

Transcrestal sinus floor elevation performed twice with collagen sponges and using a sonic instrument

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Abstract

Objective

The objective of this study was to describe a minimally invasive transcrestal modified technique for sinus floor elevation performed twice with a sonic instrument (Sonosurgery).

Materials and methods

During the first surgical stage, a split-thickness flap was dissected and an osteotomy performed to prepare a crestal bone window using a sonic surgical device. The bone window was subsequently pushed apically toward the sinus and only collagen sponges were compressed into the subantral created space. After four months of healing, a second surgical stage followed using similar procedures to those used in the first stage, and implants were subsequently placed.

Results

After three years, from the analyses of the cone beam computed tomography scans, no marginal loss was found and bone was observed all around the implant surface. No complaints were reported by the patient. At the clinical follow-ups, no clinical signs of periimplant soft-tissue inflammation and no technical complications were noted during the three-year period of observation.

Conclusion

The technique illustrated in the present article allowed the placement of implants of proper length in a widely pneumatized sinus where the bone height of the floor was insufficient for immediate stabilization. After three years of function, neither marginal bone loss nor clinical signs of inflammation were observed.

Keywords

Sonosurgery, sonic instrument, sinus floor elevation, transcrestal approach, collagen sponge, sinus lift.

Introduction

After tooth extraction, shrinkage of the alveolar process is expected that may reach 50% of the original horizontal width.¹ In the posterior maxilla, the resorption of the radicular portion of the sockets that may protrude into the sinus could yield a further bone volume reduction due to sinus pneumatization. In the molar area, the resorption is greater than in the premolar area, owing to the larger volume of the extraction sockets that requires more time to be filled by newly formed bone, thus allowing the time for sinus pneumatization.²

In periodontally compromised patients, a large sinus pneumatization, together with the concomitant alveolar crestal resorption, may result in an inadequate bone height, which may hinder the primary stability of implants in the edentulous posterior maxilla.^{3–5}

The maxillary sinus floor elevation technique with a lateral approach has been well described in literature.⁶ This surgical approach was based on a previously unpublished technique presented by Tatum at the Alabama Birmingham meeting in 1976. The safety and reliability of the technique have received large consensus by clinicians and researchers. Several modifications of the sinus floor elevation technique have been subsequently proposed for the surgical procedures and grafting materials used. Many of the sinus floor elevation techniques include the use of grafting materials to fill the subantral space, aiming to maintain the volume created.

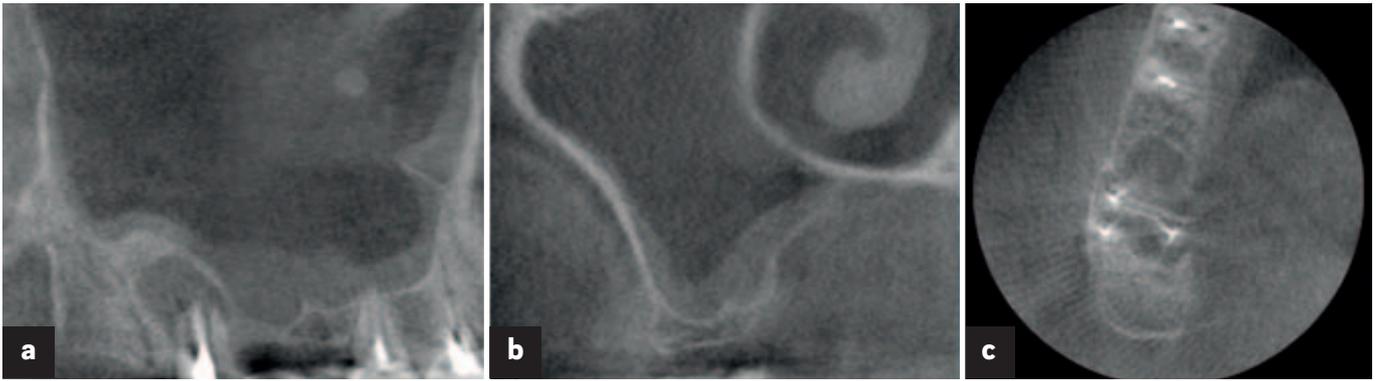
However, clinical studies on sinus floor elevation performed concomitantly with implant placement have shown that the establishment of an isolated space between the bone wall surface and the sinus mucosa, resulted in spontaneous formation of new bone, even without the use of grafting materials.^{4–7} Moreover, the integrity of the sinus membrane is known to be a prerequisite for success of the technique because it prevents the shift of the grafted material inside the sinus cavity; shifting of the material may favor acute or chronic infective complications and possibly compromise bone regeneration.⁸ Another technique frequently adopted for sinus floor elevation requires a crestal access,⁹ first carried out with the use of osteotomes and autologous bone as filler material.¹⁰ The crestal approach may reduce the perforation of the sinus membrane (4.7%)¹¹ compared with the lateral approach (44%).¹²

