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Case Report

Osteogenerative behavior of a new xenograft in a maxillary sinus lift: computed tomographic and histological findings

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Abstract: The installation of implants in the maxillary posterior area is currently a challenge in implant-supported rehabilitation, which is why most of the times the maxillary zone must be reconstructed with different types of materials and grafts. An analysis was made of the osteogenerative behavior, computed tomographic (CT) and histological characteristics of a xenograft (Orthogen®). Six consecutives patients (8 sinuses) underwent a maxillary sinus lift using the Orthogen graft. All the patients had CT examinations in the preoperative and immediate postoperative stage as well as at 6 months postoperatively. A final average gain of 12.65 mm was obtained. The eight sinus lift procedures selected from the six patients in the study were subjected to a Shapiro-Wilk statistical analysis. The variables were maxillary height in the preoperative and immediate postoperative periods and at 6 months after the maxillary sinus lift. A statistically significant difference between pre and post operative conditions was obtained, with $P \leq 0.0005$. The good clinical results obtained with these xenografts enabled the subsequent installation of osseointegrated implants. However, further studies are needed to support this evidence.

Keywords: Maxillary sinus, dental implants, bone reconstruction, xenograft

Introduction

The positioning of implants in the maxillary posterior area is currently a challenge in fixed implant-supported rehabilitation. With tooth loss the stimuli that maintains the alveolar bone disappear, inducing a degenerative process that causes a narrowing in the width of the bone crest and, consequently, the cancellous bone and its height decreases. There are also other directly related factors, such as pneumatization of the maxillary sinus, inadequate morphology, bone quality of the region and age, which is inversely proportional to the bone density [1, 2].

In the maxillofacial region, bone defects are highly prevalent as result of periodontal disease, injuries, surgical treatments of cysts and tumors, congenital malformations and, in particular, those cases of atrophy of the alveolar ridge resulting from consecutive tooth loss [3, 4]. In many occasions, bone loss is sufficiently significant as to render the correct prosthetic rehabilitation impossible, and such cases must be reconstructed using grafts prior to the installation of osseointegrated implants.

Among the various techniques to reconstruct deficient bone structure, the autologous bone graft is the gold standard in the reconstruction of defects in the maxillofacial area [5]. It has become a predictable and well-documented type of graft, since it has optimal osteogenic, osteoinductive and osteoconductive properties, as well as being immunologically safe. However, the use of autologous bone does have some disadvantages such as chronic pain in the donor zone, loss of sensation, shape defects, hernias, pathological fractures, bruising and hemorrhages. Therefore, other types of materials are used such as bone bank allografts, grafts of animal origin (xenograft) [6] and of synthetic origin (alloplastic) [7].

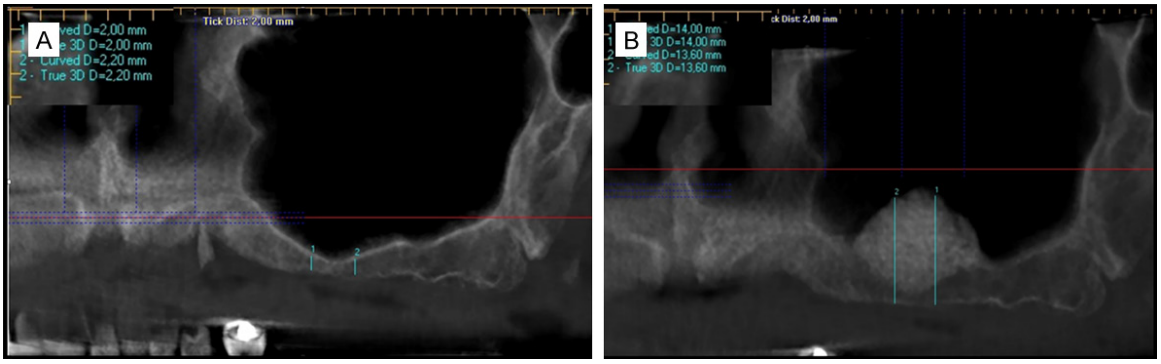

Figure 1. Preoperative CT (computed tomographic) (A) and postoperative CT (B) prior to the installation of the implants, which was 6 months after the surgery.

