

A randomized clinical trial comparing two particle sizes in lateral window sinus lift with deproteinized bovine bone mineral: clinical and histological results

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Abstract

The treatment of edentulous maxilla frequently faces limitations regarding bone availability in the posterior area. Sinus lift procedures have become a very useful tool to treat these cases. The use of deproteinized bovine bone mineral as an osteoconductive biomaterial is well documented. This split-mouth study evaluated bone formation in elevated sinuses in 20 patients who were randomly selected. The study compared two different particle sizes, S (0.25-1 mm) and L (1-2 mm). The histomorphometric analysis of the biopsies collected from implant placement sites showed 42.6% new bone, 42.5% non mineralized tissue and 14.4% of particles in the S group. The L group showed 47.2%, 38.3% and 13.7%, respectively. The Wilcoxon signed-rank test showed a $P=0.1454$ value (0.5 significance), with no statistically significant difference between the two groups. No membrane perforations were observed during the osteotomy, and the implant survival rate was 100% after one year.

Keywords: sinus lift, deproteinized bovine bone mineral, histomorphology, piezoelectric surgery.

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Introduction and background

Prosthetic implant treatment of the edentulous maxilla frequently faces limitations regarding bone availability in the posterior area, as well as the high prevalence of low-density bone⁽¹⁾. Posterior bone loss is conditioned by the pathological processes of teeth that affect the alveolar bone, by traumatic extraction techniques and by maxillary sinus pneumatization expressed in sinus alveolar extensions favored by tooth loss⁽²⁾. Different strategies are implemented to overcome the problems that make it difficult or impossible to place posterior implants. These include the use of short subantral implants^(3,4), buccal or palatal implants when there is bone availability in the respective walls⁽⁵⁾, the placement of pterygoid implants⁶, and the recovery of bone volume in both the alveolar apophysis and inside the sinus. Sinus bone augmentation techniques, procedure known as sinus lift, becomes particularly relevant as it has a strong impact on the therapeutic options available. Their main advantage is the possibility of placing implants in the site and with the exact axis required by the dentures.

Various approaches have been suggested to increase the subantral height available⁷, among them the crests approach techniques, such as those developed by Summers⁽⁸⁾, Gosci⁽⁹⁾ and Trombelli⁽¹⁰⁾, as well as the lateral approach techniques developed by Salagaray and Losada in 1980, and Tatum in 1986⁽¹¹⁾ in one and two operative times, with specific indications. Bone regeneration in pneumatized sinuses can be combined with horizontal or vertical alveolar bone regeneration for placing prosthetic-guided dental implants. Intrasinus implants have a high survival rate, low functional load (97%), regardless of the technique and the materials used⁽¹²⁾.

Different materials have been used to fill the sub-Schneiderian space, such as autograft, homograft and xenograft⁽¹³⁾. The use of autograft is limited by the need for a donor site (greater complexity and morbidity). This graft can have intra-oral sources, when the reconstruction need is small, or extra-oral sources, for complex cases⁽¹⁴⁾.

According to the literature, autogenous bone has a higher rate of bone resorption compared with the mixture of autogenous bone and slowly resorbable bone substitute. Various authors claim that when a maxillary sinus is filled with a xenograft, such as DBBM, alone or in combination with autologous bone, bone volume is preserved. However, when it is filled only with autologous bone, the grafted volume decreases significantly. An increased use of DBBM has been reported for bone regeneration in the maxillary sinus⁽¹⁵⁾. This material is presented in two particle sizes: Bio-Oss® S (0.25-1 mm) and Bio-Oss L (1-2 mm), which have been used in sinus lift.

The use of DBBM provides a secure and predictable method for new bone formation, avoiding the morbidity of the donor site, reducing operative time, and rationalizing the use of resources. Additionally, there is histological evidence of new bone formation and radiographic evidence that shows the preservation of the initial volume obtained.

