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CLINICAL AND RADIOGRAPHIC EFFECT OF EXTRACTED AUTOGENOUS DEMINERALIZED DENTIN AS A BONE GRAFT SUBSTITUTE IN MANAGEMENT OF PERIODONTAL INTRABONY DEFECTS: A CASE SERIES

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ABSTRACT

Aim: The study aimed to assess the effectiveness of using an autogenous demineralized dentin graft (ADDG) as a bone substitute with modified minimally invasive surgical technique (M-MIST) in improving the radiographic and clinical outcomes of intra-bony defects.

Methods: Ten periodontitis patients diagnosed as Stage III, Grade B were enrolled in the trial, with 2 or 3 walled intra-bony defects, probing depth (PD) ≥ 6 mm and intra-osseous defect depth ≥ 3mm and having unrestored or supernumerary tooth that needed extraction were treated with M-MIST and ADDG after receiving steps 1 and 2 periodontal therapies. Clinical parameters as clinical attachment level gain (CAL) (primary outcome), gingival margin level (GML) and probing depth (PD) were measured at baseline then after three and six months, while radiographic parameters as radiographic linear defect depth (RLDD) change, radiographic bone fill (RBF) and radiographic bone density (RBD) were measured at baseline and after six months.

Results: There was a statistically significant gain in CAL, reduction in PD and GML after 3 months. These measurements then showed no statistically significant change from three to six months. Additionally, There was statistically significant decrease in RLDD and a measurable increase in bone density after six months.

Conclusion: M-MIST and ADDG exhibited major improvements in radiographic and clinical parameters 6 months post-operative. This suggests the potential use of ADDG instead of conventional types of bone grafting materials in management of the intra-bony defects of periodontitis patients.

KEYWORDS: Periodontitis, intrabony defect, modified minimally invasive surgical technique, M-MIST, autogenous demineralized dentin graft, radiographic linear defect depth.

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INTRODUCTION

Periodontitis is considered host-mediated and microbialy-associated inflammation that leads to loss of periodontal attachment. Clinical attachment loss (CAL) is identified by using a standardized periodontal probe to measure distance from the cemento-enamel junction to the base of the periodontal pocket, assessing all erupted teeth in a comprehensive, or "circumferential," manner (Tonetti, Greenwell and Kornman, 2018). This process leads to the progressive destruction of the alveolar bone and periodontal ligament, ultimately leading to pocket formation, gingival recession, or a combination of both (JE and G., 2012). Following non-surgical periodontal therapy, deep intrabony defects often persist, increasing the threat of disease progression and eventual tooth loss (Cortellini and Tonetti, 2015). A key objective in periodontology is to regenerate the periodontal tissues in compromised areas shifting the prognosis of questionable teeth to a more maintainable state (Tsai *et al*., 2020). The ideal treatment outcome for intrabony defects involves no bleeding on probing (BOP) and the conversion of deep periodontal pockets into shallow, healthy ones. The ultimate goal is true periodontal regeneration, this involves creating of a new alveolar bone, a new root cementum and a functionally oriented PDL, all without any associated soft tissue recession (Sculean *et al*., 2015).

Over the last several decades, significant advancements have been made in periodontal regenerative procedures (Cortellini and Tonetti, 2015). These changes have involved new flap designs and the use of various materials to promote tissue regeneration. A wide array of techniques has been developed, including the usage of various bone grafts and substitutes, guided tissue regeneration, and the application of growth factors and enamel matrix proteins (EMD), often in various mixtures, to achieve periodontal regeneration (Sculean *et al*., 2015).

There are four categories of bone substitutes used to reconstruct bony defects; autografts, allografts, alloplasts, and xenografts. The selection of these materials for periodontal regeneration is dependent on a variety of factors, including the specific clinical application, volume of the defect, and the supporting evidence-based studies (Zhao *et al*., 2021). Autografts are known to be the gold standard in periodontal regenerative treatments as for their osteo-inductive, osteo-conductive, and osteogenic properties. However, their usage is limited by high patient morbidity and potential resorption at the harvest site, whether intraoral or extraoral. Furthermore, allografts and xenografts have limited use due to concerns over high costs and the potential for disease transmission (Jeong *et al*., 2011).