In this study, a computed tomographic (CT) and histological analysis of the osteogenerative capacity of a new xenograft available in the market (Orthogen®, Baumer, Brazil) was conducted, considering its osteoconductive properties and its behavior after maxillary sinus lift surgery.

Materials and methods

The study was conducted at the Implantology Program of the Faculty of Dentistry, Universidad Mayor, Santiago, Chile. Sample was comprised of 8 maxillary sinuses from 6 patients (2 patients underwent a bilateral sinus lift). Participants fulfilled the inclusion criteria and signed an informed consent. The study was a case series in which the bone regeneration of 8 maxillary sinuses was described and evaluated. Each patient underwent a sinus lift surgery as described by Tatum [1] using Orthogen® (Baumer, Brazil), prior to placement of implants. Results were assessed with CT and histological techniques at 6 months postoperatively.

Inclusion criteria in the present study considered patients between 18 and 70 years old with severe grade IV height bone loss in the posterior maxilla according to Misch's classification (< 4 mm), which requires a maxillary sinus lift to permit implant installation. Exclusion criteria considered presence of uncontrolled systemic diseases that contraindicated surgery (e.g., diabetes or blood/immune disorders), history of acute sinusitis or allergies with a respiratory component, and presence of a cyst or tumor pathology of the maxillary sinuses. All patients signed an informed consent concerning to pre- and postoperative diagnostics, surgical technique to be applied, the use of biomaterials and risks of surgery complications.

Radiographic evaluation

The ICAT CB500 cone-beam computed tomography (CBCT) scanner was used to take the measurements. Data were analyzed with the i-CAT Vision software. With this software, the maxillary height was measured mesially and distally from the grafted zone in each patient. Measurements were taken prior to the surgery (**Figure 1A**) immediately afterwards, and prior to the installation of the implants, which was 6 months after the surgery (**Figure 1B**). This last CT (6 months from the reconstruction) was performed to assess the effectiveness of the reconstruction, comparing it with the measurements obtained in the previous CT to be able to plan the placement of the implants. After six months, the final maxillary height continued to be favorable for the installation of osseointegrated implants.

Measurement methodology

Three-dimensional (3D) imaging was used to scan the area of interest, which was then visualized and analyzed with the i-CAT Vision software. This program allows to computationally measure the desired structures at a 1:1 ratio.

The cone beam computed tomography (CBCT) imaging was done in the same center with the same operator so that the study was standardized. The CBCT scan after the sinus lift surgery took the highest point of the graft and measured to the maxillary residual cortical bone. From that measurement a perpendicular line

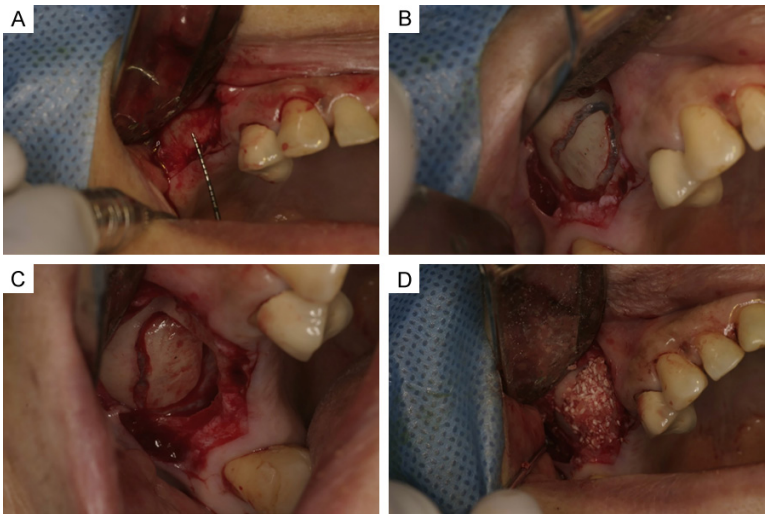

Figure 2. Mucoperiosteal flap (A), bone window in the side wall of the maxillary sinus (B), Schneiderian membrane exposed (C), Orthogen mineralized bovine xenograft introduced into the pocket (D).

was drawn to a certain height to an immobile structure, anterior or posterior cortical bone of the sinus. Then, this measurement was moved to the same point on the diagnostic CBCT scan and to the CBCT image taken prior to the installation of the implants. Two parallel lines were drawn to the center, at the beginning and at the end of the grafted zone, so that this was divided into three parts. The two lines that divided the three thirds were measured with the same perpendicular references used in the first measurement and parallel to the other lines.