A meta-analysis conducted by Shanbhag et al. reports that the use of slow resorption osteoconductive biomaterials is favorable when compared with autologous bone. Mordenfeld reports the presence of 17.3% of the particles after 11 years, which justifies the success reported⁽¹⁶⁾. Chackartchi et al. compared the amount of new bone formed after a sinus lift procedure with two different DBBM particle sizes by conducting a clinical, tomographic and histological assessment. The authors conclude that both particle sizes fulfilled their role in the sinus lift technique, both clinically and histologically⁽¹⁷⁾.

General objective

The purpose of this study was to evaluate new bone formation in patients with fixed implant-supported dentures in maxillae previously treated with bilateral sinus lift using two different DBBM particle sizes.

Specific objectives

1. To histologically and histomorphometrically assess the new bone in relation to the two particle sizes
2. To determine the perforation rate of the Schneiderian membrane with piezoelectric surgery.
3. To evaluate the survival rate of the implants.
4. To radiographically assess sinus re-pneumatization.

Methodology

A randomized clinical trial was conducted with twenty consecutive patients treated at the Course of Specialization in Oral Implantology, of the School of Dentistry of Universidad de la República. They were included in the sample between November 2011 and August 2013.

Inclusion criteria

- Good general health, ASA 1 and ASA 2
 - Not being under medical treatment or taking drugs that may compromise the surgical procedure
 - Absence of sinus pathologies that may be a contraindication for surgery
 - Non-smokers
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- Absence of periodontitis
 - Bilateral posterior edentulism of the maxilla with subantral bone availability lower than four millimeters, sufficient width and which requires fixed implant-supported rehabilitation
 - Capacity to bear the financial costs of their rehabilitation
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Exclusion criteria

- Patients with systemic diseases which may be a contraindication for minor oral surgery
 - Patients who consumed oral bisphosphonates for more than three years
 - Smokers
 - Pathologies: maxillary sinusitis, untreated periodontal disease, active caries disease, tumors and cysts in the jaws
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The patients included in the study received the information regarding the project and signed an informed consent to confirm their participation. The patients were treated with bilateral sinus lift in two times, in a split-mouth study with one operator. Each patient was randomly awarded a DBBM particle size: 0.25-1 mm (S) and 1.0-2.0 mm (L), by staff that were not part of the research team. The cases of perforation of the Schneiderian membrane were recorded.

Surgical technique

The team, in strict compliance with the biosecurity standards of the institution⁽¹⁸⁾, performed the following procedures:

1. Perioral antisepsis with 2% chlorhexidine
 2. Isolation of the operative field with sterile surgical field
 3. Intraoral antisepsis with 0.12% chlorhexidine
 4. Regional infiltration local anesthesia with 2% mepivacaine with adrenaline 1:100,000
 5. Mucoperiosteal incision on the crest of the bone ridge with a No. 15 blade and mesial and distal relieving incisions away from the procedure area
 6. Elevation of full-thickness flap
 7. Determination of the osteotomy site with the help of the surgical guide
 8. Osteotomy with piezoelectric surgery (Piezotome®-Satelec) using a diamond-coated tip under saline irrigation. Next, an elliptical lateral window was made, with its upper border at 15 mm above the alveolar crest, the anterior border 3 mm behind the anterior border of the maxillary sinus, the lower border 3 mm above the sinus floor, and the posterior border according to the number of implants placed. The window dimensions were 10 mm in height and 12 mm in mesiodistal width.
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9. Perforations of the Schneiderian membrane during the osteotomy were diagnosed, both visually and through the Valsalva maneuver.
10. Separation of sinus membrane with Biomet3I® sinus currettes
11. Membrane perforations were diagnosed as a result of the separation, according to what is established in item 9.
12. As the Schneiderian membrane had perforations, a Bioguide resorbable collagen membrane was placed® (Geistlich) before filling the sinus, following Fugazzoto and Vlassis⁽¹⁹⁾.
13. The sub-Schneiderian space was filled with DBBM according to the particle size allocated in the draw; no collagen membrane covering the antrostomy was placed⁽²⁰⁾.
14. Flap replacement
15. The area was closed with 4-0 silk suture (Ethicon®).
16. Postoperative management and application of systemic medication protocol

The same procedure was performed on the contralateral side (Fig. 1 and 2).

