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Radiographic and Clinical Assessment of Socket Preservation Using Autogenous Demineralized Dentin Matrix versus Xenograft: A Randomized Controlled Trial

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Abstract

Background: Autogenous Demineralized Dentin Matrix (ADDM) provides a bio-interactive, growth-factor-enriched substitute for deproteinized bovine bone mineral (DBBM) xenograft. This research assessed the radiographic and clinical results of socket preservation utilizing ADDM in contrast to DBBM within a membrane-free regimen.

Methods: In this prospective, randomized controlled trial (RCT), 40 patients requiring maxillary premolar extractions were randomly assigned (1:1) to undergo socket grafting with either ADDM ($n = 20$) or DBBM ($n = 20$) without a barrier membrane. Radiographic parameters including bucco-lingual ridge width, marginal bone loss (MBL), and volumetric bone change were measured via Cone-Beam Computed Tomography (CBCT) at baseline and 6 months postoperatively. Clinical parameters specifically keratinized Gingival Width (KGW) and Visual Analogue Scale (VAS) pain scores were recorded over 7 days and 6 months follow-up period.

Results: At 6 months, both cohorts exhibited significant intra-group reductions in bucco-lingual ridge width, bone volume, KGW, and VAS pain scores over time ($p < 0.05$). However, no significant differences emerged between ADDM and DBBM across any evaluated outcomes, including bucco-lingual ridge width loss at the crest ($p = 0.0920$), middle ($p = 0.9013$), or apex ($p = 0.3641$), mesial ($p = 0.1911$) or distal ($p = 0.6362$), MBL, volumetric bone loss ($p = 0.4246$), KGW alterations ($p = 0.7515$), or postoperative VAS scores.

Conclusions: ADDM is non-inferior to DBBM for maintaining hard and soft tissue dimensions and limiting post-extraction ridge resorption when using a membrane-free socket preservation approach. Consequently, ADDM serves as a viable, host-derived alternative to traditional xenografts.

Trial registration: ClinicalTrials.gov, **NCT07777588**, retrospectively registered on **15 August 2026**

Keywords: Autogenous Demineralized Dentin Matrix; Deproteinized bovine bone mineral; Bucco-lingual ridge width; Socket grafting.

1. Introduction

The process of tooth extraction commences a sophisticated and dynamic healing trajectory involving the production of a blood clot, infiltration by inflammatory cells, development of granulation tissue, and eventual remodeling of bone ^[1]. This biological mechanism often leads to gradual resorption and reduction in both the height and width of the alveolar ridge ^[2]. Post-extraction ridge resorption can significantly undermine the aesthetic and functional results of later restorative procedures, especially implant insertion or fixed prosthodontics ^[2, 3].

To mitigate post-extraction bone resorption, practitioners often execute socket preservation by inserting particulate bone graft material directly into the socket, foregoing the use of a barrier membrane ^[4, 5]. The independent grafting of the socket offers an instant physical framework that secures the blood clot, reinforces the delicate adjacent bony structures, and preserves the socket's volume as new host bone gradually develops ^[1, 4]. Excluding a barrier membrane streamlines the surgical process, diminishes total operation duration and expenses, and eliminates the necessity for significant soft tissue manipulation or primary closure, thereby maintaining the current connected gingival structure ^[5-7].

Certainly, the efficacy of any socket preservation initiative depends on the selected graft material ^[4]. Deproteinized bovine bone mineral (DBBM) xenograft is often an endorsed choice due to its gradual resorption rate, which serves as a durable physical framework for the ridge. Nonetheless, xenografts are exclusively osteoconductive material that lack the capability to autonomously stimulate new bone formation. Conversely, autogenous bone obtained from secondary intraoral locations such as the chin or ramus is regarded as the definitive gold standard, providing a combination of osteogenic, osteoinductive, and osteoconductive characteristics ^[8]. Regrettably, procuring bones from another location necessitates an additional surgical incision, increased discomfort for the patient, and a restricted availability of viable bone ^[9].

These disadvantages have sparked interest in an innovative solution: repurposing a patient's own excised teeth into an Autogenous Demineralized Dentin Matrix (ADDMM) ^[10, 11]. Because dentin and jawbone both originate from cranial neural crest cells ^[12], they are strikingly similar in structure and chemical makeup ^[13, 14]. Both consist of a carbonated hydroxyapatite matrix supported by Type I collagen ^[15]. Dentin serves as a vital reservoir for essential growth hormones, such as Bone Morphogenetic Proteins (BMPs), Transforming Growth Factor-beta

(TGF- β), Insulin-like Growth Factors (IGFs), and Vascular Endothelial Growth Factor (VEGF) [16, 17]. By partially demineralizing treated dentin particles using acid, these concealed signaling proteins are revealed, transforming what was previously clinical waste into a bio-interactive graft devoid of any risk of immunological rejection [6, 18].

Notwithstanding these promising advancements, substantial clinical evidence directly juxtaposing ADDM with traditional xenografts is still scarce. A notable deficiency exists in randomized controlled trials that assess both soft-tissue clinical recovery and quantitative radiography bone changes after extraction.

This randomized controlled experiment was formulated to assess and contrast the clinical and radiological results of socket preservation utilizing ADDM vs DBBM post- extraction. Our key hypothesis was that ADDM would be non-inferior to regular xenograft material in preserving clinical parameters and radiographic bone changes.

2.Materials and Methods

2.1 Study Design and Setting

This study was conducted as a prospective, blinded, two-arm parallel randomized controlled trial (RCT) designed to compare the clinical and radiographic outcomes of socket preservation using ADDM versus DBBM xenograft in a membrane-free protocol. The study protocol was reviewed and approved by the Institutional Ethics Committee of Delta University for Science and Technology, (Approval No. DU:125052221; agreed in June 2025). This study was conducted in accordance with the ethical principles of the Declaration of Helsinki (2013 revision), and in alignment with the 2010 Consolidated Standards of Reporting Trials (CONSORT) criteria. A written informed consent was obtained from all participants before enrollment who were recruited between June 2025 and September 2025. The trial was registered at ClinicalTrials.gov (Identifier: NCT07777588; registered on 15/08/2026) “Retrospectively registered.”. and the date of study start was 28/06/2025 and study completion was 22/04/2026)

The sample size was calculated based on a study performed by Elfana et al., 2021 who assessed the alteration in bucco-lingual alveolar ridge width subsequent to socket preservation utilizing autogenous whole-tooth compared to autogenous demineralized dentin grafts. A variation of 0.6 mm was deemed clinically acceptable, accompanied by a standard deviation of 0.41 mm.

