Maxillary Sinus Augmentation with Autologous and Heterologous Bone Graft: A Clinical and Radiographic Report of Immediate and Delayed Implant Placement

Mario Santagata · Umberto Tozzi · Gianpaolo Tartaro ·
Vincenzo Santillo · Corrado Giovanni · Ettore Lamart ·
Angelo Iтро · Giuseppe Colella · Salvatore D'Amato

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Abstract

Purpose The aim of this study was to evaluate cumulative survival rate of implants placed on augmented maxillary sinus using a mixture of autologous bone harvested from the maxillary tuberosity and bovine-derived HA and to assess the height of the grafted material through radiographic evaluation.

Methods Thirty-five patients were treated with maxillary sinus augmentation and 93 implant fixtures were installed. The height of the augmented sinus and the gain of bone volume were measured by Cone Beam CT Scan and intraoral radiographs immediately after augmentation and up to 48 months subsequently. Changes in the height of the sinus graft material were calculated radiographically.

Results The cumulative survival rate was 98.92 % in all 93 implants. Additionally, normal healing process without any complication was observed in all patients. The original sinus height was a mean of 4.52 mm (range 2.0–6.4 mm) and the augmented sinus height was a mean of 14.1 mm (range 12.0–16.5 mm) after the surgery. The bone volume gain was a mean 9.613 mm (range 7–13 mm).

Conclusions Within the limitations of this study, it would appear from the clinical and radiographic results that the sinus lift procedure with autologous bone graft harvested from the maxillary tuberosity combined with deproteinized

bovine bone allows for a predictable outcome regarding the amount of bone formation in sinus floor augmentation and the immediate placement of implants, when possible, is recommended.

Keywords Dental implants · Maxillary sinus · Autologous bone graft · Heterologous bone graft · Survival rate · Immediate implant placement · Delayed implant placement

Purpose

The presence of alveolar bone with sufficient volume and/or density is considered to be a prerequisite for implant placement, integration, and load behavior. However, bone resorption following tooth extraction or due to advanced periodontal disease and/or pneumatization of the maxillary sinus may result in insufficient bone in horizontal and/or more frequently vertical dimension for the placement of dental implants. Although good results have been presented with short implants [1], larger implants are generally preferable in order to endure loading forces on the prosthetic reconstruction; in fact, increased failure rates with short and/or narrow implants have been reported previously [2, 3]. The most common treatment planning in the posterior maxilla is the augmentation of the maxillary sinus floor, which involves a modification/reduction of the sinus cavity aiming at the production of bone inside a space previously being a portion of the sinus cavity. This is most often achieved in combination with bone grafts and/or substitutes that are placed inside the sinus cavity with the aim to create space for and accelerate bone formation. Implant placement is performed simultaneously with the sinus-lift procedure if adequate amounts of alveolar bone

M. Santagata · U. Tozzi · G. Tartaro · V. Santillo ·
C. Giovanni · E. Lamart · A. Iтро · G. Colella · S. D'Amato
Multidisciplinary Department of Medical and Dental Specialties,
Oral and Maxillofacial Surgery Unit, AOU–SUN (Second
University of Naples), Naples, Italy

M. Santagata (✉)
Piazza Fuori Sant'Anna, 17, 81031 Aversa, Italy
e-mail: mario.santagata@tin.it

are present and a good primary stability of the implants can be achieved or at a later time point when some new bone formation is expected to have occurred inside the sinus cavity.

The aim of this study was to determine the clinical and radiographic efficacy of a mixture of autologous bone harvested from the maxillary tuberosity using bone scraper (safescraper twist—META, Reggio Emilia, Italy), bovine-derived HA (Bio-Oss—Geistlich Pharma, Wolhusen, Switzerland; particle size of 0.25–1 mm) placed as a graft to elevate the maxillary sinus floor, and the use of a bioresorbable porcine-derived collagen membrane (Bio-Gides, Geistlich Pharma, Wolhusen, Switzerland) covering lateral access window. In order to accomplish this, the survival rate of the implants was evaluated. Furthermore, in all patients mean values were calculated. Differences in RHBG (residual height bone graft) according to the timing of implantation were analyzed. Correlation between the RHBG and follow-up period was determined.

Materials and Methods

Patients

A total of 35 patients (15 women and 20 men; ages ranged 24–75 years) were included in this study and provided with a total of 93 implants (Table 1). The study was performed according to the Helsinki declaration of [4].

