Oral and Implantology

A Journal of Innovations and Advanced Techniques for Oral Health

Vol. 18 | No. 1 | 2026 | pp. 41-51 | eISSN 2035-2468

Open Access

CC BY 4.0

Edikta srl

Comparative evaluation of three-dimensional bone volume and density following indirect sinus floor augmentation with venous blood, injectable PRF, and alloplastic graft: a randomized controlled clinical trial

Mallikarjuna Ragher, Sanath Kumar Shetty, Rajesh Shetty, Savitha Dandekeri, Nafiya Abdul Aziz, Sunaina M

Yenepoya (Deemed to be University), University Road, Deralakatte, Mangalore, Karnataka, India

** Corresponding author: Mallikarjuna Ragher - ragher@yenepoya.edu.in*

Abstract

Background

The rehabilitation of the posterior maxilla utilizing dental implants is often constrained by diminished residual bone height and suboptimal bone quality. Transcrestal (indirect) sinus floor augmentation has been proposed as a method to promote bone formation; however, comprehensive three-dimensional evidence comparing autologous and synthetic grafting strategies remains scarce.

Objective

To evaluate and compare three-dimensional endo-sinus bone volume and regional bone density following indirect sinus floor augmentation utilizing blood clot alone, venous blood, injectable platelet-rich fibrin (I-PRF), and an alloplastic graft material.

Methods

This prospective, parallel-arm, randomized controlled clinical trial involved 64 participants with a posterior maxillary residual ridge height of 4–6 mm. Participants were randomly assigned through computer-generated block randomization into four groups (n = 16 per group): (1) blood clot (no graft), (2) venous blood, (3) I-PRF, and (4) alloplastic graft (NovaBone® dental putty). All subjects underwent crestal indirect sinus floor elevation utilizing the CAS kit with concurrent implant placement. A standardized volume of 0.5 cc of the allocated material was administered prior to the insertion of the implant.

The three-dimensional endo-sinus bone volume, which involves coronal and sagittal segmentation across consecutive CBCT slices, and regional bone density, evaluated in Hounsfield units at designated apical, buccal, and palatal sites, were assessed at six months utilizing Planmeca Romexis® software by a blinded examiner. The sample size was determined through an a priori power analysis. Intergroup comparisons were conducted using one-way ANOVA coupled with Tukey's post-hoc tests ($\alpha = 0.05$).

Results

Significant differences were observed among groups for coronal and sagittal bone volume ($P<.001$), with the alloplastic graft group demonstrating the highest volumetric bone formation. Regional bone density differed significantly at apical, buccal-apical, and palatal-apical regions ($P<.001$), with higher density values in the alloplastic group. No statistically significant differences were observed in mid-sinus regions. Venous blood and I-PRF showed modest increases compared with blood clot alone, with no significant difference between these two groups in most regions.

Conclusion

Alloplastic graft-assisted indirect sinus floor augmentation exhibited a statistically significant increase in three-dimensional bone volume and superior apical bone density at six months when compared to autologous techniques and blood clot alone. These findings suggest a potential advantage of synthetic grafting materials; however, further research is required to evaluate long-term clinical outcomes.

Keywords: Indirect sinus floor augmentation; Injectable platelet-rich fibrin; Alloplastic bone graft.

Article History

Received: January 6, 2026

Accepted: April 23, 2026

Published: June 15, 2026

DOI

https://doi.org/10.11138/oi.v18i1.206

Journal Info

eISSN 2035-2468

Peer Review: Double-blind

Published: quarterly

How to Cite

Mallikarjuna Ragher, Sanath Kumar Shetty, Rajesh Shetty, Savitha Dandekeri, Nafiya Abdul Aziz, Sunaina M: Comparative evaluation of three-dimensional bone volume and density following indirect sinus floor augmentation with venous blood, injectable PRF, and alloplastic graft: a randomized controlled clinical trial.
Oral and Implantology. 2026;18(1):41-51.
doi:10.11138/oi.v18i1.206

