

Grafting after sinus lift with anorganic bovine bone alone compared with 50:50 anorganic bovine bone and autologous bone: results of a pilot randomised trial at one year

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Abstract

Our aim was to compare the outcome of implants inserted in maxillary sinuses augmented with anorganic bovine bone grafts compared with those augmented with mixed 50:50 bovine and autologous bone grafts. Twenty sinuses with 1–4 mm of residual crestal height below the maxillary sinuses were randomised into two groups according to a parallel group design ($n = 10$ in each). Sinuses were grafted using a lateral approach. In one group the grafts were 50:50 anorganic bovine bone and autologous bone and in the other anorganic bovine bone alone. After 7 months, 32 implants had been inserted. Outcome measures were survival of implants, complications, marginal changes in the height of the bone, and soft tissue variables (pocket probing depth and bleeding on probing). Probabilities of less than 0.05 were accepted as significant. No patient failed to complete the trial and no implant had failed at 1 year. There were some minor complications. After 12 months, the mean (SD) marginal bone loss (mm) was 1.06 (0.61) in the 50:50 group and 1.19 (0.53) in the anorganic bovine group. The mean (SD) values for pocket probing depth (mm) and bleeding on probing (score) were 2.49 (0.38) and 1.59 (0.82) in the 50:50 group and 2.31 (0.64) and 1.36 (0.87) in the anorganic bovine group (neither difference was significant). The present data are consistent with the hypothesis that the outcome of implants inserted in sinuses grafted with either material is comparable.

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Introduction

Resorption of bone in edentulous regions often requires augmentation before an implant can be inserted. Augmentation

of the floor of the maxillary sinus is a well-established procedure used to increase the height of the bone in the atrophic posterior maxilla to allow placement of dental implants. In reconstructive surgery, autologous bone is usually considered to be the gold standard, primarily because of its osteogenic potential and remodelling capacity.¹ Its disadvantages are the limited availability of bone, and often the need to harvest it from extraoral sites. To reduce morbidity at such donor sites, allogeneic, xenogenous, alloplastic, and composite materials have been introduced.²

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A recently published review concluded that the amount of new bone that formed was comparable when anorganic bovine bone or anorganic bovine bone together with autologous bone was used as the graft material³ but, in terms of the clinical outcome, it remains unclear which is better for sinus lifting. Despite several studies that seem to validate the use of both materials, more clinical trials are needed. The aim of the present pilot study was to test the hypothesis that implants inserted in maxillary sinuses augmented with anorganic bovine bone grafts showed comparable outcomes to those augmented with 50:50 bovine bone and autologous bone graft.

Patients and methods

This study was a randomised, controlled, pilot trial between November 2011 and February 2013 and registered at ClinicalTrials.gov (NCT02170129). It was approved by the Research Committee of the Department of Surgical, Microsurgical and Medical Science, University of Sassari, Italy, and the data were analysed at the same university. The study was conducted in accordance with the guidelines of the Helsinki Declaration.

Patients were treated by the same oral surgeon (SM) who followed the same surgical and prosthetic protocol. Patients were recruited at three centres for insertion of implants into the posterior maxilla after sinus grafting. All patients presented with a large pneumatized sinus, and residual alveolar bone height of no more than 4 mm.

Inclusion criteria were: the need to insert an implant in an atrophic posterior maxilla with a residual alveolar bone height of 1–4 mm, the patient was 18 years of age or older; the patient provided written informed consent, and there were no signs of a sinus cyst or active sinusitis.

Exclusion criteria were: any general contraindication to implant surgery; signs of periodontitis; bruxism; any signs of immunosuppression; a previous history of irradiation to the head and neck area; uncontrolled diabetes; smoking more than 10 cigarettes/day; poor oral hygiene; current or past treatment with bisphosphonates; substance abuse; psychiatric disorder; inability to complete a follow-up of 1 year; or lactation.

The study was explained thoroughly and all participants provided written informed consent before enrolment. Because this was a preliminary study, no sample size was calculated beforehand. Sixteen patients were enrolled, four of whom had bilateral implants, giving a total of 20 sinuses ($n = 10$ in each group). These were assigned randomly to be grafted with 50:50 anorganic bovine bone and autologous bone or anorganic bovine bone alone.