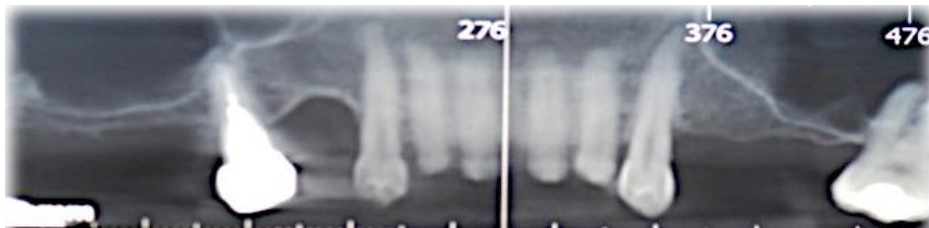


Fig. 1



Fig. 2

Systemic medication protocol

Two capsules of 1000 mg of amoxicillin/clavulanic acid were prescribed an hour before surgery, as well as a dose of tablets every twelve hours for seven days. In the case of allergic patients, 600 mg of Clindamycin was prescribed an hour before surgery, and a dose of 300 mg every six hours for seven days. Oral dexamethasone 8 mg was prescribed: one tablet before surgery and one tablet daily for three days.

Surgical technique for implant placement

Nine-twelve months after the sinus lift procedures, the implant was placed on each patient. Before placement, a tissue sample was taken with a trephine for histomorphometric studies in the Anatomic Pathology Laboratory of the School of Dentistry of Universidad de la República, under the following conditions:

1. Perioral antisepsis with 2% chlorhexidine
 2. Isolation of the operative field with sterile surgical field
 3. Intraoral antisepsis with 0.12% chlorhexidine
 4. Regional infiltration local anesthesia with 2 tubes of mepivacaine with adrenaline 1:100000
 5. Mucoperiosteal incision on the crest of the ridge with a No. 15 blade and mesial and distal relieving incisions away from the procedure area
 6. Separation of full-thickness flap
 7. Placement of surgical guide
 8. Location of implant sites; osteotomy was initiated with a number 6 round bur (Maillefer®) up to 3 mm deep, and then a 3 mm outer diameter and 2 mm inner diameter trephine was used (Biomet3I®), up to 8 mm deep.
 9. A biopsy sample was obtained by removing the bone tissue from inside the trephine.
 10. Biopsy sample was stored in 10% formalin.
 11. Osteotomy was completed according to the implant selected.
 12. Osseotite (Biomet3I®) implant was placed (4 mm in diameter and 10-11 mm in length).
 13. The screw cap of the implant was placed (Fig. 3).
 14. 4-0 silk suture without tension
 15. Postoperative management and application of systemic medication protocol
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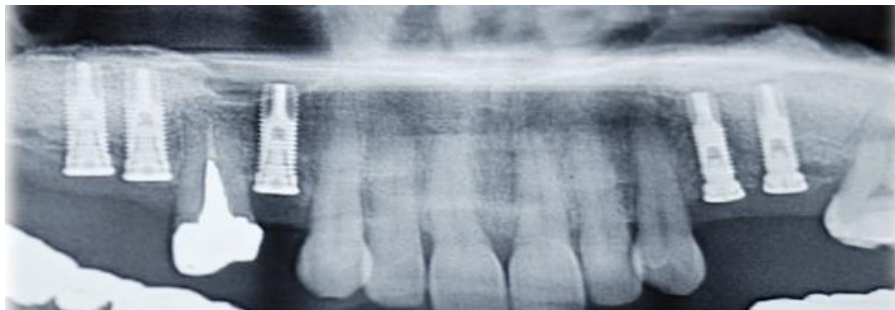


Fig. 3

The first post-operative control was scheduled for seven days after the surgery, when the sutures were removed. Four months after placing the implant, osseointegration was assessed, rehabilitation procedures began through fixed implant-supported dentures. The criteria used to evaluate success rates were based on relevant literature⁽²¹⁾.

