Original Article

Comparison of large versus small Bio-Oss bone particles in maxillary sinus floor elevation procedures (A clinical and Histological study)

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ABSTRACT

Aim: The aim of this study was to compare between different particle sizes of Geistlich BioOss bone graft material in sinus floor augmentation procedure in terms of bone height gain and histological analysis of a bone core biopsy obtained during the second stage surgery of implant placement.

Materials and Methods: Ten patients (seven males and three females with a mean age of 54.4 ± 6.9 years) with bilaterally deficient maxillary posterior bone height (3-4 mm) and seeking the placement of dental implants were included in this study. A split mouth technique for the ten patients with a total number of twenty sinus lifting procedures were carried out and divided equally into two groups. One side was randomly assigned to be augmented with large bio-oss particles (Group A) and the contra-lateral side was augmented with small bio-oss particles (Group B). Both groups were evaluated radiographically and histologically after 3 months postoperatively.

Results: There was a non-statistically significant difference between large and small bio-oss bone granules concerning bone height gain and histomorphometric analy**sis**

Conclusion: Our results showed a non-statistically significant difference radiographically and histologically between large and small BBM (Bio-Oss) granules in sinus floor augmentation. Both sizes demonstrated excellent results in sinus floor augmentation procedures in terms of osteoconductive potential and adequate vertical bone height gain required for placement of dental implants.

Key Words: Sinus lifting, Graft particles sizes, Histological analysis .

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INTRODUCTION

Loss of the maxillary posterior teeth are usually followed by resorption of the the alveolar ridge and pneumatization of the maxillary sinus leading to decrease in the vertical bone height necessary for implant placement.[1- 3]

In order to overcome such limitation, sinus floor elevation techniques have been introduced including either lateral or transcrestal approaches to elevate the shneiderian membrane and provide a sufficient bone volume allowing for structural and mechanical support for the dental implants. [4- 6]

Sinus floor elevation through the lateral window technique provides direct vision of the shneiderian membrane, unrestricted instrument usage and allow for more membrane elevation when compared to the transcrestal approach. [7,8] Lateral window approach is considered one of the most efficient and safe techniques for sinus floor elevation and augmentation of the posterior maxillary region. [9]

Different types of bone grafts have been used for sinus floor augmentation including autogenous bone graft, hydroxyapatite, tricalcium phosphate and deproteinized bovine bone mineral (BBM). [10-13]

Bio-Oss is a BBM preparation available in the market in two particle sizes, 0.25-1 mm and 1-2mm. It was found to be a biocompatible osteoconductive material that provide a scaffold leading to lamellar bone formation and increase in bone density. [14- 16]

In this study, a comparison was performed between different particle sizes of bone graft material (Bio-Oss® Geistlich-Switzerland) in sinus floor augmentation procedure in terms of bone height gain and histological analysis of a bone core biopsy obtained during the second stage surgery of implant placement.

MATERIALS AND METHODS:

Ten patients (seven males and three females with a mean age of 54.4 ± 6.9 years) with bilaterally deficient maxillary posterior bone height and seeking the placement of dental implants were selected from the outpatient clinic of Oral and Maxillofacial Surgery, Faculty of Dentistry, Cairo University.

Non-smoking patients with bilateral residual posterior

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bone height of 3-4 mm were included in the study. Any patient with psychological disorders, maxillary sinusitis, maxillary sinus tumours, bleeding tendency, diabetes or any systemic diseases that jeopardize the surgical procedure and/or implant placement were excluded from the study. This study was accepted by the committee of research ethics of Cairo University # 24 -11- 24.

Sample size calculation: This power analysis used histomorphometric soft tissue percentage as the primary outcome. According to the results of the study performed by Kurkcu et al [17], the mean and standard deviation (SD) values were 37.99 (5.92) and 44.86 (4.28) %, respectively. Using alpha (α) level of (5%), β level of 0.8 (Power = 80%); the effect size (dz) for paired t-test was 1.298 and the minimum estimated sample size was seven subjects. The sample size was raised to ten patients to compensate for any drop-outs. G*Power Version 3.1.9.2.software was used to calculate the sample size. A split mouth technique for ten patients with a total number of twenty sinus lifting procedures were carried out and divided equally into two groups. Each patient underwent bilateral sinus floor augmentation procedure.

