, the suggested treatment for class II and III furcation involvement defects of mandibular molars with pockets is regenerative or resective, except for maxillary class II furcation defects, for which the provided treatment is non-regenerative [3]. Various methods are suggested to treat bone defects including open flap debridement, odontoplasty, root resection, regeneration, and extraction [2]. Root resection or root amputation refers to removal of one root of a multi-rooted tooth; while, in apicoectomy, only the root apex is removed. In hemisection, one root and its related coronal structure are removed. In class III and multiple class II furcation involvement defects, non-surgical instrumentation, tunneling, root separation, or root resection and biomimetic agents, like enamel matrix derivatives, platelet-rich plasma, platelet-derived protein, and bone morphogenetic proteins may be used [3]. However, the results of these procedures are influenced by local and systemic factors. Local factors that need to be controlled prior to initiation of treatment include removal of restoration overhangs, cervical enamel projections, enamel pearls, and bifurcational ridges.

Different materials such as bone morphogenetic proteins, endothelial growth factor, fibroblast growth factor, human leukocyte antigen, insulin-like growth factor, interleukins, platelet-derived growth factor, and transforming growth factor are used as graft materials. The materials that are used as graft must have optimal mechanical and physical properties and should be biocompatible [4].

Bone defects due to periodontitis are classified into four main groups of horizontal, vertical, crater-shaped, and furcation involvement defects. In teeth with multiple roots, periodontitis causes periodontal destruction between the roots. Molars with furcation defects are at higher risk for attachment loss and tooth loss [5,7-9]. This review summarizes the techniques and materials utilized for treatment of alveolar bone loss due to periodontitis.

Materials and Methods

A search was done through PubMed, Google Scholar, and Cochrane Library from 1990 to 2021 using "periodontitis", "bone loss", "treatment", "bone regeneration" and "graft" as keywords. The primary screening was based on relevance of the titles and the keywords. A study was selected for inclusion if it evaluated periodontitis, treatment, and bone loss and was published in English. The second screening was based on full-text analysis. Studies on techniques and materials used to treat bone loss due to periodontitis were included. We included randomized clinical trials, non-randomized clinical trials, and ex-vivo and in-vitro studies. The purpose of the search was to collect all English articles from 1990 to 2021 (n=133).

Results

This review evaluated 18 studies about furcation involvement defects, and 13 studies about intra-bony defects. There was no specific study on crater defects. Only two studies were on animals, and others were human studies. There are many studies on treatment of furcation involvement defects. Of the assorted furcation involvement defects, class II is the simplest candidate for regenerative treatments [10-12]; thus, most of the studies were about class II furcation involvement defects.

According to Dommisch et al., the treatment of class II furcation defects is simpler than class III, and surgical procedures like root amputation, root separation or resection, and tunneling have no superiority over non-surgical procedures like scaling and root planing. In their study, they first evaluated the tooth survival, and then vertical probing attachment gain, and reduction of probing pocket depth (PPD) [13].

Garg and Pradeep [14] performed scaling and root planing along with 1.2% rosuvastatin and 1.2% atorvastatin to treat furcation defects and showed that rosuvastatin improved all clinical parameters. Statins have anti-inflammatory, immunomodulatory, antioxidant, antithrombotic, and anti-inflammatory properties, and can stabilize the endothelium, and induce osteoblastic differentiation, and thus, they may be used to treat periodontitis [15-17].

Bevilacqua et al. reported that open flap debridement was more cost-effective than surgical techniques but it was less effective for improvement of bleeding on probing, PPD, periodontal height, and CAL after one year of follow-up. They showed that root recontouring significantly decreased inflammation [18].

Oliveira et al. suggested different treatments for furcation defects such as guided tissue regeneration (GTR) with polytetrafluoroethylene barrier (ePTFE), enamel matrix derivative (EMD), β-tricalcium phosphate, hydroxyapatite, and bioresorbable collagen membrane. They found no significant difference among these treatment approaches [19] but all of them are associated with a risk of treatment failure due to systemic conditions or patient-related factors [20].

