Minimally Invasive Transcrestal Sinus Floor Elevation Procedure in Severely Atrophic Ridge: A Case Report

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Typically, the greater the atrophy of the process, the more extensive and invasive the sinus floor elevation procedure is. This case of a 39-year-old man demonstrates a minimally invasive hydrostatic sinus lift from 1.7-mm height process in the site of lost tooth No. 16. Using a small flap, safe drills for a crestal approach diameter of 2.8 mm, 2 mL of saline solution under pressure of a syringe plunger, and 1 g of particulated bovine xenograft, a 14-mm height and 12-mm width sinus floor elevation was obtained. The implant was placed with a torque of 30 Ncm, and a healing cap was attached. Despite the very difficult conditions, the presented method not only resulted in a very good therapeutic effect but also reduced the number of procedures and time necessary for complete rehabilitation of the patient. The total treatment time to the final crown delivery was 6 months.

Key Words: sinus lift, minimal invasive, hydrostatic, crestal approach

Introduction

Implant surgeons have endeavored to overcome challenges in the maxillary posterior region using various techniques. Placement of conventional dental implants in the maxillary posterior regions can be compromised due to both severe ridge resorption and sinus pneumatization. Moreover, density in this region is often less than ideal, adding a condition of low-quality bone to an already compromised situation of low-quantity bone.[1–3] To overcome these challenges, different procedures have been suggested, including the hydrostatic method.

Techniques of maxillary sinus floor elevation have been developed to increase the vertical dimension of the bone for simultaneous or subsequent placement of an implant. To increase the apicocoronal height of the subantral region, graft material is introduced between the membrane and the residual alveolar process before or along with implant placement. This was first described by Tatum[4] and Boyne and James,[5] and it is frequently referred to as a lateral window sinus lift.[6] This procedure can be associated with substantial postoperative swelling and discomfort. In 1994, Summers presented a less invasive technique for lifting the maxillary sinus floor with rodlike osteotomes that are used to lift just that portion of the sinus membrane through the osteotomy immediately apical to the implant site. Referred to as the *Summers technique*, this procedure involves the application of an osteotome to the coronal aspect of the deficient edentulous ridge and is recommended in cases in which the height of the remaining subantral bone is at least 5–6 mm.[7] This method avoids the need for an opening of the sinus through its lateral wall and is thus considerably less invasive, although it has its limitations and introduces an increased risk of sinus membrane perforation during the course of the procedure.[7–13]

In the pursuit of less invasive sinus elevation, a number of techniques have been developed, with the goal of providing more predictable and more delicate approaches. The hydraulic method was first introduced by Chen and Cha in 2005.[14] Their method incorporated the use of the air and water spray of the traditional high-speed handpiece with a diamond-tipped bur in the subantral bone. Later, a dedicated syringe system was designed as an alternative to the handpiece to be used in a more controlled fashion. One such device is the crestal approach sinus (CAS) kit, which includes a hydraulic elevation device (Osstem Implant Co, Ltd).

Carefully injecting saline through the osteotomy to hydraulically elevate the membrane, also referred to as *hydrostatic sinus elevation* or *hydrodissection*, can provide numerous benefits. Although the use of bone graft material to lift the membrane can introduce sharp edges and points against the delicate membrane, the application of fluid avoids this potential danger. While it is often said that introduction of bone graft material into the sinus produces evenly distributed pressure and symmetrical lifting of the membrane, the anatomy of the region complicates this ideal picture. The Schneiderian membrane is moderately elastic and of variable thickness, causing it to react with an uneven response to pressure. Furthermore, the irregular concavities, convexities, and sometimes even sharp peaks (septa) of the bony architecture of the sinus contribute to an inconsistent response to pressure from uneven sources. When employing a hydraulic lift system, greater than 10 mm of elevation can be expected.[15–18] Hydrodissection permits forces to be more evenly dispersed on the membrane, and this may result in a more delicate