A randomisation code was created using Excel (Microsoft, Redmond, WA, USA), which combined a sequence of randomised non-consecutive numbers and matched them with the two groups. These were assigned by an independent operator (RP) who was not involved in the trial. The codes were



Fig. 1. Panoramic radiograph before sinus grafting.

placed in envelopes. Data were collected in spreadsheets (Excel) by a physician (FL) at the Dentistry Unit, University of Sassari, Italy.

Protocol

All patients were evaluated clinically and their medical histories were recorded. Preliminary screening, including panoramic radiographs (Fig. 1), was done to evaluate the patients' potential eligibility. Patients who met the selection criteria were given instructions in oral hygiene and had their teeth debrided, after which bone volumes were analysed using cone-beam computed tomography (CT; Imaging Sciences International, Hatfield, PA, USA).

A staged approach was used, so that sinus lift grafting was followed 7–8 months later by placement of implants. All patients were given amoxicillin and clavulanic acid (Augmentin, GlaxoSmithKline, Verona Italy) 1 g twice daily from 1 h before the implant was inserted to 6 days postoperatively. Local anaesthesia was induced using 1:100,000 articaine with 1.8 ml adrenaline (Pierrel, Milan, Italy).

We used the lateral approach technique in which a mucoperiosteal buccal flap is raised to expose the lateral bony wall of the antrum. A round diamond bur was used to outline the demarcation of the lateral window, which completely exposed the underlying Schneiderian membrane. The membrane was separated from the bone around it, and a tension-free reflection to expose the walls of the sinus was achieved by gently pushing it away with a large flat curette.

At this time, the envelope containing the randomisation code was opened, the surgical site having been prepared with no knowledge of the graft to be placed. The established voids were then filled with 100% anorganic bovine bone (Bio-oss[®], Geistlich Pharma AG, Wolhusen, Switzerland), or with 50:50 (Bio-oss[®]) plus autologous bone. Autologous bone was harvested with a bone scraper (Micros Meta, Divisione medicale Meta Reggio Emilia, Italy) from the region of the maxillary tuberosity. In both groups, the material to be grafted was mixed with saline and blood. After grafting, the open lateral window was sealed by the placement of a collagen membrane (Bio-Gide[®], Geistlich Pharma AG) and the soft tissue was closed primarily with 4/0 polyglactin 910

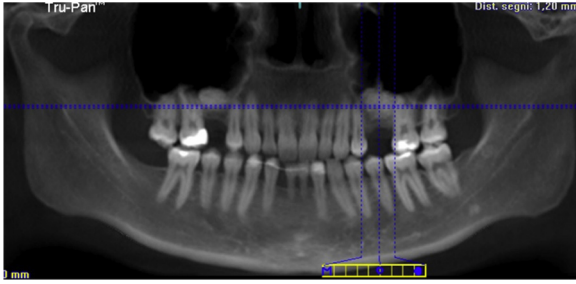


Fig. 2. Computed tomographic scan 7 months after sinus grafting: panoramic view.

sutures (Vicryl, Ethicon J&J International, Saint-Stevens-Woluwe, Belgium).

Postoperatively, ketoprofen (Oki; Dompé, Milan, Italy) 80 mg two or three times daily was prescribed for as long as required. Patients were instructed to rinse with 0.2% chlorhexidine (Curasept Curaden Healthcare, Saronno, Varese, Italy) for 2 weeks and to take only a soft diet for 10 days. Sutures were removed after 2 weeks. Dexamethasone (Rekah Pharmaceutical Products Ltd.) 4 mg/day was given for an additional 2 days to minimise oedema. At 7–8 months after augmentation of the sinus, CT scans (Fig. 2) were obtained to assess the stability of the graft and the normal thickness of the Schneiderian membrane, and to locate the regenerated radiopaque tissue and graft.

Implants were placed using a conventional approach. Intrasulcular and crestal incisions were made and a mucoperiosteal flap raised. Drills were used to prepare the recipient bed and all implants were installed with an insertion torque >30 N cm and <45 N cm, as measured with a manual torque wrench by the operating surgeon.