EMD has remarkable effects on cementum formation, periodontal ligament, alveolar bone, epithelial cell growth, transforming growth factor β, fibroblast growth factor, extracellular matrix metalloproteinases and osteoclast maturation. Soares et al. showed that EMD had no significant superiority over treatment with open flap debridement and beta-tricalcium phosphate/hydroxyapatite bone graft [21].

Murphy and Gunsolley compared GTR with other treatments. They found a significant difference between GTR and open flap debridement, and showed that augmentation with GTR barrier with a particulate graft enhanced vertical pocket depth, vertical periodontal attachment level, and horizontal open probing attachment [10].

Jaiswal and Deo found that using bone graft and GTR with or without EMD had significant effects on CAL, horizontal probing depth, and PPD compared with open flap debridement alone after 12 months of follow-up [22]. Avila-Ortiz et al. showed that regenerative therapies had greater effects on maxillary molar class III furcation involvements and maxillary pre-molar class II and III furcation involvements [23].

Mineral trioxide aggregate (MTA) and calcium enriched mixture (CEM) cement are also used to treat furcation involvement defects. MTA was introduced for lateral perforation repair in 1993 by Loma Linda University. In 2006, CEM cement was introduced to dental market [24]. MTA is a type I Portland cement derivative composed of dicalcium silicate, tricalcium silicate, tricalcium aluminate, and tetra calcium aluminoferrite.

MTA induces the formation of hard tissue bridges, and CEM cement exhibits effects like those of MTA [24]. Ghanbari et al. evaluated varieties of cements and found that MTA and CEM cement with collagen membrane had no difference with each other, and both enhanced the treatment of class II furcation defects [25].

Among platelet concentrates, leukocyte- and platelet-rich fibrin is a second-generation blood product prepared by peripheral blood centrifugation with no anticlotting agent to obtain a dense three-dimensional clot architecture with concentrated platelets, fibrin, leukocytes, cytokines, and growth factors. Paolantonio et al. suggested treating intra-bony defects with leukocyte- and platelet-rich fibrin and autogenous bone graft and reported that they are superior to EMD [26]. Del Fabbro et al. reported that not many studies are available on autologous platelet concentrates in combination with other methods or materials [27].

A study by Kaya et al. on horizontal bone defects found no significant difference between treatment with particulate demineralized bone matrix and putty demineralized bone matrix and open flap debridement in treatment of horizontal treatment defects [28].

Vertical defects are divided into three groups: 1) wall vertical defects, 2)wall vertical defects, and 3)wall vertical defects.

Bio-Oss has been utilized for several years. Bovine porous bone mineral (Bio-Oss) could be a relatively new material for periodontal regeneration. It is prepared by protein extraction of bovine bone, which leads to formation of a structure like human cancellous bone and might enhance bone formation [29]. Freeze-dried bone allograft offers certain advantages to autogenous sources for bone graft material. Richardson et al. found no significant difference between bovine-derived xenograft and demineralized freeze-dried bone allograft in outcome of treatment [30].

Combined treatment modalities with GTR are being investigated to obtain more reliable results. A combination of GTR with low-level laser therapy is one suggested modality. Dogan et al. used low-level laser therapy with GTR and reported significant improvements [7].

Mesenchymal stem cells are multipotent cells that can differentiate into cementoblasts, osteoblasts, and periodontal fibroblasts. Platelet-rich fibrin (PRF) is a second generation platelet concentrate that enriches the fibrin membranes with platelets and growth factors. PRF looks like a fibrin network and causes more efficient cell migration and proliferation. It can serve as a carrier for cells essential for tissue regeneration. PRF can serve as an appropriate scaffold for in vitro culture of human periosteal cells, which can be used for bone tissue engineering [31]. Simsek et al. found that using autogenous cortical bone alone or with platelet-rich plasma (PRP), and mesenchymal stem cells with PRP significantly improved periodontal parameters, but PRP alone caused no significant change [32].