Employing G*Power software (version 3.1.9.7), an independent-samples t-test, a two-tailed alpha level of 0.05, 80% statistical power, and a 1:1 allocation ratio, the minimum sample size required was 9 participants per group. Presuming a 20% attrition rate led to 12 individuals each cohort. The ultimate sample size was increased to 20 people per group to enhance statistical reliability, estimate treatment effects more accurately, and allow for any exclusions or incomplete data during the longitudinal radiographic evaluation. Consequently, a total of 40 participants were designated, with 20 assigned to each therapeutic group. The enrollment and allocation of participants was illustrated at the depicted flowchart in figure (1).

2.1.1 Eligibility criteria

Subjects were systematically healthy individuals aged 18 to 50 with either single or multi-rooted maxillary premolars necessitating extraction. For clinical and radiological assessments, the post-extraction alveolar socket required a minimum of three intact bony walls and an adjacent natural tooth as a standard reference point. Orthopantomograms (OPGs) were assessed for all potential participants to verify the necessity of extracting an impacted third molar. Individuals undergoing head and neck radiotherapy, receiving bisphosphonate treatment, experiencing bone metabolism issues, or facing challenges with wound healing were omitted. Local infection, tobacco consumption (exceeding 10 cigarettes daily), inadequate oral hygiene, and conditions of pregnancy or lactation were also excluded.

2.2 Randomization

Eligible patients were randomly assigned to either the Test Group receiving socket preservation with ADDM or the Control Group, receiving DBBM xenograft. Allocation was concealed using opaque, sequentially numbered, sealed envelopes. Radiographic assessment was performed using the iCAT FLX V17-Series Cone-Beam Computed Tomography (CBCT) machine (Imaging Science International, ISI, PA, USA) with imaging protocol of 16cm x 13cm Field of View (FOV) (120 KV, 5 mA, 8 sec) and 0.2 mm voxel size.

2.3 Surgical Procedures

For the recipient site, surgical removal of remaining roots was conducted under local anesthesia (2% Lignocaine with 1:100,000 Epinephrine) using periostomes and elevators for minimally invasive extractions that preserved the buccal and lingual alveolar plates. Following extraction, sockets were curetted to remove pathological soft tissue and thoroughly irrigated

with sterile 0.9% saline as seen in figure (2). For the test group, a non-carious third molar was extracted under local anesthesia to harvest autogenous tissue; the harvested tooth was immediately preserved in Hank's Balanced Salt Solution (HBSS), and the donor surgical site was primarily closed using sutures. The extracted teeth were then processed into ADDM graft material by mechanically removing soft tissues, enamel, cementum, and restorations under water cooling, grinding and sieving the clean dentin into 300–1200 μm particles as seen in figure (3), demineralizing the particles in 2% nitric acid for 20 minutes to unmask growth factors and neutralizing and sterilizing the graft with phosphate-buffered saline and 70% ethanol as seen in figure (4). According to the membrane-free protocol, either ADDM or DBBM xenograft particles (0.25–1.0 mm) were incrementally packed into the socket to the crestal bone level as seen in figure (5).

Patients were provided with standard home-care guidelines, a 5-day regimen of systemic antibiotics (Amoxicillin 500 mg three times daily), and analgesics (Ibuprofen 400 mg as needed) following surgery. Subjects were instructed to gargle with a 0.12% chlorhexidine gluconate solution twice daily for a duration of 14 days and to abstain from mechanical brushing of the surgery site for one week to uphold oral hygiene and prevent injury. Sutures were examined and extracted between 7 and 10 days' post-surgery.

Radiographic outcomes were evaluated by CBCT scanning captured after 6 months with the same imaging protocol. CBCT data were checked to evaluate whether there were any motion artifacts in images at coronal, horizontal and sagittal planes. Raw DICOM data from CBCT scanning were transferred to specific image analysis software. After superimposing pre- and post-operative scans in a fusion project as seen in figure (6) were evaluated using OnDemand3D App software (Cybermed Inc., Seoul, Korea), linear and volumetric bone changes were assessed. The dimensions of the bucco-lingual ridge were assessed at three descending horizontal levels: the crest of the alveolar bone, the midpoint, and the apex of the extraction socket as presented in figure (7). The marginal bone loss (MBL) was quantified from the alveolar crest to the socket's base, located 2 mm from the adjacent teeth on either side depicted in figure (8). The volume of the extraction socket was assessed by segmenting the volume occupied by the root before extraction as observed in figure (9)

Clinical parameters were evaluated at baseline (immediately post-grafting) and 6 months postoperatively. Soft-tissue dimensional stability and mucogingival architecture preservation were evaluated by measuring the keratinized gingival width (KGW) with a calibrated periodontal probe, calculated as the distance from the mucogingival junction to the free gingival margin at the grafted site seen in figure (10). In addition, early inflammatory response and patient healing comfort were monitored by recording self-reported post-surgical pain daily for the first 2 days, 7 days using a 10-point Visual Analogue Scale (VAS; 0 = no pain, 10 = worst imaginable pain).

2.4 Outcome Measures

All clinical measurements were performed by a blinded examiner not involved in the surgeries. The following outcomes were recorded:

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2.6 Statistical Analysis

Statistical analyses were performed using IBM SPSS Statistics (version XX; IBM Corp., Armonk, NY, USA). Continuous variables were assessed for normality using the Shapiro–Wilk test, histograms, and Q–Q plots, with Levene’s test used to assess variance homogeneity. Normally distributed data are presented as mean $\pm$ SD, and non-normally distributed data as median (IQR); categorical data are presented as frequencies and percentages. Within-group

pre- and post-intervention changes were assessed using paired t-tests or Wilcoxon signed-rank tests, as appropriate, while between-group differences were evaluated using Welch's t-test or the Mann–Whitney U test. Effect sizes were reported as Hedges' g or rank-biserial correlations with 95% CIs. VAS scores were additionally analyzed using a two-way mixed-effects model assessing time, group, and their interaction, with Holm-adjusted post hoc comparisons and Friedman's test for within-group changes. All tests were two-sided, with $P < 0.05$ considered statistically significant.

3. Results

3.1 Patient Characteristics and Surgical Details

A total of 40 participants were analyzed, including 20 participants allocated to ADDM and 20 allocated to Xenograft. There were no missing values in the analyzed variables. The demographic information, encompassing age and gender, exhibited no statistically significant difference between the two groups, as illustrated in table (1).