One side was randomly assigned to be augmented with large bioss particles (Group A) and the contra-lateral side was augmented with small bioss particles (Group B) where each group included ten cases. Cone-beam CT was performed for all the patients preoperatively to evaluate the residual posterior maxillary bone height and width (Figs.1, 2).

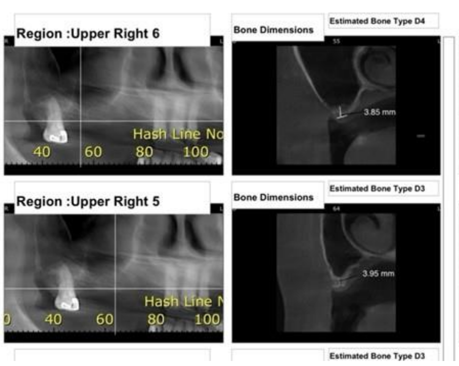

Figure1: Showing preoperative cone-beam CT for group A (Large granules) cases

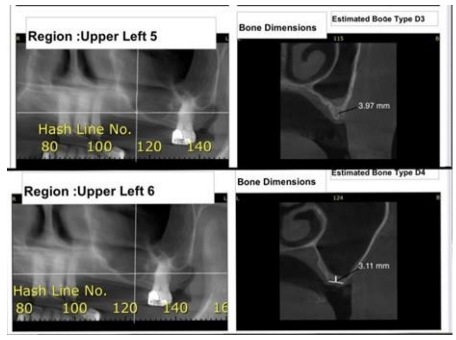

Figure 2: Showing preoperative cone-beam CT for group B (Small granules) cases

Surgical procedure

In both groups, the surgical procedure was performed under local anesthesia (ARTINIBSA 40 mg/0.01 mg/ml, Inibsa Dental S.L.U, Barcelona, Spain). A slightly palatal crestal incision with posterior vertical releasing incision was carried out and a full thickness mucoperiosteal flap was elevated exposing the lateral bony wall of the maxillary sinus. A piezotome was used to create the osteotomy window with the inferior border about 5mm from the alveolar crest. After exposing the shneiderian membrane, sinus lifting instruments were used carefully to dissect and detach the membrane from the surrounding bone.

In group A, the space created by the membrane elevation was filled with large bio-oss particles while in group B the space was filled by small bio-oss particles taking into consideration that the graft particles are in close contact to the surrounding bone. The flap was sutured back in place using 4-0 vicryl sutures (Assut Assucryl PGA, Switzerland) and the graft was left to heal for three months (Figs.3, 4, 5). Cone-beam CT was performed Immediate postoperatively for both groups.

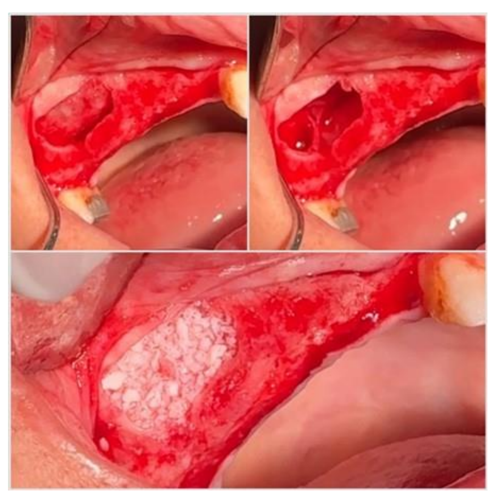

Figure 3: Showing sinus membrane elevation and floor augmentation using large bone granules

