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Radiologic and Histological Evaluation of Allogenic Bone graft Blocks in Bounded Anterior Maxillary Alveolar Ridge Defects

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Aim: To evaluate the osteogenic potential of allogenic bone block grafts for horizontal alveolar ridge augmentation in the bounded anterior maxillary region, both radiologically and histologically.
Materials & Methods: Study was conducted as a case series on 10 Medically free patients, which were selected from the outpatient clinics of the Oral and Maxillofacial surgery departments, faculty of dentistry, Ain Shams University, and Future University. These patients had horizontal defects in the alveolar ridge. These defects were located in the anterior maxillary region. The residual ridge width was ≤ 4mm and they were seeking implant treatment for the restoration of missing teeth. Allogenic bone blocks were used for augmentation of the bone defect in the maxillary region. The results of bone augmentation were assessed radiographically using cone beam computerized tomography (CBCT) by comparing bone width preoperatively and postoperatively after 6 months of follow up at crestal, middle and apical regions. The volume of bone gain was assessed by superimposition of 3D bone models obtained from CBCT. Histologic analysis was done on bone biopsies obtained by trephination drilling at the site of gained bone at the time of implant placement.
Results: This study results showed significant increases in bone width and bone volume after 6 months of follow up. Histologic analysis revealed new bone formation with minimal fibrous tissue formation.
Conclusion: Allogenic bone blocks used for bone augmentation produced a significant increase in bone width and bone volume and can be used as effective grafting material for bone augmentation in maxillary region.

Keywords: Allogenic, grafting, blocks, histology, radiography

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Introduction

Multiple adverse effects of tooth extraction on hard and soft tissues were discussed were mentioned in literature including alveolar bone loss.[1,2,3,4,5] Different techniques for bone augmentation have been proposed to face this problem and gain bone volume to face this problem, such as guided bone regeneration (GBR), ridge splitting, distraction osteogenesis, bone block (both inlay and onlay techniques), and cortical shell technique, which aim to obtain adequate bone volume, especially in case of horizontal bone defects. [6,7,8, 9,10,11]

Multiple bone substitutes are used for augmentation of bone defects. The gold standard for usage during bone augmentation is Autogenous bone grafts. They provide osteoinductive, osteoconductive and osteogenic properties. [12] On the other hand, Autogenous bone grafting has some disadvantages or complications like harvesting donor site morbidity, pain, nerve injury, hematoma, infection and fracture at the donor site. [12] Other types of bone substitutes like allografts that are harvested from cadavers. They possess osteoinductive and osteoconductive properties, but they require sterilization and preparation of proteins normally found in the healthy bone to prevent the risk of disease transmission. [12,13] Xenografts bone blocks were introduced as bone substitutes, which come from other species that include bovine, equine, porcine and coralline calcium carbonate derived bone minerals, which only possess osteoconduction capability. There is biocompatibility of the bone mineral matrix. This matrix has a macro-and microscopic porous structure that is interconnected. This matrix helps support ingrowth and formation of new bone at the implantation site. [14]

A gap of knowledge exists about the effectiveness of allogenic bone blocks in augmentation of horizontal defects in maxillary arch, and their efficiency to gain bone volume to allow for successful implant placement procedures outcome. Thus the aim of this study was to evaluate the osteogenic potential of allogenic bone block grafts for horizontal alveolar ridge augmentation in the bounded anterior maxillary region, both radiologically and histologically

Materials and Methods

Ethical Approval

The research plan was reviewed and accepted by the research ethical committee, Faculty of Dentistry Ain-Shams University and all patients signed informed consents following explanation of the whole procedure. The ethical committee approval number for this study is FDASU-ReclM021904.

