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Original Article

Dentistry Section

Comparative Evaluation of Bone Ring versus Particulate Bone Graft using CBCT in Buccal Bone Augmentation with Simultaneous Implant Placement: A Randomised Controlled Trial

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ABSTRACT

Introduction: Dental implant placement in defective sockets often compromises its predictability and long-term success. Although various techniques have been suggested for augmentation of defects around implants, the most recent advanced three-dimensional reconstruction technique is the Bone Ring Technique (BRT).

Aim: To compare and evaluate the buccal bone regenerative capacity of bone ring and particulate bone graft.

Materials and Methods: This randomised controlled parallel group trial was conducted at the Department of Periodontology, Karpaga Vinayaga Institute of Dental Sciences, Kancheepuram, Tamil Nadu, India, for a duration of six months, from August 2025 to February 2026. In the present study, among 24 edentulous sites, 12 were included in the Bone ring group (Group A), and 12 were included in the particulate graft group (Group B). Buccal height, palatal height and ridge width were assessed between baseline and six months. Wilcoxon Signed Ranks Test and Mann-Whitney U Test were used for intra- and intergroup comparison, respectively. The Statistical Package for Social Sciences (SPSS) software, version 21.0 was used, and $p<0.05$ was considered significant.

Results: The CBCT analysis before and after six months of implant placement showed that both group A and group B demonstrated significant height and width augmentation of buccal bone. While comparing the augmentation between group A and group B, group A showed significantly higher bone gain than group B, in both buccal height and width, with p-values of 0.037 and < 0.001, respectively.

Conclusion: The Bone Ring Technique (BRT) is a newer viable option for restoring complex defects around dental implants with three-dimensional bone augmentation.

Keywords: Alveolar ridge augmentation, Bony defect, Dental implants

INTRODUCTION

Successfully replacing missing natural teeth using osseointegrated implants may be challenging if residual bone is less [1]. Avulsion, traumatic extraction or prolonged post-extraction period would often lead to loss of buccal plate, leading to insufficient quantity of residual bone for implant placement [2]. When the buccal bone wall is less than 1 mm in the anterior maxilla, the thin bone wall will remodel and lead to significant buccal wall dehiscence at 8 weeks after tooth extraction [3]. El Nahass et al demonstrated that 77% of teeth in the anterior aesthetic zone showed a thin bony wall (<1 mm) [4]. To achieve long-term stable biologic and aesthetic outcomes, an intact and thick buccal bone wall (≥1 mm) is mandatory [5]. Thin resorbed ridges warrant bone augmentation before implant placement. Bone augmentation techniques like interpositional grafting, distraction osteogenesis, and ridge splitting demands two stage technique with delayed placement of the implant [6]. Although other bone augmentation techniques like guided bone regeneration can be combined with implant placement, they have limited ability to augment bone in both horizontal and vertical dimension, also it needs additional procedures and materials to stabilise the graft. Techniques like onlay grafting demand the harvest of a block graft from a secondary surgical site, which causes increased trauma [7].

To overcome the setback of earlier bone augmentation techniques, a novel technique known as the 'BRT' has been developed to augment the alveolar bone three-dimensionally with simultaneous implant placement [8]. This technique overcomes the earlier drawbacks; the implant itself acts as an anchorage to stabilise the grafted material. Moreover, the graft has a three-dimensionally stable morphology which allows bone to be augmented in both vertical and horizontal manner. Omara M et al., evaluated the consolidation of autogenous chin bone rings following augmentation of severely defective sockets and their clinical application in the premolar-molar region with simultaneous implant placement in a single-stage procedure, concluding that the autogenous BRT is a reliable approach [9]. However, existing studies have primarily employed autogenous or allogeneic bone rings. The present study addresses this gap by investigating the use of a xenogeneic bone ring. Therefore, the present study aimed to compare and evaluate the buccal bone regenerative capacity of bone ring and particulate bone graft.

MATERIALS AND METHODS

This randomised controlled parallel group trial was conducted at the Department of Periodontology, Karpaga Vinayaga Institute of Dental Sciences, Kancheepuram, Tamil Nadu, India, from August 2025 to February 2026. Approval from the Institutional Ethics Committee (IEC Approval No. KIDS/IEC/2024/II/014) was obtained before the study commenced. All the procedures followed were according to the Helsinki Declaration of 1975, which was revised in 2013. The trial was registered in the Clinical Trials Registry- India (CTRI) under the code (CTRI/2025/08/093762).

