POSITIONING OF A CONTEXTUAL IMPLANT ALONG WITH A SINUS LIFT ANCHORED WITH A BLOCK OF HETEROLOGOUS BONE

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SUMMARY
During a sinus lift procedure the main requirement in order to position an implant is to have a maxillary sinus floor cortical bone thick enough to guarantee a primary stability in the implant inserted. In this way, the healing process is facilitated and osseointegration of the titanium surface may occur simultaneously, thus reducing the waiting time for the engraftment of the implant into the body. Unfortunately, these conditions are not always present. Hence, the need of developing an alternative approach that could simultaneously allow to perform sinus floor elevation along with an implant placement.
Here we present the case of a 62-year-old patient that requires implant-prosthetic rehabilitation from 1.2 to 1.6 at diagnosis. In this study, we reported a novel application derived from the use of a heterologous bone scaffold (SmartBone@) in a sinus lift procedure. We showed the successful implant along with sinus lift with SmartBone@, both at the time of the surgery and after follow-up of the patient at 10 months from the implant. The possibility to perform simultaneously the contextual implant along with sinus lift dramatically reduced the waiting time for the patient of minimum 5-6 months required for osseointegration of the grafted biomaterials, before performing the implant procedure. This surgery represents an advance both in terms of medical technique and as life-benefit for the patient.

Key words: implants, case report, sinus pneumatization, sinus lift, heterologous bone, SmartBone®.

Introduction

Maxillary sinus lift is a surgical procedure that usually requires a period of osseointegration of the grafted biomaterials (1) and an additional recovery period for the correct positioning of the implant, in order to finally achieve a complete engraftment of the prosthetic implant into the body (2, 3, 67).
In case the medical conditions of the patient are permissive, the contextual implant can be positioned during the maxillary sinus lift surgery, in order to promote simultaneously osseointegration of the biomaterials and fixtures, hence reducing the waiting times (4-9, 68).
During a sinus lift, the main requirement in order to efficiently position the implant is to have a proper thickness of maxillary sinus floor cortical bone that might guarantee a primary stability in the inserted implant. Thus, the healing process could be facilitated and osseointegration of the titanium surface around the biomaterials may occur simultaneously, leading to stability and engraftment of the prosthetic implant after a shorter period (10-16).
Unfortunately, these optimal conditions are not always present. Indeed, surgeons often deal with the contraction of the edentulous saddle along with an expansion of the maxillary sinuses,

which determine a rather limited thickness of sinus floor cortical, not suitable for an implant insertion (17-26, 69). In order to overcome the absence of suitable thickness and reduce waiting times, it has been proposed a novel technique that positions the contextual implant at the same time as the sinus lift, by fixing the apical part of the same implant to a block of heterologous bone positioned between the sinus floor and the Schneider membrane. If properly drilled, this functions as a sort of nut to which the apical part of the implant is attached and acts as a screw. The platform for this screw, which rests underneath the same cortical sinus floor, tightens the system at the screwing stage and achieves the stability that is required for osseointegration.

Case description

This case study presents the diagnosis of a 62-years-old patient that requires implant-prosthetic rehabilitation from 1.2 to 1.6, because of a sinus pneumatization associated with loss of jaw cortical pavement bone due to dental agenesis (Figure 1). The medical history does not indicate any particular contraindications for surgical therapy.
The extraction of element 1.6 was performed around eighty days before the CT scan, where there was evidence of posterior maxillary atrophy with low cortical sinus floor thickness. Rehabilitation associated with the opportunity to insert a contextual implant during maxillary sinus lift surgery was planned, using a block of heterologous bone molded and inserted into the maxillary sinus, which acts as a nut for a screw, as previously described.
All clinical investigations were carried out under strict observance of the Declaration of Helsinky, and patient informed consent has been collected and recorded accordingly.

Description of method

In order to fully plan out the work and demonstrate the aim, data from the Cone-Beam radiographic examination were used to make a stereolithographic (3D) model. This solid model was mounted on an articulator and after a diagnostic assembly process the position where the implants should have been inserted was evaluated (Figure 2). The proposal for the distal implant indicated its future position at the level of the first molar and suggested the following point where to situate the block of bone that would serve as a nut. At the time of the sinus lift, this would naturally be immersed in biomaterial granules selected for the purpose.