Several modifications of the crestal approach have been subsequently proposed, aiming to elevate the sinus floor while maintaining the integrity of the Schneiderian membrane. For this purpose, a variety of osteotomes, used with or without bone fillers,^{13, 14} or drills designed to avoid membrane perforation,¹⁵ or the use of specific devices^{16, 17} or ultrasonic instruments^{18, 19} have been proposed. With the use of osteotomes, an elevation of the sinus membrane of up to 10 mm in total may be obtained without causing tearing.²⁰ Another modification of the transcrestal approach was proposed^{21–23} based on the principle of the edentulous ridge expansion technique.²⁴ This approach includes the use of a blade to perform the osteotomies and, subsequently, the use of blunt osteotomes.

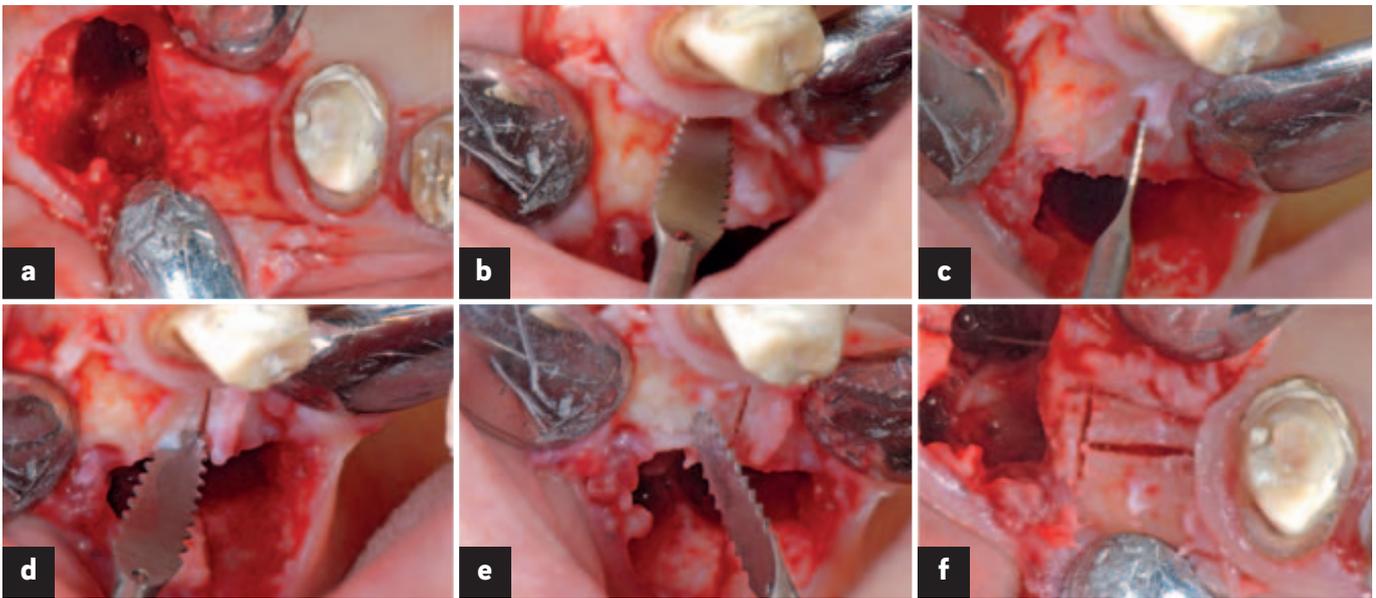
The preservation of sinus walls appears to have an important role in bone formation in the sinus floor elevation procedure. In fact, in an experiment in monkeys on the early healing at elevated floor sinuses,^{25, 26} it was shown that new bone only originated from the bone walls and septa of the sinus. In that study, no evidence of bone formation was observed from the sinus mucosa, even though other studies have demonstrated that the Schneiderian membrane has the potential to produce bone.^{27–30} A minimum height of 4–6 mm of the sinus floor has been suggested to guarantee the stability of the implant and, consequently, the success of the crestal access for sinus elevation.^{10, 31–35} When the primary stability of an implant cannot be guaranteed, a two-stage approach may be followed and implant placement would have to be postponed for several months, depending on the quality of the filler material used.^{31–35} A two-stage procedure has also been described for sinus floor elevation through a crestal access using blades, osteotomes and a mallet.²¹ The aim of the present study is to describe a minimally invasive two-stage technique for sinus floor elevation through a crestal access, using in both stages a trapdoor prepared with the Sono-surgery system.