For compensating the drawbacks of autografts, many researchers devoted their search to use human teeth as an intraoral donor site for regenerative procedures because the structural and chemical similarity between alveolar bone and dentin as both show a low crystalline hydroxyl appetite with comparable ratio of calcium to phosphorus (Kim *et al*., 2013). Also, the primary component of their extracellular matrix is Type I collagen (Kim *et al*., 2013) ,so bone grafts derived from teeth was encouraged to be used in numerous clinical applications (Gharpure and Bhatavadekar, 2018).

Moreover, dentin contains several growth factors such as bone morphogenetic protein-2 (BMP-2), transforming growth factor beta (TGF-β) and insulin-like growth factor-II (IGF-II). These factors are crucial for promoting healing and regeneration (Schmidt-Schultz & Schultz, 2005). This in addition to the demineralization process of the tooth dentin graft also helps expose its collagen, releasing growth factors, and in turn, boosts its ability to regenerate tissues (Kim *et al*., 2010).

To the best of our knowledge, while some case reports have used autogenous demineralized dentin graft (ADDG) for intra-bony defects, this is considered as the first clinical trial case series conducted to evaluate radiographic and clinical outcomes following the application of autogenous demineralized dentin graft (ADDG) with M-MIST in intra-bony defects of patients with stage III periodontitis.

MATERIALS AND METHODS

Study design and registration

The design of this clinical trial is a case series study. This study Protocol was registered in (www.clinicaltrials.gov) on June 2022 with registration ID no. (NCT05445202). The study's research protocol and informed consent forms received approval from the Ethics committee of scientific research, Faculty of Dentistry, Cairo University in May 2023 (IRB: 11422). Patients were well informed of the surgical procedure and its objective prior to the research and agreed to sign an informed consent. Between November 2021 and March 2022, patients were enrolled from the outpatient clinic of the Periodontology's department at Faculty of Dentistry Cairo University.

Participants

10 participants were recruited for this case series clinical trial with inclusion criteria as enumerated: 1) age 18 years or older, 2) motivated patients ready to follow proper oral hygiene instructions and approves the 6 months follow-up period, 3) patients diagnosed with stage III periodontitis, 4) having 2 or 3 walled intra-bony defects, with PD ≥6mm and intra-bony defect depth ≥3mm (Sanz *et al*., 2020), 5) using a another tooth scheduled for extraction such as an unrestorable or fractured tooth, an impacted wisdom tooth, or a supernumerary tooth as a dentin graft within a bone defect. Exclusion criteria were 1) grade III mobility or teeth with supra-bony defects , 2) Patients with underlying health conditions or systemic diseases that could negatively impact the body's natural healing processes or bone metabolism(such as uncontrolled diabetes and hyperthyroidism) , 3) pregnant women (Boehm and Kim, 2025), 4) smokers (Javed *et al*., 2012).

Outcomes

Clinical periodontal parameters

Clinical outcomes were recorded at baseline, three & six months post-surgically which includes CAL as the primary outcome, PD and GML. Clinically attachment level was measured from the CEJ to the base of pocket, and PD from gingival margin to base of pocket (Ramfjord, 1967), while GML was determined as the distance from the most coronal extension of the gingival margin to the CEJ (Lindhe and Nyman, 1980). The GML position was classified as an apical shift with a negative sign (−), a coronal shift with a positive sign (+), or at the level of the CEJ (0)(Gupta and Vandana, 2009). Measurements were taken at the site of interproximal intra-bony defect using a UNC-15 Periodontal probe (Martin™ graduated periodontal probe, KLS Group, Germany). A customized surgical stent, constructed from acrylic resin on a diagnostic cast, was fabricated for each surgical site. This appliance was designed to seat on the occlusal surfaces of at least four teeth, with a vertical reference notch incorporated on the buccal and lingual aspects of the intra-bony defect for standardization of the clinical measurements (Gupta *et al*., 2018).

Radiographic outcomes

Radiographic outcomes included radiographic linear defect depth (RLDD) and radiographic bone fill (RBF) which were recorded at baseline and after six months.

Using paralleling technique with a KCP film holder, a periapical radiograph was taken for each patient to assess alveolar bone loss. Radiographic images were analyzed using the DIGORA system. To calculate changes, the baseline values were subtracted from the 6-month follow-up.