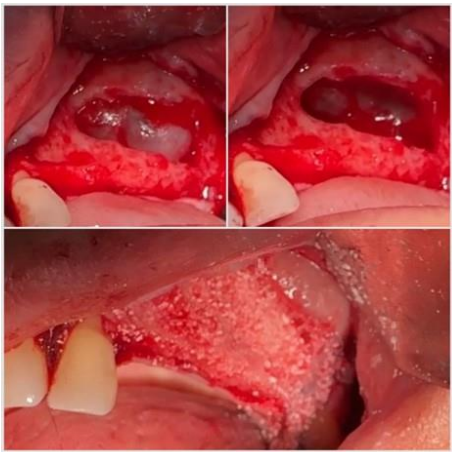

Figure 4: Showing sinus membrane elevation and floor augmentation using small bone granules

Figure 5: Showing bilateral suturing using 4-0 vicryl sutures

The patients were instructed to bite on a gauze pack for 60 minutes, apply ice packs on the same day of surgery, avoid nasal blowing, and rinse with chlorohexidine mouth wash for 2 weeks postoperatively.

Medications:

-Antibiotic (Augmentin 1 gm. GlaxoSmithKline Co.) was prescribed prophylactically every 8 hours for 1 week.
-Analgesics (Brufen, Ibuprofen 600 mg) was prescribed to control pain whenever needed.
-Nasal decongestant (oxymetazoline nasal spray) 1 puff in each nostril every 12 hours

The second stage surgery was scheduled after 3 months posoperatively where a cone-beam CT was performed for all the cases (Figs.6, 7). Prior to implant insertion, a bone core biopsy was obtained using 2.5 mm trephine bur and sent for histological analysis (Fig. 8).

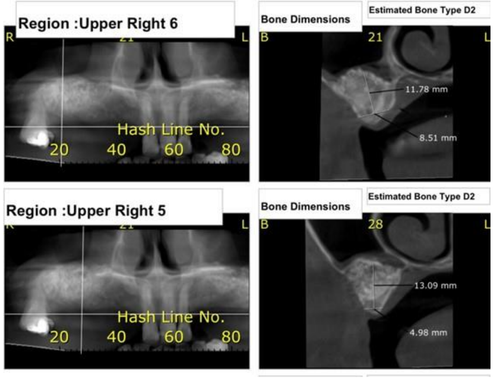

Figure 6: Showing 3 months post-operative cone-beam CT for group A (Large granules) cases

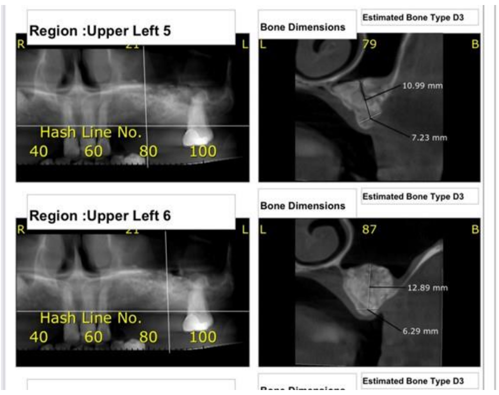

Figure 7: Showing 3 months post-operative cone-beam CT for group B (Small granules) cases

Figure 8: Showing a bone core biopsy obtained using 2.5 mm trephine bur

Histologic and histomorphometric processing

All the samples from both groups were gently retrieved from the trephine bur and fixed in 10 % calciphormol, decalcified in EDTA solution, dehydrated in ascending grades of alcohol, cleared in xylol and embedded in paraffin. Then the specimens were sectioned along their longitudinal axis and sections of six microns thickness were deparaffinized and stained with hematoxylin and eosin stain for histological investigation through the light microscope. The morphometric analysis of the histological slides was performed using the image analyzer computer system.

The microscope (Leica Microsystems Wetzlar GmbH, type: DMLB2/11888116, Germany) was connected to the image analyzer computer system applying the software Leica Owin 500 (Leica Microsystems LTD. CH9435 Meerbrugg Type: DFC295 "12730469", Serial number 0557060916, Switzerland).