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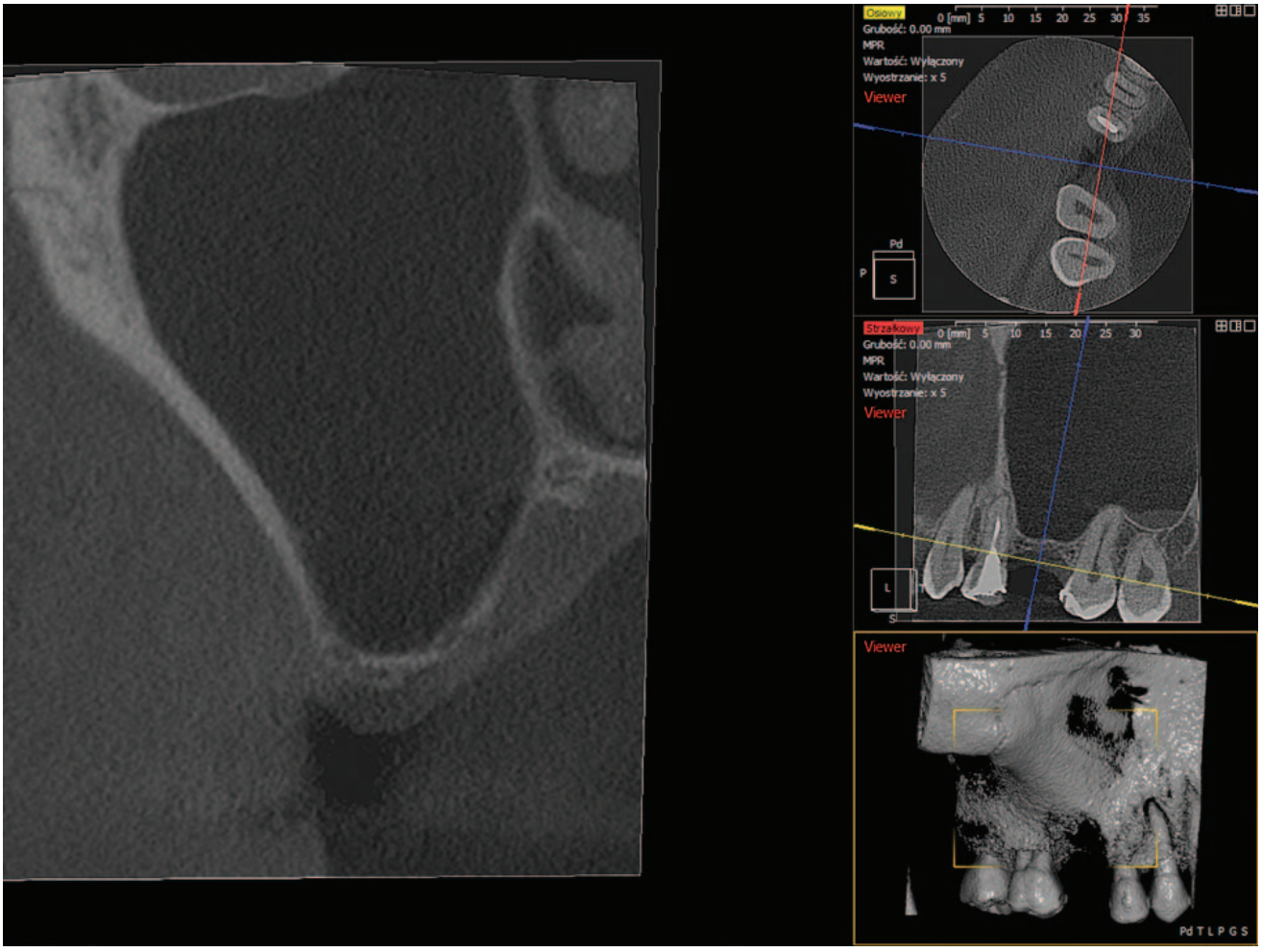


Figure 1. Preoperative cone-beam computerized tomography (CBCT) view. The axial slice is drawn through the subantral bone parallel to the adjacent teeth and, more importantly, to the proposed angle of osteotomy preparation. This is an important detail because improper measurement angulation can contribute to significant under- or overestimation of the actual dimension of subantral bone, complicating osteotomy formation endeavors by risking membrane perforation.

