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Sinus Pack for maxillary sinus augmentation: a new technique

M. A. LOPEZ[1], P. C. PASSARELLI[2*], E. RELLA[3], F.R. ALTAMURA[3], L. SANTACROCE[4], M. CASALE[1], A. D'ADDONA[5]

[1] Unit of Otolaryngology, University Campus Bio-Medico, 00128 Rome, Italy
[2] Master Coordinator, Department of Head and Neck and Sensory Organs, Division of Oral Surgery and Implantology, Fondazione Policlinico Universitario A. Gemelli IRCCS—Università Cattolica del Sacro Cuore, Rome, Italy
[3] Department of Head and Neck and Sensory Organs, Division of Oral Surgery and Implantology, Fondazione Policlinico Universitario A. Gemelli IRCCS—Università Cattolica del Sacro Cuore, Rome, Italy
[4] onian Department, Microbiology and Virology Lab., Policlinico University Hospital of Bari, Bari, Italy
[5] Professor and Head, Department of Head and Neck and Sensory Organs, Division of Oral Surgery and Implantology, Fondazione Policlinico Universitario A. Gemelli IRCCS—Università Cattolica del Sacro Cuore, Rome, Italy

* Co-first author

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ABSTRACT

Aims Maxillary sinus lift is a surgical procedure suitable to restore vertical deficiencies of the posterior maxilla and can be executed either with a lateral or with a crestal approach. One of the most important aspects of a bone regeneration is the stability of the graft. The aim of this study is to introduce a new grafting technique for sinus lift with a lateral approach, which is called Sinus Pack Technique.

Methods Four patients with severe vertical atrophy of the alveolar bone in the posterior maxilla who needed unilateral dental implant rehabilitation of the edentulous maxillary region were treated according to the Sinus Pack technique- After 6 months a Computed Tomography scan was taken to assess the obtained bone volumes, implants were placed, and a bone sample was obtained with a 4mm trephine bur.

Results Three males and one female (age range 36-75 years) were treated ; no intra- and post-operative complications were recorded. According to the measurements performed on the CT scan before surgery and six months after surgery we found an average vertical gain of 6.95mm. According to the histological and histomorphometric analysis the membrane was completely resorbed, new bone had formed and only a slight percentage of bone-filling granules was still present.

Conclusion The Sinus Pack technique has the advantage of being a minimally invasive and safe surgery procedure, with results similar to other sinus lift techniques. More reports are needed to confirm the lower hypothesized complication rate and its efficacy.

INTRODUCTION

The loss of one or more dental elements in posterior maxilla leads to a vertical and horizontal atrophy of the alveolar bone. This can also be associated with a contextual bone loss due to sinus pneumatization. In order to place implants of the proper length, and to achieve a favorable crown-to-root ratio, it is often necessary to perform a more complex surgery, creating the needed bone volume; an approach frequently used is Maxillary sinus augmentation (or sinus floor elevation), which can either be performed with a lateral approach (1–3), or by a crestal approach (4,5). The latter is less-skill intensive and is a faster procedure, but it is not indicated if the height of the residual bone ridge is less than 4-5 mm, where a lateral approach is needed (6).

Since the introduction of the lateral sinus floor elevation, by Tatum Jr. et al. (7,8) and Boyne and James (9) in the 1980s, the technique has been studied, has reached a widespread consensus (10), and has been refined to reduce the risk of complication, either intra-operatory or post-operatory, making the technique less invasive to the patient (11). This procedure involves the exposure of the lateral wall of the maxillary sinus, which is then opened to detach the Schneiderian membrane and create a space where a bone graft can be placed (12).