Maxillary reconstruction

Surgery was performed with local anesthesia (2% lidocaine). After verifying the effectiveness of the anesthesia, a crestal incision with an anterior relief incision at the midline and posterior line was made at the level of the tuberosity. A mucoperiosteal flap (**Figure 2A**) was lifted, widely exposing the side wall of the maxillary sinus. The bone window was made in the side wall of the maxillary sinus (**Figure 2B**), with a handpiece, carbide, and diamond drills with abundant irrigation with physiological saline solution. Surgical dimensions of the window and data were recorded. The wall was raised, exposing the Schneiderian membrane, and the divulsion was performed, separating it from the walls of the maxillary sinus until the desired pocket was obtained (**Figure 2C**). Orthogen mineralized bovine xenograft was introduced, 2 to 3 mL, with a particle size 0.75 to 1 mm, into the pocket (**Figure 2D**). Surgery was finalized by replacing the flap and suturing it.

Biopsy sampling

Six months after the sinus lift surgery, a biopsy was taken from each patient using a 3-mm diameter trephine. The same bed was used to install implants greater than 4 mm in diameter in the same surgical procedure. Samples were assessed histologically.

Stadistical analysis

Preoperative and postoperative measurements of the bone height were summarized as a descriptive analysis, including the mean, standard deviation and a boxplot. In addition, an inferential statistical analysis was carried out to compare the immediate postoperative means and at 6 months obtained after surgery of maxillary sinuses. Parametric tests for related samples, T-Student and the SPSS Software version 22 were used for the statistical analyzes.

Evaluation of osseointegrated implants at 1 year

Once the eight sinuses had been grafted, there was a wait of approximately 6 months for the installation of the osseointegrated implants, which were rehabilitated by means of a fixed prosthesis. Clinical and radiologic check-ups were done at 6 and 12 months, confirming the stability of the implants in relation to the grafted zone.

Results

Table 1 shows the tomographic results obtained in the three analysis stages. In the preoperative analysis, data collected through the measurements taken on the eight sinuses yielded an average preoperative initial maxillary height of 1.54 mm, with the least being 0.7 mm and the greatest 2.2 mm. In the immediate postoperative analysis, an increase was noted in the height, observing an average of 15.05 mm, with the minimum height being 13.6 mm and the maximum 15.8 mm. At a 6-month follow-

Table 1. Comparison of the computed tomographic results obtained in the preoperative and immediate postoperative analysis, and check-up at 6 months in the sample of 8 maxillary sinuses

Maxillary sinuses	Preoperative analysis		Immediate postoperative analysis		Check-up analysis at 6 months	
	Preoperative maxillary height		Postoperative maxillary height		Maxillary Height, check-up at 6 months	
	Mesial measurement	Distal measurement	Mesial measurement	Distal measurement	Mesial measurement	Distal measurement
1	2.0	2.2	13.6	14	12.6	13.4
2	1.5	1.5	14	14.7	13.0	13.5
3	1.0	1.6	15	15	14.2	14.0
4	2.0	1.8	15.5	15.8	14.8	14.5
5	0.6	0.8	15.4	15.8	15.2	14.8
6	0.8	0.7	16	15.5	14.9	15.0
7	2.0	2.0	14.6	15	13.8	14.0
8	2.2	1.9	15.4	15.5	14.8	14.5
Mean	1.5	1.6	14.9	15.2	14.2	14.2
SD	0.6	0.5	0.8	0.6	1.0	0.6