Lohi et al. found that using bioactive ceramic composite granules with PRF yielded superior results compared with its application alone [33].

Porous hydroxyapatite bone graft material has shown clinically acceptable results in filling of periodontal intra-bony defects and optimal osteoconductivity. Pradeep et al. [34] showed that using hydroxyapatite with PRF and open flap debridement improved regenerative effects for treatment of 3-wall vertical defects. Sharma and Pradeep found that using autogenous PRF with open flap debridement improved bone fill of 3-wall defects [35].

Mathur et al. showed that both PRF and autogenous bone graft significantly improved the treatment of 3-wall defects [36].

Different graft materials are successfully utilized for treatment of intra-bony defects. The materials most typically used are autografts and allografts. Prakash et al. [37] indicated that adding hard tissue replacement polymers (such as Bioplant

HTR) as a bone graft material to open flap debridement technique made not much difference in properties of defects.

Kinaia et al. demonstrated that using resorbable membrane for class II furcation involvement made a substantial difference regarding vertical bone loss compared with non-resorbable membrane, and significantly changed the periodontal parameters as compared with open flap debridement. They concluded that using xenograft with resorbable membrane can improve the results of treatment [1].

A number of bioabsorbable membranes result in greater crestal bone resorption than non-resorbable membranes. The best membrane for GTR is ePTFE, a porous Teflon membrane. Walters et al. [38] found no difference in results of treatment with porous and non-porous ePTFE membranes with xenograft.

Eickholz et al. indicated that using GTR with or without synthetic bioabsorbable polyglactin 910 barriers yielded better outcomes than periodontal surgery since using bioabsorbable barriers in GTR eliminates the need for a second surgical procedure to remove the non-resorbable membrane [39]. Jenabian et al. evaluated Bio-Gen and showed that using it with connective tissue was more effective for bone filling than Bio-Gen with collagen membrane [2]. Becker W and Becker BE used ePTFE as a barrier membrane with open flap debridement and found this method to be effective after 8 years of follow-up [40].

Jung et al. found contradictory results about using bovine hydroxyapatite/collagen as a membrane in 1-wall vertical defects. Still, utilization of a barrier membrane for non-contained-type defects is suggested to enhance the graft material's stability and condense it [41]. Gurinsky et al. [42] demonstrated that adding demineralized freeze-dried bone allograft to EMD improved the treatment outcome in hard tissue.

Jepson et al. found that regenerative techniques significantly affected horizontal CAL gain, vertical CAL gain, and PPD reduction, compared with open flap debridement, and employing a non-resorbable membrane with bone replacement graft is the best treatment for furcation defects [43].

Table 1 presents a summary of reviewed articles.

Conclusion

To choose the best technique to treat our patients, we must always consider various factors such as the location of defect, the patient's systemic condition, oral hygiene of patient, and other factors that may affect the treatment results. For treatment of furcation involvement defects, we must always pay attention to the followings:

1. There is no superiority of surgical procedures over non-surgical procedures. It has been shown that both treatment methods lead to persistent reduction in gingival inflammation, plaque, and calculus, and neither process seems to be superior concerning these parameters.

2. Open flap debridement is the most cost-effective method.

3. Resorbable membranes are better than non-resorbable membranes and open flap debridement.

4. GTR is one of the best treatments. The clinical superiority of GTR compared with standard therapy (open flap debridement) for class II furcation defects has been documented, probably as the result of regeneration.