Control imaging studies

To assess the volume of new bone and to monitor maxillary sinus re-pneumatization, CBCT scans were taken, and the distance between the end of the implant and the elevated sinus floor was measured. These tests were conducted after the functional loading of implants and will be repeated after five years.

Results

In all cases there was a successful recovery of bone volume, with the presence of mature intrasinus bone, which made it possible to place the planned implants, and to rehabilitate them. In the sinus lift procedures there were no perforations of the Schneiderian membrane during the osteotomy, with only two instances of perforation during manual separation of the membrane, associated to intrasinus anatomy (a septum and a root projected towards the inside of the antrum).

Histological analysis and processing

The histological and histomorphometric study was conducted at the Anatomic Pathology Laboratory of the School of Dentistry of Universidad de la República. The samples were placed in 10% buffered formalin with a pH of 6.5 to be preserved, and for the technical processing of paraffin embedding, after decalcifying them. The pieces were placed in a Biocare Medical *Ion-Exchange Decal (I.E.D.) Unit* for 24 hours a day for decalcification. The I.E.D. Unit includes a strong cation ion-exchange resin in a weak acid solution to remove calcium ions from bone, while replacing them with hydrogen ions. The ion-exchange process does not require strong concentrated acid solutions as in traditional decalcification methods; delicate cellular structures remain intact, which improves microscopic observation. Decalcified bone cylinders were longitudinally sectioned following the central axis with a microtome knife, obtaining from each specimen two bone fragments with a cutting surface from the center of the cylinder (Fig. 4).

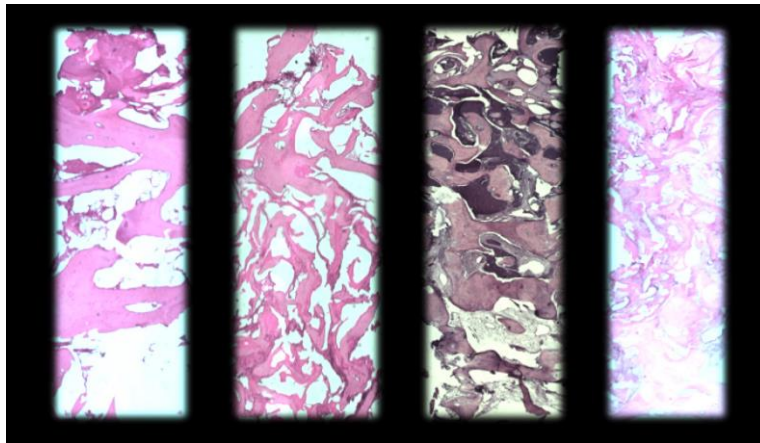


Fig. 4

A Thermo SLEE automatic tissue processor was used, with seven stations: five of them in alcohols of increasing degrees until 100% isopropyl alcohol was reached, and two of paraffin. From the paraffin blocks, 4 μ m histological sections were made and then stained with hematoxylin and eosin. The sheets were coded with continuous ordinal numbers starting from 1 to preserve patient confidentiality and to blind observers for the histological analysis. In this way, they were unaware of the type of bone graft (S or L Bio-Oss® particles) placed on each patient. The histological analysis was performed in an Olympus BX 50 binocular microscope by a

single observer, who was blind, calibrated and experienced in the observation of this material. The microscopic images of the slides were captured with an Infynit1 video camera, attached to the binocular microscope. Image Pro Plus ® version 7.0. was used to capture the images, and Live Tiling was used to scan the slide, thus obtaining a complete image of the bone cylinder with a 10x magnification (Fig. 5)