For each surgical site, custom bite blocks were created from acrylic resin using diagnostic casts. Radiographs were taken using a Dürr Dental sensor (size two) (Bietigheim-Bissingen; Country: Germany), and an XCP X-ray holder kit (Dentsply Sirona, Charlotte, USA).The standardized X-rays were obtained with a Heliodent Plus machine set at 60 kVp, 8 mA, and a 0.10-second exposure. Using DIGORA software (KaVo Dental GmbH), Berlin, Germany, and Kerr Corporation, Detroit, Michigan, California), in each defect site, three key reference points were pinpointed on the radiograph: the cemento-enamel junction , the alveolar crest and the defect base (Fig. 1A). Three reference lines were also drawn: one along the tooth's long axis, a second running parallel to the root surface from the CEJ to the defect base and another line starting from alveolar crest ending perpendicularly on the long axis line (Fig. 1C). The radiographic linear defect depth (RLDD) was measured from the deepest point of the bone defect (DB) to the cementoenamel junction (CEJ) line at baseline and 6 months follow up time (Tsitoura *et al*., 2004) (Fig. 1C). The change in RLDD was calculated from the periapical radiographs as the difference between the RLDD value at baseline and the values after 6 months post-surgically (Ahmad *et al*., 2019). RBF represents the percentage of bone fill at 6 months and is expressed as (RLDD Change / RLDD value at baseline) × 100 (Ahmad *et al*., 2019).

Using ImageJ software (Research Services Branch, Maryland, USA), the initial defect angle was measured by calculating the angle formed by three specific points: CEJ, DB, and the AC. (Aydemir Turkal *et al*., 2016) (Fig.1B). For assessment of the radiographic bone density (RBD) for the defect, to define the region of interest (ROI), the boundaries of the intra-osseous defect were outlined, and mean grey values within this area were then determined. The ROIs were carefully positioned to avoid overlapping with any tooth structure. The exact size and shape of the ROI from the baseline radiograph were then duplicated on the 6-month follow-up radiographs to ensure consistent measurements, and the changes in grey values were subsequently calculated (Górski *et al*., 2019) (Fig. 1).

Preoperative phase

Patients who met the study's eligibility criteria were enrolled after they signed an informed consent. They received step 1 periodontal therapy which included giving periodontitis patients the necessary health promotion and prevention resources to help them adhere to the recommended course of treatment and ensure satisfactory results and also to manage both local and systemic risk factors that could be changed, as they had a major impact on the disease. In addition to educational and preventive measures

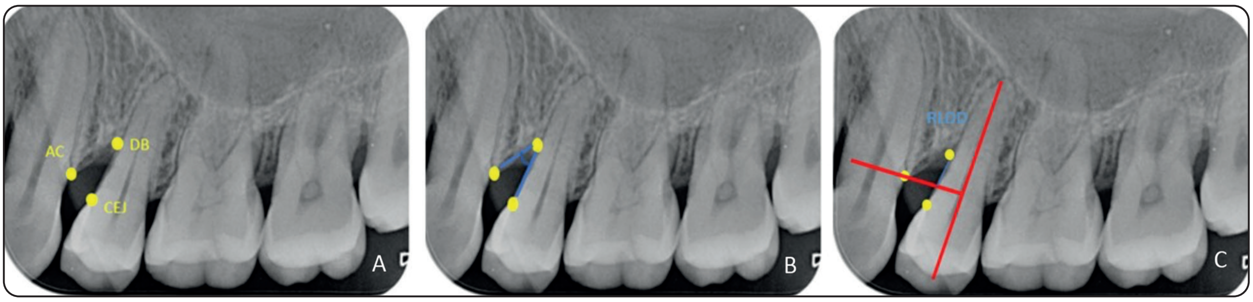

Fig. (1) Illustrates how to measure an intra-osseous defect within the bone on a radiograph. (A) It shows the key reference points: defect base (DB), cementoenamel junction (CEJ) and alveolar crest (AC). (B) A radiographic angle is drawn to connect these three points CEJ, DB, and AC. (C) Identifying reference lines (in red): A vertical line is drawn along the long axis of the tooth and a horizontal line is drawn perpendicular to it, passing through the AC and the resulting measurement is the radiographic linear defect depth (RLDD), shown in blue.

meant to reduce gingival irritation, this initial stage entails the professional mechanical plaque removal as well as removal of local retentive factors (Sanz *et al*., 2020).