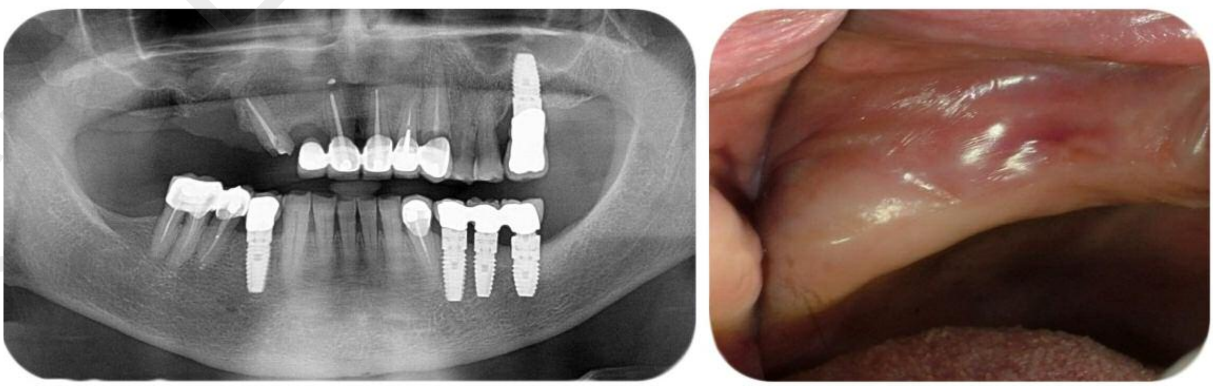

Figure 1
Sinus pneumatization with loss of jaw cortical pavement bone due to edentulism.

Figure 2
The SmartBone® plate is shaped accordingly with the stereolithographic (3D) model.

Once the length and diameter of the implant were determined the operation was simulated with replicas of the same size, and for this phase, modelling the antrostomy. A SmartBone® (SB@) block, a bovine decellularized bone matrix reinforced with bioresorbable aliphatic polyesters and RGD-containing collagen fragments (obtained by purified gelatin) was taken from a ready-made piece 3 millimeters thick (70-73). SB® was used for this purpose in order to achieve lateral access of restricted size. From these indications, the positions were obtained to build a guide mask with osseous attachment both for the correct insertion of implants and to precisely place the antrostromy. The geometry of the implant should usually present a coronal portion larger than the body which, in the screwing phase, functions as a halt on the external wall of the cortical bone of the sinus floor, in order to perform an anti-sinking action to which all the components of the system firmly hold in place. Lastly, both the replica implants and the stereolithographic model were packaged and sterilized.

Pre-operative preparation of Bone Block

Before surgery, the adjustment of the piece of bone to the interior of the maxillary sinus was carried out in a sterile field on the model, corresponding to the aforementioned hole for the implant and the antrostomy (Figure 2).
The portion of bone, taken from a piece of bone graft was shorn with bone rongeurs and the contouring completed with cutters. During these procedures, bone granules were produced, kept in small sterile containers and used as filler particles for the sinus.
SB® grafts are obtained by the reinforcement of bovine bone derived matrix with the mixture of PLCL [poly(L-lactic acid) and poly(ε-caprolactone)] and RGD-containing collagen fragments (obtained by purified gelatin) through a proprietary process. The bovine derived matrix is mineral and made of calcium hydroxyapatite (HA, $Ca_5(PO_4)_3(OH)$) that presents a chemical structure and a morphology that resemble the human bone (27, 28, 70-73). The presence of RGD-containing collagen fragments, even if extremely low quantities, increases the hydrophilicity of the scaffold, with consequent higher cell attachment and enhanced biocompatibility and osseointegration (29, 30, 70-73). The resulting composite material is able to mimic human bone microstructure and to ensure macro-scale properties: an adequate-sized open porosity with a combined rigid-elastic behavior, together with surface properties that ensure cell viability and fast tissue integration. SB@ heterologous bone was used for its specific properties of mechanical resistance (31, 70, 71). Once sample was shaped, it had been screwed into this bone; the implant torque was over 60 Newtons with no sign of fracture. This force allows, even at low thickness, the screwing of the implant to the interior bone without risk of cracks, which would cause mobility and prevent osseointegration. Then, the hole for the implant was made with specialist cutters for its size, and thanks to the innate resistance of the bone in question, there was no breakage or loss of stability in the screwing phase.
Moreover, the 3 millimeters' thickness of the bone block allowed the insertion into the sinus of a lateral opening of small size. Once inside the sinus, this reduced size lead to ease movement and accurate positioning for the screwing phase (Figure 3a).
This phase ended with the insertion of the bone and the solid model into sterile packages, which were prepared using double-bagged sterilization.

