ASDJ
AINSHAMS DENTAL JOURNAL

Print ISSN 1110-7642
Online ISSN 2735-5039

AIN SHAMS DENTAL JOURNAL
Official Publication of Ain Shams Dental School
March2025 • Vol. 37

Augmenting the Posterior Mandible Using Xeno Grafts: A Randomized Clinical Trial

Moataz Mohamed Bahaa ElDin Mostafa[1], Mohamed Sobhy Ali Saleh[2], Amr Amin Ghanem[3,4], Karim Mohamed AbdelMohsen[5]

Aim: To assess the vertical height gain in atrophic posterior mandible using different forms of xenograft through an interpositional bone grafting procedure (sandwich technique).
Materials and methods: Patient were separated into two groups, Group A (Study Group): received augmentation through the use of an organic bovine bone particulate. Group B (Control Group): received augmentation through the application of an organic bovine bone block. This study was conducted on 16 patients suffering from posterior mandibular partial edentulism with an inadequate bone height enough for favorable implant placement. The alveolar vertical dimension measured ranges from or equal to 5-8 mm from roof of the inferior alveolar canal to the alveolar crest. Both groups had equal percentages of both genders.
Results: The mean age of the participants in the block group was (35.36±2.62) years, in the particulate group it was (36.07±7.23), and the variation was not significant (p=0.798). Measured bone height in the block group was greater than the particulate group with the distinction being significant after the end of the follow-up interval (p<0.001). Bone height gain measured in the block group (3.83±0.31) (mm) was significantly greater than that measured in the particulate group (3.56±0.14) (p=0.047).
Conclusion: Bone height gain measured in block group was significantly higher than that measured in particulate group.

Keywords: Augmentation, Posterior Mandible, Xenografts

1. Lecturer Oral and Maxillofacial department, British university in Egypt.
2. Teaching assistant Oral and Maxillofacial department, British university in Egypt.
3. Assoc. Prof. of Oral and Maxillofacial Surgery, Ain Shams University.
4. Head of Oral and Maxillofacial department, British university in Egypt
5. Assoc. Prof. of Oral and Maxillofacial Surgery, Ain Shams University

Corresponding author: Moataz Mohamed Bahaa ElDin Mostafa, email: MoatazBahaa@Hotmail.com

Introduction

Alveolar ridge resorption following teeth extraction is inevitable. However, severe ridge atrophy either vertical or horizontal compromises future implant placement in an ideal prosthetic position with adequate implant length and diameter. Hence, management of alveolar ridge atrophy through different grafting techniques is important to facilitate oral rehabilitation with dental implants. [1]

Although vertical and horizontal ridge deficiencies are considered an obstacle for routine implant placement, vertical ridge atrophy is a more challenging condition rather than the horizontal ridge atrophy which is widely studied in literature having several established predictable techniques to be managed. [2]

The options recited in the literature for handling vertical ridge atrophy are the application of short as well as extra short implants, inferior alveolar nerve lateralisation and/or transposition, onlay grafts, distraction osteogenesis, and interpositional bone grafting by segmental osteotomy. However, the advantages and disadvantages of each option must be considered to avoid the potential drawbacks and allowing potential success.[3]

Autogenous bone is always preferred during ridge augmentation either individually or mixed with another type of bone graft. This superiority arises from its osteogenic, osteoinductive, in addition to osteoconductive characteristics. The mandibular symphysis, ramus or maxillary tuberosity are examples of intraoral donor sites that can be used to get autogenous bone grafts. Extraoral donor sites can also be utilized. The iliac crest, calvarium, tibia as well as fibula are some of the other extraoral donor sites.