Also known as cause-related therapy, the second therapeutic stage focused on eliminating or reducing subgingival biofilm and calculus (subgingival instrumentation). The first two steps of non-surgical periodontal treatment were performed using hand instruments as Gracey curettes (HuFriedy Gracy's curette; HuFriedy, Chicago, USA) and ultrasonic scalers (Woodpecker UDS-P, China). Also, as part of the non-surgical phase of treatment, (0.12%) chlorhexidine mouthwash (Hexitol, Adco pharma co, Egypt) was prescribed to the patients to be used daily (Sanz *et al*., 2020). Following 4 to 6 weeks of initial periodontal therapy, patients were re-evaluated. This assessment determined whether they would proceed to the third step of treatment, which is periodontal surgery or not (Graziani *et al*., 2018). Criteria included the persistence of interproximal defect with PPD ≥ 6mm, CAL ≥ 4mm and radiographic intra-osseous defect ≥ 3 mm (Sanz *et al*., 2020).

Preparation of the autogenous demineralized dentin graft (ADDG)

The area of the tooth indicated for extraction was anesthetized by 2% Mepivacaine HCl with 1:20,000 Levonordefrin (alexandria co. for pharmaceuticals, Egypt). The extracted tooth meticulously debrided of all soft tissue attachments, including periodontal ligaments and residual cementum. A high-speed fine finishing stone and saline irrigation were used to remove any existing cavities or restorative materials. Following this, pulp chamber was prepared and disinfected using sterile endodontic files. The tooth was then processed into particulate graft material using a manual bone mill. (manufactured from AISI 304 German, stainless steel) (Elfana *et al*., 2021) (Fig. 2D).

To prepare the ADDG, tooth particles were demineralized by soaking them in a 0.6N hydrochloric acid solution (chema-jet chemicals, Egypt) for 30 minutes.Following demineralization, the particles were rinsed twice with saline and then dried with a sterile gauze (Park, Kim and Pang, 2017) (Fig. 2E).

Modified minimally invasive surgical technique (M-MIST)

After anesthetizing the area, a modification of MIST (modified-minimally invasive surgical technique, M-MIST) (Cortellini and Tonetti, 2009) was performed. An entry horizontal internal bevel incision was made on the buccal side at the base of the interdental papilla using a micro-blade. Then the interdental incision and the buccal aspect of the teeth beside the defect were connected through intrasulcular incisions, without involving the neighboring papillae (Fig. 2B). A sharp dissection of the gingiva was performed, and a triangular buccal flap was minimally elevated to expose the coronal edge of the buccal bone crest, without reflecting papilla. In the M-MIST technique, the interdental papilla was kept attached from the remaining interdental bone crest and supracrestal fibers, and the palatal flap was not lifted.

The defect was thoroughly debrided using both of sharp mini-curettes and power-driven device (woodpecker UDS-P, China) (Cortellini and Tonetti, 2009), then ADDG particles were used to fill the intrabony defect (Fig. 2F). A modified internal vertical mattress suture was positioned to close the wound using 5-0 proline suture (Cortellini and Tonetti, 2009) and if needed, extra interrupted single sutures were placed to ensure primary closure of the interdental space (Fig 2G).

Postoperative care and instructions

Following the surgical procedure, patients were instructed to refrain from all oral hygiene practices (flossing and brushing) and mastication