The postoperative changes in bucco-lingual alveolar ridge width showed statistically significant reductions at all three measurement levels in both groups. At the crest, mean change was -0.53 ± 0.17 in the ADDM group ($p = <0.0001$), and -0.44 ± 0.16 in the Xenograft group ($p = <0.0001$). At the middle level, mean change was -0.36 ± 0.13 for ADDM ($p = 0.0001$) and -0.36 ± 0.14 for Xenograft ($p = 0.0001$). At the apex, mean change was -0.10 ± 0.10 in ADDM ($p = 0.0018$) and -0.12 ± 0.09 in Xenograft ($p = 0.0006$) as presented on table (2). There were no statistically significant difference between the inter-group comparison, at the level of crest was -0.09 , 95% CI -0.20 to 0.02 , ($p = 0.0920$), at the middle level was 0.05 units, 95% bootstrap CI -0.33 to 0.39 , ($p = 0.9013$), and at the apex was zero, 95% bootstrap CI -0.19 to 0.51 , ($p = 0.3641$) as showed in table (3).

Overall, the bucco-lingual dimensional change pattern was greatest at the crest, intermediate at the middle level, and smallest at the apex, with no evidence that ADDM and Xenograft differed in the magnitude of ridge width change at any level as presented in figure (7).

Between-group comparisons of marginal bone loss revealed no statistically significant differences between the ADDM and Xenograft groups at either the mesial or distal levels. On the mesial aspect, the mean difference between ADDM and Xenograft was 0.11 mm (95% CI: -0.02 to 0.23). This difference was not statistically significant ($p = 0.1911$), despite

demonstrating a medium effect size (Cohen's $d = 0.54$). Similarly, the distal level exhibited a minimal mean difference of 0.10 mm between groups. Non-parametric analysis indicated no statistically significant difference ($p = 0.6362$), with a small effect size (Rank-biserial correlation = 0.09) as seen in table (4).

Bone volume diminished from 2959.58 ± 446.02 to 2834.91 ± 462.79 in ADDM, reflecting an average alteration of -124.67 ± 61.38 . In the Xenograft, values diminished from 3068.40 ± 342.86 to 2949.55 ± 336.60 , reflecting a mean alteration of -118.85 ± 57.59 . The intra-group variation was significant in both groups (ADDM paired t-test, $p < 0.0001$; Xenograft Wilcoxon signed-rank, $p = 0.0001$). The intergroup comparison of change was not statistically significant (Mann–Whitney U, $p = 0.4246$; rank-biserial correlation = -0.15 , 95% bootstrap CI -0.52 to 0.22) as illustrated in table (5).

KGW decreased from 4.00 (3.00–4.00) to 3.00 (3.00–4.00) in ADDM and from 4.00 (3.00–4.00) to 3.00 (3.00–4.00) in Xenograft. Mean changes were -0.30 ± 0.47 and -0.35 ± 0.49 respectively. Within-group changes were significant in ADDM (Wilcoxon signed-rank, $p = 0.0143$) and Xenograft ($p = 0.0082$), but the between-group difference was not significant (Mann–Whitney U, $p = 0.7515$; rank-biserial correlation = 0.05, 95% bootstrap CI -0.25 to 0.35) as seen in table (6).

VAS pain scores significantly decreased over time in both groups. On Day 2, the average VAS was 4.30 ± 2.18 for ADDM and 5.10 ± 2.20 for Xenograft. On the seventh day, the associated values were 0.25 ± 0.55 and 0.40 ± 0.68 . The Friedman tests conducted within groups yielded significant results for ADDM ($p < 0.0001$) and Xenograft ($p < 0.0001$). Holm-adjusted intergroup comparisons yielded no significance on Day 2 ($p = 1.0000$) or Day 7 ($p = 1.0000$) as seen in figure (11).

4. Discussion

The present randomized controlled trial demonstrates that ADDM achieves clinical and radiographic dimensional preservation equivalent to DBBM xenograft when applied in a membrane-free socket preservation protocol. Across all primary endpoints, including bucco-lingual ridge width reduction at coronal, middle, and apical levels, MBL, and overall volumetric changes—no statistically significant inter-group differences were detected ($p > 0.05$). These outcomes validate the primary non-inferiority hypothesis and emphasize ADDM

as a biologically active, host-derived graft that effectively mitigates post-extraction alveolar collapse.

The pattern of dimensional change across both cohorts reflects established healing kinetics, in which horizontal resorption is most pronounced at the crestal region and progressively tapers apically. Six months post-operatively, the crestal bucco-lingual width reduction was -0.53 ± 0.17 mm in the ADDM group and -0.44 ± 0.16 mm in the DBBM group ($p = 0.0920$). These results align with recent clinical evaluations comparing dentin-derived matrix to DBBM, which consistently demonstrate comparable horizontal bone preservation [20, 21]. While functions primarily as an osteoconductive scaffold that resorbs slowly, ADDM exhibits distinct bio-interactive dynamics [20]. Demineralization exposes type I collagen and unmasks matrix-bound growth factors—such as bone morphogenetic proteins (BMPs) and transforming growth factor-beta (TGF- β)—which promote localized osteoinduction and active cell recruitment without eliciting immunogenic or foreign-body reactions [20, 22].

In the radiographic analysis, a medium effect size was detected for mesial MBL ($d = 0.54$, $p = 0.1911$). Although statistically non-significant, this effect size suggests that a larger sample size might reveal subtle localized variations in interproximal bone remodeling. Biologically, this localized trend is justified by differential graft remodeling kinetics at proximal crestal margins: whereas bovine-derived xenografts act as non-resorbable hydroxyapatite scaffolds that remain structurally static, autogenous dentin matrix undergoes gradual enzymatic turnover, which can temporarily influence early interproximal peak crest height maintenance. Nevertheless, short- to medium-term hard tissue dimensional stability remains clinically indistinguishable between autogenous dentin matrices and bovine-derived bone substitutes. This finding is corroborated by Li et al [21], who observed equivalent six-month horizontal ridge preservation, radiographic volumetric retention, and core bone mineral density between autogenous demineralized dentin matrix and xenografts, as well as Soliman et al. [23], who demonstrated comparable radiographic socket fill and interproximal marginal crest maintenance across modified dentin graft modalities.

In the present study, both treatment protocols preserved soft-tissue dimensions with minimal clinical alteration, yielding a mean change in KGW (ADDM: -0.30 ± 0.47 mm; DBBM: -0.35 ± 0.49 mm; $p = 0.7515$). Patient-reported outcomes further confirmed uneventful recovery; VAS pain scores declined rapidly by Day 7 (0.25 ± 0.55 vs 0.40 ± 0.68 ; $p = 1.0000$) and

resolved completely by Day 14 in all subjects. These positive soft-tissue and patient-centered metrics validate the feasibility of executing socket preservation without a barrier membrane as DBBM operates predominantly as a slow-resorbing osteoconductive scaffold. Omitting a membrane reduces technique sensitivity, shortens operative time, and avoids vertical flap advancement or extensive mucogingival manipulation ^[20, 22].