In 2001, Vercellotti et al. described the applications of piezoelectric surgery to maxillary sinus lift (13). This technique has the advantage of using tips that are less harmful on non-mineralized tissues than burs, therefore

preventing accidentally perforating the Schneiderian membrane (14,15), while still maintaining adequate bone-cutting capacities.
Perforating the Schneiderian membrane is the most common complication observed during a lateral approach, as it occurs in 7%-35% of sinus augmentation procedures (16,17). The Schneiderian membrane is a mucous membrane which covers the internal walls of the maxillary sinus. Its thickness varies from 0.3 mm to 0.8 mm (18), consisting of a first layer of pseudostratified columnar respiratory ciliated epithelium a second connective layer and a third periosteal layer. Its function is to lead mucus to the ostium of the maxillary sinus, and into the nasal cavity. A perforation might lead to infection of the bone graft, hampering its integration, or leading to the development of sinusitis, especially if the graft is in particles (19). Preserving the Schneiderian membrane is also fundamental to maintain the mucociliary transport system homeostasis. An alteration of this homeostasis leads to a reduction in drainage and ventilation of the maxillary sinus, which may easily induce to bacterial infections.
While maxillary sinus lift is therefore an established treatment option, the most suitable choice for the filling material is still not clear; various grafting material have been used, including autologous bone, alloplasts and mineralized or demineralized allogenic bone (20,21); also some reports have also speculated about the possibility of executing a sinus lift without any grafting material when implants are simultaneously placed (22).
Still, the major role of the inserted biomaterial is to maintain the space obtained with the detachment of the Schneiderian membrane and allow bone cells derived from the sinus periosteum to depone new bone (23). From a clinical point of view, independently of the biomaterial adopted, it's paramount to obtain sufficient stability of the graft, and to prevent any perforations of the Schneiderian membrane (24). If a perforation develops, the clinician must place a resorbable membrane, so that the inserted bone-filling material is not dispersed in the maxillary sinus, as this might be the cause for postoperative sinusitis, infection, and graft failure (25,26).
The aim of this study is to introduce a grafting technique which both allows to stabilize the graft material, and to isolate the granules from the Schneiderian membrane, therefore also helping in cases of membrane perforation. We therefore present 4 cases treated with this technique (Sinus pack) to evaluate its effects on a clinical, radiographical and histological level.

MATERIALS AND METHODS

Study population

Subjects were recruited from patients treated at the Oral Surgery unit of the Policlinico Universitario Agostino Gemelli between September 2018 and February 2019. After clinical and radiographical evaluation, we selected patients that had to rehabilitate a maxillary partial edentulism and were scheduled for a sinus lift in order to receive an implant-supported restoration, excluding patients that suffered from any disease of the maxillary sinus, or that had strong contraindications to receiving an implant-supported restoration (ie. Poor oral hygiene, irradiated maxillary bone).
All patients included in the study were sent for a Computed Tomography (CT) before surgery.
The present study was conducted in accordance to the requirements of the Helsinki Declaration of 1975 as revised in 2008. Patients were verbally informed about the surgical procedures and follow-up and gave their written consent.

Clinical Procedure

The surgeries were performed following the same surgical protocol by the experienced same oral surgeon.
Local anesthesia was administered with an infiltration method using two cartridges of 4% articaine, with 1:100,000 epinephrine . An horizontal incision and a vertical releasing incisions were performed with a 15C blade on the edentulous ridge, considering the amount of attached gingiva, in order to access the lateral sinus wall. An antrostomy was performed with a diamond bur ISO 2.3 mounted on a high-speed handpiece at 50000 rpm; keeping the bur angled at 45 degrees toward the bone and the caudal border of the antrostomy shorter than the coronal one (Fig. 1).
In order to avoid puncturing the Schneiderian membrane, the bur was used with a paintbrush motion until a bluish hue was visible. Then, the trap door was detached from the underlying soft tissues and kept hydrated, to be repositioned at the end of the surgery (Fig. 2).
After performing the antrostomy the mobility of the Schneiderian membrane was tested and any bone spicule was removed; the sinus membrane was then elevated with blunt instruments always maintaining contact with the maxillary bone, starting from the coronal part, then moving to the mesial, then to the distal, and finally detaching the caudal portion. The membrane was elevated until the medial sinus wall was reached in order to obtain sufficient space to place the graft and the implants and to improve the vascularization of the graft.
The graft was then prepared following our protocol; an extra-fine, 0,22 mm thick, pericardium, resorbable membrane was properly hydrated with saline. Then, a 80% bone-20% collagen gel, heterologous cortico-cancellous bone substitute was placed in the middle of the membrane, folding the membrane over the bone graft (Fig. 3).
This pack was finally inserted into the antrostomy, stabilized, and covered with more biomaterial (Fig. 4).
Then the trap door was cautiously repositioned over the antrostomy; thanks to the design of the antrostomy the trap door can be easily stabilized and does not fall into