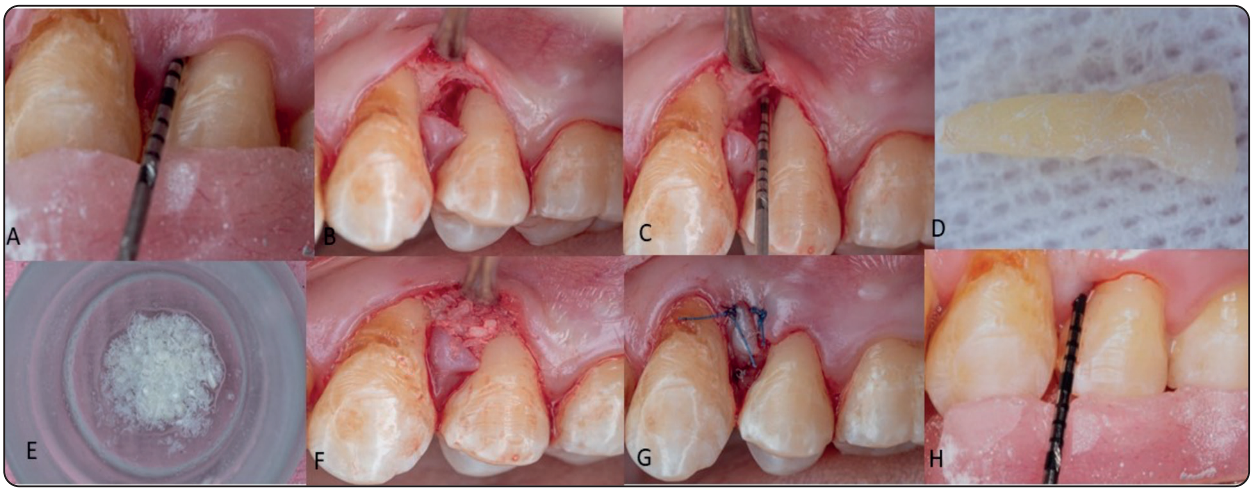

Fig. (2) A clinical representative case's steps, (A) Preoperative clinical photograph showing 7-mm PPD mesial to upper left first premolar at baseline using acrylic stent for standardization. (B, C) Clinical photograph showing the degranulated Intra-osseous defect with a vertical component of 4 mm. (D) clinical photograph of extracted loose lower central incisor of the same patient. (E) clinical photograph showing demineralization of dentin graft using hydrochloric acid for 30 minutes. (F) Clinical photograph showing placement of demineralized dentin graft inside the intra-bony defect. (G) clinical photograph representing internal vertical mattress sutures using 5-0 proline suture. (H) Clinical photograph showing 4-mm probing pocket depth after 6 months using acrylic stent for standardization.

in the surgical site for 3-4 weeks. After this period, patients were cleared to resume their regular full-oral hygiene regimen (Cortellini and Tonetti, 2007).

Participants were administered a post-operative antibiotic regimen. The standard protocol was amoxicillin, 500 mg, taken three times daily for seven days (Misr Co. for Pharmaceutical Industries, Egypt) or in case of patients with a penicillin allergy, doxycycline, 100 mg, was prescribed twice daily (Doxymycin, Nile Co. for Pharmaceuticals and Chemical Industries, Egypt) and Ibuprofen 600mg in case of severe pain (Brufen, Kahira Pharmaceuticals, Egypt) (Oswal *et al*., 2014). Patients were instructed to gently rinse with a 0.12% chlorhexidine mouthwash twice a day for two weeks. Sutures were then removed at the two-week post-operative appointment (Demetter, Calahan and Mealey, 2017).

Statistical analysis

The distribution of the numerical data was analyzed for normality using tests, specifically the Shapiro-Wilk & kolmogorov-smirnov tests. RLDD, bone density & Probing pocket depth data revealed normal (parametric) distribution while the GML and CAL data were found to be non-parametric, so they were presented using mean, standard deviation (SD), 95% confidence interval (95% CI) for the mean difference, as well as median and range values. For the parametric data, a paired t-test was used to analyze the changes in RLDD and bone density after six months. To evaluate changes in probing depth (PD) over time, a repeated measures ANOVA test was employed. For the significance in ANOVA results, a Bonferroni's post-hoc test was used for pairwise comparisons. To analyze changes over time in non-parametric data for GML and CAL, Friedman's test was applied. Following a significant result from the Friedman's test, Dunn's test was used for pairwise comparisons. Frequencies and percentages are used to present qualitative data. The significance level for all statistical analyses was set at $P \leq 0.05$. Statistical procedures were carried out with IBM SPSS Statistics for Windows, Version 23.0 (IBM corp., Armonk, NY).

RESULTS

Baseline characteristics

In this clinical trial was conducted on ten females' subjects. Mean age of **39.6 years** (SD = 6.2) years old was determined with age range for the group was from 30 to 47 years old. Most of the teeth (70%) were lower teeth. Anterior teeth comprised 30% of the study sample, premolars comprised 30% while molars comprised 40% of the studied teeth. The majority of the defects (70%) were three-wall intrabony defects. The mean (SD) values for the defect angle were 34.3 (6.2) degrees with a minimum of 26.8 and a maximum of 44 degrees.

Clinical Attachment Level (CAL) in mm (primary outcome)

Based on the statistical analysis, there was a significant change in the CAL measurements over time (*P*-value = 0.005, Effect size= 0.54). The median (range) of CAL reported was 7 (4,10), 5 (0,10) and 3.5 (0,9) at baseline, 3 and 6 months respectively. There was a statistically significant decrease in CAL measurements after 3 months, based on the pair-wise comparisons between the different time points. This period was characterized by a mean CAL gain of -1.9 (±2) mm, followed by non-statistically significant change in CAL values from 3 to 6 months with CAL gain -2.5 (±1.9) mm (Table 1).