The biological basis for these outcomes lies in the intrinsic autogenous properties of ADDM. Because it is entirely host-derived, ADDM lacks non-self-antigenicity, thereby mitigating intense foreign-body inflammatory responses and permitting uneventful secondary intention epithelialization. These clinical findings align with recent studies reporting that dentin-derived grafts, whether used alone or in combined flapless protocols—consistently exhibit low postoperative morbidity, minimal patient discomfort, and stable soft-tissue contours during alveolar ridge preservation ^[21, 23].

4.1 Limitation

Certain limitations must be noted, including a 6-month evaluation window and a sample population restricted to maxillary premolar sites. Long-term studies evaluating osseointegration rates after implant placement, along with histological core analyses, are recommended to further characterize graft remodeling rates necessity emphasized by Li et al. ^[21], who noted that while short-term dimensional stability matches xenografts, cellular turnover and substitute substitution dynamics evolve over extended healing periods.

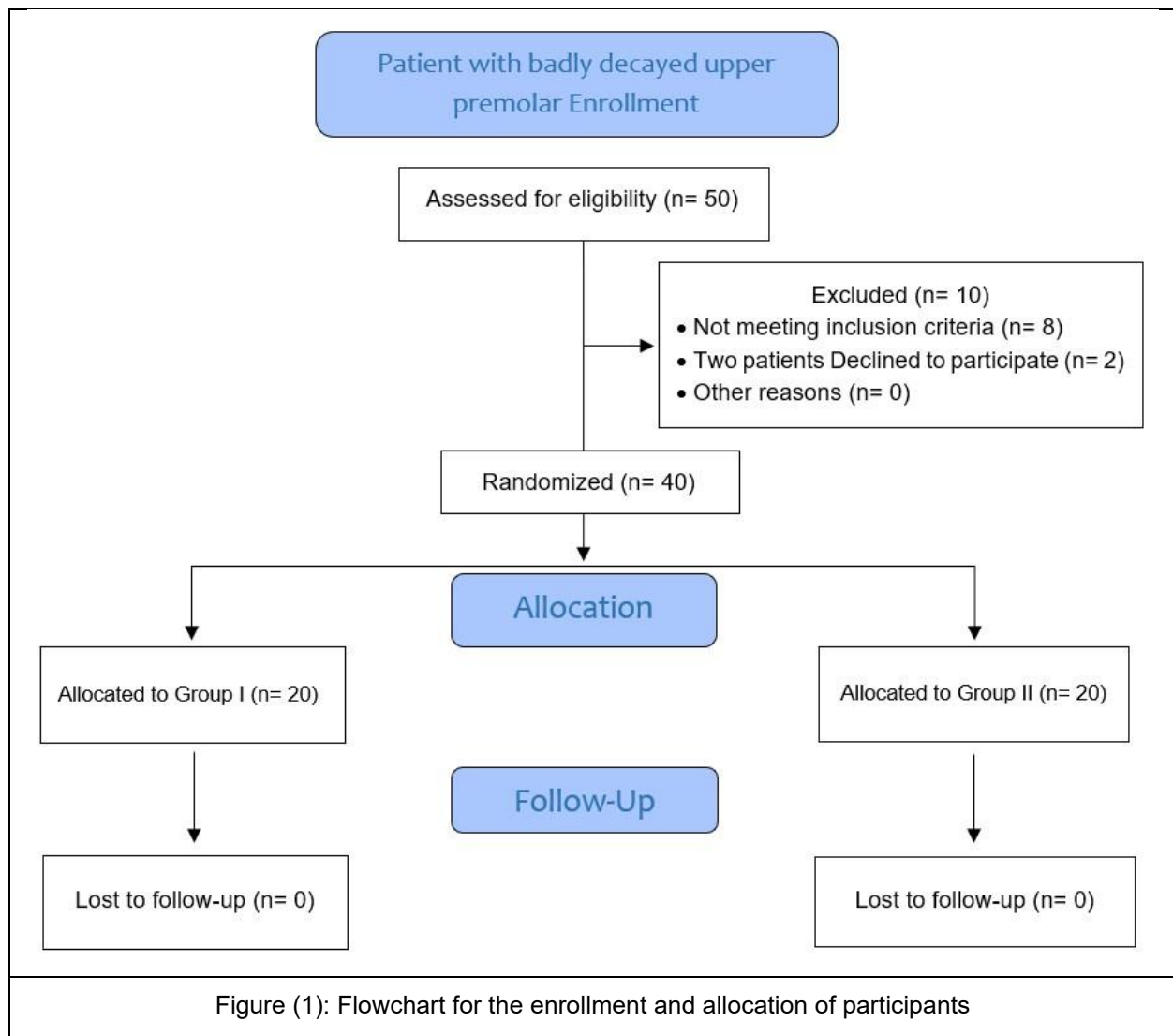
5. Conclusion

Overall, these findings demonstrate that chairside-processed ADDM serves as a predictable, safe, and cost-effective alternative to commercial xenografts for socket preservation. This directly aligns with Jalůvka et al. ^[20], who confirmed in their review that autogenous dentin significantly mitigates alveolar ridge resorption compared to un-grafted sockets without eliciting foreign-body reactions, and El-Ghareeb et al. ^[22], who validated the clinical safety, high biocompatibility, and economic viability of dentin-derived matrix protocols in socket management.

Clinical Relevance:

Autogenous demineralized dentin matrix (ADDM) demonstrated clinical and radiographic outcomes comparable to deproteinized bovine bone mineral (DBBM) for membrane-free

socket preservation. ADDM may therefore provide a feasible host-derived alternative to commercially available xenografts while maintaining alveolar ridge dimensions and favorable postoperative healing. Its use could also allow extracted teeth to be repurposed as graft material, potentially reducing dependence on commercially manufactured grafts.