5. Low-level laser therapy may improve the results of treatment.

6. For intra-bony defects, regenerative techniques are the most effective choices.

Table 1. Summary of reviewed articles

Authors/years	Type of study	Number of cases/articles	Type of defect	Method/Material	Main outcome	Result
Avila-Ortiz et al/2015 [23]	Systematic review	150 articles	Cl I & II & III FI	Regenerative/non-regenerative therapy	The indication of regenerative techniques in treatment of furcation defects is predictable in most of the cases, especially in maxillary facial or interproximal and mandibular facial or lingual class II furcation defects.	Superior results may be expected in areas where the interproximal bone level is coronal to the furcation defect opening. A thicker gingival biotype covering class II furcation defects (buccolingual gingival thickness >1 mm) had superior outcomes after GTR in comparison with thinner biotypes.
Dommisch et al/2020 [13]	Systematic review	78 articles/665 patients/2021 defects	Cl II & III FI	Periodontal surgery (root amputation, root separation or resection, tunneling)/non-surgical therapy (SRP, OFD)	No difference	Survival ranged from 38-94.4% (root amputation or resection, root separation), 62-67% (tunneling), 63-85% (OFD), and 68-80% (SRP). Treatment yielded superior results for class II than class III FI.
Jepson et al/2020 [43]	Systematic review	19 articles/575 patients/ 787 defects	Cl II & III FI	Regenerative techniques/OFD/bone replacement graft/non-resorbable membrane with BRG	Regenerative surgery of class II furcation defects is superior to OFD.	Regenerative techniques were superior to OFD for FLMP (OR =20.9; 90% crl = 5.81, 69.41), HCAL gain (1.6 mm), VCAL gain (1.3 mm) and PPD reduction (1.3 mm). Bone replacement grafts with the highest probability (pr =61%) are the best treatment for HBL gain. Non resorbable membranes + BRG are the best treatment for VCAL gain (pr=75%) and PPD reduction (pr =56%).
Kinaia et al/2011 [1]	Review	34 articles	Cl II FI	Resorbable membrane/non-resorbable membrane/OFD	Resorbable membranes were better than others	A significant improvement by resorbable compared with non-resorbable membranes was noted in vertical bone fill (0.77 – 0.33 mm; [95% CI; 0.13, 1.41]). and resorbable membranes over open flap debridement in vertical probing reduction (0.73 – 0.16 mm; [95% CI; 0.42, 1.05]), attachment gain (0.88 – 0.16 mm; [95% CI; 0.55, 1.20]), horizontal bone fill (0.98 – 0.12 mm; [95% CI; 0.74, 1.21]) and vertical bone fill (0.78 – 0.19 mm; [95% CI; 0.42, 1.15]).

Jenabian et al/2013 [2]	RCT	24 patients	Cl II FI	Biogen with Bio-collagen/Biogen with connective tissue	clinical outcomes with connective tissue grafts were better	The mean change of FAC, FHC, and mean of FHC, FBD in re-entry were different in the two groups.
Haroun et al/2019 [4]	Clinical trial	6 dogs	Cl II FI	Carbone nano tubes bone graft	Effective in the bone development process.	Assessment of cytotoxicity of graft materials confirmed their safety.
Oliveira et al/2020 [19]	Systematic review	19 articles/618 patients	Cl II FI	GTR+ePTFE/EMD/βtricalcium /Hydroxyapatite/Bio-resorbable collagen membrane	no difference	All treatments provided CAL gain, but meta-analysis did not reveal a significant difference among more commonly used treatments and controls (P=0.91; P=0.47; P=0.08, respectively).
Soares et al/2020 [21]	Systematic review	298 articles	Cl II FI	EMD/OFD+βTCP+HA±EMD	The treatments improved the periodontal clinical parameters of class II furcation defects but the use of EMD did not contribute to a significant clinical improvement.	This meta-analysis revealed no difference when comparing OFD + βTCP / HA with or without EMD in treatment of furcation defects. The EMD potential for cementum formation and angiogenesis in periodontal tissues was emphasized.
Lohi et al/2017 [33]	Clinical and radiographic practice	16 patients	Cl II FI	Bioactive ceramic composite granules ± platelet rich fibrin	use of PRF with bone graft may be a more effective treatment	Statistically significant improvement was noted in the test group compared with the control group with respect to all the measured parameters. However, complete furcation closure did not occur at any treated site.
Ghanbari et al/2014 [25]	Clinical trial	16 patients / 46 defects	Cl II FI	MTA & CEM cement + collagen membrane (regenerative therapy)	significant improvements in attachment levels and alveolar bone level.	Use of MTA and CEM cement decreased PD, VCAL, HCAL, OVFD and OHFD, with no significant difference
Bevilacqua et al/2020 [18]	RCT	25 defects	Cl II FI	OFD/odontoplasty/tunnelling /resection techniques/periodontal regeneration	Clinical (Bop, PPD, PH, Cal) and radiographic improvement	The treatment approaches showed a higher regenerative potential than OFD. The results showed the importance of flap being placed and anchored coronally, and no significant difference was found where biomaterial was applied alone.