Both groups were given tapered implants: Nobel Replace Tapered Groovy (Nobel Biocare, Goteborg, Sweden), with diameters of 4.3 or 5.0 mm and 10 mm long. The flaps were then sutured with 4/0 polyglactin 910 sutures (Vicryl, Ethicon J&J International).

Baseline intraoral radiographs were taken of both sides with a parallel technique during the operation. If the amounts of bone around the implants being studied were inconclusive, a second radiograph was taken. In total, ketoprofen (Oki; Dompé) 80 mg two or three times daily was prescribed for as long as required. After 3 months implants were checked radiologically and manually for stability, and bilateral silicone impressions were taken. Customised cast models were then produced. After a week screw-retained, temporary resin crowns on temporary titanium abutments were applied, and five months postoperatively definitive, screw-retained crowns were applied.

Intraoral radiographs of the study implants were taken at baseline and after 6 and 12 months. Patients were then enrolled in an oral hygiene programme with monitoring every 3 months for 1 year after insertion of the implants (Figs. 3 and 4).



Fig. 3. Intraoral radiograph 1 year after insertion of implant: sinus grafted with anorganic bovine bone.

Outcome measures

Survival of implants: implants were removed if they were unstable, if there was progressive marginal bone loss or infection, or if the implant fractured. The stability of individual implants was measured by the prosthodontist at the time of that the definitive crowns were applied using 35 N cm of



Fig. 4. Intraoral radiograph 1 year after insertion of implant: sinus grafted with 50:50 autologous bone.

Table 1
Increase in the mean (SD) amount of peri-implant bone (mm) ($n = 10$ in each group).

Time	50:50 bovine and autologous bone	Anorganic bovine bone	<i>p</i> Value
At insertion	0.23 (0.19)	0.17 (0.17)	0.40
6 months	0.78 (0.59)	0.64 (0.31)	0.42
12 months	1.06 (0.61)	1.19 (0.53)	0.52

removal torque. After a year the stability was tested manually with the handles of two dental mirrors.

Complications: prosthetic and biological complications were recorded, as were surgical complications such as perforation of the sinus membrane, empyema, or abscess.

Amounts of marginal bone: amounts of peri-implant marginal bone were evaluated on parallel intraoral digital radiographs taken at the time of placement of the implant, and at 6 and 12 months. If radiographs were inconclusive, they were repeated. A radiologist (FG) who was unaware of the material used and not affiliated to the study centre, interpreted all radiographs. The distances from the mesial and distal interproximal bone to the reference point (the horizontal interface between the implant and abutment) were measured with a software measurement tool (NIH Scion Image, ver. 4.0.2, Frederick, MD, USA) calibrated against the space between two threads to the nearest 0.1 mm, and the mean of these two measurements was calculated for each implant. The measurements were recorded with reference to the axis of the implant (Table 1).

Peri-implant mucosal response: probing pocket depth (mm) and bleeding on probing (score) were measured by an operator (AD) who was unaware of the material used with a periodontal probe (PCP-UNC 15, Hu-Friedy Manufacturing, Chicago, IL, USA) at 6 and 12 months. Three vestibular and three lingual values were collected for each implant by the same dentist (Table 2).

Statistical analyses

Statistical analyses were made with the aid of QI Macros SPC software (version 2010, KnowWare International, Denver, CO, USA) for Microsoft Excel. A paired *t* test was used to assess the significance of differences between groups; the values included peri-implant bone loss (mm), pocket probing depth (mm), and bleeding on probing (score) at each time point. Probabilities of less than 0.05 were accepted as significant.

Table 2
Mean (SD) peri-implant mucosal response ($n = 10$ in each group).

Time	50:50 bovine and autologous bone		Anorganic bovine bone		<i>p</i> Value	
	PPD	BoP	PPD	BoP	PPD	BoP
6 months	2.68 (0.61)	1.38 (1.12)	2.56 (0.46)	1.27 (0.72)	0.30	0.38
12 months	2.49 (0.38)	1.59 (0.82)	2.31 (0.64)	1.36 (0.87)	0.10	0.27

PPD = pocket probing depth (mm), and BoP = bleeding on probing (score).