Surgical phase

After the appropriate anaesthetic procedure, thanks to the correct releasing incision, the flap for an ease of access for the operation was prepared. Beforehand, in this type of procedure, it is common to use a scraper for autologous bone to harvest the patient's own osteoinductive material from the area which contains the largest amount of bone. About a third of the quantity of the material required should be obtained and mixed with two-thirds of SB@ granules before the application.
The canine should be extracted and the previously prepared guide mask should be positioned. Next, the implants should be located in zones 1.2 and 1.3 and the hole prepared for the implant in 1.6, where the heterologous block will be inserted. In this phase, through the appropriate cutters,

the area should also be marked for the antroscopy in the lateral wall bone of the maxillary sinus.
Once the trap door window procedure has been carried out, the Schneider membrane should be lifted and the mix of granules located alongside and below the bone, which can immediately be placed in position. Among the layers of the floor, the walls and the bone block, a small amount of material should be used in a thin layer, not to compress or raise significantly the position of the bone block, which the implant will be screwed into (Figure 3b).
As the site is correctly prepared, while holding the bone block solid with toothed forceps, the implant can be inserted, and before proceeding, the screwing process should be positioned into the hole in the same bone block. While holding the bone in place with forceps, the implant can be screwed loosely into place. When this phase is almost complete, the bone, engaging the implant, will pull on its countersunk coronal part and at the same time it will stabilize firmly onto the base of the maxillary sinus. The whole platform system, countersunk implant, cortical bone floor and the bone block, should be rigidly connected.
At this point we can proceed to fill the empty left spaces surrounding the fixed bone block, attaching a resorbable membrane and replacing the flap. For safety reasons, it is better to use a suture with mattress stitching that finishes with button sutures (Figure 3b).
After six months, a Cone Beam Computed Tomography (CBCT) was requested to check the success of the treatment. This examination showed evidence of successful osseointegration of the implanted surfaces, the bone block and the heterologous bone granules around them (Figure 4b).
Once the results are evaluated, the implants can be crowned and the soft peri-implant tissue management phases begin. Following the healing, there can be fittings and the case can be finalized (Figure 5a, 5b).

Discussion

Sinus floor elevation is a widely-practiced technique for elevation of the maxillary sinus prior to an implant placement. Particularly, in patients with a severely resorbed maxilla, minimally invasive sinus floor elevation with simultaneous implant placement using osteotomes does not appear to be the method of choice. A 2-stage procedure using a lateral window technique (32, 33) or a crestal core approach is preferred (34, 35).
Jensen recommended that the procedure should be performed with simultaneous implant placement when a residual sub-sinus alveolar bone height (RSBH) of at least 5 mm is present. When a smaller RSBH is present, primary implant stability may be compromised (17). Therefore, the implant is inserted simultaneously with a sinus lift procedure, when sufficient primary stabilization can be expected (19, 20). The healing process can be facilitated with a reduced waiting time for the finalization of the prosthetic implant.
Unfortunately, these conditions are not always present and less-than-ideal sites can result in an esthetic and functional compromise because implant placement requires an adequate quantity and quality of bone (36-42). In many cases, this anatomic problem can be solved by replacement or augmentation of autogenous bone grafts, which is considered the most predictable and successful material available (43). Although autografts are the standard procedure for bone grafting, it is sometimes not possible to harvest bone and collect an adequate amount of bone from other donor sites in the same patient (44). Moreover, autologous bone grafts have the drawback of requiring secondary surgery for autograft retrieval, with increased operation time and anesthesia, as well as donor site morbidity. However, many forms of banked bone allograft are available: fresh frozen bone (FFB), freeze-dried bone (FDB) and demineralized fresh dried bone (DFDB). Each one of these grafts carries risks and has unique limitations and handling properties (45, 46).