Introduction

The posterior maxilla frequently exhibits limited residual bone height and compromised bone quality, attributable to maxillary sinus pneumatization and progressive alveolar ridge resorption. These conditions may pose challenges to implant placement and long-term success.[1-4] To mitigate these anatomical limitations, various sinus augmentation techniques and biomaterials have been documented. The transcrestal (indirect) sinus lift, initially popularized by Summers and subsequently refined using hydraulic systems, osteotomes, and specialized minimally invasive kits, facilitates elevation of the Schneiderian membrane with reduced morbidity and permits simultaneous implant placement compared with lateral window approaches.[5-7] Autologous platelet concentrates, notably injectable platelet-rich fibrin (I-PRF), secrete growth factors and serve as biological scaffolds that promote angiogenesis and osteogenesis, as first reported by Choukroun and colleagues in regenerative and peri-implant therapy contexts.[8] Conversely, alloplastic materials such as calcium phosphosilicate putty (NovaBone®) offer an osteoconductive scaffold that stabilizes the clot and fosters bone ingrowth.[9] Nonetheless, the necessity of grafting materials in indirect sinus elevation remains a matter of debate. Systematic reviews and meta-analyses by Al-Moraissi et al. (2020) and Starch-Jensen et al. (2018) have indicated no consistent superiority of grafted over non-grafted transcrestal sinus augmentation with respect to bone height gain and implant survival. Cricchio et al. (2014) demonstrated that a stabilized blood clot alone may suffice to promote osseous formation.[10-12] However, much of the existing literature predominantly depends on two-dimensional linear measurements, with limited randomized clinical data evaluating three-dimensional volumetric bone formation and site-specific bone density. Accordingly, this randomized clinical study was designed to compare outcomes among no graft (blood clot), venous blood, injectable PRF, and an alloplastic graft in patients with posterior maxillary residual bone heights of 4–6 mm undergoing transcrestal (CAS-kit/hydraulic) sinus floor elevation. The study aimed to assess three-dimensional endosinus bone volume and regional bone density at an early healing interval of six months, a timeframe of clinical relevance. The hypothesis posited that the alloplastic graft would produce significantly greater three-dimensional bone volume and higher regional bone density compared to autologous approaches and blood clot alone, thereby providing quantitative evidence to inform material selection and enhance the predictability of indirect sinus augmentation procedures.

Materials and Methods

Study design and ethical approval

A prospective, randomized, single-centre clinical trial with four parallel arms was conducted. Ethical approval from the institutional review board and informed consent from participants were secured prior to patient enrollment.

Sample size and participants

The sample size calculation conducted using G*Power employed an effect size f of 0.5, an alpha level of 0.05, and 90% power to detect differences among four groups, resulting in a total sample size of 64 (16 per group). The procedures for inclusion and exclusion criteria, participant recruitment, and the collection of participant information and consent were carried out in accordance with the protocol.

Inclusion criteria:

The maxillary posterior ridge has successfully healed, despite the absence of a premolar or molar; residual bone height measures between 4 and 6 mm; crestal width ranges from 6 to 8 mm; and oral hygiene is maintained satisfactorily.

Exclusion criteria:

Systemic conditions such as uncontrolled diabetes mellitus, bleeding disorders, active sinusitis, sinus membrane thickness exceeding 2 mm, current smokers, pregnancy, and other related factors.

Randomization and grouping:

Participants were randomly allocated into four groups (n = 16 for each group):

- Group 1- Indirect sinus augmentation without graft (blood clot).
- Group 2 - Indirect sinus augmentation using 0.5 cc venous blood.
- Group 3- Indirect sinus augmentation using 0.5 cc I-PRF (yellow liquid fraction).
- Group 4- Indirect sinus augmentation using 0.5 cc alloplastic graft (NovaBone® Dental Putty).

Surgical procedure

A single experienced clinician executed all procedures under local anesthesia following standard aseptic techniques. After the crestal incision and flap reflection, osteotomy preparation was performed using a pilot drill and a twist drill, leaving approximately 1 mm of residual bone. The CAS crestal approach kit, consisting of the CAS drill, stopper system, depth gauge,

https://doi.org/10.11138/oi.v18i1.206

and hydraulic lifter, was used to detach the membrane; hydraulic elevation was achieved by injecting 0.3–0.5 mL of saline with a 2 mL syringe to raise the membrane approximately 5 mm. The designated material (0.5 cc) was introduced with a bone carrier/delivery gun and gently condensed. Implants, selected according to residual bone dimensions, were placed during the same appointment, and the site was sutured. Postoperative administration of antibiotics (amoxicillin), analgesics, and chlorhexidine rinses was prescribed in accordance with protocol.

I-PRF and blood collection protocol

Venous blood was collected from the antecubital fossa. For the preparation of I-PRF, 10 mL of venous blood was immediately subjected to centrifugation at 60 g RCF (approximately 700 rpm) for a duration of 3 minutes. The upper yellow fraction of liquid (approximately 0.5 cc), located above the buffy coat, was carefully harvested for use in augmentation.

Fig. 1: I-PRF preparation schematic (centrifuge settings 700 rpm / 3 min) and harvested the yellow fraction.

Radiographic assessment and volumetric/density measurements

CBCT images (pre-operative and six-month follow-up), exported in DICOM format, were analyzed utilizing Planmeca Romexis® software through manual segmentation. For volumetric assessment, the perimeter of the newly established endosinus bone was delineated on three consecutive coronal and sagittal slices, with the software subsequently calculating the volume in cubic millimeters. For density evaluation: Hounsfield Unit (HU) measurements were recorded at predetermined locations—above the implant apex, at the apex (mesial and distal), at the midpoint between the sinus floor and the implant apex (mesial and distal), and anterior to the sinus floor (mesial and distal). Additional measurements were obtained at the buccal and palatal surfaces, including superficial, middle, and apical regions.