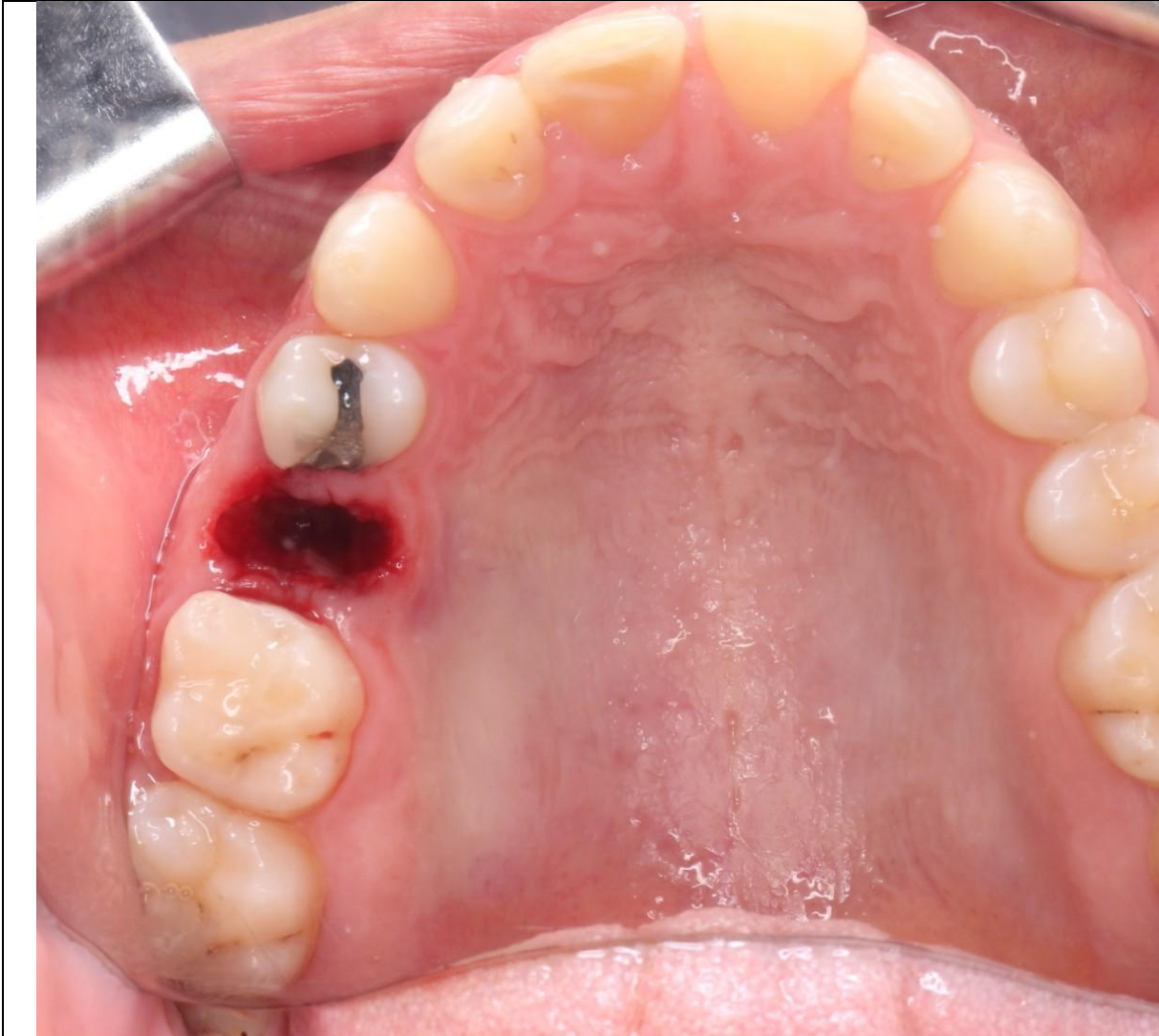


Figure (2): Fresh extraction socket for the maxillary right 2nd premolar



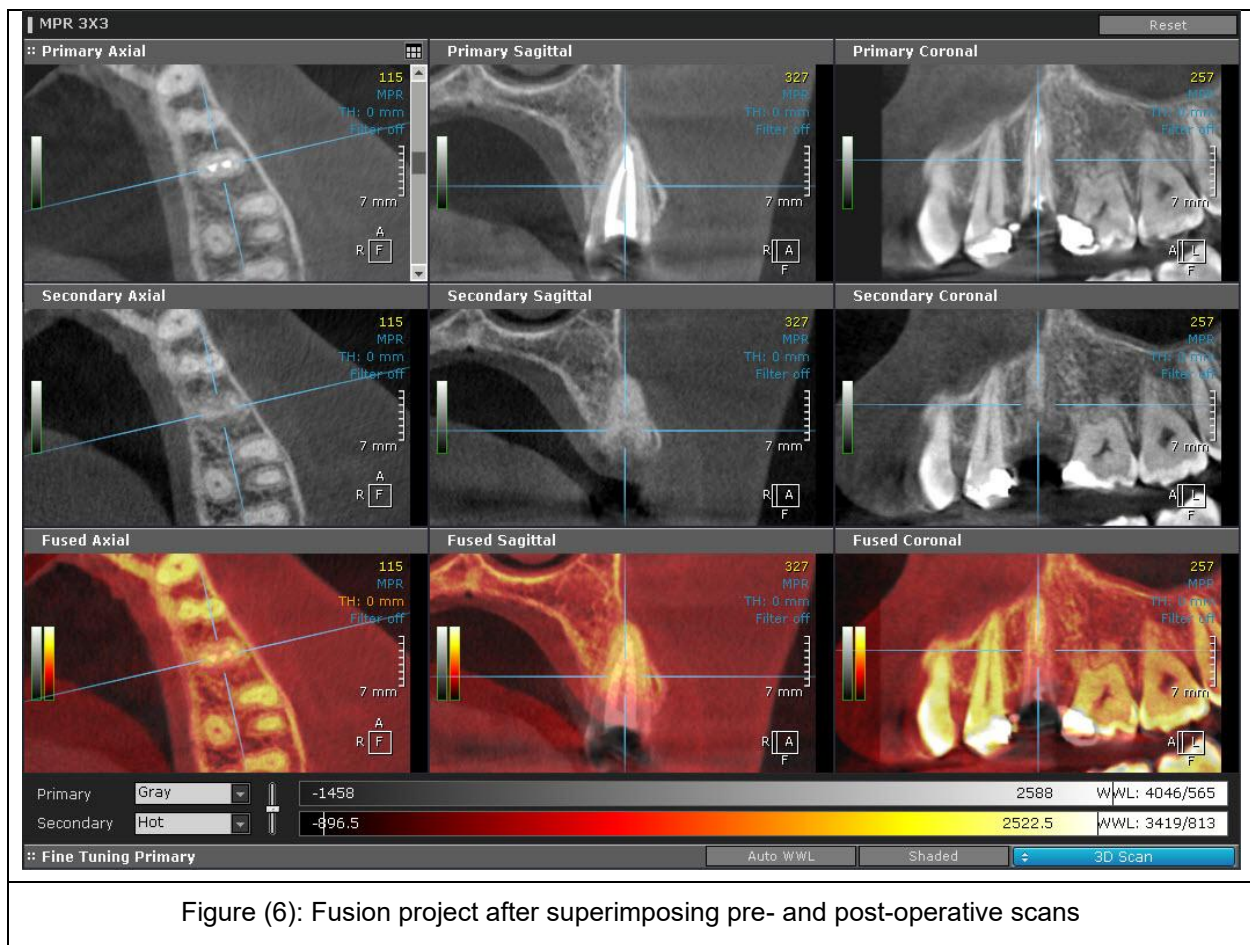
Figure (3): Clean 300–1200 μ m dentin particles