The advantages of acquiring bone grafts intraorally encompass diminished patient morbidity, absence of cutaneous scarring and reduced graft resorption due to similarities in embryologic genesis and microarchitecture. Unfortunately, the most common disadvantages include complications at the donor site, longer surgery times, damage to soft tissues and inadequate amounts of the accessible bone.[4]

The vertical augmentation capability of interpositional grafting varies from 4 to 8 mm. The advantages that have been detailed in the literature include a reduced risk of dehiscence, adequate segment vascularization, the ability to implant with crown-implant ratios that are favourable and effective graft nutrition. On the other hand, the vertical augmentation is constrained by the stretching capacity of the lingual soft tissue and there are noted disadvantages such as method sensitivity and the risk of segment sequestration.[5]

Xenografts or inorganic bovine bone matrix is a bone substitute produced from bovine mineral bone after being processed and sterilized for intraoral grafting procedures. The main composition of this bone matrix is the mineral portion of the bone and the biocompatibility of this bone substitute has already been established.[6]

Although the biocompatibility of this bone substitute (anorganic bovine bone) has already been established.[6] Yet, the lack of comparative studies between different forms of anorganic bovine bone do exist.[14]

The goal of this trail was to compare the vertical height gain in atrophic posterior mandible using different forms of xenogenic bone graft. This would help avoiding the drawbacks of using autografts and allow the use of xenograft bone particulates instead of bone blocks that cannot precisely fit into different defect sizes of an edentulous vertically atrophied posterior mandibular sites.

Materials and Methods

Study Design

This is a randomized clinical trial, 16 posterior mandibular edentulous sites exhibiting vertical alveolar ridge height deficiency with adequate ridge width were augmented through an interpositional bone grafting technique (Sandwich technique) using different forms of xenograft.

Group A (Study Group): underwent interpositional bone augmentation with the application of organic bovine bone particulate.

Group B (Control Group): underwent interpositional bone augmentation with an organic bovine bone block.

Participants were sixteen individuals from the outpatient clinic of the Oral and Maxillofacial Surgery Department at Ain Shams University's Faculty of Dentistry who had partial edentulism in the posterior jaw and bone height that was insufficient for optimal implant placement.

Inclusion criteria

- Adult individuals 20-45 years. No sex predilection.
- Partially edentulous posterior mandibular ridge characterized by a vertical bone defect with the alveolar vertical dimension measuring among 5-8 millimetres from the alveolar crest to the inferior alveolar canal's roof.
- No local pathologies that could impede bone healing.

Exclusion criteria

- Patients with an autoimmune disorders that would affect bone healing.
- History of vertical augmentation at the location of interest.
- Patients using medication that can disrupt normal bone physiology or hinder bone healing.
- Patients with a systemic disease that could affect bone healing.

PICO:

Population (P): partially edentulous patients with vertically atrophied posterior mandible (bone height ranges 5-8mm from the roof of inferior alveolar canal to the alveolar crest).

Intervention (I): using xenograft bone particulate in a sandwich osteotomy.

Comparative (C): using xenograft bone block in a sandwich osteotomy.

Outcome (O): -Primary outcome: vertical height gain in millimetres after 4 months using cone beam computed tomography (CBCT) as a measuring tool.

Sample Size Calculation

Based on data from a prior investigation (3), the sample size was calculated by G*Power 3.1.9.4 Software. The t-test was powered at eighty percent with a two-tailed significance level of five percent and a beta level of twenty percent. The calculated sample size will be 12 individuals per group for a total of 24 patients. The sample size will be augmented by ten percent to thirteen individuals per group resulting in a total of 26 patients to account for any drop-outs.

Randomization was carried out using an appropriate computer software (Microsoft Excel spreadsheet) with a ratio of 1:1. The nature of the study and detailed description of the surgical procedure with possible harms were discussed with the candidates. Candidates were able to have an informed discussion. Patients willing to participate in the trial provided a written consent from to the authors translated in Arabic for the patients' convenience.

Preoperative preparations for both groups included

History: A full detailed medical and dental history was taken to all patients identifying their chief complaint.

Clinical Examination:

- Inspection:

- Oral Hygiene status
- Inter-arch space
- Covering mucosal biotype
- Status of the adjacent and opposing tooth

- Palpation:
  - To detect any bony swellings, undercuts or tenderness.

Radiographic examination

Panoramic radiographs were done for all patients as a preoperative investigation to exclude any local pathosis in the area of interest and a cone beam computed tomography (CBCT) scan was then done to assess the alveolar ridge deficiency.