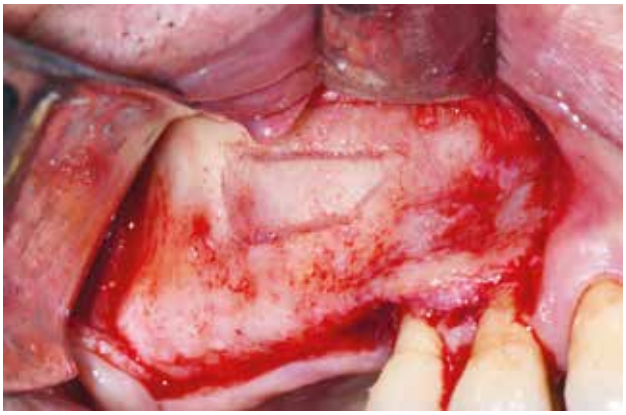

FIG. 1 The design of the antrostomy.

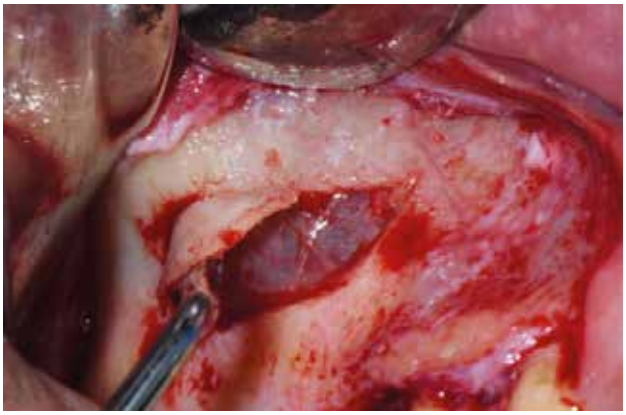

FIG. 2 The trap door removed from the surrounding tissues.

FIG. 3 The bone-filling material enwrapped by the membrane.

the antrostomy itself (Fig. 5). The trap door was then covered with more bone substitute to further stabilize it and to smooth the surface of the surgical site (Fig. 6).
The flap was then sutured with horizontal mattress sutures; patients were advised to use a 0.2% Chlorhexidine mouthwash twice a day, for 2 weeks. The sutures were removed 14 days after the surgery.

Another CT was performed 6 months after surgery to evaluate the obtained bone volumes before planning implant positioning; implants were then positioned following the implant manufacturer guidelines ; at the same time of implant placement, a bone sample was taken with a 4-mm trephine bur and was submitted to histological analysis.

Histologic and Histomorphometric analysis

Bone biopsies were fixed in 10% phosphate-buffered formalin, followed by decalcification in a hydrochloric acid/formic acid solution (4/5%). After decalcification, samples were dehydrated in a series of alcohol baths and then embedded in paraffin. 5-µm-thick histological sections were then prepared and stained with hematoxylin/eosin.
The slides were then subjected to digital scanning at various magnifications to evaluate the presence and characteristics of the newly formed bone, of the remaining grafted material, and the integration of the grafted material with the surrounding tissues.
The images from each area of the biopsy core were obtained and analyzed using image analysis software

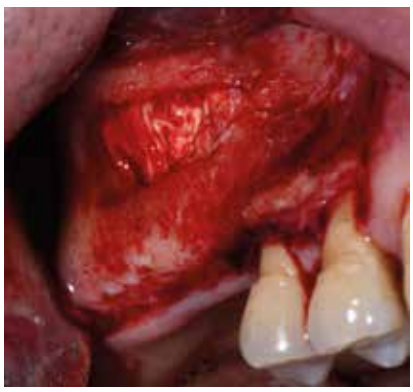

FIG. 4 The "pack" inserted in the antrostomy.