Inclusion criteria: Patients who were partially edentulous in the maxillary anterior region, willing to participate in the study, both

male and female patients aged between 20-60 years, who were systemically healthy with Salama type II socket defects [10] were included in the study.

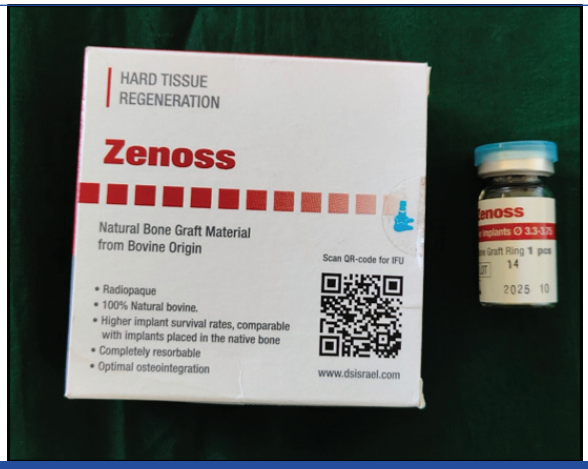
Exclusion criteria: Patients with any form of systemic illness, those under radiation therapy and those with habits like smoking and pregnant or lactating women were excluded.

Sample size calculation: G*Power software version 3.1 was used to obtain the sample size with α error of 5% (p-value=0.05), power (1- β err prob) = 0.80; the sample size was estimated to be 24.

Study Procedure

Randomisation was done using a coin flip method to divide the patients between the control and test groups. The patients were allocated in a ratio of 1:1. It was a double-blinded trial where participants and radiographic outcome assessors were blinded to group allocation, whereas the operating surgeon could not be blinded due to the nature of the intervention. A total of 24 patients with a single edentulous site (24 sites) had been recruited and randomly assigned to two groups:

Group A- Test group: Sites (n=12) received bone ring (DSI Zenoss Bone Ring) and simultaneous implant placement (AdinTM) [Table/Fig-1].



[Table/Fig-1]: DSI Zenoss Bone Ring.

Group B- Control group: Sites (n=12) received particulate bone graft (Osseograft DMBM-Xenograft) with simultaneous implant placement (AdinTM) [Table/Fig-2].

[Table/Fig-2]: Osseograft DMBM- Xenograft.

Detailed case histories were obtained from the patients, followed by scaling and root planing (Phase I therapy). Oral hygiene instructions were given. Preoperative CBCT of the recipient site was taken, and height and width of the residual bone were measured for both groups. All the procedures were performed by one trained clinician.

For the test group, the surgical site was anaesthetised using local anaesthesia (Lignocaine hydrochloride 2%; adrenaline, 1:100,000). Crestal incision and two oblique incisions were made, and a rectangular full-thickness mucoperiosteal flap was elevated on the implant site.

The available residual bone height and width were measured using preoperative CBCT, and an appropriate implant was selected. The width of the bone ring with an inner diameter that matches the diameter of the implant was selected. The height of the bone ring was determined based on the height of the defect and augmentation needed and adjusted accordingly. The bone ring was positioned 1-2 mm above the adjacent CEJ to compensate for bone resorption. The bone ring bed was prepared with a trephine bur to match the outer diameter of the bone ring. The depth of the bed was prepared to half the height of the bone ring. The bone ring was positioned, and the implant site was prepared with sequential drilling through the bone ring in place. After the final preparation, the implant was inserted through the bone ring into the prepared site and placed at the supra-crestal level.

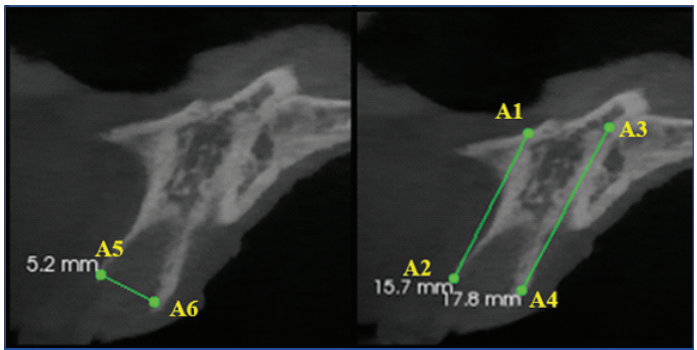
Primary stability was achieved with an insertion torque of 25 - 35 Ncm. The bone ring was covered with a GTR membrane (Healiguide® Bioresorbable collagen membrane). Eventually, the flaps were repositioned and approximated tension-free with sutures.