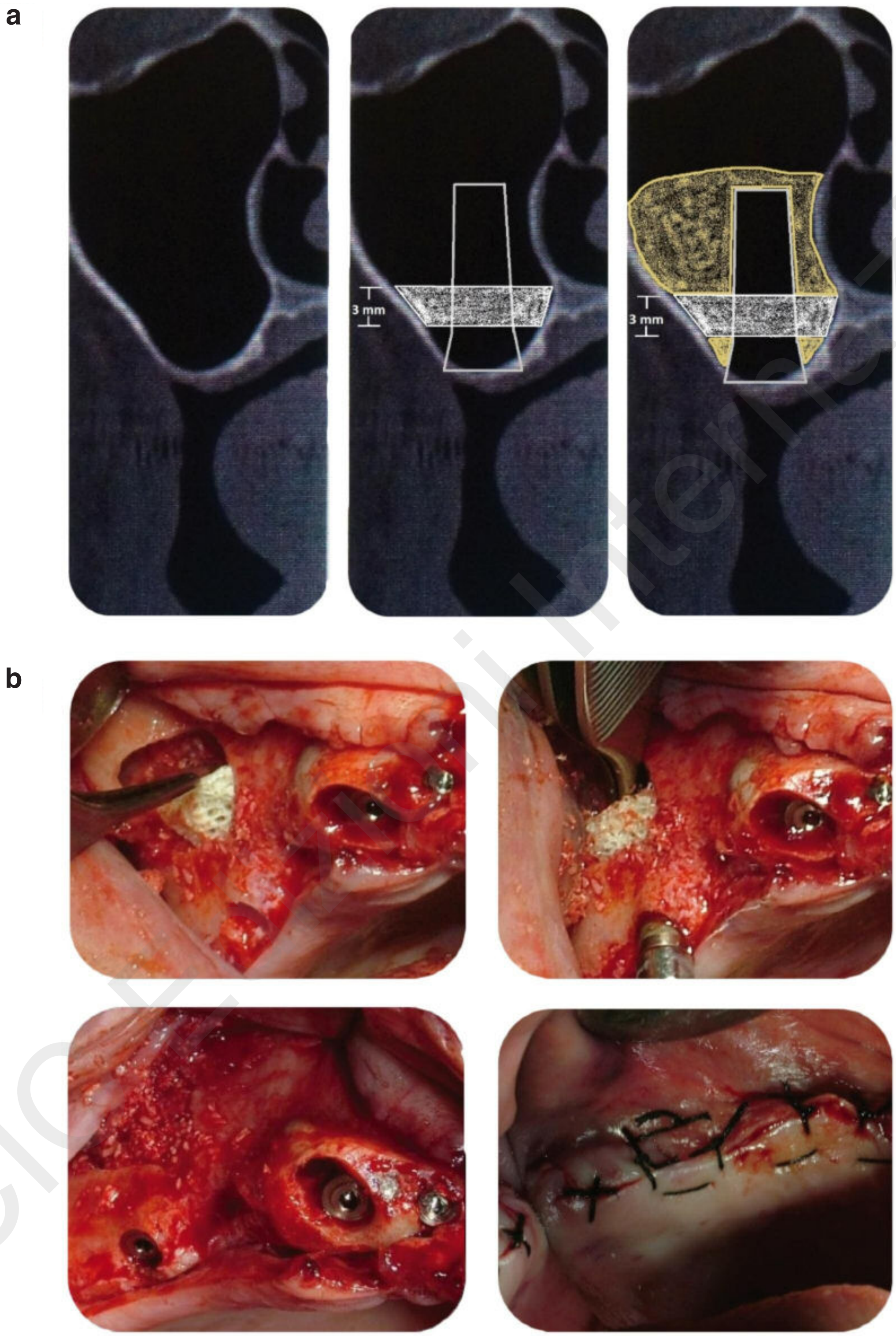

Figure 3
a) Images for bare explanatory reason: 3 mm bone block thickness inside the sinus allows an accurate positioning for the screwing phase; b) position of the solid bone block and insertion