Figure (4): Sterilized Dentin Particles



Figure (5): Packing the Graft Material into the socket to the crestal bone level



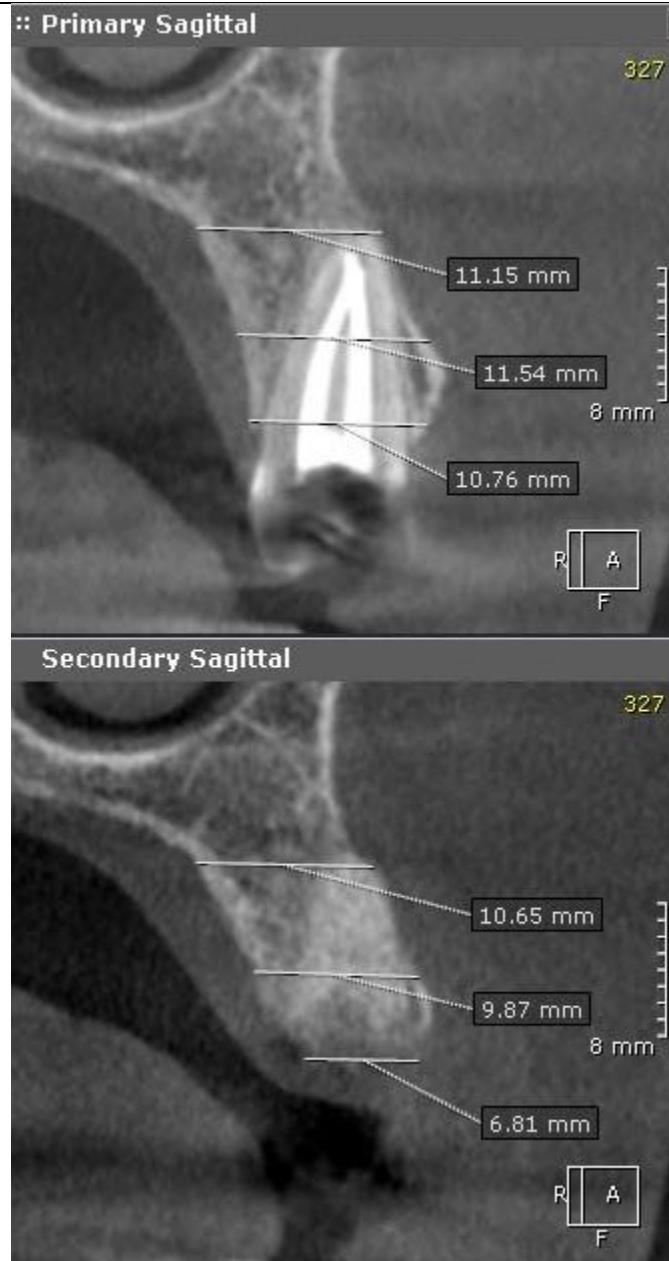


Figure (7): The bucco-lingual ridge width at the level of the crest of the alveolar bone, the midpoint, and the apex of the extraction socket

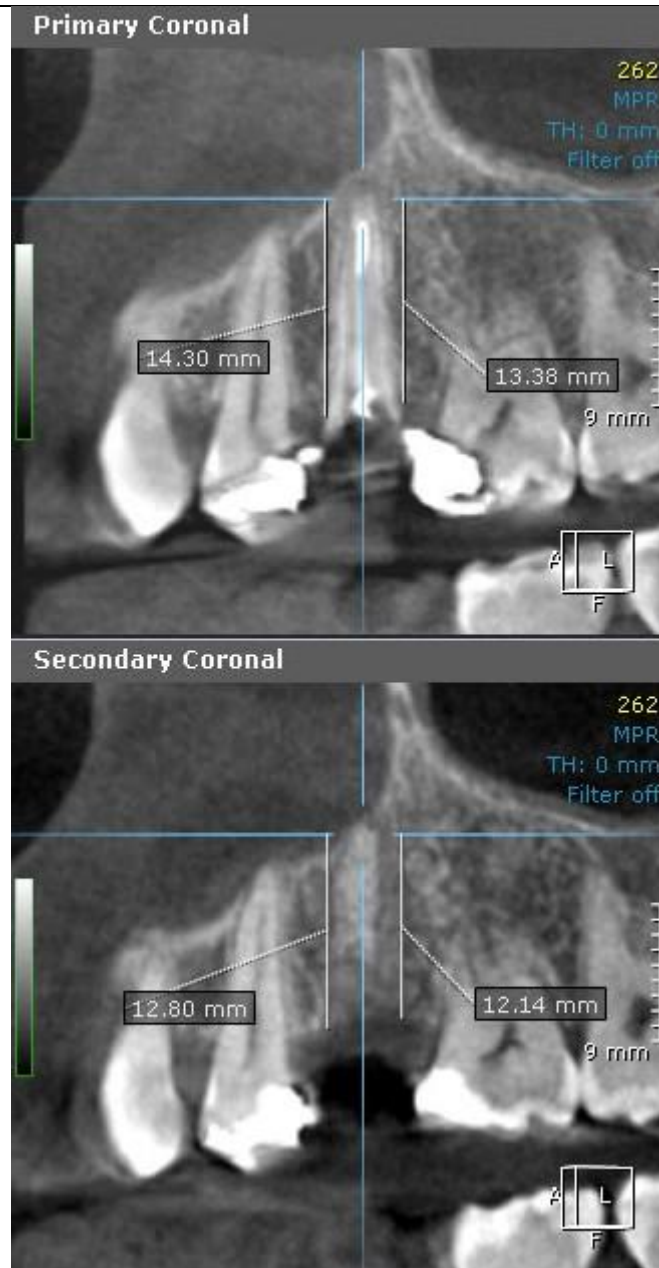


Figure (8): The marginal bone loss at the mesial and distal aspects of the extraction socket