https://doi.org/10.11138/oi.v18i1.206

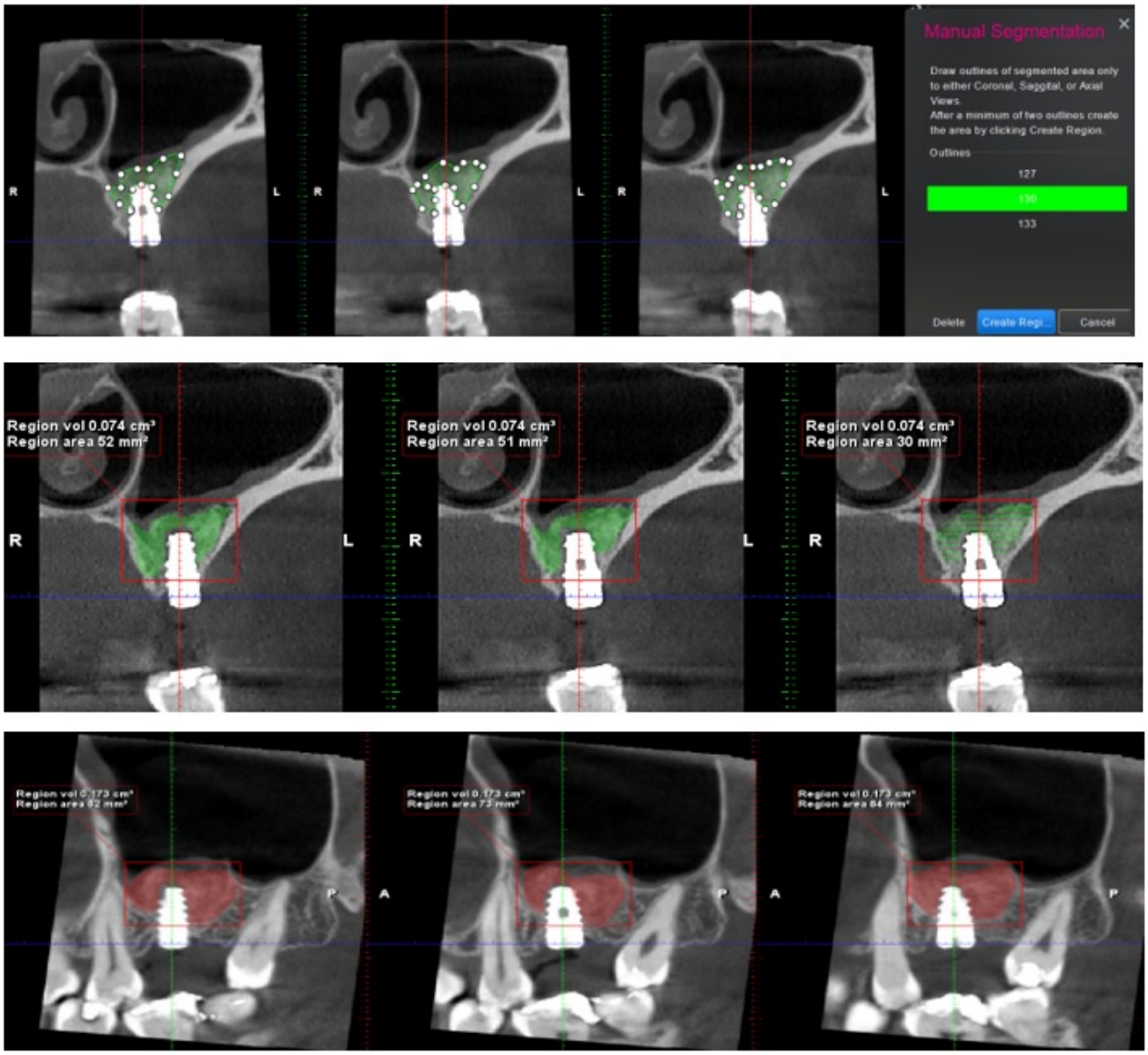

Fig. 2: CBCT segmentation example (coronal and sagittal slices and segmented endo-sinus volume).

Outcomes

Primary outcomes: coronal and sagittal endo-sinus bone volume (mm³) at 6 months, and regional bone density (HU) at the measured points. Secondary outcomes: variability (coefficients of variation) and pairwise group differences.

Statistical analysis

Continuous variables were summarized as mean ± SD; one-way ANOVA was used to compare groups for each endpoint, with Tukey post hoc pairwise comparisons. The significance threshold was set at $\alpha = 0.05$. All analyses were conducted using IBM SPSS Statistics for Windows (v23.0). The statistical outputs provided (ANOVA and Tukey tables) were utilized to compile the Results.