The preoperative diagnosis was made by carrying out Cone Beam CT Scan and periapical radiography. Patients were included in the study if no systemic or local contraindications were encountered. Particularly, the evaluation included the general health and the oral health status, and the correct interarch relationship.

Inclusion criteria were severe atrophy (< 7 mm) of the alveolar process in the sinus area bi- or unilaterally and the presence of a Misch type 3 or 4 sinus situation [5]. All patients received oral hygiene instructions before entering the study. After information about the procedure they were required to sign a consent form. Exclusion criteria were poor general health, e.g., severe renal/or liver disease, acute myocardial infarction within the past 12 months, uncontrolled coagulation disorders, uncontrolled metabolic diseases, radiotherapy to the head in the past 24 months, treatment with intravenous bisphosphonates or with oral bisphosphonates for >3 years, psychiatric problems, heavy smoking (>10 cigarettes/day), alcohol or drug abuse, maxillary sinus pathologies, oral infections, and uncontrolled periodontal disease.

Sinus floor augmentation was carried out on both sides in five patients and on one side in 30 patients. Thus, a total of 35 patients with severe atrophic maxillae or sinus

pneumatization undergoing 40 sinus lift augmentation procedures were evaluated prospectively.

Surgical Procedure

One hour before starting the surgical procedure, all patients received 2 g of amoxicillin, and immediately before the surgical procedure, they rinsed for 2 min with a 0.2 % chlorhexidine solution. All surgical procedures were completed by the same surgeon under local anesthesia. A mid-crestal incision was made, and a vertical releasing incision was additionally placed anteriorly, normally just posterior to the canine area. A mucoperiosteal flap was elevated buccally and palatally, allowing access to the lateral sinus wall. Then, an osteotomy was performed at the lateral surface of the sinus wall using a piezoelectric device (Piezosurgery, Mectron Spa, Carasco Genova, Italy) and the sinus membrane was carefully elevated superiorly starting from the inferior border of the osteotomy site, and completely and carefully dissected from the medial and inferior walls of the sinus. All surgical procedures were performed with high accuracy to avoid perforation of the sinus membrane, in order to prevent sinusitis and loss of bone graft material. The floor, lateral wall and posterior wall of the membrane were carefully detached and pushed upward to provide the required space for the implant to be placed. Two-stage implant system was used (Fig. 1). The number, diameter and length of implants in each case was determined according to the prosthetic plan and the quality and quantity of the recipient bone. Then, a portion of the antral space was filled with a composite graft consisting of the autogenous bone harvested from maxillary tuberosity by a bone scraper (safescraper twist—META, Reggio Emilia, Italy) and Bio-Oss (Geistlich Pharma, Wolhusen, Switzerland; particle size of 0.25–1 mm) (Fig. 2) and gently packed over the bone into the sinus (Fig. 3). The amount of harvested bone was obviously dependent of the lateral maxillary wall thickness; hence, the maxillary plate in the sinus area provided an amount of bone that ranged from 0.5 to 2 ml. This bone graft was placed in a receptacle in which additional Bio-Oss granules were added to increase the final graft volume that was dependent on the sinus size with a mixture in a 1:1 ratio. The lateral access window was then covered with a bioresorbable porcine-derived collagen membrane (Bio-Gides, Geistlich Pharma, Wolhusen, Switzerland) to prevent soft tissue invasion and bone graft spreading, and to promote bone formation. The Bio-Gides membrane was trimmed to cover the osteotomy window, extending about 3 mm beyond its borders, and it was not fixed with pins or tacks (Fig. 4). The mucoperiosteal flap was repositioned and sutured using 4/0 resorbable suture material (Trofilorc, LorcaMarin, SA, Murcia, Spain) to achieve closure of a tension-free flap.