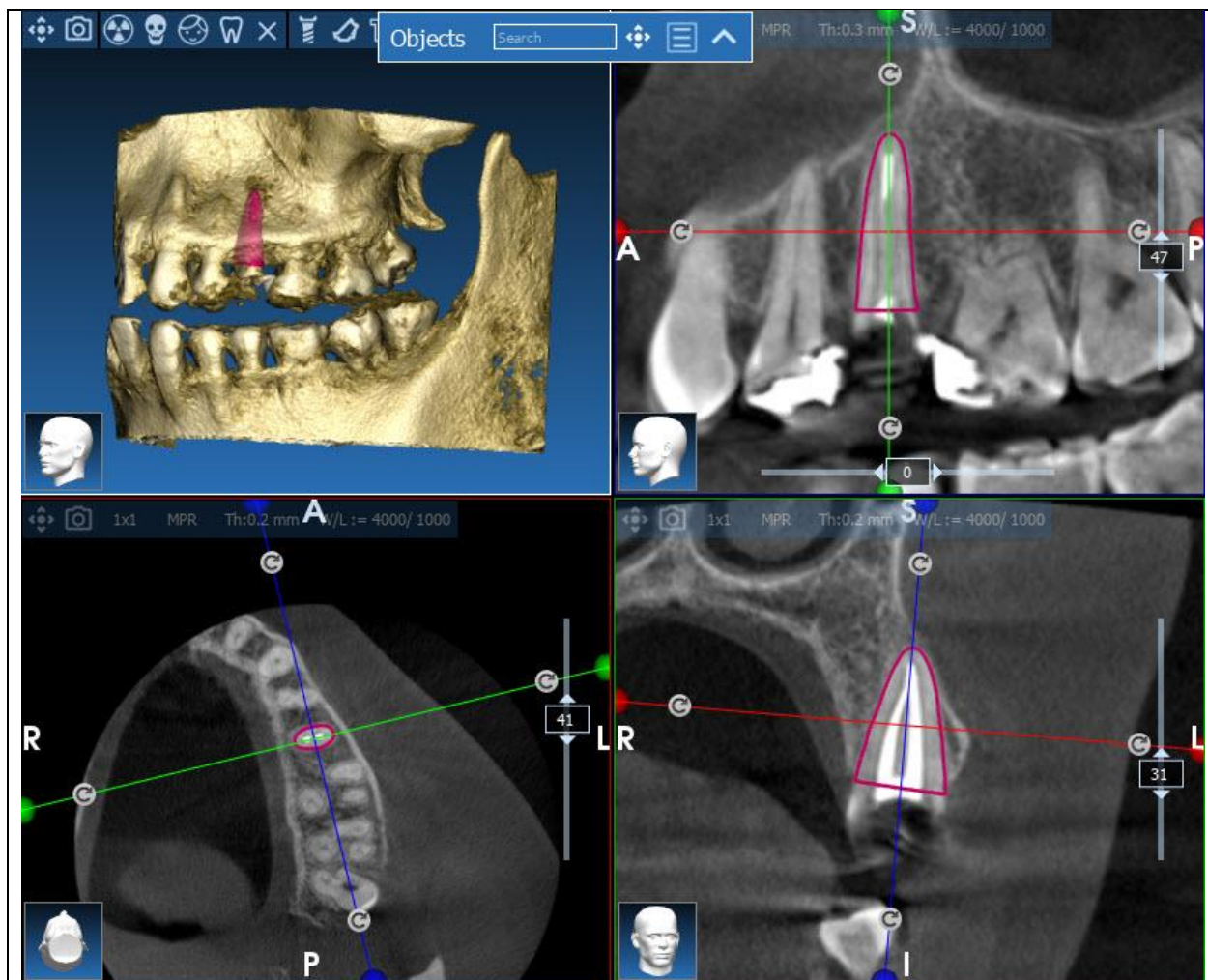


Figure (9): The bone volume of the extraction socket

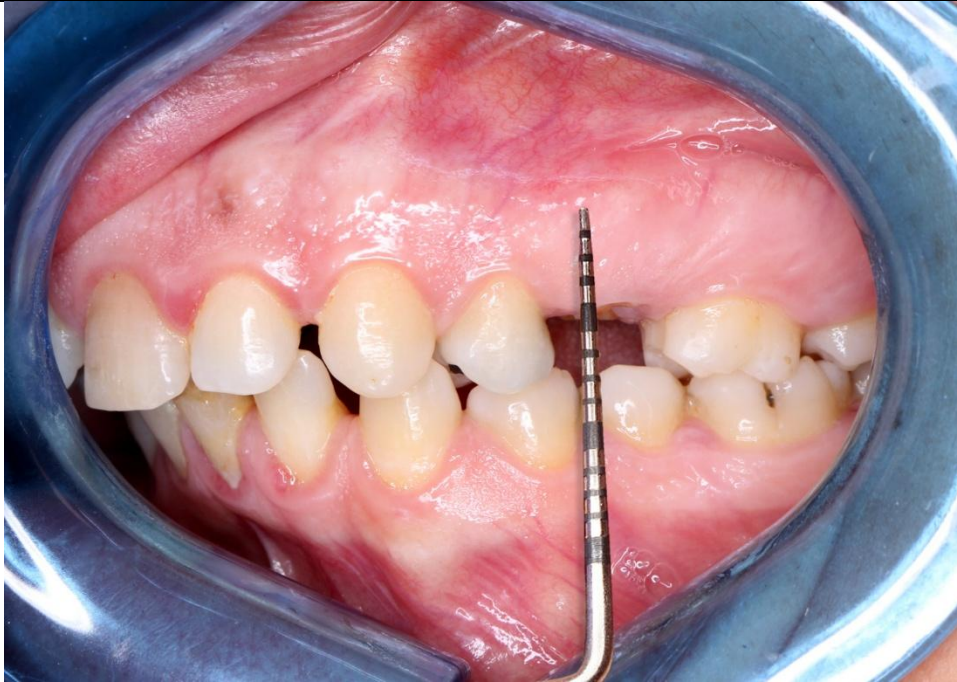


Figure (10): The keratinized gingival width measured with a calibrated periodontal probe