Results

A total of 64 participants (n = 16 per group) were randomized, and all completed the 6- month radiographic follow-up, with no dropouts or protocol deviations; implant survival and clinical parameters were analyzed separately. Significant intergroup differences were observed for both coronal and sagittal endosinus bone volumes (one- way ANOVA, P<.001), with mean ± standard deviation coronal volumes of 14. 56 ± 4. 47 mm ³ (no graft), 17. 38 ± 12. 51 mm ³ (venous blood), 23. 00 ± 15. 74 mm ³ (I- PRF), and 51. 25 ± 31. 87 mm ³ (alloplast). Post hoc Tukey testing demonstrated that the alloplastic group exhibited significantly greater volumetric bone formation than the no-graft, venous blood, and I-PRF groups (all P < .001), whereas no statistically significant differences were detected among the first three groups; sagittal volumes showed a similar pattern.

https://doi.org/10.11138/oi.v18i1.206

Effect size analysis indicated a substantial group effect (η^2), suggesting that the treatment modality accounted for a considerable proportion of the variance in volumetric outcomes. Median values and interquartile ranges demonstrated distribution patterns consistent with the mean data, with the alloplastic group exhibiting greater dispersion and right- skewed distributions. Regarding bone density, the apical region showed a progressive increase across groups, with significantly higher values in the alloplastic group compared to the other three groups (P<.05), and significantly higher values in the I-PRF group compared to the no-graft and venous blood groups. Buccal superficial and middle third regions did not show significant intergroup differences; however, the buccal apical region showed significantly greater density in the alloplastic and I-PRF groups relative to the no-graft and venous blood groups, with additional significant differences between the I-PRF and alloplastic groups. At palatal sites, superficial density was significantly higher in the alloplastic group than in the no-graft group; mid-third values did not differ significantly. In the palatal apical region, the alloplastic group again showed the highest density, significantly surpassing the other three groups, with I-PRF demonstrating higher values than the no-graft and venous blood groups. Coefficients of variation increased progressively from the no- graft to the alloplastic group for both volumetric and density outcomes, indicating greater heterogeneity in healing responses at grafted sites, likely reflecting variations in local anatomy and individual biological healing processes.

Descriptive Statistics

Parameters	Group	Mean	Std. Deviation	Coefficient of variation	ANOVA
Coronal	Group 1	14.563	4.472	0.307	
	Group 2	17.375	12.511	0.720	
	Group 3	23.000	15.735	0.684	
	Group 4	51.250	31.872	0.622	*<0.001*
Sagittal	Group 1	15.125	7.580	0.501	
	Group 2	19.125	15.301	0.800	*<0.001*
	Group 3	24.500	18.214	0.743	
	Group 4	59.188	43.367	0.733	

Post Hoc Comparisons for Volume – Coronal

		Mean Difference	SE	df	t	ptukey
Group 1	Group 2	-2.812	6.708	60	-0.419	0.975
Group 1	Group 3	-8.437	6.708	60	-1.258	0.593
Group 1	Group 4	-36.687	6.708	60	-5.469	*< .001*
Group 2	Group 3	-5.625	6.708	60	-0.839	0.836
Group 2	Group 4	-33.875	6.708	60	-5.050	*< .001*
Group 3	Group 4	-28.250	6.708	60	-4.211	*< .001*

Post Hoc Comparisons for Volume – Sagittal

		Mean Difference	SE	df	t	ptukey
Group 1	Group 2	-4.000	8.846	60	-0.452	0.969
Group 1	Group 3	-9.375	8.846	60	-1.060	0.715
Group 1	Group 4	-44.063	8.846	60	-4.981	*< .001*
Group 2	Group 3	-5.375	8.846	60	-0.608	0.929
Group 2	Group 4	-40.063	8.846	60	-4.529	*< .001*
Group 3	Group 4	-34.688	8.846	60	-3.921	*0.001*

Table 1. Endo-sinus volumetric outcomes (coronal and sagittal) — Mean ± SD by group; ANOVA P; Tukey pairwise comparisons.

https://doi.org/10.11138/oi.v18i1.206

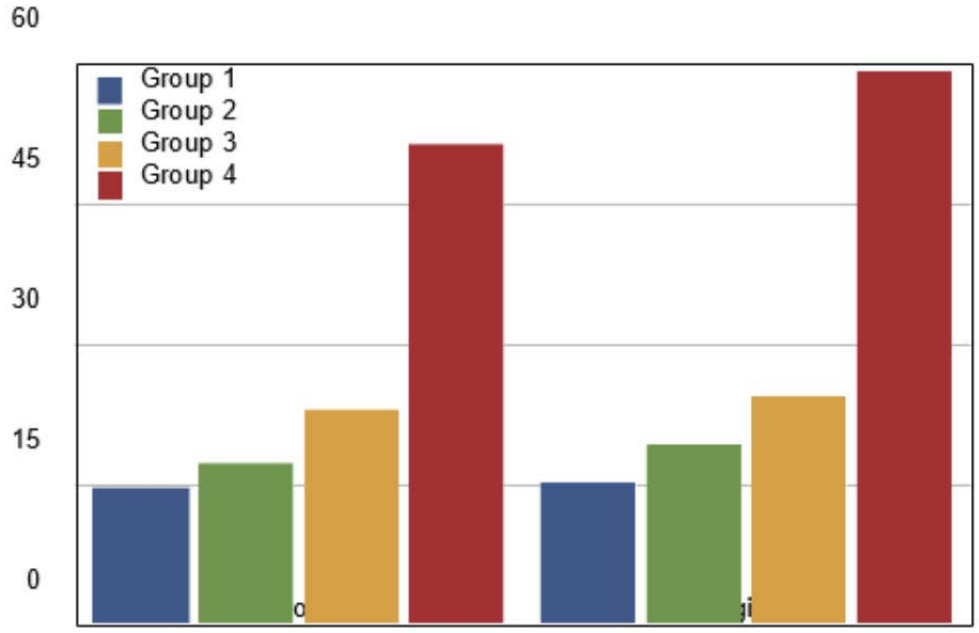

Fig. 3: Mean coronal and sagittal endo-sinus volumes (mm³) by group (Groups 1–4).