Table 1 Case summary

Case	Age	Sex	Area	System	Diameter	Length	Stage	OSH	ASH	BHG	Bone quality	Follow-up	RHBG (mm)
1	59	F	26 27	Biohorizons	4.6	12	1	4.8	13.8	9	IV	9	8.6
2	50	M	26 27	3i	3.75	13	2	2.7	14.2	11.5	IV	60	10.6
3	46	F	15 16 17	Biohorizons	3.8	12	1	6.3	14.9	8.6	IV	24	7.9
3	46	F	26 27	Biohorizons				5.7	13.7	8			7.3
4	51	M	25	Biohorizons	3.8	12	1	5.1	12.9	7.8	IV	12	7.3
4	51	M	26	Biohorizons	4.6	12							
4	51	M	27	Biohorizons	3.8	12							
5	75	F	15 16 17	Biohorizons	4.6	12	2	3.5	12.8	9.3	V	25	8.59
6	60	F	25 26	Biohorizons	3.8	12	1	6.4	15.1	8.7	IV	48	7.9
6	60	F	27	Biohorizons	4.6	12							
7	61	M	16 17	Biohorizons	3.8	12	1	5.6	13.3	7.7	IV	10	7.29
7	61	M	26 27	Biohorizons	3.8	12	1	6.4	13.8	7.4			6.99
8	75	M	15 16 17	Biohorizons	4.6	12	1	5.5	13.2	7.7	III	15	7.17
8	75	M	25 26 27	Biohorizons	4.6	12	1	5.4	13	7.6			7.07
9	45	M	16 17	Biohorizons	4.6	12	2	2.5	15.2	12.7	IV	9	12.3
10	55	M	15 16 17	Biohorizons	4.6	12	1	3.8	14.2	10.4	III	12	9.9
11	58	M	26 27	Biohorizons	4.6	12	1	5.4	14.6	9.2	III	9	8.8
12	70	M	15 16	Biohorizons	3.8	12	1	5.6	14.8	9.2	III	11	8.78
13	56	F	25 26	Biohorizons	4.6	12	1	4.4	14.4	10	III	13	9.45
14	46	F	24 25 26	Xive	3.8	13	1	5	15	10	IV	48	9.2
15	40	F	14 15 16	Xive	3.8	13	1	3	13.9	10.9	IV	48	10.1
15	40	F	14 15 16	Xive	3.8	13							
15	40	F	14 15 16	Xive	4.5	11							
15	40	F	25 26	3i	3.75	13	2						
16	48	M	14 15 16	Nobel	4	13	1	4.5	14.5	10	V	48	9.2
16	48	M	14 15 16	Nobel	4			4	16.5	12.5			11.7
17	50	M	15 16	3i	4	13	1	3.2	15	11.8	IV	48	11
18	60	M	13 14	Xive	3.8		1	4.1	14.2	10.1	V	36	9.34
18	60	M	13 14	Xive	4.5								
18	60	M	23 24 25	Xive	13		2	3.9	14.5	10.6			9.84
19	54	F	15 16	Winsix	3.8	11	1	4.9	13.5	8.6	IV	48	7.8
20	48	M	16 17	Winsix	5.2	11	1	5.1	13.7	8.6	IV	36	7.84
21	61	F	15 16 26 27	Winsix	4.5	13	2	2.9	15.9	13	IV	44	12.22
22	41	M	26 27	Winsix	4.5	13	1	5	12	7	IV	45	6.22
23	53	F	15 17	Winsix	3.8	11	1	5.1	12.9	7.8	IV	48	7
24	69	M	25 27	Winsix	5.9	11	1	5	15.6	10.6	IV	37	9.84
25	37	F	15 17 25 27	Winsix	3.8	13	2	2.7	14.6	11.9	IV	47	11.11
26	71	M	15 17 25 27	Winsix	4.5	13	1	4.8	13.7	8.9	IV	46	8.11
27	51	F	26 27	Winsix	4.5	11	1	5	13.9	8.9	IV	45	8.12
28	43	M	16 17	Winsix	4.5	13	1	4.3	15.1	10.8	IV	48	10
29	29	M	15	Winsix	4.5	13	1	4.7	12.9	8.2	III	45	7.42
30	33	M	15 16	Winsix	3.8	11	2	3	14.2	11.2	IV	47	10.41
31	68	F	26	Winsix	4.5	13	1	5.3	15.3	10	IV	48	9.2
32	24	M	15	Winsix	4.5	13	1	4.9	13.2	8.3	III	48	7.5
33	35	M	16 17	Winsix	4.5	11	1	4.7	14.7	10	IV	45	9.22
34	59	F	14 16	Winsix	4.5	13	2	2	13.1	11.5	IV	48	10.7
35	52	F	26	Winsix	3.8	11	1	4.9	13.9	9	IV	48	8.2

OSH Original sinus height, ASH Augmented sinus heights, BHG Bone height gain, RHBG Reduced heights bone gain

Fig. 1 The floor, lateral and posterior wall of the membrane were carefully detached and pushed upward to provide the required space for the implant to be placed

Fig. 3 Bone harvested from maxillary tuberosity and Bio-Oss were gently packed over the bone into the sinus

Fig. 2 Autogenous bone harvested from maxillary tuberosity by a bone scraper

Fig. 4 The lateral access window was then covered with a biore-sorbable porcine-derived collagen membrane

Postoperatively, all patients received 1 g of amoxicillin 6 h after surgery and 2 g twice daily for 4 days after surgery and non-steroid analgesic postoperatively as needed. All the patients were also instructed to rinse twice daily over a period of 2 weeks using a 0.12 % chlorhexidine gluconate solution. They were also advised not to blow their noses for 15 days. Ten days after surgery the sutures were removed.