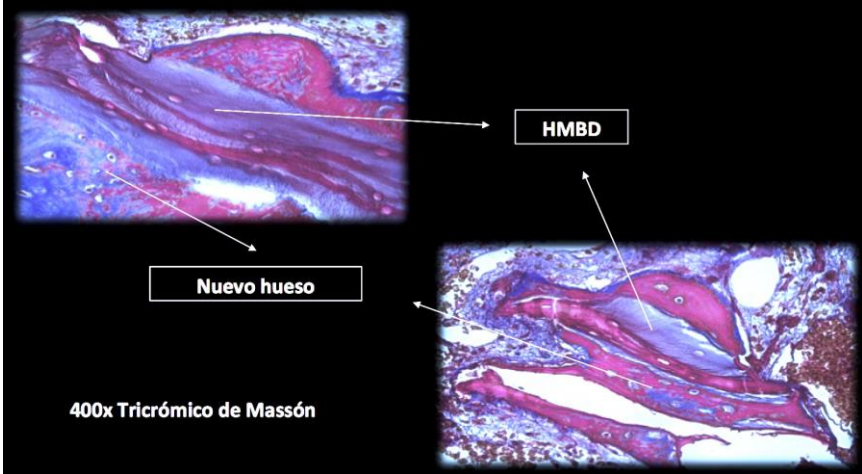


Fig.5

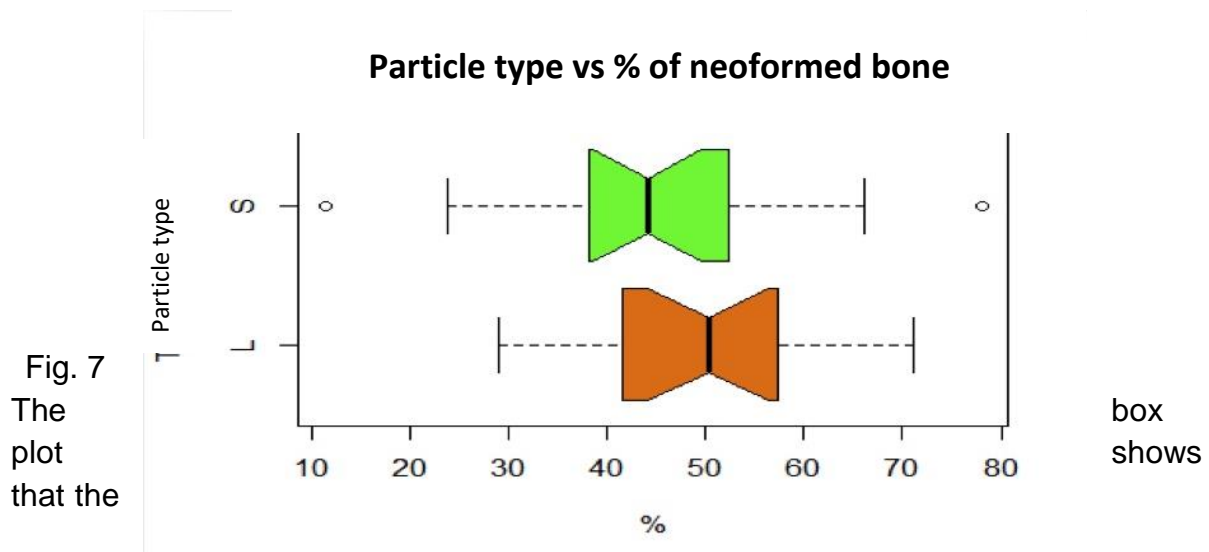
For the histomorphometric analysis, we evaluated the images by distinguishing the new vital bone tissue, the non-mineralized soft tissue, (bone marrow, connective tissue, etc.) and the grafting material. Neoformed vital bone differentiation regarding the grafting material and other structures was performed to assess the characteristics of bone with the staining used and the presence of osteocytes. The grafting material was identified by the absence of osteocytes. We measured the total area of the bone cylinder and then the different areas mentioned above, obtaining a value expressed in percentages. For this analysis, two blinded calibrated observers identified the areas. Raster Adobe Photoshop CS5 image editing software was used to quantify the percentage of different areas. Of the total area of bone cylinder, blank spaces which corresponded to areas of tissue contraction on account of histological processing were removed. The other tissues were identified with a different color and their percentages measured with the image editing software. The percentages of each tissue and grafting material are expressed in the following table (Fig. 6)