Descriptive Statistics

Parameters	Group	Mean	Std. Deviation	Coefficient of variation	ANOVA
Apex	Group 1	44.125	99.985	2.266	*<0.001*
	Group 2	64.813	179.348	2.767	
	Group 3	351.125	415.065	1.182	
	Group 4	640.000	233.200	0.364	
Buccal – SF	Group 1	688.063	218.297	0.317	0.104
	Group 2	691.875	366.032	0.529	
	Group 3	789.000	256.016	0.324	
	Group 4	911.875	322.630	0.354	
Buccal – M	Group 1	642.813	185.748	0.289	0.365
	Group 2	679.250	396.566	0.584	
	Group 3	704.000	216.201	0.307	
	Group 4	811.125	268.411	0.331	
Buccal – A	Group 1	207.813	291.081	1.401	*<0.001*
	Group 2	175.813	282.592	1.607	
	Group 3	656.000	351.015	0.535	
	Group 4	1147.750	793.001	0.691	
Palatal – SF	Group 1	559.063	186.799	0.334	*0.019*
	Group 2	648.063	293.584	0.453	
	Group 3	757.250	278.449	0.368	
	Group 4	847.313	288.774	0.341	
Palatal – M	Group 1	571.875	183.097	0.320	0.166
	Group 2	628.750	337.536	0.537	
	Group 3	679.813	394.853	0.581	
	Group 4	826.938	365.721	0.442	

https://doi.org/10.11138/oi.v18i1.206

Descriptive Statistics					
Parameters	**Group**	**Mean**	**Std. Deviation**	**Coefficient of variation**	**ANOVA**
Palatal – A	Group 1	84.688	106.242	1.255	***<0.001***
	Group 2	143.125	236.083	1.649	
	Group 3	440.000	381.098	0.866	
	Group 4	749.313	335.864	0.448	

Table 2. Regional bone density (HU) — Apex, Buccal (SF/M/A), Palatal (SF/M/A) — Mean ± SD by group; ANOVA P; Tukey pairwise comparisons.

Post Hoc Comparisons – Apex						
		Mean Difference	**SE**	**df**	**T**	**Ptukey**
Group 1	Group 2	-20.687	93.202	60	-0.222	0.996
Group 1	Group 3	-284.875	93.202	60	-3.057	***0.017***
Group 1	Group 4	-534.750	93.202	60	-5.738	***< .001***
Group 2	Group 3	-264.188	93.202	60	-2.835	***0.031***
Group 2	Group 4	-514.063	93.202	60	-5.516	***< .001***
Group 3	Group 4	-249.875	93.202	60	-2.681	***0.046***

Table 3. Regional bone density (HU) — Apex; Tukey pairwise comparisons.

Post Hoc Comparisons - Buccal SF						
		Mean Difference	**SE**	**df**	**T**	**Ptukey**
Group 1	Group 2	-24.750	107.261	60	-0.231	0.996
Group 1	Group 3	-121.875	107.261	60	-1.136	0.669
Group 1	Group 4	-244.750	107.261	60	-2.282	0.114
Group 2	Group 3	-97.125	107.261	60	-0.906	0.802
Group 2	Group 4	-220.000	107.261	60	-2.051	0.181
Group 3	Group 4	-122.875	107.261	60	-1.146	0.663

Table 4. Regional bone density (HU) — Buccal (SF); Tukey pairwise comparisons.

Post Hoc Comparisons - Buccal M						
		Mean Difference	**SE**	**df**	**T**	**Ptukey**
Group 1	Group 2	-36.438	98.513	60	-0.370	0.983
Group 1	Group 3	-61.188	98.513	60	-0.621	0.925
Group 1	Group 4	-168.313	98.513	60	-1.709	0.328
Group 2	Group 3	-24.750	98.513	60	-0.251	0.994
Group 2	Group 4	-131.875	98.513	60	-1.339	0.542
Group 3	Group 4	-107.125	98.513	60	-1.087	0.699

Table 5. Regional bone density (HU) — Buccal (M); Tukey pairwise comparisons.

Post Hoc Comparisons - Buccal A						
		Mean Difference	**SE**	**df**	**T**	**Ptukey**
Group 1	Group 2	32.000	169.249	60	0.189	0.998
Group 1	Group 3	-448.188	169.249	60	-2.648	***0.049***
Group 1	Group 4	-939.938	169.249	60	-5.554	***< .001***
Group 2	Group 3	-480.188	169.249	60	-2.837	***0.031***

https://doi.org/10.11138/oi.v18i1.206

Post Hoc Comparisons - Buccal A						
		Mean Difference	SE	df	T	Ptukey
Group 2	Group 4	-971.938	169.249	60	-5.743	***< .001***
Group 3	Group 4	-491.750	169.249	60	-2.905	***0.026***

Table 6. Regional bone density (HU) — Buccal (A); Tukey pairwise comparisons.