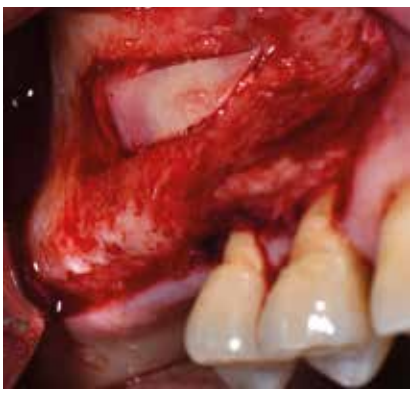

FIG. 5 The trap door repositioned over the antrostomy.

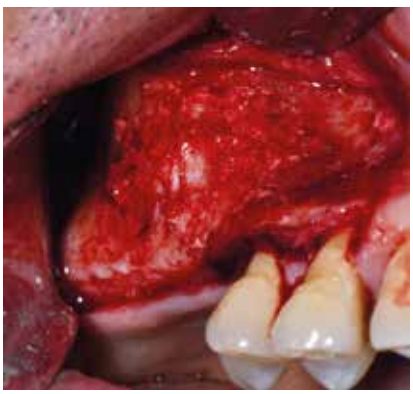

FIG. 6 The trap door covered by more biomaterial.

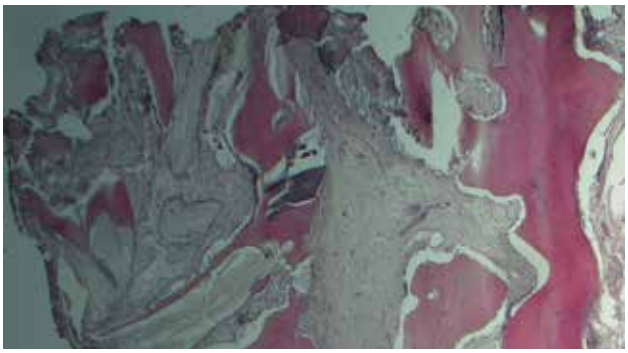

FIG. 7 The regenerated tissues 6 months after surgery (Hematoxylin and eosin stain).

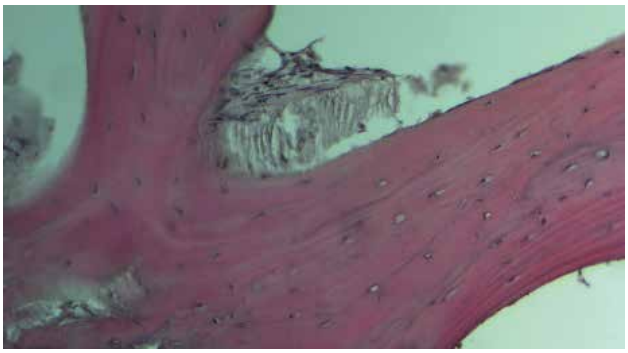

FIG. 8 Close-up of figure 7 shows sound, mineralized bone (Hematoxylin and eosin stain).