Statistical Analysis

Kolmogorov-Smirnov and Shapiro-Wilk tests were used to explore the numerical data for normality through checking of data distribution. Normal parametric distribution was evident for all the data which was presented as mean and standard deviation (SD). Comparison between both groups and the changes within each group were evaluated using the paired t-test and the repeated measures Anova test. Whenever the ANOVA test is significant, Bonferroni's post-hoc test was used to perform pair-wise comparisons. $P \leq 0.05$ was set as the level of significance and the whole statistical analysis was performed using IBM SPSS Statistics for Windows, Version 23.0. NY: IBM Corp..

RESULTS

Histologic and Histomorphometric Results :

The histological results revealed that both particle sizes of both study groups produced similar architecture and pattern of new bone formation. However, the small size particle group appeared more frequently surrounded by new vital bone than by connective tissue when compared to the large size particle group. The trabeculae of the new bone appeared perpendicular to each other forming a network extending around and in between the residual bone graft particles in various regions in association with osteon formation. Also, they were surrounded by osteoblasts and presented basophilic resting lines. The newly formed bony trabeculae appeared highly cellular with numerous clearly distinguishable osteocytes in their lacunae indicating bone vitality. In addition, multinucleated giant cells (osteoclasts) in their Howship's lacunae were seen on the surface of some bony trabeculae and surrounding the residual graft particles in both groups specially the small size particle group .The remaining tissue seen in the samples was delicate highly vascular connective tissue comprising fibroblasts, collagen fibers and small blood capillaries.

The histological results showed no evidence of marked inflammatory reactions and no occurrence of foreign body in any of the histologic specimens. In addition, the graft size particles in each group could be distinguished based on their typical homogenous structure and pale eosinophilic stain being integrated into the native bone and partially surrounded by connective tissue rich in cells and newly formed vessels (Figs.9, 10).

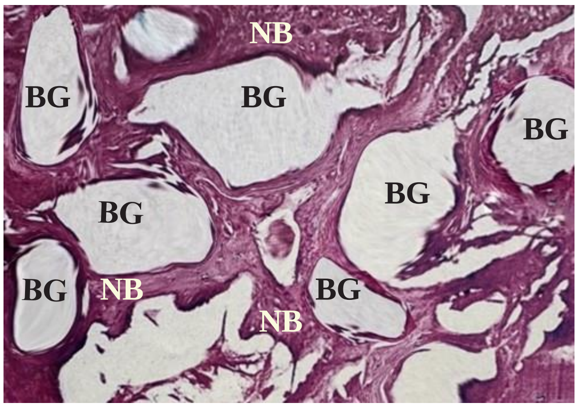

Figure 9: Showing histological structure of bone specimen of group A (Large particles) with newly formed bony trabeculae (NB), residual large bone granules (BG) and vascular soft connective tissue (CT), (X.100)

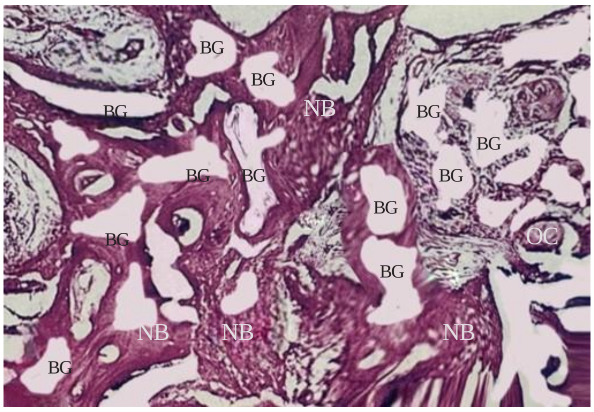

Figure 10: Showing histological structure of bone specimen of group B (Small particles) with new bone trabeculae (NB), residual small bone granules (BG), osteoclast (OC) and vascular soft connective tissue (CT), (X.100)

Histo-morphometric analysis

There was no statistically significant difference between new bone %, BBM granules % as well as soft tissue % in the two groups (Table 1) (Fig.11).