Post Hoc Comparisons - Palatal SF						
		Mean Difference	SE	df	T	Ptukey
Group 1	Group 2	-89.000	93.877	60	-0.948	0.779
Group 1	Group 3	-198.188	93.877	60	-2.111	0.161
Group 1	Group 4	-288.250	93.877	60	-3.071	***0.016***
Group 2	Group 3	-109.188	93.877	60	-1.163	0.652
Group 2	Group 4	-199.250	93.877	60	-2.122	0.158
Group 3	Group 4	-90.062	93.877	60	-0.959	0.773

Table 7. Regional bone density (HU) — Palatal (SF); Tukey pairwise comparisons.

Post Hoc Comparisons - Palatal M						
		Mean Difference	SE	df	T	Ptukey
Group 1	Group 2	-56.875	116.875	60	-0.487	0.962
Group 1	Group 3	-107.938	116.875	60	-0.924	0.792
Group 1	Group 4	-255.063	116.875	60	-2.182	0.140
Group 2	Group 3	-51.063	116.875	60	-0.437	0.972
Group 2	Group 4	-198.188	116.875	60	-1.696	0.335
Group 3	Group 4	-147.125	116.875	60	-1.259	0.592

Table 8. Regional bone density (HU) — Palatal (M); Tukey pairwise comparisons.

Post Hoc Comparisons - Palatal A						
		Mean Difference	SE	df	T	Ptukey
Group 1	Group 2	-58.437	100.788	60	-0.580	0.938
Group 1	Group 3	-355.312	100.788	60	-3.525	***0.004***
Group 1	Group 4	-664.625	100.788	60	-6.594	***< .001***
Group 2	Group 3	-296.875	100.788	60	-2.946	***0.023***
Group 2	Group 4	-606.188	100.788	60	-6.014	***< .001***
Group 3	Group 4	-309.313	100.788	60	-3.069	***0.017***

Table 9. Regional bone density (HU) — Palatal (A); Tukey pairwise comparisons.

https://doi.org/10.11138/oi.v18i1.206

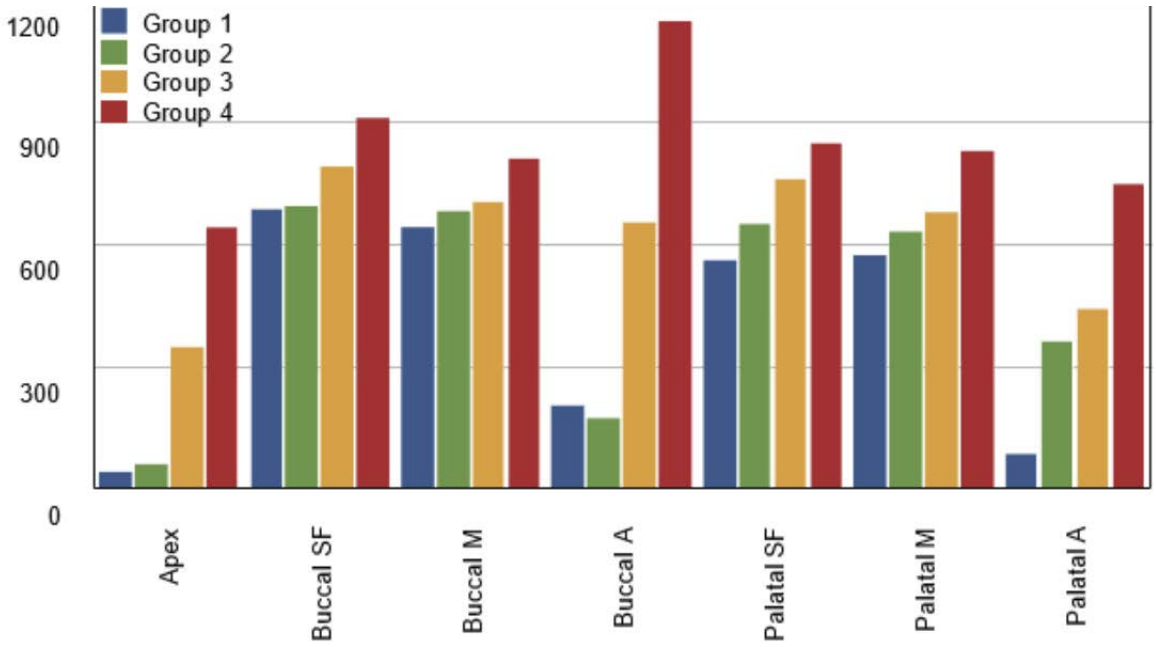

Fig. 4: Mean coronal and sagittal bone density by group (Groups 1–4).

Discussion

This randomized clinical trial evaluated three-dimensional volumetric bone formation and regional bone density following crestal sinus floor elevation performed using no graft, venous blood, injectable platelet-rich fibrin (I-PRF), and an alloplastic calcium phosphosilicate putty (NovaBone®. The principal finding was that the alloplast group demonstrated significantly greater endosinus volumetric bone formation and higher regional bone density values at the apical and apical buccal/palatal regions at 6 months. Nevertheless, these radiographic advantages should be interpreted cautiously, as increased volume and density do not necessarily translate into superior long-term implant survival or functional outcomes.