Surgical procedure

1. Prior to any operations undergoing local anesthetic, patients were instructed to gargle with a mouthwash containing 1.25 percent chlorhexidine hydrochloride (Orovex mouthwash, Macro group, Egypt). A (Articaine 4%) block was administered to the inferior alveolar and lingual nerves. In order to stop the bleeding during the procedure, more infiltration anesthetic was injected into the surgical sites.
2. Different application of xenograft was done using interpositional grafting in the two groups.
3. All Osteotomies were done using Piezoelectric Surgery Device using surgical guide.
4. Augmentation was then done as follows:

a. Group A (Study Group):

Para-crestal incision was done equivalent to the defect together with sulcular incision extended one tooth anterior and posterior followed by 2 vertical releasing incisions.

i. A full thickness flap was reflected.
ii. Two vertical osteotomies were done anterior and posterior at least two mm from the dentulous area.
iii. Surgical guide was precisely adapted and fixed in place using microscrews (figure 1).

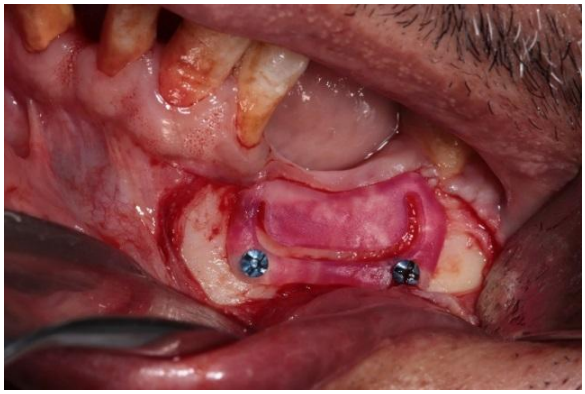

Figure 1: Surgical guide adapted and fixed by 2 microscrews

iv. Horizontal osteotomy was done 4mm from the roof of the mandibular canal from buccal side to lingual side leaving the lingual side undetached (figure 2).

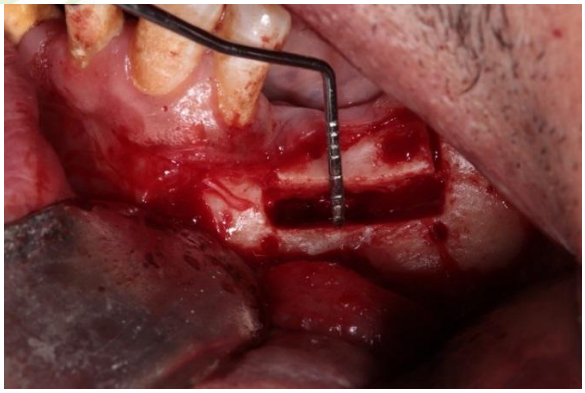

Figure 2: 4mm gap ready to be augmented

v. Chisel was used to revise the osteotomy and elevate the cut bone.
vi. Particulate xenograft after its volume being measured using a plastic syringe to account for the required 4mm vertical increase was packed in place between the immovable & movable part of the alveolar ridge which were then fixed in position using microplates & screws (figure 3).

vii. Securing the particulate graft in place using resorbable collagen membrane was done.
viii. Buccal flap undermining was then done to accommodate for the new vertical dimension followed by flap closure using simple interrupted Suturing technique.

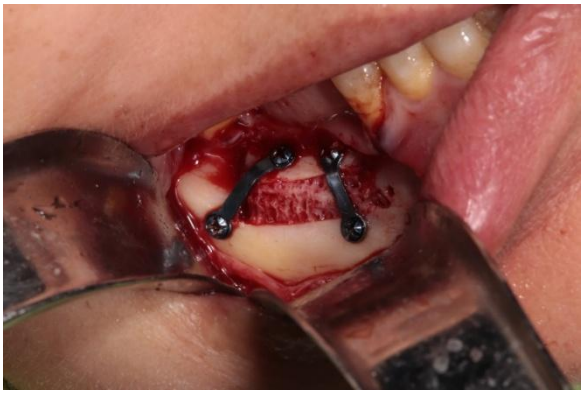

Figure3: Xenograft bone block in place and fixation using microplates and screws

b. Group B (Control Group)

i. Same Procedure as group A, but a pre shaped 4mm height block xenograft was placed to fit in position between the immovable and movable part of the alveolar ridge instead of particulate xenograft.

Postoperative care

Augmentin (Amoxicillin + Clavulanic acid) 1gm tablets twice daily for 1 week was prescribed, Dexamethasone 8mg/2ml ampoule I.M immediately postoperative, Brufen 600mg tablets (t.i.d) for 3 days and Orovex-H mouthwash (t.i.d) for one week.