In 9 cases, the sinus were of type 4 of Misch [5], and therefore implants were placed after a healing period of 8 months (two-stage surgery). In the remaining 31 cases, on which there were >5 mm of bone present between the residual alveolar crest and the floor of the maxillary sinus, the implants were immediately placed.

A total of 93 screw-shaped titanium implants were inserted: 37 tapered internal implants with a laser

microgrooved coronal design (Biohorizons, Birmingham, Ala); 36 implants Winsix (Winsix Ltd, Lincoln Inn's Field, London); 3 implants Branemark System (NobelBiocare AB, Gotenborg, Sweden); 11 implants were from Xive (Dentsply Friadent, Mannheim, Germany), and 6 implants were from 3i (BIOMET 3i, Riverside Drive Palm Beach Gardens, FL). The diameters of Biohorizons's implants were 3.8 mm (15); 4.6 mm (22) and their lengths were 12 mm. The diameters of Winsix's implants were 3.8 mm (11); 4.5 mm (21); 5.2 mm (2); 5.9 mm (2) and their lengths were 11 mm (15) and 13 mm (21). The diameter of Branemark's implants were 4.0 mm (3) and their lengths were 13 mm (3). The diameters of Xive's implants were 3.8 mm (8); 4.5 mm (3) and their lengths were 11 mm (1) and 13 mm (10).

All patients were rehabilitated with fixed implant-supported prostheses (Fig. 5). None of the patients were rehabilitated with removable implant-supported overdentures. All implants were loaded.

Table 2 Radiographic analysis (mean $\pm$ SD)

12 months: RHBG (mm)/Time (mo): mean 0.71 ± 0.41
48 months: RHBG (mm)/Time (mo): mean 0.90 ± 0.41
R2:0.089

RHBG reduced height of bone graft

(a)

(b)

Fig. 5 All patients were rehabilitated with fixed implant-supported prostheses: **a** From buccal point of view, **b** from occlusal point of view

Radiographic Examinations

Cone Beam CT scan was obtained before the surgery (baseline), immediately after the sinus augmentation, the 1 year after the surgery. Additional radiographs were obtained every 12 months through the follow-up period. In the defined implant area, bone density was measured in Hounsfield units.

The periapical radiographs used for analysis were taken with the long-cone technique and were analyzed by a computerized measuring technique with image analysis software (Digora, Soredex, Helsinki, Finland) measuring the distance between two points. Internal calibration was

Fig. 6 Schematic drawing of the parameters measured on radiographs

performed for each radiograph on three inter-thread distances (3.7 mm), given that the tips of two consecutive threads are separated by 1.2 mm. The precision of the measuring system was 0.01 mm.

The landmarks, appearing in Fig. 6, served to calculate the measurements, where:

RBH: the vertical distance between the most coronal bone-implant contact and the most apical implant-bone contact.

ASH: were measured from the 1st bone to implant contact points to the base of the maxillary sinus, which was elevated with bone graft at the mesial and distal aspects of the implants.

All measurements were made twice by one blinded investigator with a 12-month interval between the measurements.

The augmented sinus heights (ASH) were measured from the 1st bone to implant contact points to the base of the maxillary sinus, which was elevated with bone graft at the mesial and distal aspects of the implants. The volume of marginal bone loss (MBL) was obtained compared with the periapical radiographs and CBCT scan, cross-sectional slices, immediately taken after the surgery and 1 year postoperatively. The reduced height of bone graft (RHBG) was calculated based on the changes in the ASH and MBL.

Statistical Analysis

In all patients mean values were calculated. There was a substantial difference in the sample means of RHBG in the two sub-samples (Stage 1 and Stage 2) respectively of 8.47 and 10.70 mm. This result was subjected to a test of significance to verify the inference result of the sample on the population of origin.

Table 3 Differences according to the timing of implantation (mean $\pm$ SD)

	Simultaneous	Delayed
RHBG (mm)	8.47 $\pm$ 0.41	10.70 $\pm$ 0.31

RHBG reduced height of bone graft

It was assumed that the two populations were independent with unknown but equal variances.