Sample Size Calculation

A power analysis was designed in order to have adequate power that would result in the application of a two-sided statistical test of the null hypothesis that no difference would be found in values measured at different intervals. By adopting an alpha (α) level of (0.05) and a beta (β) level of (0.2) (i.e., power=80%) and an effect size (d) of (1.29) calculated based on the results of a previous study; the total required sample size (n) was found to be (7) cases. In order to compensate for possible dropouts, the sample size was increased to be (10) cases. R statistical analysis software version 4.3.2 for Windows was used to calculate the sample size.

Patient Selection

a- Inclusion Criteria

Ten patients were selected from the outpatient clinics of the Oral and Maxillofacial surgery departments, faculty of dentistry, of both Ain Shams University and Future University in Egypt. Case selection was according to the following criteria: age above 18 years, patients with horizontal bone defects in anterior maxillary region where the where the residual ridge width is ≤ 4mm for patients seeking implant treatment in

maxillary region and sufficient mesiodistal length.

b- Exclusion Criteria

Patients excluded from this study who had any systemic disease that affected bone quality and healing process, or on medication that affect bone quality like chemotherapy and immunosuppressive medications, in addition to pregnant females, heavy smokers, patients with poor oral hygiene and patients with infection at defect area.

Surgical Procedures

Preoperative analysis was performed for patients with recording medical and dental history as well as clinical examination for defect area (Figure 1 a & b) and radiographic analysis using CBCT (Figure 2). Surgical intervention included two phases:

a- presurgical phase which included strict oral hygiene for patients and using mouthwash 0.2 % Chlorhexidine Hcl (Hexitol, Arab drug company, Egypt.) for one week prior to surgery.

b- Surgical phase which included crestal flap incised with two oblique incisions using blade No. 15 (Figure 3) under local anesthesia (articaine 4% and adrenaline 1:100,000, Artinabase, Inisba Dental S.L.U, Spain).

Before placement of the bone block graft (Botiss, GmbH, Germany) trephination of the bone was performed to increase blood supply at the recipient site. Titanium fixation screws were used to fix the allogenic bone block grafts to the recipient site. (Figure 4) Following fixation of the allogenic graft block in place, flap release performed to make total coverage of the graft block. Flap was sutured with Polyglycolic acid resorbable suture (Isorb, Eldawlia, Turkey). Following the surgery, postoperative medications were prescribed for the patient including: Antibiotic, analgesic and antiseptic mouth wash, together with instructions for the patient to keep on clear fluid diet, use ice packs to prevent edema and follow oral hygiene instructions.

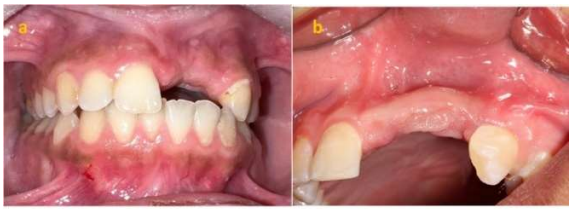

Figure 1 (a & b): Preoperative clinical examination for the site of bone defect.

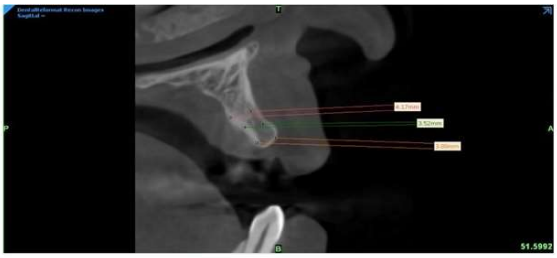

Figure 2: Preoperative CBCT.

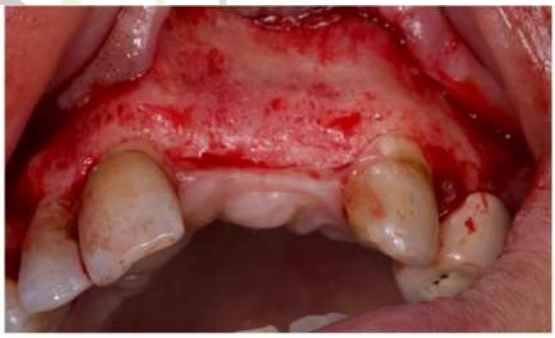

Figure 3: crestal incision at the recipient site with Full thickness flap reflection.