Gingival Marginal Level (GML) in mm

Based on the statistical analysis, there was a significant change in the GML measurements over time (*P*-value=0.030, ES=0.35). The median (range) of GML reported was 1 (-3, 2), 0 (-5,2) and 0 (-5,2) at baseline, 3 and 6 months respectively. There was a statistically significant decrease in GML measurements after 3 months, based on the pair-wise comparisons between the different time points with a mean change of -0.8 (±0.8) mm. Following this period, the GML continued to decrease, but the change from 3 to 6 months was not statistically significant with a mean change of -0.5 (±1.3) mm. (Table 1).

Pocket Depth (PD) in mm

Based on the statistical analysis, a significant change was noted in the GML measurements over time (*P*-value=0.001, ES=0.804). The mean (±SD) of PD reported was 6.8 (±1.2), 4.1 (±1.4) and 3.8 (±1.3) at baseline, 3 and 6 months respectively. There was a statistically significant decrease in PD measurements after 3 months, based on the pair-wise comparisons between the different time points This period was characterized by a mean PD reduction of -2.7 (±1.8) mm, followed by non-statistically significant change in PD values from 3 to 6 months showing a mean PD reduction during this interval of -3 (±1.6) mm (Table 1).

Radiographic Linear Defect Depth (RLDD) in mm

A statistically significant decrease in RLDD was noticed after 6 months (*P*-value=0.005, ES=0.675). The mean (±SD) of RLDD measurements reported were 3.96 (±0.9) and 3.09 (±1.3) at baseline and 6 months respectively. Descriptive statistics for millimeter and percentage bone fill are presented in Table (2) where the percentage of bone fill was calculated as bone fill / base line RLDD × 100. After 6 months, the mean bone fill was 0.87 (±0.74) mm, and the percentage bone fill was 24.1 (±22.2) %.

Bone density (Grey value)

Descriptive statistics for increase in radiographic bone density and percentage increase in bone density are presented in Table (2). The percentage increase in radiographic bone density was calculated as change in bone density / base line bone density × 100. There was a statistically significant increase in radiographic bone density after six months (P-value=0.003 ES=1.17). The mean (±SD) of Bone density reported at baseline and 6 months was 59.8 (±17) and 84.9 (±23.9) respectively. After 6 months, the mean change of radiographic bone density was 25.1 (±19.9) and percentage mean change in bone density was 47.8 (±36.3) %.

TABLE (1) Descriptive statistics and results of repeated measures ANOVA test for comparison between PD measurements at different time points. Friedman's test and descriptive statistics were used to compare GML and CAL measurements at various time point

	Mean (±SD)	**Median (Range)**	**P-value**	**Effect size (w)**
CAL				
Baseline	6.7 (±1.8)	7 (4,10) [A]		
3 months	4.8 (±3)	5 (0,10) [B]	0.005*	0.54
6 months	4.2 (±2.7)	3.5 (0,9) B		
CAL gain 3 months (mm)	-1.9 (±2)	-2 (-5,2)		
CAL gain 6 months (mm)	-2.5 (±1.9)	-3 (-5,1)		
CAL gain 3 months (%)	-32.5 (±35.7)	-28.6 (-100,28.6)		
CAL gain 6 months (%)	-40.7 (±33.1)	-47.3 (-100,14.3)		
GML				
Baseline	0.1 (±1.5)	1 (-3, 2)[A]		
3 months	-0.7 (±2)	0 (-5,2)[B]	0.030*	0.35
6 months	-0.4 (±2.1)	0 (-5,2)[B]		
Change 3 months (mm)	-0.8 (±0.8)	-1 (-2, 0)		
Change 6 months (mm)	-0.5 (±1.3)	-1 (-2, 2)		
Change 3 months (%)	-13.3 (±95.8)	0 (-100, 200)		
Change 6 months (%)	-43.3 (±113.4)	-100 (-200, 200)		
PD				
	Mean (±SD)	**95% CI for the mean difference (Lower limit, Upper limit)**	**P-value**	**Effect size (Partial Eta Squared)**
Baseline	6.8 (±1.2)[A]			
3 months	4.1 (±1.4)[B]	(1.1, 4.3)	0.001*	0.804
6 months	3.8 (±1.3)B	(1.6, 4.5)		
Change 3 months (mm)	-2.7 (±1.8)			
Change 6 months (mm)	-3 (±1.6)			
Change 3 months (%)	-38.7 (±22.8)			
Change 6 months (%)	-43.4 (±19.5)			