Therefore we wanted to test whether the two means were equal to each other ($H_0: \mu_1 = \mu_2$) against the alternative hypothesis that the sample mean (Stage 1) was less than the average for the second sample (Stage two) ($H_1: \mu_1 < \mu_2$).

Estimating that the sampling variances will reach a value of statistical Student's *t* test of $-7,569$, compared with the value of the standardized *t* distribution with 91 degrees of freedom and a significance level of 0.05, is much lower:

$$t(91) < t(91)_{0.05} \rightarrow -7,569 < -1,662$$

This result leads to the rejection of the null hypothesis and acceptance of the alternative hypothesis of a significant reduction in the sample RHBG Stage 1 vs Stage 2.

There was no linear correlation between RHBG and follow-up, in fact the adjusted R^2 was 0.089, which was very close to 0 hence the linear model does not fit our case.

Patient Outcome Analysis

In all cases, implant lengths, time of follow-up, and perioperative and postoperative complications were recorded (Table 1). In this study, data on implant survival were considered only for those implants that were loaded for a minimum of 9 months.

Implant Survival Rate

The success criteria for implants presented by Buser et al. [6] was used.

Results

Thirty-five patients with a total of 40 sinus graft procedures were followed clinically in a prospective manner. All patients were initially evaluated at intervals of 3–6 months for the first year and annually thereafter for up to 4 years. Mucosal tears occurred in five of 40 sinuses grafted (12.5 %) and since the tears were very less no treatment was needed.

In two cases (5.0 %), there were infections in the postoperative period that were resolved with antibiotics.

Implants were loaded after a healing interval of 4 months for the two-stage approach and after 9 months for one-stage cases. The range length of follow-up after implant loading was 9–48 months.

The original sinus height (OSH) was a mean of 4.52 mm (range 2.0–6.4 mm) and the augmented sinus height (ASH) was a mean of 14.1 mm (range 12.0–16.5 mm) after the surgery. The bone height gain was a mean of 9.613 mm (range 7–13 mm). The marginal bone loss up to 1 year was measured as 0.30 ± 0.45 mm.

Linear measurements to evaluate the marginal bone levels were performed on digitized images. The graft apical to the implants demonstrated a gradual reduction in height. The RHBG 1 year postoperatively was 0.71 ± 0.41 mm, and at 48 months postoperatively was 0.90 ± 0.41 mm (Table 2).

A substantial difference in the reduced volume of the bone graft was observed according to the timing of implantation (Table 3).

One implant was lost before loading (1.075 %). The remaining 92 implants were stable and free of complications at the end of the study. Thus, the implant survival rate was 98.92 %.

Discussion

Since the initial description of maxillary sinus floor elevation by Boyne and James [7] and Tatum [8], several sinus augmentation techniques have been proposed. Initially, a modified Caldwell–Luc procedure was used to approach the sinus, by infracturing a rectangular or trapezoidal osteotomy of the lateral wall of the maxilla. Later, Garg and Quiñones [9] modified this technique, designing the osteotomy in an ovoid shape in order to minimize the chances of schneiderian membrane perforation with sharp corners produced in a rectangular or a trapezoidal osteotomy. Here, we propose this technique.

The choice of augmentation material is of principal importance in sinus surgery. However, the ideal bone graft has not yet been determined. Autologous bone is considered the gold-standard material in terms of osteogenic potential, because it supplies not only osteoblasts but also provides organic and inorganic matrices for osteoinduction and osteoconduction [10, 11]. Bone can either be gained extraorally, from the iliac crest [7] or the cranial vault [5], or harvested intraorally, mainly from the chin [12]. However, a limited amount of bone is available at intraoral donor sites, and the use of an extraoral one usually calls for general anesthesia, increasing the time and the cost of treatment and giving rise to considerable morbidity [13]. Furthermore, autologous bone shows a trend toward bone resorption that reduces the initial graft volume, and

morbidity at the donor site, which could be seen in almost 8 % of operations [11, 14]. The source of autologous bone could be relevant.

When an autogenous bone is harvested from the oral cavity, such as the mandible ramus or the symphysis, its quantity is frequently insufficient for the surgical procedure that a sinus floor elevation involves [15]. To surmount these problems, bone substitutes have been used instead of bone or mixed with it [16, 17].

Bovine-derived HA or anorganic bone is a xenogenic material from which all organic components have been removed [18], which ensures that no immune response or allergy *in vivo* is induced. Bovine HA is a highly biocompatible and osteoconductive material [19–21], and it seems to promote more early bone formation than other bone substitutes [22]. However, its long term fate is still unknown, because the literature is not conclusive regarding its degradation.