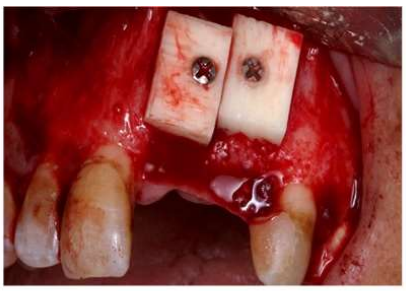

Figure 4: Allogenic bone graft block placement and fixation.

Follow up of cases

Follow up included immediate postoperative CBCT after graft placement, and monthly follow up for six months to check for any signs of failure of infection at

graft site. After 6 months, bone gain was evaluated using CBCT with measuring bone width at crestal, middle and apical regions. Further evaluation of volumetric analysis of bone gain was done by using DICOM images imported from CBCT to Mimics medical software. DICOM files were rendered into 3D models for bone. The produced models for preoperative and 6 months postoperative bone were superimposed inside the software to asses the gained bone volume in cubic millimeters (Figure 5 a & b).

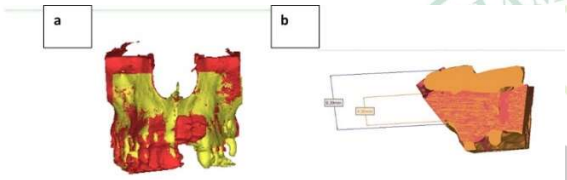

Figure 5: a: Superimposition of 3D rendered bone models, b: measurement of total bone volume gain

Histological Analysis

For the sake of histological analysis of the bone gained at the time of implant insertion, full thickness flap was reflected followed by trephination drilling using a trephine bur to obtain a core biopsy. Specimen was prepared to be stained for histologic analysis. CBCT was used for planning implant placement in the grafted site, using implant planning software (Bluesky plan, USA) , and implant fixtures were placed in the augmented site (B&B dental, Italy) following the drilling sequence proposed by the manufacturer.

Statistical Analysis

Numerical data were presented as mean with 95% confidence interval, standard deviation, minimum and maximum values. Normality was explored by checking the data distribution. The Shapiro-Wilk test was also used. Data were normally distributed and an analysis was done by using paired t-test. Within all tests, the significance level was set at $p<0.05$. R statistical analysis software version 4.3.1 for Windows was used for the statistical analysis.

Results

Comparison of bone width increase at different levels was shown in (Table 1)
The value that was measured at 6 months (8.28±0.73) was found to be significantly higher than value that was measured at baseline (3.70±0.31) ($p<0.001$). The value that was measured at 6 months (8.58±0.38) was found to be significantly higher than the value that was measured at baseline (3.55±0.62) ($p<0.001$). The value that was measured at 6 months (9.18±0.29) was found to be significantly higher than the value measured at baseline (4.35±0.31) ($p<0.001$).

Table 1: Intergroup comparisons of bone width measurements (mm)

Measurement	Bone width (mean ± SD) (mm)		p-value	Difference (95% CI) (mm)
	Baseline	6 months		
Crestal bone width	3.70±0.31	8.28±0.73	**<0.001***	4.58 (5.16:4.00)
Mid bone width	3.55±0.62	8.58±0.38	**<0.001***	5.03 (5.44:4.62)
Apical bone width	4.35±0.31	9.18±0.29	**<0.001***	4.84 (5.13:4.54)

*p-value <0.05 is significant

Also, results have shown that bone volume value that was measured at 6 months (1719.47±59.87) was found to be significantly higher than the value measured at baseline (1143.28±54.50) ($p<0.001$). (Table 2).