Materials & methods

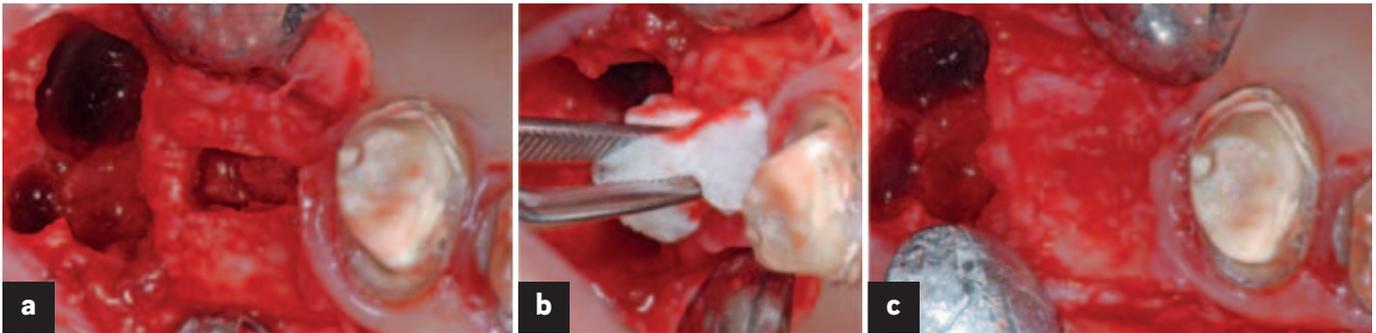
The case of a patient who required oral rehabilitation by means of implants in the posterior maxillary area and presented with a widely pneumatized sinus was chosen to present the step-by-step procedure of the technique. The height of