Table (1). Descriptive statistics and results of paired t-test comparing the histo-morphometric results of both groups.

Measurement (%)	Group A (n = 10)		Group B (n = 10)		P-value	Effect size (d)
	Mean	SD	Mean	SD		
New bone	20.56	1.47	21.48	1.09	0.074	0.702
BBM granules	35.8	1.46	36.66	0.93	0.209	0.476
Soft tissue	43.64	2.02	41.46	0.47	0.063	0.884

*: Significant at $P \leq 0.05$

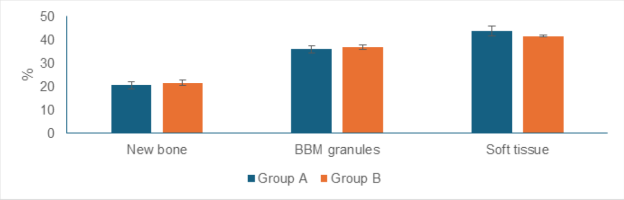

Figure 11: A Bar chart showing the mean and SD of the histomorphometric analysis measurements in both groups

Bone height measurements (mm)

Pre-operatively, immediately post-operative and after three months postoperatively, a non-statistically significant difference between the two groups was reported (Table 2) (Fig.12).

Pair-wise comparisons between time periods revealed that there was a statistically significant increase in bone height measurements immediate post-operative followed by a statistically non-significant decrease in bone height measurements after three months (Table 2) (Fig.12).

A non-statistically significant difference between the two groups was reported concerning the changes in bone height through all periods (Table 3) (Fig.12).

Table (2). Descriptive statistics and results of repeated measures ANOVA test for comparison between bone height measurements (mm) in the two groups and the changes within each group

Time	Group A (n = 10)		Group B (n = 10)		P-value	Effect size (Partial Eta squared)
	Mean	SD	Mean	SD		
Pre-operative	3.48 [C]	0.34	3.51 [C]	0.27	0.866	0.866
Immediate post-operative	12.17 [A]	0.8	12.28 [A]	0.58	0.762	0.762
3 months	11.95 [B]	0.73	12.19 [B]	0.54	0.479	0.479
P-value	<0.001*		<0.001*			
Effect size (Partial Eta squared)	0.995		0.997			

*: Significant at P ≤ 0.05, Statistically significant changes within each group are indicated with different superscripts in the same column

Table (3). Comparison of changes in bone height (mm) between both groups represented through descriptive statistics and the paired t-test

Time	Group A (n = 10)		Group B (n = 10)		P-value	Effect size (d)
	Mean	SD	Mean	SD		
Pre-operative – Immediate post-operative	8.69	0.72	8.77	0.6	0.824	0.079
Pre-operative – 3 months	8.47	0.67	8.68	0.57	0.539	0.216
Immediate post-operative - 3 months	-0.22	0.1	-0.12	0.05	0.055	0.905

*: Significant at P ≤ 0.05

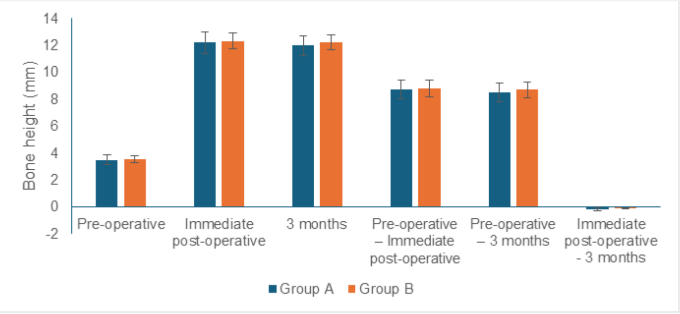

Figure 12: A Bar chart showing the mean and SD of the bone height measurements in both groups

DISCUSSION

In the present study, the residual posterior maxillary bone height was 3-4 mm in the selected patients which indicates sinus floor augmentation through lateral window approach in a two-stage procedure. This coincides with the findings of Kang [18] and Toffler [19] who reported that residual alveolar bone height of less than 5 mm requires a staged approach as the primary stability of the implant might be compromised. Toffler[19] and Santagata et al [20] also reported that transcrestal approaches allows only 2-3 mm of sinus floor elevation and if more floor elevation is required the lateral window approach would be recommended.