Follow up

Immediate postoperative Panorama was done. Patient was recalled one week postoperative to assess wound healing and soft tissue closure and postoperative CBCT was done after 4 months. Superimposition of the preoperative & postoperative CBCT was done to assess the amount of vertical gain.

Evaluation Parameters

1. **Clinical follow up paramaters:**
   Patient was recalled after 1 week to detect: Extent of post-operative edema, wound healing, soft tissue closure, pus discharge and paresthesia or dysthesia
2. **Radiographic follow up parameters:**
   Immediate post-operative: panorama to ensure an untouched inferior alveolar canal and after 4 months: CBCT to be superimposed over the preoperative CBCT to assess the vertical height gain.
3. **Statistical analysis**
   Frequencies and percentages were utilized to express the categorical data. The means and standard deviations of the numerical data were reported. Visual examination of the distribution and the use of the Shapiro-Wilk test were used to evaluate the data for normalcy. When comparing groups, we used independent t-tests and paired t-tests, respectively, to ensure that the data followed a normal distribution. For every test, a p-value less than 0.05 was used as the significance level. Analyses were carried out using the R statistical tool, specifically version 4.3.2 for Windows.

Results

The study was conducted on 16 cases that were randomly and equally allocated to each of the studied groups (i.e., 8 cases each). Both groups had equal percentages of both genders. The mean age of the participants in the block group was (35.36±2.62) years while in the particulate group it was (36.07±7.23) and the difference was not statistically significant (p=0.798).

Table 1: Intergroup comparisons and summary statistics for demographic data.

Parameter		Block group	Particulate group	Test statistic	p-value
Gender [n (%)]	Male	4 (50.0%)	4 (50.0%)	NA	NA
	Female	4 (50.0%)	4 (50.0%)		
Age (Mean±SD) (years)		35.36±2.62	36.07±7.23	0.26	0.798ns

NA: Not Applicable*; significant (p<0.05) ns; non-significant (p>0.05)

Pre and post-operatively, measured bone height in the block group was greater than the particulate group yet the variation was not significant (p>0.05). However, there was a significant increase in measured bone height after the end of the follow-up interval (p<0.001).

Table (2): Inter, intragroup comparisons, mean as well as SD for bone height (mm).

Time	Bone height (mm) (Mean±SD)		t-value	p-value
	Block group	Particulate group		
Pre-operative	6.38±0.81	6.30±0.72	0.20	0.848ns
4 months	10.20±0.55	9.86±0.64	1.13	0.277ns
t-value	41.22	85.63		
p-value	<0.001*	<0.001*		

Bone height gain measured in the block group (3.83±0.31) (mm) was significantly higher than that measured in the particulate group (3.56±0.14) (p=0.047).

Table (3): Intergroup comparisons, Mean ± SD for bone height gain (mm).

Bone height gain (mm) (Mean±SD)		t-value	p-value
Block group	Particulate group		
3.83±0.31	3.56±0.14	2.18	0.047*

All patients in both groups have undergone uneventful procedures and follow ups.

Discussion

The use of implant-supported prostheses for the rehabilitation of partially or fully edentulous posterior mandibles has increased in recent decades providing long-term reliability. Nevertheless, certain local circumstances of the edentulous ridges would not be ideal for implant placement. This is because there might not be enough bone height above the inferior alveolar nerve to support dental implants without additional alveolar bone height augmentation.[17]

The rationale behind any graft is to optimize the blood supply to the dependent bone graft. In order to prevent hypoxia and the subsequent ischemic changes at the distal portions of the flap, Schettler in 1976 initially described the sandwich osteotomy approach with interpositional bone transplantation for vertical augmentation of the anterior edentulous jaw while preserving the lingual periosteum integrity. [8 9]

The utilization of bone substitutes forms the basis of bone regeneration treatments. There are four main categories of bone transplant materials: autografts, xenografts, allografts and synthetic biomaterials. The first three categories provide the necessary conditions for blood clot formation, maturation and remodelling which in turn facilitates bone formation in osseous defects.[10]