The improved volumetric preservation observed in the alloplast group may be ascribed to the osteoconductive and space-maintaining characteristics of calcium phosphosilicate materials, which offer a scaffold for new bone formation and stabilize the elevated sinus membrane during the initial healing phase. Comparable radiographic results have been documented by Rao et al. (2016), who demonstrated substantial CBCT-based increases in bone height and density with calcium phosphosilicate putty in sinus augmentation procedures. Malik et al. compared NovaBone® with a particulate xenograft (Bio-Oss®) and reported that although xenografts yielded marginally higher density values, NovaBone® attained equivalent clinical success. Furthermore, Sleman (2025) highlighted the versatility and predictable osteoconductivity of alloplasts such as bioactive glasses and calcium phosphates, especially when space maintenance is required. Nonetheless, systematic evidence indicates that radiographic superiority does not invariably translate into clinical superiority.

Importantly, the biological potential of non-grafted sinus elevation has been supported in the literature. Cricchio et al. demonstrated that a stabilized blood clot alone may be sufficient to induce bone formation after transcrestal sinus elevation, and meta-analyses by Al-Moraissi and Starch-Jensen have reported comparable implant survival rates between grafted and non-grafted approaches. These findings suggest that while graft materials may improve early radiographic outcomes, the success of implants may not be solely reliant on the utilization of biomaterials.

The I-PRF group in the present study exhibited modest improvements in volumetric and density parameters in comparison to the no-graft and venous blood groups, although most differences did not reach statistical significance. This observation reflects the biological but non-structural function of I-PRF. Choukroun et al. initially described platelet-rich fibrin as a second-generation platelet concentrate abundant in growth factors, including PDGF, TGF-β, and VEGF, and capable of enhancing angiogenesis and early osteogenesis. (8) Miron and Pikos (2018) reported that PRF alone may be sufficient for smaller sinus cavities (<10 mm) but may be inadequate for larger volumes due to rapid resorption and limited space maintenance. (13) Malcangi et al. (2023) concluded in their systematic review that, while platelet concentrates promote early vascularization and soft tissue healing, their impact on volumetric bone formation remains inconsistent unless combined with osteoconductive scaffolds.(14) Francisco et al. (2024) further demonstrated that PRF combined with NanoBone® resulted in greater

https://doi.org/10.11138/oi.v18i1.206

bone formation and vascularization than NanoBone® alone, thereby reinforcing the adjunctive role of PRF.

Regional density variations observed in this study warrant careful interpretation. Although the alloplast group consistently demonstrated higher HU values at the apex and apical buccal/palatal regions, no significant differences were noted at the buccal superficial, buccal mid, and palatal mid regions. These findings likely reflect the influence of local anatomic and biologic factors, including proximity to native bone, Schneiderian membrane activity, vascular supply, and localized mechanical environment. Density gains in the apical regions are clinically meaningful because these sites contribute to primary implant stability and early osseointegration, although radiographic density does not always directly correlate with true histologic bone quality.

From a clinical standpoint, the present findings suggest that alloplastic grafts such as NovaBone® may enhance early radiographic bone fill and density following transcrestal sinus elevation. However, clinicians should avoid assuming that these radiographic advantages automatically translate into superior long-term implant survival. No-graft and blood-clot–based techniques remain viable options, especially in patients with favorable anatomy and adequate residual bone height. Cost considerations are also relevant: alloplastic biomaterials impose an additional financial burden, whereas autologous blood- or clot-based approaches are more economical and eliminate concerns about foreign body reactions.

The strengths of this study include its randomized design, standardized CAS-kit hydraulic elevation technique, use of three-dimensional CBCT segmentation for volumetric analysis, and blinded, site-specific density measurements. Nonetheless, limitations must be acknowledged. The 6-month follow-up period was sufficient only for early radiographic assessment and did not allow evaluation of long-term volumetric stability, implant survival, or functional loading. Histologic confirmation of true bone formation was not feasible, and CBCT-derived Hounsfield unit values may be influenced by machine calibration and imaging parameters. Additionally, objective implant stability parameters such as insertion torque and resonance frequency analysis were not assessed.

Future investigations ought to encompass extended follow-up periods of 12–24 months, integrate histomorphometric assessments where ethically permissible, and establish correlations between radiographic findings and clinical parameters such as the Implant Stability Quotient (ISQ), insertion torque, prosthetic success, and patient-reported outcomes. The use of combination strategies involving osteoconductive scaffolds supplemented with autologous platelet concentrates may be a promising approach to optimize both volumetric stability and biological healing.
Overall, while calcium phosphosilicate putty demonstrated superior radiographic volumetric and density outcomes at 6 months, existing evidence suggests that long-term clinical implant success may not differ substantially from no-graft or blood-clot–based approaches. Well-designed, long-term randomized controlled trials with survival and functional endpoints are required before definitive clinical recommendations can be established.