of the implant into the hole in the same bone block during surgery.

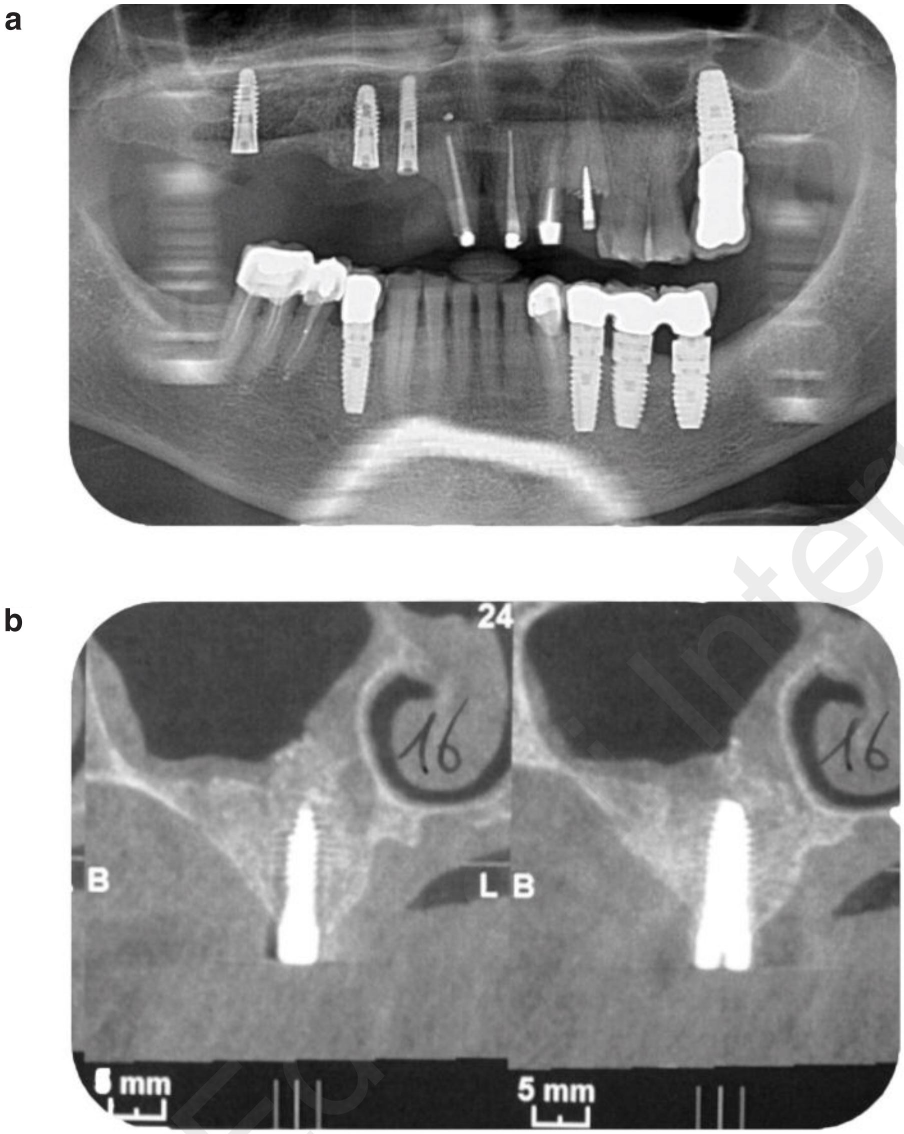

Figure 4
a) Cone Beam Computed Tomography (CBCT) after surgery. b) Cone Beam Computed Tomography (CBCT) after 6 months.