Because of its osteoconduction, osteoinduction, osteogenicity as well as osteointegration qualities, the autogenous bone transplant is the best option for bone augmentation procedures. However, several disadvantages have been identified including donor site morbidity, prolonged operational duration, soft-tissue damage and a high resorption rate. [11]

This study utilized bovine bone graft as an alternative to autogenous bone transplant to mitigate donor site morbidity and the elevated resorption rate. This was established based on the prior findings of

Rodriguez et al. (2003) and Martinez et al. (2010) who identified that bovine bone exhibits up to 75% porosity and a significant specific surface area of approximately 100 m2/g thereby enhancing angiogenesis and aiding in new bone formation. [12] [13]

In the present study, pre- and post-operatively measured bone height in the block group was higher than the particulate group with the variance being significant after the end of the follow-up interval ($p<0.001$). Bone height gain measured in the block group (3.83±0.31) (mm) was significantly higher than that measured in the particulate group (3.56±0.14) ($p=0.047$).

In agreement with our results, Troeltzsch et al. (2016) in a previous systematic review to evaluate the efficacy of grafting materials in lateral and vertical ridge augmentations concluded that horizontal and vertical gain by 3.7 mm on average can be achieved using particulate materials. This can be increased by using titanium meshes. Substantial vertical gains beyond this dimension require the use of extraoral bone block grafts. [16]

Similarly, Sheta et al. (2022) reported the alveolar bone height gain for group I which utilized autogenous bone graft was 10.76 ± 1.043 mm after six months of augmentation, while for group II which utilized bovine bone graft it was 11.24 ± 0.3721 mm. Each group did not show a significant distinction in the amount of height they gained if $p > 0.05$. Although the bovine group had more graft remains. The osteointegration was good overall as well as both groups showed appropriate extension of the interface among the host bone and the graft particles. [14]

As concluded, Aludden et al. (2021) found that volumetric bone changes are comparable between deproteinized bovine bone mineral, particulate autogenous bone, various ratios of the two (50:50, 75:25, and 100:0) and autogenous bone block in combination with deproteinized bovine bone mineral covered by a collagen membrane. Deproteinized bovine bone mineral and particulate autogenous bone with different composition ratios we well as the autogenous bone block covered by deproteinized bovine bone mineral experienced a reduction ranged from 18% to 37%.[7]

Reduction in bone volume was as follows: 50:50-1.7 millimetre (-33.1 percent), 75:25-1.8 millimetre (-37.8 percent), 100:0-1.7 millimetre (-35.8 percent) and autogenous bone block - 0.2 millimetre (-3.7%), after 30 weeks. The preservation of augmentation height was significantly better with autogenous bone block in comparison to the 50:50, 75:25 and 100:0 ratios. No substantial variation in volumetric decrease was observed among the 50:50, 75:25, and 100:0 ratios after thirty weeks. However, the 100:0 ratio exhibited a significantly lesser reduction compared to the 50:50, 75:25 and autogenous bone block after ten and twenty weeks. [7]

This concludes that the augmentation made of 100% deproteinized bovine bone mineral particulates did the best job of preserving the bone volume unless an autogenous bone block came in charge. [7]

This discrepancy in the two-dimensional measurement results from this research might be due to the fact that the autogenous bone block has a higher-pressure resistance than the particulate grafts. This is because the mandible augmentation was done outside the skeletal envelope, making it difficult to avoid applying pressure to the augmented area which could have displaced the particulate graft material.[16]

The xenogenic bone block outperforms particle grafts in terms of acquired width, according to a prior systematic review.[16]

The resorption rate for the particle grafts in this research was higher than that of the xenogenic bone block. The displacement of the particulate graft and the more

resistance to pressure of the block graft may explain this. [16]

Based on the results of this study, further studies are recommended with larger sample size, different grafting materials and longer follow up period for more valid results.

Conclusion

Bone height gain measured using xenogenic bone block in the block group was significantly higher than that measured in the particulate group using xenograft bone particulates.

Financial support and sponsorship

Self-funded

Data Availability

All the data available upon request.

Ethics approval and consent to participate

This clinical study aligns with the guidelines outlined in the "Helsinki declaration concerning ethical principles for research involving human subjects." The research protocol and the consent form underwent evaluation and received approval from the Ethics Committee of Scientific Research at the Faculty of Oral & Dental Medicine – Ain Shams University. Approval Code: FDASU-RecIM022119

Conflict of Interest

The authors declare that there are no conflicts of interest regarding the publication of this article.