Table 2: Intergroup comparisons of bone width volume (mm3)

Bone volume (mean±SD) (mm^3)		p-value	Difference (95% CI) (mm^3)
Baseline	6 months		
1143.28±54.50	1719.47±59.87	**<0.001***	576.19 (644.96:507.43)

*p-value <0.05 is significant

Histologic analysis revealed trabeculae of intact woven bone as well as newly formed bone embedded within a stroma of fibrous tissue. The bone that was newly formed showed less calcification than the older bone (rather eosinophilic), while the

fibrous tissue is better identified in Masson's trichrome stain being green in color. Analysis revealed that the mean area of new bone formation (%) was (29.72) with 95% confidence interval of (25.56:33.87), standard deviation was (6.70).

Discussion

The bone loss following tooth loss is a common problem that occurs, which can lead to bone deformities further problems during replacement of such missing teeth using implants. [15]

Autogenous bone is bone that is derived from a different donor site. However, this donor site is from the same individual. This autogenous bone renders the properties of osteoconduction (new bone formation occurs over the scaffold that was provided), osteoinduction (undifferentiated pluripotent cells are recruited and stimulated to become bone-forming cells) and osteogenesis (which is when the graft cells cause the formation of new bone). Unfortunately, these beneficial properties do not come without their own complications, the biggest one being the occurrence of donor site morbidity. Apart from donor site morbidity, the previously mentioned properties of autogenous bone is what causes it to be considered as the gold standard in bone augmentation cases.[16]

This study was done in order to evaluate the osteogenic potential of allogenic bone block grafts for horizontal alveolar ridge augmentation in bounded maxillary region, and its efficiency to be used as an alternative for autogenous bone grafts, which were considered, when it comes to bone grafting, as the gold standard.

Selection criteria for including patients in this study were set according to literature to be free from any local or systemic risk factors that could jeopardize the outcome of bone graft, such as poor oral hygiene, systemic disease affecting bone like diabetes or any treatment/medications as bisphosphonate that can affect bone quality or local infection [17,18,19,20], and the same was applied for smoking patients. [21,22,23]

The surgical procedures were standardized under aseptic conditions that can result in failure of augmentation process. [24,25] Surgical procedures were performed to finally, tension supply for the augmented area through flap design and bone trephination, proper fixation of bone graft and finally, tension free primary wound closure to protect the grafted area from microbiological and mechanical forces. [26]

The results of this study either radiographic analysis using CBCT or bone volume gain assessed by superimposition of 3D rendered bone models obtained from DICOM files revealed significant bone gain after 6 months of follow up. The results were supported by studies that revealed the effect of allogenic bone grafts as they have osteoconductive and osteoindictive properties that help in new bone formation. [27,28,29, 30,31]

Also, the histologic findings showed a significant increase in new bone formation percentage, with minimal or no percentages of fibrous tissue were observed in the histologic sections. Studies consider the new bone formation as an indicative sign for the success of bone grafting procedures. [28,29,32,33] These histologic findings could be further attributed to the osteoinductive and osteoconductive behavior of allogenic bone grafts.[34,35]

These histologic findings show the success of bone grafting process.

Conclusions

Within the limitation of this study, the following conclusions could be made:

1. Allogenic bone block used for bone augmentation produced a significant increase in bone measurements at crestal, middle and apical regions of bone.

2. Allogenic bone grafts produced an increase in overall bone volume.
3. Allogenic bone blocks can be used as effective grafting material for bone augmentation in maxillary region.

Funding

This study is self-funded, as There was no grant from funding agencies in the public, commercial, or not-for-profit sectors.

Data Availability

Full data is available for anyone. It may be acquired by requesting it by email.

Ethics Approval and Consent to Participate

The research plan was reviewed and accepted by the research ethical committee, Faculty of Dentistry Ain-Shams University and all patients signed informed consents following explanation of the whole procedure. The ethical committee approval number for this study is FDASU-ReclM021904.

Competing Interests

The authors have no conflicts of interest to declare.