For the control group, after flap elevation, the implant was inserted after sequential drilling, followed by a particulate xenograft (Osseograft DMBM-Xenograft) being placed to fill the defect and covered with a GTR membrane. The flaps were approximated tension-free and sutured (Ethicon Mersilk 3-0).

For both groups, patients were prescribed a five-day regimen of antibiotics consisting of amoxicillin (500 mg capsules) and metronidazole (400 mg tablets) to be taken three times per day. A combination of aceclofenac and paracetamol tablets was prescribed twice daily for a duration of five days. The patients were then advised to rinse with 0.12% chlorhexidine mouthwash twice daily for two weeks. Also, the sites were assessed for the healing process or any signs of infection. Temporary prostheses were provided for the interim period. After six months, CBCT was repeated with the same standardisation protocol and was evaluated for bone formation.

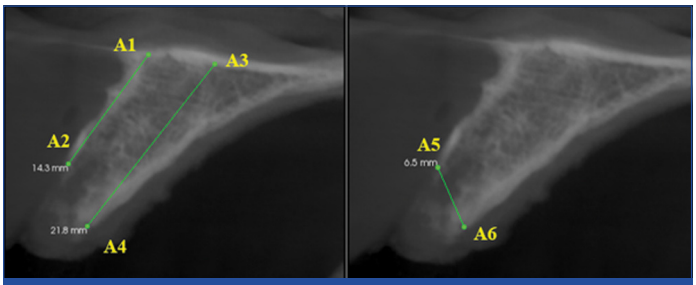
Radiographic Parameters Recorded

The CBCT (Carestream CS 9600) with exposure parameters of 120 kVp, 6.30 mA, 19 seconds and 6 cm field of view (FOV) were standardised. Radiographic reference points were made on CBCT. A1: floor of nasal cavity over the buccal crest, A2: Crest of buccal ridge, A3: floor of nasal cavity over the palatal crest, A4: Crest of palatal ridge A5: Outer wall of the labial cortical plate at crest level, A6: Outer wall of the palatal cortical plate at crestal level. Radiographic measurements for buccal bone height were made from A1 to A2, palatal bone height from A3 to A4, and bone width was measured from A5 to A6. Both preoperative and postoperative measurements were compared for both intra-group and inter-group and assessed for potential bone gain [Table/Fig-3,4].

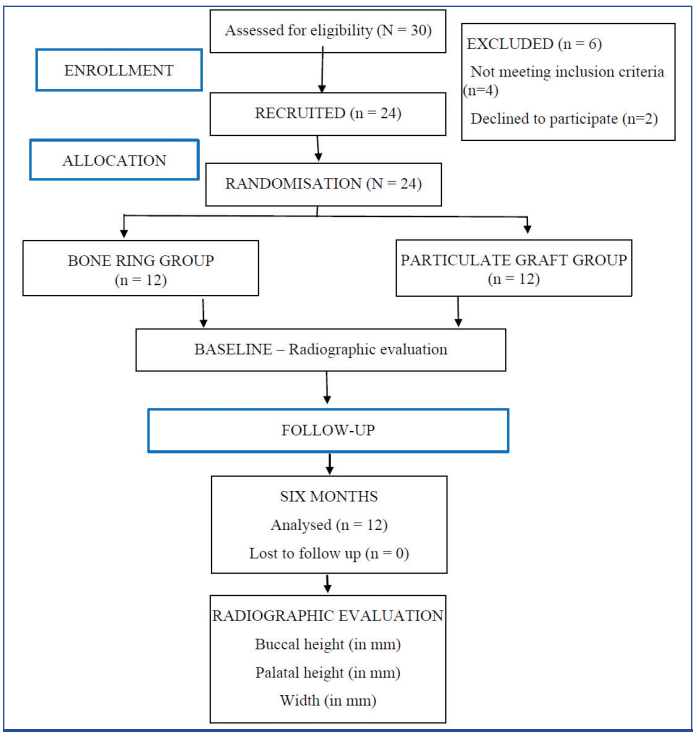


[Table/Fig-3]: Group A: Preoperative radiographic measurements. Ridge width: 5.2 mm, buccal plate height: 15.7 mm, and palatal height: 17.8 mm.