It has been reported that smoking habits with sinus floor augmentation techniques interfere with bone formation and remodeling due to vasoconstriction of the blood vessels and decrease in oxygen flow induced by nicotine [14, 21, 22], hence, all the selected patients in this study were non-smokers.

In the current study, a piezotome was used to create the lateral osteotomy window where no membrane perforation was reported in all the cases. This agrees with Wallace et al [23] and Vercellotti et al [24] who reported that piezotome is a safe choice in delicate sites requiring bone removal with preservation of soft tissues. They also reported that new bone formation was more rapid by using piezotome compared to rotary burs. In our study, it was taken into consideration to place the graft material in close contact with the surrounding bone in both groups in order to achieve better healing. This is found to be in agreement with Coyac et al [25] who reported that maximum contact between the graft and the native bone of the sinus should be achieved to obtain a good bone quality. Autogenous bone is considered the gold standard for grafting procedures however; donor site morbidity and high resorption rates were reported as disadvantages. [26, 27]

In this study, the demineralized bovine bone graft (Bio-Oss) was selected for sinus floor augmentation and it showed excellent results regarding bone height gain and new bone formation in both groups. These findings support the results of other authors [28-31] who concluded that Bio-Oss bone graft is osteoconductive, safe with a low resorption rate and high success regarding the quality and quantity of bone formation.

In this study, the changes in graft height within each group and between the two groups after three months postoperatively were insignificant. This is found to be in agreement with Kirmeier et al [32] and Shanbhag et al [33] who reported that delayed implant placement results in less graft shrinkage compared to simultaneous implant placement in sinus floor augmentation procedures. Pommer et al [34] and Stacchi et al [35] also reported that the amount of graft shrinkage is determined by the type of the graft used together with degree of vascularization and mineralization of the graft material.

In the present study, the histological and histomorphometric analysis revealed the presence of new bone formation with non-statistically significant difference between the two groups. This agrees with Karageorgiou & Kaplan [36] and Dorozhkin [37] who reported that particles having the same size of micro pores allow bone cells attachment, permeation of osteoinductive agents and bone ingrowth regardless of the graft particle sizes. In addition, the interconnecting porous structure enhances the vascularization of the graft which explains the presence of blood vessels seen in the histological results.

In our study, the histological and histomorphometric analysis of both groups revealed the presence of residual bovine bone mineral with non-statistically significant difference between the two groups. This coincides with findings of other studies [38-40] reporting that particles degradation is necessary to provide space for new bone formation. This might explain the presence of osteoclasts specially with small size particles in our results. However; too rapid degradation of the particles is undesirable as this will decrease the osteoconductivity of the graft material. They also reported that the small quantity of phosphate in the BBM allows for slow resorption of the particles which is considered an advantage to the material.

In the present study, the newly formed bony trabeculae appeared highly cellular with numerous osteocytes indicating their vitality. They were also surrounded by osteoblasts with the presence of osteoclasts supporting the activity of bone remodeling and replacement of the new provisional bone by the mature lamellar bone. Moreover, the absence of the signs of inflammation as well as any foreign body in both particle sizes groups, confirms the highest biocompatibility of the selected bone particles type used in our study. [41]

CONCLUSION:

Our results showed a non-statistically significant difference radiographically and histologically between large and small BBM (Bio-Oss) granules in sinus floor augmentation. Both sizes demonstrated excellent results in sinus floor augmentation procedures in terms of osteoconductive potential and adequate vertical bone height gain required for placement of dental implants.

CONFLICT OF INTEREST

This clinical study was self-funded by the authors, with no conflict of interest.

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