References

1. Tan WL, Wong TLT, Wong MCM, Lang NP. A systematic review of post-extractional alveolar hard and soft tissue dimensional changes in humans. Clin Oral Implants Res 2012;23(SUPPL. 5):1–21.
2. Atwood DA, Coy WA. Clinical, cephalometric, and densitometric study of reduction of residual ridges. J Prosthet Dent 1971;26(3):280–295.
3. Cardaropoli G, Araujo M, Lindhe J. Dynamics of bone tissue formation in tooth extraction sites. J Clin Periodontol. 2005;30:809–818.
4. Scala A, Lang NP, Schweikert MT, de Oliveira JA, Rangel-Garcia I Jr, Botticelli D. Sequential healing of open extraction sites: an experimental study in monkeys. Clin Oral Implant Res. 2014;25:288–295.
5. Cha, H.-S.; Kim, J.-W.; Hwang, J.-H.; Ahn, K.-M. Frequency of bone graft in implant surgery. Maxillofac. Plast. Reconstr. Surg. 2016; 38, 1–4.
6. Carls FR, Sailer HF. Seven years clinical experience with mandibular distraction in children. J Cranio-Maxillofacial Surg 1998;26(4):197– 208.
7. Mechery R, Thiruvalluvan N, Sreehari AK. Ridge split and implant placement in deficient alveolar ridge: Case report and an update. Contemp Clin Dent 2015;6(1):94-99.
8. Dahlin C, Sennerby L, Lekholm U, et al. Generation of new bone around titanium implants using a membrane technique: an experimental study in rabbits. Int J Oral Maxillofac Implants 1989; 4: 19-25.
9. Becker W, Becker BE. Guided tissue regeneration for implants placed into extraction sockets and for implant dehiscences: surgical techniques and case report. The Int J Periodont Restorat Dent 1990; 10: 376-91.
10. Gokhan Gurler, Cagri Delilbasi, Hasan Garip and Sukran Tufekcioglu. Comparison of alveolar ridge splitting and autogenous onlay bone grafting to enable implant placement in patients with atrophic jaw bones Saudi Medical Journal December 2017; 38 (12) :1207-1212.
11. Lixin Qiu, Huajie Yu. Onlay grafting with bovine bone mineral block for horizontal reconstruction of severely atrophic alveolar ridges in anterior maxillae: A 6-year prospective study. Journal of Cranio-Maxillofacial Surgery. 2018; 46,(8):1199-1204.
12. Roberts, T.T.; Rosenbaum, A.J. Bone grafts, bone substitutes and orthobiologics: The bridge between basic science and clinical advancements in fracture healing. Organogenesis 2012; 8: 114–124.
13. Amini Z, Lari R. A systematic review of decellularized allograft and xenograft–derived scaffolds in bone tissue regeneration. Tissue and Cell. 2021; 69:101494.
14. Uzbek, U.H.; Rahman, S.A.; Alam, M.K.; Gillani, S.W. Bone Forming Potential of An-Organic Bovine Bone Graft: A Cone Beam CT study. J. Clin. Diagn. Res. 2014; 8:73–76.
15. Hansson S, Halldin A. Alveolar Ridge Resorption After Tooth Extraction: A Consequence of a Fundamental Principle of Bone Physiology. J Dent Biomech. 2012;3(1):1-8.
16. Ahmed W., Asim M.A., Ehsan A., Abbas Q. Non-vascularized autogenous bone grafts for reconstruction of maxillofacial osseous defects. J. Coll. Phys. Surg. Pak. 2018; 28:17–21.
17. Toscano N, Holtzclaw D, Hargitai IA, et al. Oral implications of cancer chemotherapy. J Implant Adv Clin Dent. 2009; 1: 51- 67.
18. McCabe LR. Understanding the pathology and mechanisms of type I diabetic bone loss. J cell Biomech. 2007;102(6):1343-1357.
19. Nooh N. Dental implant survival in irradiated oral cancer patients: a systematic review of the literature. Int J Oral Maxillofac Implants. 2013; 28(5): 1233- 1242.