The Consolidated Standards of Reporting Trials (CONSORT) flow diagram is shown in [Table/Fig-5].



[Table/Fig-4]: GROUP B: Pre-operative radiographic measurements. Buccal plate height: 14.3 mm, palatal height: 21.8 mm, and ridge width: 6.5 mm.



[Table/Fig-5]: CONSORT Flowchart.

STATISTICAL ANALYSIS

The data were entered in the Excel spreadsheet and were analysed through the SPSS software version 21.0 (IBM Corp, Armonk, New York). Descriptive and inferential statistics were used to analyse the data in the study. Normality was checked using the Kolmogorov–Smirnov test and Shapiro-Wilk. The data distribution had skewness and the data were non-normally distributed. Therefore, non parametric analysis was used: Mann Whitney U test and Wilcoxon signed-rank test. A p-value <0.05 was considered significant.

RESULTS

A total of 24 partially edentulous patients (mean age, 35 years; age range, 20–60 years; 10 females, 14 males) with Salama type II socket defect were randomly selected, and implant placed and the defect augmented with either a bone ring or a particulate graft. All the implants were placed in the maxillary anterior region.

Radiographic evaluation was done using CBCT before and after six months of implant placement. The buccal and palatal bone height and width measurements were done for both the groups. While comparing the parameters at baseline, no significant difference was noted in both the groups [Table/Fig-6].

In group A, all the measurements were statistically significant from baseline to six months with p value of 0.002 [Table/Fig-7].

In group B, all the measurements were statistically significant from baseline to six months with the p value of 0.002 in buccal height and ridge width, and p value of 0.049 in palatal height [Table/Fig-8].

Variables	Time intervals	Groups	Mean±SD	Mean difference	p-value
Buccal height (in mm)	Baseline	Group A	12.27±2.37	0.14	0.795
		Group B	12.13±2.07		
Palatal height (in mm)	Baseline	Group A	14.49±1.93	-0.31	0.729
		Group B	14.80±1.53		
Width (in mm)	Baseline	Group A	5.72±1.40	0.08	0.664
		Group B	5.64±0.90		

[Table/Fig-6]: Intergroup comparison of radiographic parameter between Group A and Group B at baseline using Mann-Whitney U Test.

Variables	Time intervals	Mean±SD	Mean difference	p-value
Buccal height (in mm)	Baseline	12.27±2.37	-2.58	0.002*
	6 months	14.85±1.91		
Palatal height (in mm)	Baseline	14.49±1.93	-1.36	0.002*
	6 months	15.85±2.04		
Width (in mm)	Baseline	5.72±1.40	-2.64	0.002*
	6 months	8.36±1.18		

[Table/Fig-7]: Intragroup comparison of radiographic parameter between baseline and after six months in Group A using Wilcoxon Signed Ranks Test.
*p<0.05 significant

Variables	Time intervals	Mean±SD	Mean difference	p-value
Buccal height (in mm)	Baseline	12.13±2.07	-0.99	0.002*
	6 months	13.12±1.72		
Palatal height (in mm)	Baseline	14.80±1.53	0.36	0.049*
	6 months	14.44±1.57		
Width (in mm)	Baseline	5.64±0.90	-0.43	0.002*
	6 months	6.07±0.86		

[Table/Fig-8]: Intragroup comparison of radiographic parameters between baseline and after six months in Group B using Wilcoxon Signed Ranks Test.
*p<0.05 significant

While comparing the radiographic parameters after six month follow-up between group A and group B, group A (Bone ring group) showed significantly better results in buccal height gain with a mean difference of 1.73 mm and 2.29 mm mean difference for bone width and was found to be statistically significant with p-values of 0.037 and <0.001, respectively [Table/Fig-9].

Variables	Time intervals	Groups	Mean±SD	Mean difference	p-value
Buccal height (in mm)	6 months	Group A	14.85±1.91	1.73	0.037*
		Group B	13.12±1.72		
Palatal height (in mm)	6 months	Group A	15.85±2.04	1.41	0.088
		Group B	14.44±1.57		
Width (in mm)	6 months	Group A	8.36±1.18	2.29	<0.001*
		Group B	6.07±0.86		