The goal of our approach was to combine the biocompatibility and tissue integration of natural materials with the possibility to tune mechanical and physical properties typical of synthetic ones. Indeed, composite grafts best mimic the real nature of healthy human bone, being rigid and elastic, compact but porous, dense but viable to cells and vessels. Bone regeneration should be performed with adequate material after controlling the periodontal disease since it can have an impact on peri-implantitis onset (47-66).
Custom hand-made SB@ of 3 millimeters was used for this purpose in order to achieve lateral access of restricted size. Data from the CBCT radiographic examination was used to make a stereolithographic (3D) model mounted onto an articulator. The positions were obtained to build a guide mask with osseous attachment both for the correct insertion of implants and to correctly place the antrostomy.

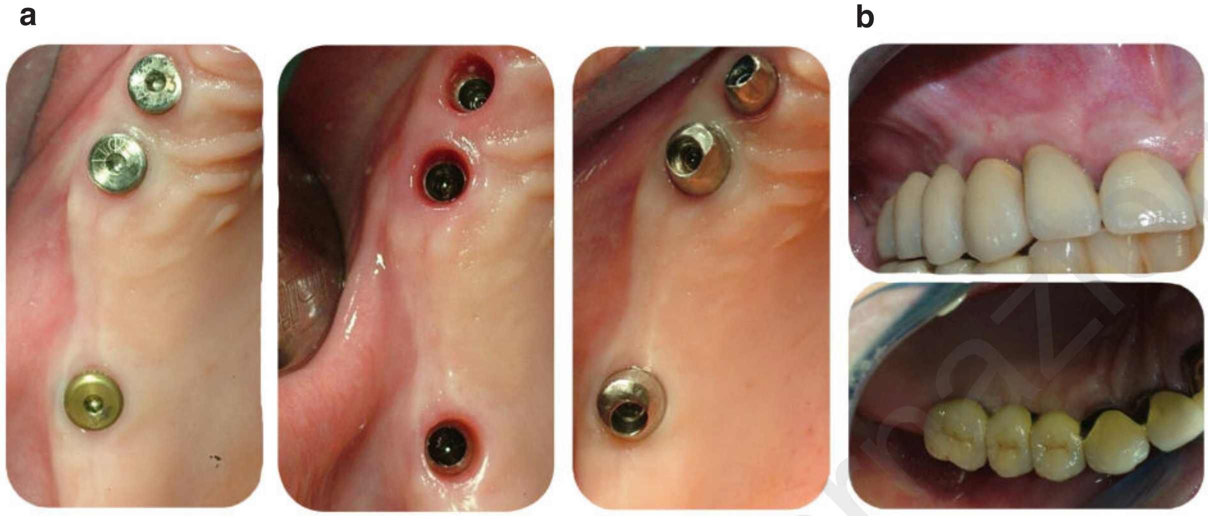

Figure 5
a) Aesthetically good gum contour and good bone augmentation after 9 months. b) Final prosthesis after 10 months.

Conclusions

In this study, we showed that the use of the SmartBone® represents a novel and successful medical application in a maxillary sinus lift procedure, which need to be considered in cases with a limited thickness of the sinus floor cortical.

The quality of life of the patient is strongly improved. The waiting time for the patient is reduced to 5-6 months in order to have a rehabilitated set of teeth, without the necessity to wait for the osseointegration of the grafted biomaterials before performing the implant procedure. Moreover, the simultaneous insertion of the implant with a sinus lift avoid a series of the various inconveniences, which can occur in between the procedure of sinus floor elevation and implant placement, and are due to the absence of dental elements (lack of occlusal function, reduction of masticatory units, aesthetic appearance).

Clinical significance

The successful realization of a contextual implant during maxillary sinus lift surgery allows the 62-year-old patient the comfort of a rehabilitated set of teeth and a consequent improvement of its quality of life, within a shorter time frame of at least 5-6 months.

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