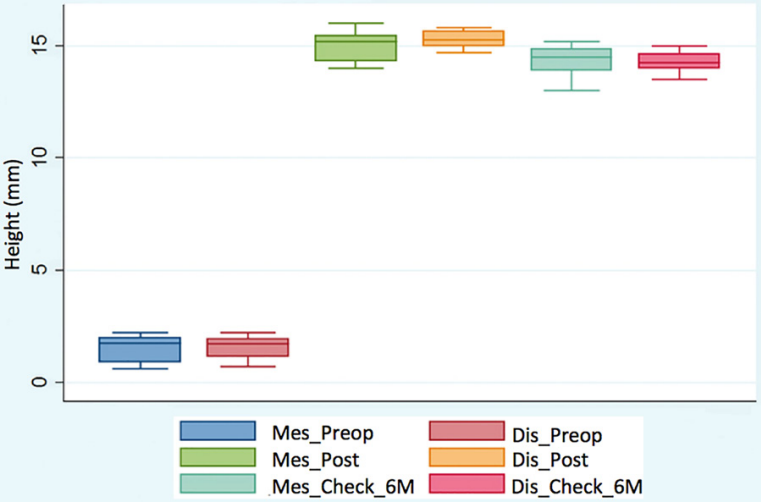

Figure 3. Boxplot shows no significant differences between mesial and distal maxillary height measurements. (Mes: Mesial; Preop: Preoperative; Post: Postoperative; 6M: Six months; Dis: Distal).

up, a slight reduction in maxillary height was noted in the eight maxillary sinuses compared with the immediate postoperative measurement. On average, the reduction was 0.86 mm. With respect to the difference between the mesial and distal maxillary height measurement, the boxplot in **Figure 3** shows that there were no significant differences between the averages of the two measurements, obtaining a similar height gain in both sectors.

The 8 samples selected from the 6 patients in the study were subjected to a Shapiro-Wilk statistical analysis. The variables were maxillary height in the immediate postoperative periods and 6 months after the maxillary sinus lift, obtaining a normal distribution of the analyzed samples. Then, a paired t test was performed. A statistically significant difference was obtained, with $P < 0.0001$ for both variables, including mesial ($P = 0.000121$) and distal ($P = 0.000023$) values.

Histological analysis

Bone tissue samples were analyzed using hematoxylin and eosin, picrosirius red, and Van Gieson staining. Optical and polarized light microscopes were used to evaluate the presence of lamellar bone, osteocytes, osteoblasts, and evidence of bone-forming areas (**Figure 4**). No control samples were used for this analysis. Presence of the above structures was defined as features of bone vitality.

The presence of lamellar bone was confirmed in all samples, identifying well-defined lamellae. Osteocytes in lacunae were consistently observed in all samples, confirming the existence of strong vitality of bone tissue. Abundant osteoblasts were also observed in the periphery of calcified tissue and also in a reactive fashion, confirming the existence of bone-forming areas (**Figure 5**).

The analyzed biopsies of the 8 maxillary sinuses showed the degree of biocompatibility in

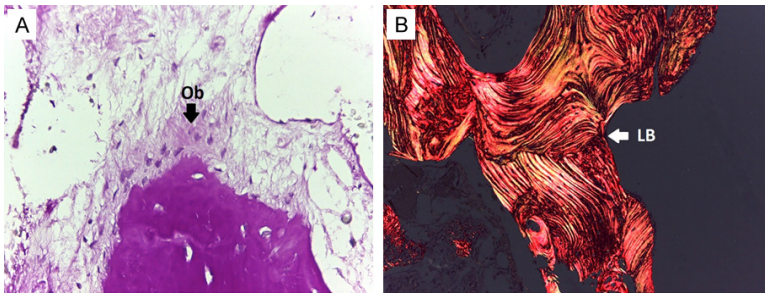

Figure 4. Osteoblasts (Ob) in the periphery of calcified tissue, 40x HE (A). Lamellar bone (LB), Picrosirius 40x (B).

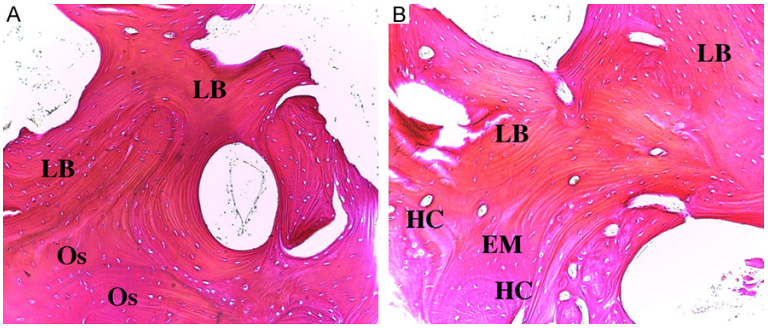

Figure 5. Vital bone tissue with presence of lamellar bone (LB), osteocytes (Os), extracellular matrix (EM) and Haver's canals (HC) (10x).

relation to this type of graft, meaning it is suitable for use in humans.