Dogan et al/2016 [7]	Clinical study	33 defects	Cl II FI	GTR/GTR+Low level laser therapy	Effective	Laser therapy caused greater improvements in PPD, CAL, HPD and ALP values at 6 months (p<0.05).
Jaiswal and Deo/2013 [22]	Clinical study	30 patients	Cl II FI	EMD/BG/OFD/GTR	Significant differences were seen after 12 months	All three groups showed a statistically significant PPD reduction at 12 months post-surgery. EMD+ BG+GTR showed greater PPD reduction in comparison with BG+GTR. OFD+EMD+BG+GTR showed a higher vertical clinical attachment gain at 12 months compared with BG+GTR as well as OFD.
Garg and Pradeep/2017 [14]	RCT	19 patients	Cl II FI	Rosuvastatin/Atorvastatin	RSV improves in all clinical parameters	RSV group showed better probing depth reduction and greater gain in relative VCAL and relative HCAL than ATV group at 6 and 9 months.
Simsek et al/2012 [32]	Clinical study	3 dogs/18 defects	Cl II FI	MSCs/ PRP	PRP with ACB or MSC improved the results of treatment	The efficacy of ACB, ACB/PRP, and MSCS/PRP treatments was not different on any clinical parameters.
Paolantonio et al/2020 [26]	Clinical study	44 patients	Intra-bony defects	Leukocyte & platelet fibrin with autogenous bone graft/EMD+ABG	No significant difference	The control group - test group differences for the parameters CAL gain -0.248 mm (-0.618 to 0.122), PPD reduction -0.397 mm (-0.810 to 0.015), GR change 0.059 mm (-0.300 to 0.418), DBL gain -0.250 mm (-0.746 to 0.246) were all within the non-inferiority margin of 0.5 mm.
Del Fabbro et al/2018 [27]	review	38 articles/1402 defects	Intra-bony defects	APC+OFD/OFD/ APC+OFD+BG/OFD+BG/APC+GTR/ GTR/ APC+EMD/EMD	Low-quality evidence	All studies in all groups reported a survival rate of 100% for the treated teeth. No complete pocket closure was reported. No quantitative analysis regarding patients' quality of life was possible.

Kaya et al/2009 [28]	RCT	25 patients/125 defects	Horizontal defects	Particulate demineralized bone matrix (DBM)/putty DBM/OFD	no significant difference	There was no difference among groups in any parameter (P > 0.05). Particulate DBM, putty DBM and OFD showed similar interproximal soft tissue changes especially increasing interproximal PI and GI scores at the 3-month follow-up.
Prakash et al/2010 [37]	Clinical and radiographic study	5 patients/16 defects	Vertical defects	HTR polymer (bio-plant HTR)/OFD/OFD+HTR	Bioplant HTR material is a biocompatible, easy to handle and a beneficial grafting material for the treatment of periodontal osseous defect	The probing pocket depth reduction was different between the groups (P<0.05). Hard tissue showed significant changes.
Walters et al/2003 [38]	RCT	24 patients	Vertical defects	Porous and non-porous Teflon polytetrafluoroethylene membrane with Xenograft	Similar result	There were no statistically significant differences (p> 0.05) between NP and P groups for any open or closed probing measurement at any time.
Eickholz et al/1998 [39]	Clinical study	26 patients/29 defects	Vertical defects	GTR + periodontal surgery ± synthetic bioabsorbable polyglactin	the use of bioabsorbable barriers may be recommended	Both methods showed (P < 0.001) probing depth reduction of -4.49 ± 1.94 mm (n = 13, test) and -3.22 ± 1.48 mm (n= 14, control), and CAL gain of 3.41 ± 1.59 mm (test) and 2.07 ± 1.10 mm (control).
Gurinsky et al/2004 [42]	Clinical study	40 patients/67 defects	Vertical defects	Demineralized freeze derived bone allograft and EMD/EMD	An enhancement of hard tissue parameters may be obtained when EMD is added to DFDBA	Combination of EMD + DFDBA yielded statistically significant improvements in bone level and crestal resorption in comparison with EMD alone (P <0.001).
Richardson et al/1999 [30]	Clinical study	17 patients	Vertical defects	Bio-Oss: A bovine-derived xenograft/DFDBA	No difference between the two materials in any parameter	Measurements showed bone fill of 2.4 mm for the DFDBA group and 3 mm for the BDX group.