According to Misch and Dietsh [23], a mixture of autologous bone with synthetic material was most frequently used in clinical trials investigating sinus floor augmentation. A significant advantage of this approach was healing time reduction when anorganic bone was combined with autografts. In fact, a healing period of 6–8 months is necessary to allow for the vascularization and incorporation of the grafts and subsequent maturation of newly formed bone tissue [23], less time than needed when only a bone substitute is used as a graft. In this work, we describe a technique that consists of grafting the maxillary sinus with a mixture in a 1:1 ratio of deproteinized bovine bone and autologous bone harvested from the maxillary tuberosity, thus avoiding the need for the use of a different or even a distant donor site.

Controversy still exists regarding the need to cover the lateral osteotomy site with a membrane to contain the grafted material, prevent its migration or dispersion into the soft tissues and limit soft tissue invasion into the sinus cavity. Tawill and Mawla [24] observed that the use of a collagen barrier to cover the antrostomy site when machined-surface implants were used in sinuses grafted with Bio-Oss seemed to improve the quality of the graft healing and the survival rate of the implants loaded between 6 and 9 months after placement. Instead, implants used in this study have moderately rough surfaces that probably yield a better survival rate than the implants used in the Tawill and Mawla study [24].

The implant success rate following sinus graft with deproteinized bovine bone varies from 90 to 98 % [15, 25]. In the present study, only one of 93 implants had to be removed. Consequently, the survival rate was 98.92 %.

Hieu et al. [26] radiographically evaluated the changes in height of the xenogenic materials (Bio-Oss, Geistlich Sons,

Wolhusen, Switzerland) after maxillary sinus augmentation over the course of 2 years. This study reported that significant material resorption can take place over time. Nonetheless, it could be assumed that many other factors, e.g., the air pressure in the maxillary sinus, the form of augmented material, the density of the grafted material, the use of a bioresorbable porcine-derived collagen membrane are more important than the time flow. Therefore, it is possible that the resorption rate of the grafted material is affected by the host's environment. This would be expected to be clarified with further study.

Linear measurements to evaluate the marginal bone levels were performed on digitized images. The graft apical to the implants demonstrated a gradual reduction in height. In fact, the residual height bone graft (RHBG) was 0.71 ± 0.41 mm in the first year and at the 4-year examination, it was 0.90 ± 0.41 (Table 2).

Two dimensional panoramic radiographs have been used to evaluate the grafted material and its relationship with implants [27].

In the present study, in addition to periapical radiographs we also used the Cone Beam Computed Tomography in cross-sectional slices which supplies 3-dimensional images that would provide a more accurate volumetric measurement of the bone graft. A substantial difference in the reduced volume of the bone graft was observed according to the timing of implantation. In fact, there was a substantial difference in the sample means of RHBG in the two sub-samples (Stage 1 and Stage 2) respectively of 8.46 and 10.70 mm. This result was subjected to a test of significance to verify the inference result of the sample on the population of origin.

There was no linear correlation between RHBG and follow-up, in fact the adjusted R^2 was 0.089, which was very close to 0 hence the linear model does not fit our case. After careful analysis: we want to test the correlation between RHBG as the dependent variable (or subsequent) and the dichotomous variable Stage as an independent (or earlier). The method of least squares was used to estimate the parameters reached in this regression line: $RHBG = 6.23 + 2.23 \text{ STAGE}$.

This means that, given that the regression coefficient (2.23), increases by one unit of STAGE, the RHBG increases more than proportionally, namely, in going from 1 to 2 timing of implantation, we will have an average increase reduction of bone height of 2.23 mm. The model explains only 38 % (adjusted $R^2 = 0.38$) of the variability of the empirical RHBG. However, combining this result with statistics on the sample differences, it is confirmed that the results obtained from the sample of observed cases is found in the starting population and that in passing from Stage 1 to Stage 2 there is considerable loss of bone height.

Conclusion

In conclusion, within the limitations of this study, it would appear from the clinical and radiographic results that the sinus lift procedure with autologous bone graft harvested from the maxillary tuberosity combined with deproteinized bovine bone allows for a predictable outcome regarding the amount of bone formation in sinus floor augmentation and the immediate placement of implants, when possible, is recommended. In fact, there was a substantial difference of RHBG with a value of 8.47 mm in case of immediate implant placement after maxillary sinus augmentation and 10.70 mm in case of delayed implant placement.

Conflict of interest The authors report no conflicts of interest.

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