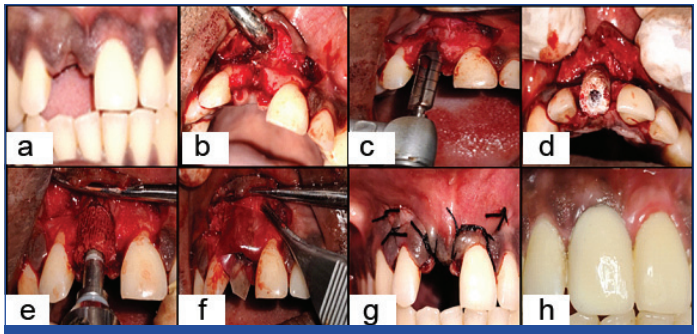
[Table/Fig-9]: Intergroup comparison of radiographic parameter between Group A and Group B after six months using Mann-Whitney U Test.
*p<0.05 significant

Notably, the implant survival rate was 100% during the six-month follow-up period.

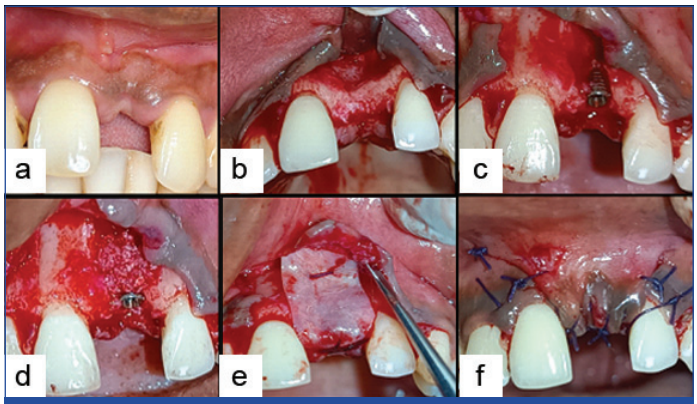
All the patients experienced slight postoperative oedema the next day following surgery, which subsided completely after two to three days. No major biological complications were observed.

The clinical images from groups A and B, respectively, are shown [Table/Fig-10,11].

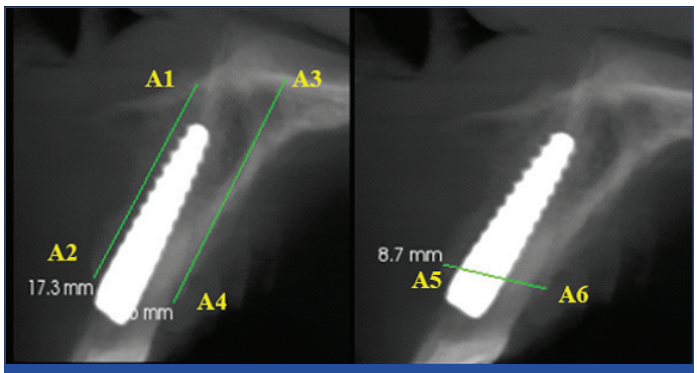
The postoperative radiographic measurements at the end of six months for all 24 patients using CBCT are shown [Table/Fig-12,13].



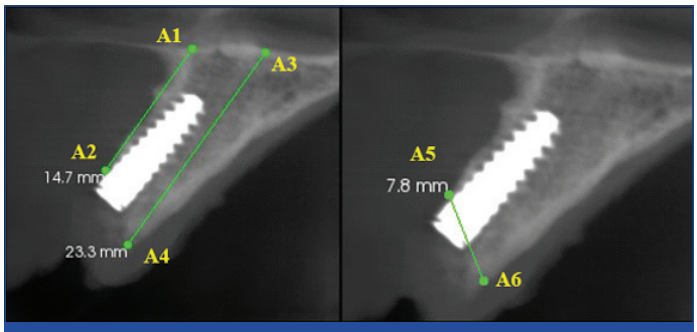
[Table/Fig-10]: Group A: A) Preoperative image; B) Full thickness flap elevated; C) Bone ring bed prepared with trephine bur; D) Bone ring placed; E) Implant inserted; F) Membrane placed; G) Sutures placed.



[Table/Fig-11]: Group B: A) Preoperative image; B) Full thickness flap elevated; C) Implant inserted; D) Particulate graft placed; E) Membrane placed; F) Sutures placed.



[Table/Fig-12]: Group A: Postoperative radiographic measurements. Buccal height: 17.3 mm, palatal height: 18.6 mm, and ridge width: 8.7 mm.



[Table/Fig-13]: Group B: Postoperative radiographic measurements. Buccal height: 14.7 mm, palatal height: 23.3 mm, and ridge width: 7.8 mm.