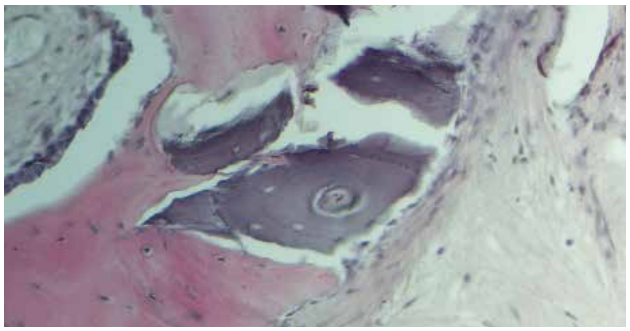

FIG. 9 Close-up of figure 7 shows some of the remaining, not yet resorbed, biomaterial (Hematoxylin and eosin stain).

(ImageJ) (27) and the percentages of residual graft particles, newly formed bone, and soft tissue components (i.e., bone marrow and/or connective tissue) in each specimen.

RESULTS

Four patients, between 36 and 75 years, were recruited, and were treated according to the previously presented protocol.
After six months, a new CT allowed to consider the maturity status of the graft on each patient. The graft was not completely reabsorbed, especially close to its apical part, but it continued to act as a scaffold for bone regeneration. Overall, all the defective sites had exhibited an excellent bone formation, and a mean vertical gain of 6.95mm (standard deviation = 1.05mm) was observed. There were no cases of infection, and no complications were recorded intraoperative and during the follow up. 6 Dental implants were placed, all achieved primary stability, and the surgical site healed uneventfully.

Histologic and Histomorphometric results

All biopsies included vital, newly formed bone. The membrane had been completely resorbed and could not be discerned in the examination (Fig. 7, 8, 9). The histomorphometric analysis demonstrated that a third (33.14%) of the samples was vital bone, while only a minimal part was composed of unresorbed bone granules (1.74%); soft tissues (either bone marrow, or not mineralized connective tissue) was still largely present in the sites (65.12%).

DISCUSSION

The Sinus Pack technique proposes to apply the biomaterial surrounded with a resorbable membrane, as if to create a pack. This approach has several advantages; it's easier and faster to obtain the filling of the sinus, as the bone-filling granules are added in a single step; also, if any perforations occur during the detachment of the Schneiderian Membrane the clinician can still normally follow the technique, as the membrane protects the biomaterial and prevents any dispersion of the granules in the sinus cavity, also preventing any complications coming from undetected, minor perforations.
The selection of the used materials is of paramount importance; GTO is a mix of porcine granules and type I and III collagen; given its composition, is extremely sticky and tends to blot. This behavior allows the clinician to easily wrap the biomaterial with the membrane, which immediately adheres to the granules, and to replace and stabilize the trap door over the antrostomy, preventing any ingrowth of soft tissue from the alveolar mucosa.
As the biomaterial must be quickly vascularized after the surgery, it's important to use a resorbable membrane that is both very thin and that has a short resorption time, still sufficient to stabilize the bone-filling material in the first days after the surgery, giving the Schneiderian membrane the appropriate time to heal.
The radiographical analysis is in line to what other papers state, that lateral sinus lift can allow for a vertical augmentation up to 6-7 mm (28,29), allowing the clinician to place implants of the proper length. Our histologic and histomorphometric evaluations also show

that this newly obtained, radiopaque volume, thanks to the combination of the stability offered by the technique and the adopted biomaterials, is new, vital bone, where bone-filling granules are largely resorbed.
Our study has some limitations; first and foremost, we did not conduct a volumetric analysis which should be needed to properly define the effects of this technique on the maxillary bone; also, biopsies should be taken at different time points to properly assess the physiological processes that lead to the resorption of the membrane and that allow the deposition of new sound bone. New studies, with bigger samples and longer follow-ups are needed to compare the Sinus Pack technique to other procedures commonly followed for the rehabilitation of the posterior maxilla.

CONCLUSIONS

The sinus pack technique is a reliable approach to sinus lift, as after 6 months new regenerated bone is obtained. Future research on this technique is needed to observe its effects on the rate of complications, and to compare this procedure to other techniques.

Conflicts of interest

The authors declare no conflicts of interest.

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