References

1. Bokavšek L. Implant prosthetic possibilities for rehabilitation of atrophic jaws: University of Zagreb. School of Dental Medicine; 2024.
2. Chiapasco M, Casentini P. Horizontal bone-augmentation procedures in implant dentistry: prosthetically guided regeneration. Periodontology 2000. 2018;77:213-40.
3. Abdelmoneim HS, Ashraf M, Elsharkawy RT. Fixation free Inter-positional mandibular grafting a novel technique for alveolar ridge height augmentation versus the conventional fixation technique.(Randomized control clinical trial). Egyptian Dental Journal. 2020;66:123-30.
4. Aytekin M, Arisan V. Alveolar Ridge Augmentation Techniques in Implant Dentistry. Oral and Maxillofacial Surgery: IntechOpen London, UK; 2020.
5. Cordaro L, Terheyden H. Ridge augmentation procedures in implant patients: a staged approach: Quintessenz Verlag; 2019.
6. Mitra S, Kamath DG. Xenografts in Periodontal Regeneration: A Viable Alternative. Indian Journal of Forensic Medicine & Toxicology. 2021;15.
7. Aludden H, Mordenfeld A, Cederlund A, Dahlin C, Spin-Neto R, Veiss-Pedersen P, et al. Radiographic changes in height and volume after lateral GBR procedures with different ratios of deproteinized bovine bone mineral and autogenous bone at different time points. An experimental study. Clin Oral Implants Res. 2021;32:167-79.
8. Koymen R, Karacayli U, Gocmen-Mas N, Ertugrul-Koymen C, Ortakoglu K, Gunaydin Y, et al. Flap and incision design in implant surgery: clinical and anatomical study. Surg Radiol Anat. 2009;31:301-6.
9. Schettler D. [Sandwich technic with cartilage transplant for raising the alveolar process in the lower jaw]. Fortschr Kiefer Gesichtschir. 1976;20:61-3.
10. Gallo P, Díaz-Báez D, Perdomo S, Aloise AC, Tattan M, Saleh MHA, et al. Comparative analysis of two biomaterials mixed with autogenous bone graft for vertical ridge augmentation: A histomorphometric study in humans. Clin Implant Dent Relat Res. 2022;24:709-19.
11. Nkenke E, Neukam FW. Autogenous bone harvesting and grafting in advanced jaw resorption: morbidity, resorption and implant survival. Eur J Oral Implantol. 2014;7 Suppl 2:S203-17.
12. Rodriguez A, Anastassov GE, Lee H, Buchbinder D, Wettan H. Maxillary sinus augmentation with deproteinated bovine bone and platelet rich plasma with simultaneous insertion of endosseous implants. J Oral Maxillofac Surg. 2003;61:157-63.
13. Martinez A, Franco J, Saiz E, Guitian F. Maxillary sinus floor augmentation on humans: Packing simulations and 8 months histomorphometric comparative study of anorganic bone matrix and β-tricalcium phosphate particles as grafting materials. Mater Sci Eng C Mater Biol Appl. 2010;30:763-9.
14. Sheta M, Shoushan M, Elshall M, Nowair I, Megahed E. Augmentation of Atrophic Posterior Mandible using Inlay Xenograft versus Autograft Bone Blocks. Egyptian Dental Journal. 2022;68:295-303.
15. Gultekin BA, Cansiz E, Borahan MO. Clinical and 3-Dimensional Radiographic Evaluation of

Autogenous Iliac Block Bone Grafting and Guided Bone Regeneration in Patients With Atrophic Maxilla. J Oral Maxillofac Surg. 2017;75:709-22.
16. Troeltzsch M, Troeltzsch M, Kauffmann P, Gruber R, Brockmeyer P, Moser N, et al. Clinical efficacy of grafting materials in alveolar ridge augmentation: A systematic review. J Craniomaxillofac Surg. 2016;44:1618-29.
17. Messias A, Nicolau P and Guerra F. Different interventions for rehabilitation of the edentulous maxilla with implant-supported prostheses: an overview of systematic reviews. Int J Prosthodont. 2021;34:s63-s84