DISCUSSION

Defective sockets often result in insufficient bone quantity and quality, limiting the predictability of implant placement. The Salama classification of extraction size defects is based on the effect of the degree of buccal wall defect and its influence on implant positioning and adjunctive augmentation procedures [10].

According to the Salama and Salama classification of defective sockets, type I defects can be predictably managed by Guided Tissue Regeneration (GTR). Type II defects can be converted into type I defects by using orthodontic extrusive augmentation or by GTR. Immediate implantation is possible in both type I and type II defects. However, type III defects are severely compromised, and immediate implant placement is usually not possible. In such cases, a two-step approach is used. The first step is the augmentation procedure, while the second step is the actual implant placement [10].

Several techniques aimed at solving this problem have been reported. However, to reduce the overall treatment time and difficulties in the management of severely defective sockets, the BRT was first reported by Benard Giesenhagen. It can augment the defective socket three-dimensionally with simultaneous implant placement in a single-stage procedure [11]. Giraddi and Saifi reported a bone gain of 3.70±1.10 mm when an autogenous ring was placed simultaneously with an implant [12].

Based on previous reports, allogeneic bone ring grafts have been used in a few clinical trials and case reports and have achieved adequate bone augmentation [9,13]. Still, the application of allogeneic grafts remains limited due to factors such as high cost, limited sources, potential risk of disease transmission, and immunologic tissue reactions.

In the present study context, xenogeneic bone has been widely used clinically owing to its favourable biomechanical properties, osteoconductivity, and a wide range of sources. Furthermore, a study revealed that bovine cancellous bone exhibits superior histological characteristics compared with other bone substitutes [14].

Therefore, in the current study, the bovine cortico-cancellous bone ring graft (DSI Zenoss Bone Ring) was used to repair serious dental defects. The material is made of bovine cancellous bone which underwent decellularisation and deglazing treatment, thereby fully retaining the type I bovine tendon collagen and hydroxyapatite components. The natural three-dimensional porous structure of the material can promote new bone growth and regulate bone regeneration [15].

The xenogeneic bone ring showed greater graft stability and mechanical support to repair severe defects in both horizontal and vertical directions. In a recent article, Jinno Y et al., had reported reduced new bone-to-implant contact in the xenogeneic group and further suggested that covering of the graft with membrane was necessary to prevent tissue ingrowth and new bone formation [16].

In the present study, both treatment modalities resulted in a gain in bone height and width from baseline to six months. However, in the test group where a BR was used, bone gain was found to be highly statistically significant (p-value=0.002). These findings are in accordance with the study conducted by Chandra RV et al., where the bone gain after six months was 1.90 mm (p-value=0.001) [17].

Xue Chen et al., evaluated the clinical efficacy and aesthetic outcomes of the BRT for single implant placement in the maxillary anterior region over a 2–3 year follow-up period. All implants achieved successful osseointegration, with mean vertical and horizontal bone gains of 5.55±0.87 mm and 4.73±0.70 mm, respectively [18].

Nevertheless, a drawback of BRT is that a minimum of 3–4 mm of apical native bone is required to stabilise the implant and the bone ring [19]. In a systematic review, they stated that the most common complications observed after BRT were swelling (1.94%), transient numbness of the lower lip (1.29%), and wound dehiscence (0.64%). In any case, according to these findings, BRT showed a low rate of complications regardless of the type of bone ring used [20].

Limitation(s)

Further research is needed to evaluate the histological findings, the incidence of complications and the marginal bone loss after a longer observational time and a larger-scale clinical trial to validate this approach.

CONCLUSION(S)

In conclusion, BRT could be a valid option for restoring single complex defects with dental implants in terms of bone gain. The present study demonstrated the benefits of the xenogeneic bone ring for the regeneration of alveolar bone in both horizontal and vertical dimensions. It also offers multiple advantages in reducing the treatment time and morbidity. However, further studies with longer follow-up periods are needed to evaluate the long-term predictability and complications of the technique.

Author's contribution: PASP and AA: Conceived and designed the experiments of the present study; PASP: Performed the experiments; PASP, LM, DCP: Analysed the data; PASP and DSP: Drafted the manuscript; AA, DCP and IP: Revised the manuscript critically. All the authors read and approved the final version of the manuscript. Amanullah A and Mahalingam L confirmed the authenticity of all the raw data.

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