AREA	S	L
Neoformed vital bone tissue	42.6%	47.2%
Non-mineralized tissues	42.5%	38.3%
Grafting material	14.4%	13.7%

Fig. 6

These results were statistically processed at the Statistics Unit of the School of Dentistry. When applying the Wilcoxon signed-rank test²² a p value of 0.1454 was

found. With a 0.05 significance level, there is no statistically significant difference to rule out the equality of medians between both populations (Fig. 7)



confidence intervals for the median overlap, which shows that the medians of both groups differ.

The implant survival rate was 100% after one year. Considering the following criteria⁽²¹⁾:

- Success (optimal health): satisfactory function and aesthetics, absence of pain and mobility, marginal bone loss lower than 2 mm in the first year and absence of inflammation.
- Implant survival: good function, aesthetic compromise, absence of pain and mobility, bone loss greater than 4 mm and absence of inflammation.
- Failure: pain during function, mobility, advanced bone loss and loss of osseointegration.

Discussion

The results of this study are in line with previous work that used DBBM as osteoconductive material for sinus lift. The use of two particle sizes in this study seems not to influence the result in terms of new bone formation. In 2010, Chackartchi et al. found no clinical or histological differences between the two DBBM presentations when studying them in the sinus lift: both were successful¹⁷. The results of this study confirm the high rates of new bone formation, regardless of the particle size used (L and S) (47.2% and 42.6% respectively).

Regarding the tearing of the Schneiderian membrane, in a study of 100 consecutive cases, Wallace et al. reported a 30% perforation rate when using rotary instruments, and a 7% with piezoelectric instruments²³. A meta-analysis published by Atieh et al. in 2015 does not find significant differences between both techniques²⁴. This study found that piezosurgery had an optimum performance as the antrostomies performed

had no membrane perforations. The only two cases of perforation occurred during separation (4.54%), attributed to the existence of a septum and the projection of a tooth root into the sinus floor.

Regarding the placement of a collagen membrane covering the antrostomy, in 2005 Wallace et al. reported an increase in bone using a collagen membrane to cover the antrostomy⁽²⁰⁾.

In 2015, Suárez et al.⁽²⁵⁾ published a meta-analysis showing that placing a membrane does not influence the percentage of neoformed vital bone (with barrier 32-36%, and without barrier 33-37%). A collagen membrane was not used in this study, which did not seem to influence the histological results. The possible involvement of bone quality, when not using a barrier, can be seen on the surface of the filler material, and in many cases an immature osteoid surface is found. This condition does not affect the implant site located in the center of the volume of new bone, which justifies the excellent results and conclusions of the Suárez study⁽²⁵⁾.

In line with what has been reported by authors such as Di Stefano et al.⁽²⁶⁾, Felice et al.⁽²⁷⁾, Oliveira et al.⁽²⁸⁾ and Meloni et al.⁽²⁹⁾, we observed a 100% implant survival rate after one year.

Conclusions

With the methodology implemented, all patients in this study showed a high rate of bone neoformation in the elevated maxillary sinuses, recovering the volume and allowing for the safe insertion of the implants as well as their successful rehabilitation.

Piezoelectric surgery is recommended for sinus lift procedures to reduce the risk of perforating the Schneiderian membrane during the osteotomy.

The study showed that there is no statistically significant difference in the amount of new bone formed in relation to the size of the particles used. Therefore, it would be advisable to use large particles (L) that have a better performance in volume (45%), thus reducing the cost of the procedure.

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