Jung et al/2011 [41]	Clinical study A histometric analysis	5 dogs	I-walled vertical defects	Bovine hydroxyapatite collagen without a barrier	Inconsistent results	The measured parameters had large standard deviations, and the mean values showed no difference between the experimental and sham-surgery control sides.
Mathur et al/2015 [36]	A comparative analysis	38 defects	III-walled vertical defects	ABG and OFD	Effective	PPD reduction, CAL gain, defect fill and defect resolution at both PRF and ABG treated sites with OFD were observed. Inter-group comparison was non-significant (P > 0.05)
Becker W & Becker BE/1993 [40]	Long term evaluation of treated patients	32 patients	III-walled vertical defects	Flap debridement and ePTFE with barrier membrane	Significant improvement after a long term follow-up	Reductions in PD, gains in CAL, recession, reduction in crestal resorption, and gain in bone fill were observed.
Sharma & Pradeep/2011 [35]	RCT	56 defects	III-walled vertical defects	Autogenous platelet-rich fibrin + OFD/OFD	Better bone fill	The mean PD reduction was greater in the test group (4.55 – 1.87 mm) than the control group (3.21 –1.64 mm), and the mean CAL gain was greater in the test group (3.31 – 1.76) in comparison with the control group (2.77 – 1.44 mm). A greater percentage of mean bone fill was found in the test group (48.26% – 5.72%) in comparison with the control group (1.80%-1.56%)
Pradeep et al/2017 [34]	RCT	90 defects	III-walled vertical defects	Autologous PRF+OFD/PRF+HA+OFD/OFD	PRF with HA increases the regenerative effects in treatment of 3-wall intra-bony defects.	Mean PD reduction was greater in PRF (3.90 + 1.09 mm) and PRF+HA (4.27 + 0.98 mm) groups than control group (2.97 + 0.93 mm) while mean CAL gain was greater in PRF (3.03 + 1.16 mm) and PRF+HA (3.67 + 1.03 mm) in comparison with controls (2.67 + 1.09 mm).

FI: furcation involvement, SRP: scaling and root planning, OFD: open flap debridement, BRG: Bone replacement grafts, HCAL: horizontal clinical attachment level, VCAL: vertical clinical attachment level, PPD: Probing pocket depth, HBL: horizontal bone level, FHC: furcation horizontal component, FBD: fornix to base of defect, CAL: clinical attachment level, EMD: enamel matrix protein derivative, BTCP: beta-tricalcium phosphate, HA: hydroxyapatite, MTA: mineral trioxide aggregate, CEM: calcium enriched mixture, GTR: Guided tissue regeneration, BG: Bone graft, ACB: autogenous cortical bone, MSCs: mesenchymal stem cells, PRP: platelet rich plasma , APC: autologous platelet concentrates, ePTFE: expanded polytetrafluoroethylene, ABG: Autogenous bone graft

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