20. Mohamed Talaat Khalifa, Iman Abd-El Wahab Radi, Nagla M.H. Nassouhy, Mohamed Amr ElKahsab. Implant loss in Diabetic Patients: A Systematic Review. Ain Shams Dental Journal. 2022; 26(2): 15-23.
21. Jaidaa Ismail, Iman Abd-El Wahab Radi, Nagla M.H. Nassouhy, Mohamed Amr ElKahsab. Effect of Smoking on Dental Implant Failure: A Systematic Review. Ain Shams Dental Journal. 2021; 23(3): 86-111.
22. Travis J, Pike R, Imamura T, Potempa J. The role of proteolytic enzymes in the development of pulmonary emphysema and periodontal disease. Am J Respir Crit Care Med. 1994;150:S143–6.
23. ynder HB, Caughman G, Lewis J, Billman MA, Schuster G. Nicotine modulation of in vitro human gingival fibroblast beta1 integrin expression. J Periodontol. 2002;73:505–10.
24. Camps-Font O, Figueiredo R, Valmaseda-Castellon E, Gay-Escoda C. Postoperative infections after dental implant placement: prevalence, clinical features, and treatment. Implant Dent. 2015; 24(6): 713- 719.
25. Keenan JR, Veitz-Keenan A. Antibiotic prophylaxis for dental implant placement? Evid Based Dent. 2015; 16(2): 52- 53.
26. Wang HL, Boyapati L. 'PASS' principles for predictable bone regeneration. Implant Dent 2006;15(1):8–17.
27. Waasdorp J, Reynolds MA. Allogeneic bone onlay grafts for alveolar ridge augmentation: a systematic review. Int J Oral Maxillofac Implants. 2010;25(3):525-31.
28. Wei L, Miron RJ, Shi B, Zhang Y. Osteoinductive and osteopromotive variability among different demineralized bone allografts. Clin Implant Dent Relat Res. 2015; 17(3): 533- 542.
29. Onisor-Gligor F, Juncar M, Campian RS, Baciu TG, Bran S, BaciuT MF. Subantral bone grafts, a comparative study of the degree of resorption of alloplastic versus autologous grafts. Rom J Morphol Embryol. 2015; 56(3): 1003- 1009.
30. Dasmah A, Thor A, Ekestubbe A, Sennerby L, Rasmusson L: Marginal Bone-Level Alterations at Implants Installed in Block Versus Particulate Onlay Bone Grafts Mixed with Platelet-Rich Plasma in Atrophic Maxilla. A Prospective 5-Year Follow-up Study of 15 Patients. Clinical implant dentistry and related research 14 15: 7 14,2013.
31. Herford AS, Tandon R, Stevens TW, Stoffella E, Cicciu M: Immediate Distraction 10 Osteogenesis: The Sandwich Technique in Combination with Rhbmp-2 for Anterior Maxillary and Mandibular Defects. Journal of craniofacial surgery. 2013; 24: 1383-1387.
32. Maiorana C., Sigurta D., Mirandola A., Garlini G., Santoro F. Sinus elevation with alloplasts or xenogenic materials and implants: An up-to-4-year clinical and radiologic follow-up. Int. J. Oral Maxillofac. Implants. 2006; 21:426-432.
33. Jo SH, Kim YK, Choi YH. Histological Evaluation of the Healing Process of Various Bone Graft Materials after Engraftment into the Human Body. Materials (Basel). 2018 May 2;11(5):714.
34. Ciszyński M, Dominiak S, Dominiak M, Gedrange T, Hadzik J. Allogenic Bone Graft in Dentistry: A Review of Current Trends and Developments. Int J Mol Sci. 2023 Nov 22;24(23):16598.
35. Zhao R., Yang R., Cooper P.R., Khurshid Z., Shavandi A., Ratnayake J. Bone grafts and substitutes in dentistry: A review of current trends and developments. Molecules. 2021;26:3007.