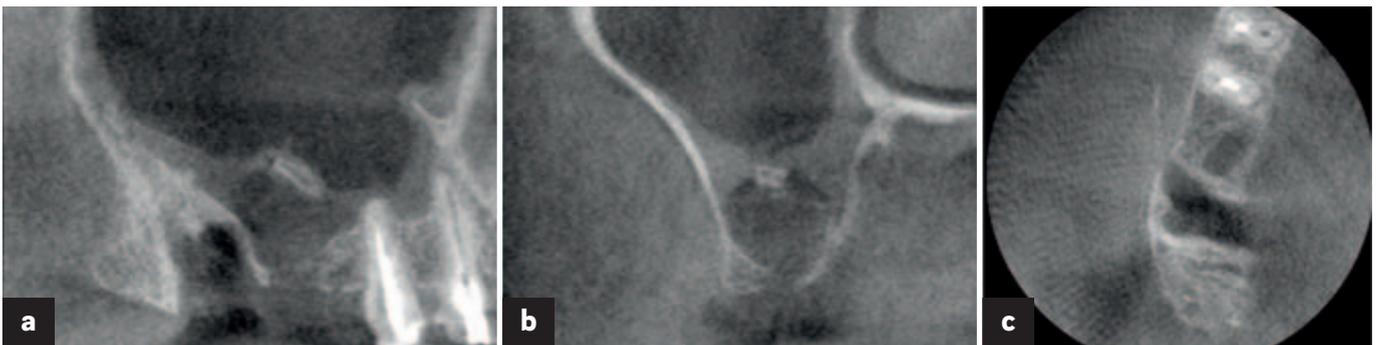
Figs. 1a-c



Figs. 2a-f



Figs. 3a-c



Figs. 4a-c

the sinus floor ranged between 2 mm and 4 mm, depending on the outline of the base of the sinus. It was not possible to guarantee implant primary stability; thus, a two-stage approach was followed (**Figs. 1a–c**). Micro-cone beam computed tomography (CBCT) scans (Kodak 9000, Carestream Health, Rochester, N.Y., U.S.) were taken before surgery.

First stage of sinus floor elevation

A split-thickness flap was dissected using a scalpel blade (BD Beaver 376400, BD Medical Ophthalmic Systems, Waltham, Mass., U.S.). A longitudinal incision was performed on the alveolar crest 3–4 mm palatal to the center of the crest. Short paramarginal releasing incisions were performed mesially (**Fig. 2a**). The dissection of the flap at the buccal aspect was extended up to the mucogingival junction, leaving only a thin layer of connective tissue on the bone surface in order to better visualize the bony crest morphology. After flap elevation, a bone trapdoor was prepared with the use of a vibrating sonic handpiece (Sonosurgery, TeKne Dental, Calenzano, Italy) into which a straight micro-saw (SFS 102, Komet Dental Gebr. Braseler, Lemgo, Germany) had been inserted. The trapdoor was produced in the center of the alveolar crest and was < 2.5 mm wide in the buccolingual plane. The bone incision was extended in a mesiodistal direction for the entire edentulous area to be treated. However, a safe distance of about 1.5 mm from the premolar was maintained to avoid damaging the root (**Figs. 2b–f**).

The osteotomy of the bone trapdoor was performed with a micro-saw 0.25 mm thick and exercising minimal pressure, similar to that of a pencil when writing (a maximum of 2–3 N). These incisions on the bone were performed with an external bevel, so that the bone trapdoor had a trapezoidal cross-section, the largest base being at the cranial and the smallest at the caudal aspect of the trapdoor. A continuous movement along the incisions had to be carried out by the operator using the sonic insert, gradually penetrating into the bone, until a distinct change of material texture was perceived, indicating that the base of the sinus had been reached. After that, the trapdoor was released along the osteotomies using a surgical mallet on blunt chisels (KLS Martin Group, Umkirch, Germany) with gentle taps (**Fig. 3a**). Collagen sponges (Gingostat, GABA VEBAS,

Rome, Italy) were placed into the space obtained in order to prevent the Schneiderian membrane from tearing, and these were subsequently pushed within the subantral space using the blunt chisels and mallet (**Figs. 3b & c**). The 3-D hydraulic pressure produced by the collagen soaked with blood encouraged the sinus membrane detachment from the bone walls. After sinus elevation, the buccal flap was repositioned and sutured to the palatal aspect, allowing a primary intention wound closure. A CBCT scan with a low radiation dose was taken immediately after the surgery (**Figs. 4a–c**). Intra-oral radiographs were taken one, two and three months after the first sinus elevation (**Figs. 5a–c**).

Second stage of sinus floor elevation

Four months after the first surgical session, an intra-oral radiograph was taken and assessed (**Fig. 5d**). The radiographs showed that the base of the sinus had gained about 3–4 mm in height compared with the original situation, yielding a total height of about 5–6 mm, which could allow for primary implant stability. No clinical signs of inflammation were observed. A surgical procedure similar to that used in the first stage was performed, including the mucosal incision. Again, a buccolingual crestal osteotomy < 2.5 mm wide was made (**Figs. 6a & b**).

The augmented dimensions of the sinus floor compared with the initial situation allowed the execution of deeper osteotomies with more pronounced bevels than those carried out during the previous surgical stage. Consequently, the bone trapdoor was higher and wider in the cranial regions in comparison with that prepared in the first surgical stage.