In relation to the graft particles present in the sample, formation of woven bone (osteoid) was observed, which corroborates the osteoconductive property of the graft acting as scaffolding for the formation of new bone.

At 40x magnification, it was possible to note on the border between the graft and osteoid tissue the presence of a more basophile line that represents the osteoblast/osteoclast activity. Osteocyte lacunae in mature bone with connective tissue and remodeled bone with osteoclasts were observed.

Evaluation of the osseointegrated implants at 1 year

One year after rehabilitation on the implant using a fixed prosthesis, a clinical and radiographic follow-up was performed on all the maxillary sinuses operated on to verify the stability of the Orthogen graft, the implants, and the fixed rehabilitation. The success rate was 100%; all grafts were stable and the implants were satisfactory with a functioning fixed prosthesis.

Discussion

The use of osseointegrated dental implants is increasing. However, one of the primary obstacles to this therapy is the atrophic maxillary bone, since there is a large number of patients without sufficient bone volume, primarily in the posterior sector of edentulous maxilla with pneumatization of the maxillary sinus [1, 2]. The installation of implants in this area can be jeopardized by the limited volume and the mechanical properties of the existing bone; in addition, higher failure rates have been reported for implants in the posterior upper maxilla than implants in other regions. Therefore, we need biomaterials to reconstruct atrophic edentulous areas, as well as areas with bone defects for the subsequent installation of implants [3].

This study analyzes tomographically and histologically the use of the Orthogen® xenograft, which is comparable to the Bio Oss graft (Geistlich Pharma, Switzerland) due to its similar characteristics. The Bio Oss xenograft has had very good results in the maxillary sinus lift for many years [8], which is why the Orthogen graft would be a more accessible alternative due to its better affordability and results that are comparable to the Bio Oss graft. In this study, it was noted in the initial preoperative CT analysis that the patients presented a significant atrophy of the posterior upper maxilla. However, 6 months after placing the Orthogen xenograft, the CT scans showed a total maxillary height gain of 9.5 mm on average, comparable to the results obtained with the Bio Oss xenograft [6].

Histologically, new bone formation from this graft was observed, demonstrating the formation of new bone at 6 months, with osteoconductive characteristics, functioning mainly as scaffolding for the bone formation. Biologically,

the long-term goal is the total replacement of the graft by new bone formation. In our study, we had this result at 6 months, although graft particles were found to be present, which indicates to us that it has an adequate resorption rate, with follow-up needed to analyze the graft remnant over time [8]. The long-term expectation is that the bone height will be maintained or decrease slightly, since the bone remodeling is a process lasting approximately 6 months, although that does not discount the different processes to which it will be subjected (implant placement) and its future load, which could produce differences. Analysis of the postoperative maxillary height gain showed a large increase of greater than 10 mm in all the maxillary sinuses; and, although it decreased at 6 months, the final maxillary height continued to be favorable for the installation of osseointegrated implants.

It is expected that most of the bone xenografts will be reabsorbed and replaced entirely by natural bone [9-11]. The 8 samples studied showed an optimal height gain. In the immediate postoperative examination, the average height gain was 13.51 mm, which decreased slightly after 6 months, obtaining on average a final gain of 12.65 mm. In the biopsies, the formation of woven bone was observed (osteoid), which indicates that this graft would function as scaffolding for new bone formation. In terms of cost-benefit, the use of the Orthogen xenograft is more accessible, with favorable clinical results that make possible the later placement of implants with a good prognosis. Although the current literature shows varying results with the use of different types of graft materials in different types of surgery, further study is needed with better levels of validity and reliability to determine if this Orthogen xenograft has good clinical results in the long term.

Disclosure of conflict of interest

None.

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