Results

Sixteen patients (nine men and seven women, mean age of 46 (range 24–70) years) were considered to be eligible. No patient left the study within 1 year after insertion of implants. There were no deviations from the protocol. Data were collected at baseline, and 6 and 12 months after insertion of implants. A total of 32 implants were placed, 16 in each group. The mean length of the reconstructed edentulous span was 12.87 mm in the 50:50 group and 13.03 mm in the anorganic bovine bone group.

There was no reported mobility, infection, or fracture of any implant, all of which were stable at the end of the study.

No prosthetic or biological complication was recorded in either group. One surgical complication (perforation of the sinus membrane of less than 3 mm) developed in the 50:50 group. The perforation was repaired with a collagen membrane and the patient was then treated according to the study protocol.

The mean (SD) change in the amount of interproximal marginal bone was recorded for each implant: after 6 months they were 0.78 (0.59) for the 50:50 group and 0.64 (0.31) in the anorganic bovine bone group. After 12 months, the corresponding measurements were 1.06 (0.61) and 1.19 (0.53), respectively. There were no significant differences between the two groups at any time.

The mean (SD) pocket probing depth was 2.49 (0.38) for the 50:50 group and 2.31 (0.64) for the other group. After 12 months the corresponding scores for bleeding on probing were 1.59 (0.82) and 1.36 (0.87), respectively. There were no significant differences between the groups at any time.

Discussion

Various graft materials have been used for sinus augmentation.^{4–6} Autologous bone is the material of choice, but its use is limited by morbidity at the donor site.^{7,8} Deproteinised bovine bone has been used successfully in the maxillary sinus.^{9,10}

There are many different aspects of sinus grafting: lateral or crestal approaches, simultaneous placement of implants or staged approaches, and various filling materials, which makes the sinus lift an interesting area of research.^{11–15} The complete replacement of autologous bone by bone substitutes

has been evaluated in many studies.^{16,17} However, according to Jensen et al., the hypothesis that there is no difference in sinus lifting with anorganic bovine bone alone or mixed 50:50 with autologous bone for the maxillary sinus using a lateral window approach cannot be confirmed or rejected because there is insufficient evidence.¹⁷ Comparative studies on outcomes of implants are rare, and there is no available strong evidence about which is the best graft material.

Survival of implants using anorganic bovine bone alone or mixed 50:50 with autologous bone has been compared in a few studies, and no significant difference in histological or clinical outcome has been shown after implants have been in place for a year.^{18,19} Long-term comparative data for survival do not yet exist to our knowledge. Only few papers have described survival data for implants placed in augmented sinuses with the sole use of Bio-Oss®, and the survival has ranged from 91% to 100%.^{20–22} Most of the data are from retrospective analyses, not random control trials.^{19–23} Additionally most of the studies have not analysed marginal bone remodelling or soft tissue changes (pocket probing depth and bleeding on probing). For these reasons, more comparative clinical trials are needed.

The purpose of the present pilot study was to compare the outcome of implants inserted in maxillary sinuses augmented with grafts of anorganic bovine bone alone compared with it mixed 50:50 with autologous bone using a lateral approach, and to test the hypothesis that there was no difference.

According to our data, and other studies, the use of anorganic bovine bone alone is suitable in grafting of the maxillary sinus.^{18,22,24} Our study seems to confirm the results of Hallman et al.,¹⁸ that the addition of autologous bone to anorganic bovine bone had no obvious beneficial effect and the clinical outcome was comparable with that of anorganic bovine bone alone.

This was a pilot study that had some limitations, including the small sample and the short follow-up, so it provides only moderate evidence. However, the results seem to confirm the first hypothesis that the clinical outcome of implants inserted in sinuses grafted with anorganic bovine bone alone compared with those grafted with 50:50 anorganic bovine bone and autologous bone, are comparable. Further controlled trials with more patients and longer follow-up are needed to provide better evidence, with the purpose of avoiding the use of autologous bone for grafting maxillary sinuses.

Conflict of interest

We have no conflict of interest.

Ethics statement/confirmation of patients' permission

The study was approved by the Research Committee of the Department of Surgical, Microsurgical and Medical Science,

University of Sassari, Italy, and all patients gave signed informed consent.

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