: Significant at P ≤ 0.05, Different superscripts indicate statistically significant change by time

TABLE (2) Descriptive statistics and results of paired t-test for comparison between RLDD, Bone density measurements at base line and after 6 months

	Mean (±SD)	95% CI for the mean difference Lower limit, Upper limit	*P*-value	*Effect size (d)*
RLDD				
Base line	3.96 (±0.9)	(0.34, 1.4)	0.005*	0.675
6 months	3.09 (±1.3)			
Bone fill				
mm bone fill at 6 months	0.87 (±0.74)			
% bone fill at 6 months	24.1 (±22.2)			
Bone density				
Base line	59.8 (±17)	(10.9, 39.4)	0.003*	1.17
6 months	84.9 (±23.9)			
Change in Grey value at 6 months	25.1 (±19.9)			
% Change in grey value at 6 months	47.8 (±36.3)			

***: Significant at $P \leq 0.05$**

DISCUSSION

Periodontitis, a very common disease, causes the breakdown of the structures that support and surround the teeth. This multifactorial disease originates from the gingival tissue which if left untreated results in destruction of the deeper tissues, and eventually can cause tooth loss (Petersen and Baehni, 2012). Periodontitis has different staging and grading system which is important for achieving proper diagnosis and treatment. Significant damage to the teeth's attachment system is present in stage III periodontitis, and if advanced treatment is not received, there is a substantial probability of tooth loss (Tonetti, Greenwell and Kornman, 2018). The current study included patients with Stage III periodontitis since this stage includes deep periodontal defects that reach the middle region of the root rendering the management of this periodontitis stage difficult with a negative impact on the affected teeth's long-term prognosis (Tonetti, Greenwell and Kornman, 2018). Therefore, steps 1 and 2 periodontal therapies aim mainly at providing periodontitis patients with the necessary health promotion and the disease is managed by controlling relevant local and systemic risk factors, along with professional mechanical plaque removal and the elimination of any local factors that promote plaque retention (Sanz *et al*., 2020).

Intrabony periodontal defects, a common consequence of periodontitis, may have a detrimental impact on the long-term health of the teeth if not addressed. The ultimate goal of treatment of intrabony defects is thought to be achieved when there is no bleeding on probing, periodontal pockets are reduced in depth following successful periodontal regeneration. This regeneration involves the formation of new root cementum and new alveolar bone, which are then connected by newly formed, functionally-oriented periodontal ligament fibers (Cortellini and Tonetti, 2015). Thus, persistent interproximal defect with PPD ≥6mm, CAL ≥4mm and radiographic intra-osseous defect

≥ 3mm (Sanz *et al*., 2020), were included in the present study since these criteria need additional surgical intervention to help ceasing the disease progression.

Modified minimally invasive surgical technique is known for its limited patient morbidity & excellent clinical improvements in terms of CAL gain, minimal gingival recession and probing depth reduction. This is attributed to the minimal interdental defect access with no papilla reflection, which ensures excellent primary closure, better blood supply and flap stability (Cortellini and Tonetti, 2009).

Autografts are known to be gold standard for bone grafting because they have three key properties: osteoinductive, osteoconductive, and osteogenic potential. However, autogenous bone grafts harvested from intra or extra-oral sites have the limitations of significant morbidity and potential bone'resorption in addition to the patients' discomfort of having two surgical sites (Zhao *et al*., 2021). While the other alternative bone grafts as xenografts and allografts, despite their potential regenerative power, still have high cost and possible disease transmission which limited their use (Jeong *et al*., 2011). Recent research has increasingly focused on using human teeth as a source for bone grafts this is because dentin is chemically and structurally similar to alveolar bone, both containing a type of low-crystalline hydroxyapatite with a comparable calcium-to-phosphorus ratio (Kim *et al*., 2013). The tooth enamel composed of 96% inorganic material and only 4% water. In contrast, dentin and alveolar bone share a similar composition, with both consisting of 65% inorganic substances and 35% organic substances. Meanwhile, cementum has a more balanced composition, with 45-50% inorganic material and 50-55% organic material and water (Kim *et al*., 2013).