Chisels of increasing thickness were used to distract the bone toward the sinus, following the incisions made with the sonic micro-saw. This, in turn, meant that the chisels had a working direction with the same angulation as the osteotomies. Once the trapdoor had been split and mobilized by blunt chisels and a mallet, both buccally and palatally from the parent bone, collagen sponges were added and an implant with a conical shape (Pilot, Sweden & Martina, Due Carrare, Italy) was placed (**Fig. 6c**). The implant apex pushed the collagen and the bone further, producing an additional sinus floor elevation. Implant primary stability was obtained by means of the pressure of the

Figs. 1a–c

First sinus floor elevation stage in the three planes. In the initial CBCT scan, a fracture of the second molar and a periapical radiolucency were observed. The insufficient sinus floor height in the first molar position did not allow for immediate implant placement. **(a)** Panoramic view. **(b)** Cross-sectional view. **(c)** Axial view.

Figs. 2a–f

Clinical view of the surgical procedures. **(a)** Site after flap dissection and extraction of the first molar. The osteotomies were performed with an external bevel using a micro-saw 0.25 mm thick and exercising minimal pressure. The bevel cuts were orientated **(b)** mesially, **(c)** palatally, **(d)** distally, and **(e)** buccally, respectively. **(f)** The osteotomies of the trapdoor were finalized.

Figs. 3a–c

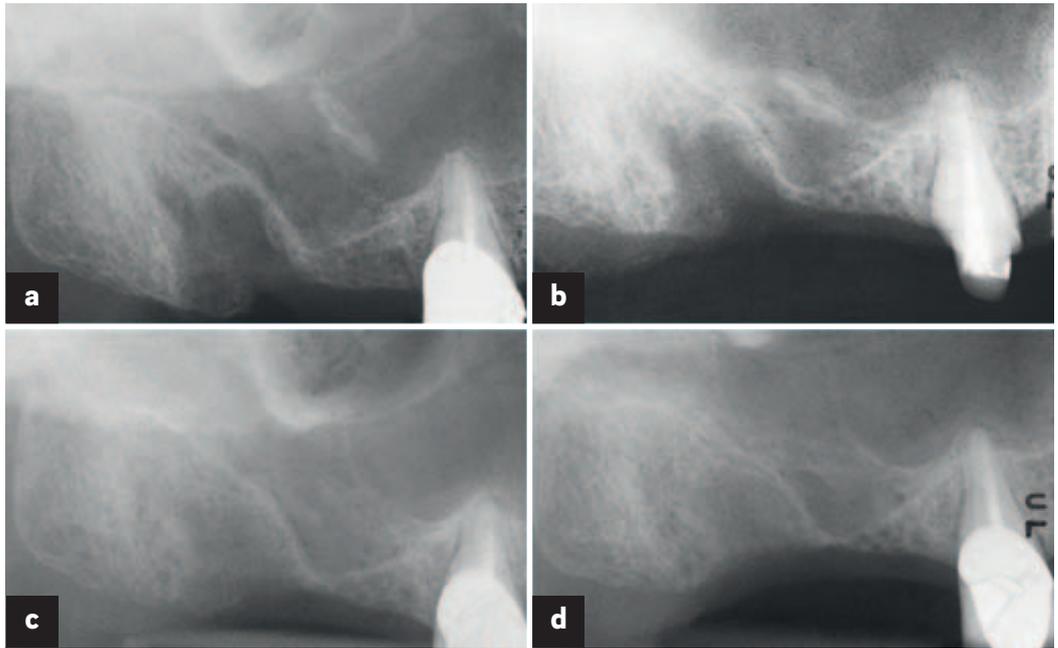
(a) The elevation of the trapdoor and of the sinus floor was performed with a surgical mallet on blunt chisels. **(b)** Collagen sponges were placed into the space obtained, and these were subsequently pushed within the subantral space using the blunt chisels and mallet. **(c)** Situation after the placement of collagen sponges.

Figs. 4a–c

A CBCT scan was taken immediately after the surgery. **(a)** Panoramic view. **(b)** Cross-sectional view. **(c)** Axial view.