Conclusion

The use of an alloplastic graft, specifically NovaBone® dental putty, for indirect sinus floor augmentation yielded the most substantial three-dimensional endo-sinus bone volume. Moreover, it was associated with increased regional bone density at the implant apex and the apical buccal/palatal regions after six months, when compared to venous blood, injectable platelet-rich fibrin (I-PRF), and the absence of grafting. Both injectable PRF and venous blood resulted in modest improvements over the no-graft approach, although no statistically significant differences were observed between these two autologous methods for most outcome parameters.

References

1. Demirkol M, Demirkol N. The effects of posterior alveolar bone height on the height of maxillary sinus septa. Surgical and Radiologic Anatomy. 2019 Sep 6;41[9]:1003-9. https://doi.org/10.1007/s00276-019-02271-2

2. Gerken U, Esser F, Möhlhenrich SC, Bartella AK, Hölzle F, Fischer H, Raith S, Steiner T. Objective computerised assessment of residual ridge resorption in the human maxilla and maxillary sinus pneumatisation. Clinical oral investigations. 2020 Sep;24[9]:3223-35. https://doi.org/10.1007/s00784-020-03196-6

3. Cavalcanti MC, Guirado TE, Sapata VM, Costa C, Pannuti CM, Jung RE, CÉSAR JB. Maxillary sinus floor pneumatization and alveolar ridge resorption after tooth loss: a cross-sectional study. Brazilian oral research. 2018 Aug 6;32:e64. https://doi.org/10.1590/1807-3107bor-2018.vol32.0064

4. Tatum Jr H. Maxillary and sinus implant reconstructions. Dental Clinics of North America. 1986 Apr 1;30[2]:207-29. https://doi.org/10.1016/S0011-8532[22]02107-3

https://doi.org/10.11138/oi.v18i1.206

5. Tatum Jr OH. Sinus augmentation. The New York state.;26.

6. Kühl S, Kirmeier R, Platzer S, Bianco N, Jakse N, Payer M. Transcrestal maxillary sinus augmentation: Summers' versus a piezoelectric technique-an experimental cadaver study. Clinical oral implants research. 2016 Jan;27[1]:126-9 https://doi.org/10.1111/clr.12546

7. Mehrotra S, Varghese J. Technical concepts in the management of posterior maxillary implants: a review update. Current Oral Health Reports. 2024 Mar;11[1]:40-58. https://doi.org/10.1007/s40496-023-00360-1

8. Choukroun J, Adda F, Schoeffer C, Vervelle A. PRF: an opportunity in perio-implantology. Implantodontie. 2000;42:55-62.

9. Richa Kaushik MD, Rajan Gupta MD, Parveen Dahiya MD, Mukesh Kumar MD. Comparative Evaluation of Two Alloplastic Graft Materials in Treatment of Infrabony Periodontal Defects. Group.;1(6.40):0-966.

10. Rao SG, Mehta S, Nayyar AS. Efficacy of Calcium Phosphosilicate (CPS) Putty As Alloplastic Bioactive Graft Material in Sinus Augmentation Procedures: An Original Study. Journal of Dentistry and Oral Implants. 2016 Sep 2;1[3]:27-54. https://doi.org/10.14302/issn.2473-1005.jdoi-16-1196

11. Malik D, Panwar M, Kosala M, Dias JJ. Comparative evaluation of efficacy of calcium silicophosphate putty versus particulate xenograft in maxillary sinus augmentation procedure: A clinical and tomographical study. Journal of the International Clinical Dental Research Organization. 2018 Jul 1;10[2]:76-80. https://doi.org/10.4103/jicdro.jicdro_4_18

12. Sleman N, Khalil A. A Comprehensive Review of Biomaterials for Maxillary Sinus Floor Augmentation: Exploring Diverse Bone Graft Options. The Open Dentistry Journal. 2025 Jul 21;19[1]. https://doi.org/10.2174/0118742106378788250715114923

13. Miron RJ, Pikos MA. Sinus augmentation using platelet-rich fibrin with or without a bone graft: what is the consensus. Compend Contin Educ Dent. 2018 Jun 1;39[6]:355-61.

14. Malcangi G, Patano A, Palmieri G, Di Pede C, Latini G, Inchingolo AD, Hazballa D, de Ruvo E, Garofoli G, Inchingolo F, Dipalma G. Maxillary sinus augmentation using autologous platelet concentrates (platelet-rich plasma, platelet-rich fibrin, and concentrated growth factor) combined with bone graft: a systematic review. Cells. 2023 Jul 6;12[13]:1797. https://doi.org/10.3390/cells12131797

15. Francisco L, Francisco M, Costa R, Vasques MN, Relvas M, Rajão A, Monteiro L, Rompante P, Guerra F, Infante da Câmara M. Sinus floor augmentation with synthetic hydroxyapatite (NanoBone®) in combination with platelet-rich fibrin: A case series. Biomedicines. 2024 Jul 25;12[8]:1661. https://doi.org/10.3390/biomedicines12081661

https://doi.org/10.11138/oi.v18i1.206