These similarities between the bone and dentin might contribute to a possible regenerative potential when using dentin graft. This, in addition to the various growth factors as insulin-like growth factor-II (IGF-II),transforming growth factor beta (TGF-β) and bone morphogenetic protein-2 (BMP-2), which is important for the healing event (Kim *et al*., 2010).

The minimal invasive surgical technique (M-MIST) has proven being effective in this study in improving all clinical parameters (CAL gain and PD reduction) after three and six months. This significant improvement in clinical parameters is similar to (Sun *et al*., 2025) who attained superior results with collagen-enriched bovine-derived xenograft and M-MIST, possibly attributed to the longer two-year follow-up time and larger sample size. Furthermore, the enhanced clinical results in this study are confirmed by (Cortellini *et al*., 2022) and (Priyanka, Reddy and Pradeep, 2023) who used Emdogain with M-MIST. This confirms the effectiveness of this surgical technique in treating intrabony defects despite the variability in the amount of millimeter reduction of CAL and PD and the type of regenerative material used. However, the added benefit of autogenous dentin graft as a scaffolding material and as a source of growth factors could be beneficial for supporting such defects with true periodontal regeneration (Kim *et al*., 2010).

The radiographic outcomes of this case series, including RLDD and radiographic bone density, showed significant improvement after six months. This is consistent with findings from (Cortellini *et al*., 2022) who achieved superior results using M-MIST with Emdogain and a bone-mineral-derived xenograft. Their enhanced outcomes may be attributed to the bone graft-augmented growth factor-releasing material, the longer one-year follow-up period, the larger sample size, and the rigorous supportive periodontal care program. Similarly, a case report by (Garg, Bhardwaj and Chawla, 2024) also showed superior bone fill using a demineralized dentin graft and rhPDGF-BB with a papilla preservation flap design, which is likely because of the promoted wound healing aided by rhPDGF-BB which stimulates cell proliferation and migration and enhance angiogenesis. On the other hand, the inferior results observed when using demineralized dentin graft with open flap debridement (OFD) in a case report (Samba Siva Reddy, 2017) highlights the advantages of M-MIST over OFD, particularly in achieving minimal interdental defect access, excellent primary closure, better blood supply, and flap stability. This explains the added benefit of a barrier membrane as chorion membrane when used with demineralized dentin graft in another case report (Tamloorker *et al*., 2019). Thus, it could be concluded that unless a papilla preservation minimally invasive technique is used, a barrier membrane would be necessary to support the bone graft material in the intrabony defect. Therefore, M-MIST is an excellent choice for supporting the blood clot and for preventing interdental papilla collapse. Another fact could be emphasized that any material that has the ability to release growth factors will be beneficial to the grafting material used for the healing and the regenerative process.

Despite the observed clinical and radiographic improvement in this trial, still the results must be clearly and cautiously interpreted, and the study limitations should be highlighted. First, the sample size and the case series study design represent only a convenient restricted population sample, however this was due to the limited prospective reports in the literature that studied demineralized dentin graft in intra-osseous defects. Second, the current trial did not employ use of the Smart Dentin Grinder which could have standardized the graft particle size in all cases and could have saved the time needed to obtain the demineralized dentin graft making the procedure easier for both the patients and the operator. Third, despite reducing the cost via using autogenous bone graft from the extracted tooth, still the procedure of having two surgical sites rendered difficult healing events. Fourth, the absence of a comparator group did not allow this study to compare to other types of bone grafts.

CONCLUSIONS

Based on the limitations of this clinical trial, the conclusion was that using M-MIST with an autogenous demineralized dentin graft (ADDG) resulted in significant improvements in both radiographic and clinical outcomes six months after the procedure. This study results shed information on the potential benefits of ADDG in treating intrabony defects and offers it as cost-effective option to be used instead of the conventional types of bone graft for periodontitis patients.

Recommendations

To further evaluate the ADDG as a bone graft material for treating intrabony defects, randomized controlled clinical trials and histological studies with longer follow-up time and bigger sample size are necessary. More comparisons to other bone graft materials or to other regenerative techniques will be beneficial to accurately assess the clinical and radiographic outcomes. Also, radiographic 3-D examination of the intrabony defects could add valuable information for the defect configuration and the added regenerative potential of the dentin graft.

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