Figs. 5a–d

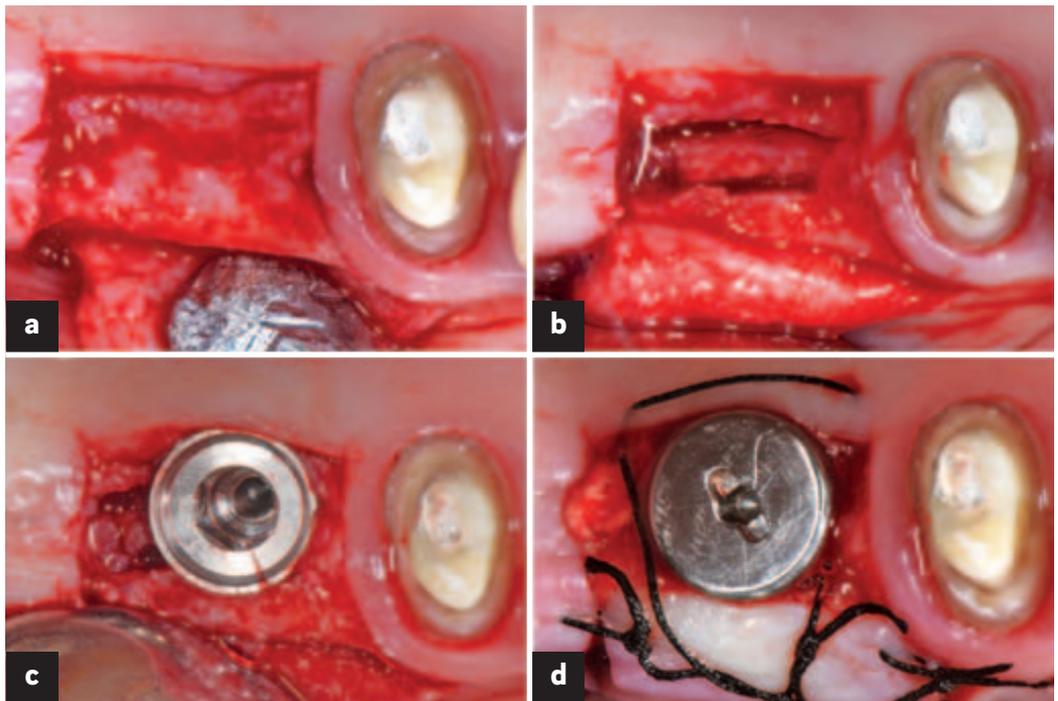
Radiographs showing the healing (a) one, (b) two, (c) three and (d) four months after the first sinus floor elevation procedure.



Figs. 5a–d

Figs. 6a–d

Clinical view of the surgical procedures of the second sinus floor elevation. (a) Buccal flap elevated. (b) The trapdoor was prepared, split and mobilized from the parent bone by chisels and a mallet. (c) Collagen sponges were added and an implant with a conical shape was placed. (d) The flaps were sutured with apical repositioning at the buccal aspect.



Figs. 6a–d

Figs. 7a–c

Low-dose CBCT scan taken immediately after the second surgery. (a) Panoramic view. (b) Cross-sectional view. (c) Axial view.



Figs. 7a–c

implant collar on the walls of the access. The buccal and lingual flaps were sutured with apical repositioning at the buccal aspect (**Fig. 6d**). A low-dose CBCT scan was taken immediately after the second surgery (**Figs. 7a–c**).

Prosthesis delivery and follow-up

After four months of uneventful healing, impressions were taken and a metal–ceramic crown was fabricated and seated over the implant (**Figs. 8a–c**). Checkups were performed during the healing period and regularly up to three years afterward. Intra-oral radiographs were taken immediately after prosthesis seating and yearly thereafter.

Results

After three years, from the analyses of the CBCT scans, no marginal loss was found and bone was observed all around the implant surface. The location of the implant apex corresponded to the new sinus floor (**Figs. 9a–c**). No complaints were reported by the patient. At the clinical follow-ups, no clinical signs of periimplant soft-tissue inflammation and no technical complications were noted during the three-year period of observation (**Fig. 9d**).

Discussion

The surgical technique with a crestal trapdoor approach may present advantages over classical sinus floor elevation performed through a lateral window access. The crestal approach, conversely to the lateral access, avoids opening large flaps, performing long vertical releasing incisions, and strong pulling on the flaps during surgery. Moreover, it allows for easier access to the distal zones with less exposure of the surgical area.