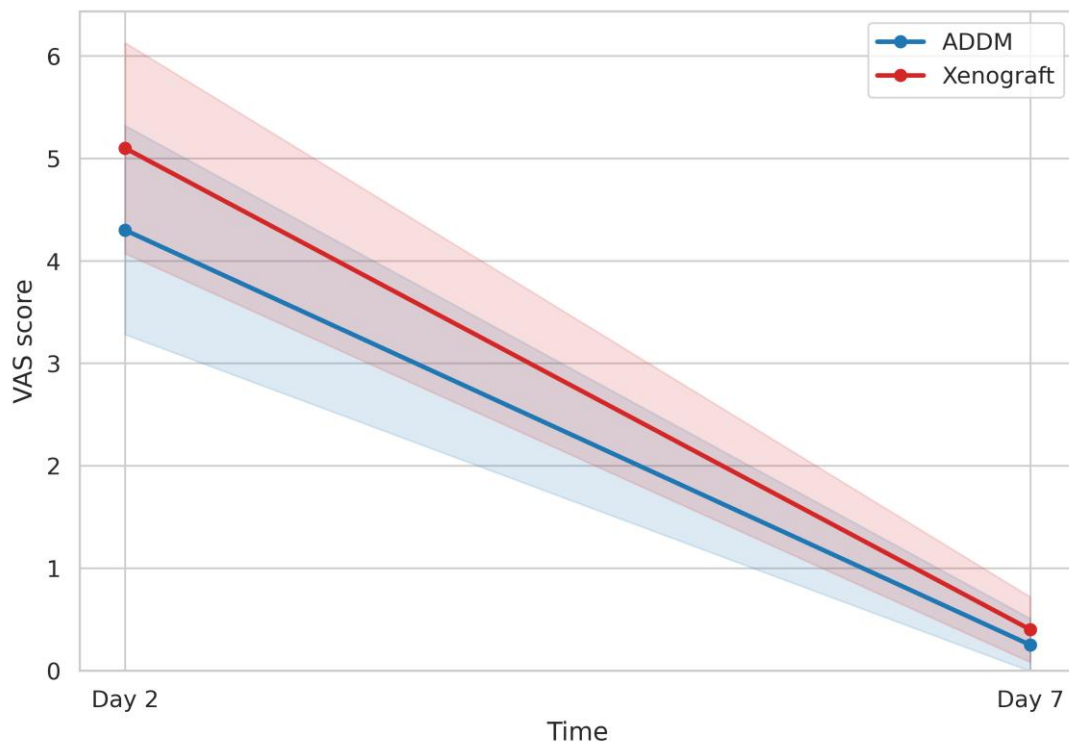


Figure (11): Postoperative pain assessment over time

Table (1): The preoperative demographic data between groups				
		Test Group receiving socket preservation with ADDM (n=20)	Control Group receiving DBBM xenograft (n=20)	Significance (p-value)
Age (years)	Mean $\pm$ SD	42.95 $\pm$ 8.11	43.40 $\pm$ 7.58	0.857
Gender (%)	Male	6 (30.0%)	10 (50.0%)	0.333
	Female	14 (70.0%)	10 (50.0%)	

Table (2): The intra-group comparison of the bucco-lingual alveolar ridge width					
Level	Group	Preoperative	Postoperative	Mean Change	p-value
Crest	ADDM	6.85 $\pm$ 0.80	6.32 $\pm$ 0.80	-0.53 $\pm$ 0.17	p = <0.0001
	Xenograft	6.70 $\pm$ 0.76	6.26 $\pm$ 0.81	-0.44 $\pm$ 0.16	p = <0.0001
Middle	ADDM	6.84 $\pm$ 0.58	6.48 $\pm$ 0.59	-0.36 $\pm$ 0.13	p = 0.0001
	Xenograft	7.00 $\pm$ 0.70	6.65 $\pm$ 0.76	-0.36 $\pm$ 0.14	p = 0.0001
Apex	ADDM	7.14 $\pm$ 0.67	7.04 $\pm$ 0.67	-0.10 $\pm$ 0.10	p = 0.0018
	Xenograft	7.16 $\pm$ 0.75	7.04 $\pm$ 0.76	-0.12 $\pm$ 0.09	p = 0.000

Table (3): The inter-group comparison of the bucco-lingual alveolar ridge width					
Group	Level	Between-group Difference	95% CI	p-value	Effect Size
ADDM	Crest	-0.09	-0.20 to 0.02	0.2760	-0.55 (Cohen's d)
Xenograft					
ADDM	Middle	0.05	NA	0.9013	0.02 (Rank-biserial correlation)
Xenograft					
ADDM	Apex	0.00	NA	0.7282	0.17 (Rank-biserial correlation)
Xenograft					

Table (4): The inter-group comparison of marginal bone loss					
Group	Level	Between-group Difference	95% CI	p-value	Effect Size
ADDM	Mesial	0.11	-0.02 to 0.23	0.1911	0.54 (Cohen's d)
Xenograft					
ADDM	Distal	0.10	NA	0.6362	0.09 (Rank-biserial correlation)
Xenograft					

Table (5): The intra- and inter-group comparison of bone volume		
Parameter	ADDM	Xenograft
Preoperative	2959.58 ± 446.02	3068.40 ± 342.86
Postoperative	2834.91 ± 462.79	2949.55 ± 336.60
Mean Change	-124.67 ± 61.38	-118.85 ± 57.59
p-value	p < 0.0001	p = 0.0001
Between-group Difference	-14.00	
95% CI	NA	
p-value	0.4246	
Effect Size	-0.15 (Rank-biserial correlation)	

Table (6): The intra- and inter-group comparison of keratinized tissue width		
Parameter	ADDM	Xenograft
Preoperative	3.75 ± 0.79	3.65 ± 0.88
Postoperative	3.45 ± 0.76	3.30 ± 0.73
Mean Change	-0.30 ± 0.47	-0.35 ± 0.49
p-value	0.0143	0.0082
Between-group Difference	0.00	

95% CI	NA
p-value	0.7515
Effect Size	0.05 (Rank-biserial correlation)

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Competing interests

The authors declare no competing interests.

Ethics approval and consent to participate

The study was conducted in accordance with the Declaration of Helsinki and was approved by the Ethics Committee the Institutional Ethics Committee of Delta University for Science and Technology, (Approval No. DU:125052221; agreed in June 2025). Written informed consent was obtained from all participants before their inclusion in the study. The trial adhered to ethical guidelines for clinical research, ensuring patient confidentiality and the safety of all participants throughout the study.

Consent for publication

“Not applicable.”

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Clinical trial number

The study was registered on (<http://www.clinicaltrials.gov>: (NCT07777588) Retrospectively registered. on 15/08/2026) and the the date of study start was 28/06/2025 and study completion was 22/04/2026)

Data availability

The data that support the findings of the current study are available from corresponding author upon resonable request.

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