The absence of biomaterial grafts, other than the rapidly resorbable collagen sponge, decreases the possible loss of material into the sinus and, consequently, the risk of infection in case of unexpected perforation of the sinus mucosa. Moreover, no membranes are needed to cover the access osteotomy, reducing the total biomaterial cost.³⁶ The absence of grafted material allows a more reliable radiographic evaluation of the progressive mineralization within the elevated area, whereas when a radiopaque grafting material is used, its radiopaque nature may hinder the evaluation of bone formation.

The use of a crestal access may avoid crossing the anastomosis between the posterior superior alveolar artery and the infraorbital arteries. This anastomosis may be quite large in diameter and may cause severe hemorrhages when it is unintentionally damaged and possibly

Figs. 8a–c

Clinical view of the outcome. **(a)** Implant four months after the second sinus floor elevation. **(b & c)** Crown just seated over the implant from the occlusal and buccal views, respectively.

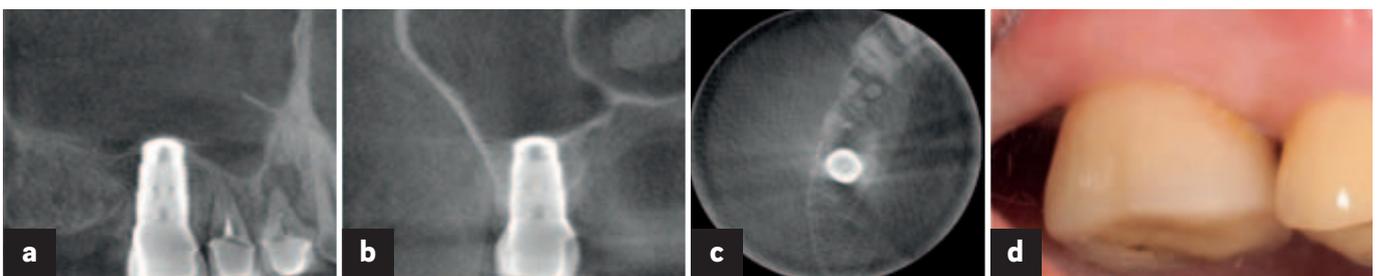
Figs. 9a–d

Low-dose CBCT scan taken after three years. **(a)** Panoramic view. **(b)** Cross-sectional view. **(c)** Axial view. **(d)** Clinical view.

Figs. 8a–c



Figs. 9a–d



compromise the blood supply of the region.^{37–40} One of the most important advantages of the present technique is, however, the presence of intact bone walls, whereas in the lateral access technique, the lateral wall is removed to a large extent, compromising bone formation. In fact, it has been shown that bone is formed from parent bone, while the sinus mucosa does not contribute to such formation, at least during the earliest periods of healing.^{25,26} Finally, in the case of thin alveolar ridges, a split-crest procedure may be applied concomitantly, so that the width of the ridge may also be augmented.

The crestal approach described in the present article also has some disadvantages, such as the low visibility within the elevated zone and the complex learning curve. The chisels and mallet have to be used carefully to avoid damage to the sinus membrane and discomfort for the patient. Moreover, the technique illustrated in the present article requires the sinus elevation to be performed twice, the implant being placed during the second surgery.

The sonic handpiece instrument and the micro-saw inserts used allow the operator to perform sharp and thin incisions with a clear view of the area, cleaned of bone smear and blood by irrigation. Moreover, incision with vibrating tools weakens the bone along the lines of

the osteotomy, minimizing the use of the mallet and consequently resulting in less discomfort for the patient. Sonic instruments have been shown to produce a very low increase in temperature compared with ultrasonic instruments⁴¹ and very limited soft-tissue damage.^{42–44} The use of sonic instruments has been proposed for the extraction of impacted canines⁴⁵ and successfully tested for implant placement in an animal experiment.⁴⁶

Conclusion

The technique illustrated in the present article allowed the placement of implants of proper length in a widely pneumatized sinus where the bone height of the floor was insufficient for immediate stabilization. After three years of function, neither marginal bone loss nor clinical signs of inflammation were observed.

Competing interests

IA developed the Sonosurgery device and micro-saw inserts used in the treatment of this case, and hence declares a competing interest. DB declares that he has no competing interests in relation to this study. The study was self-funded by the authors.

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