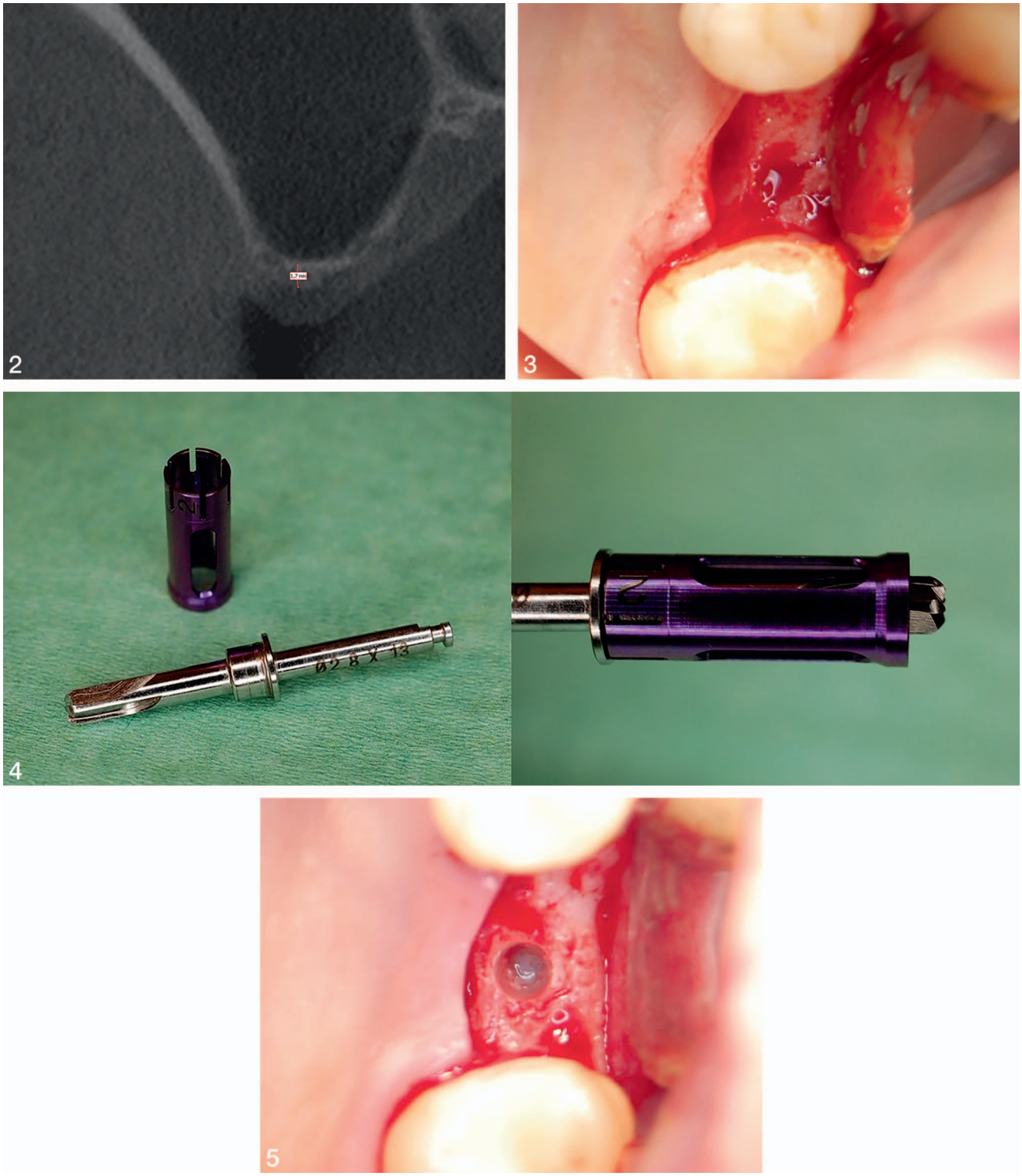
elevation that can overcome such obstacles as varying membrane thickness and irregular bony architecture.[17,18]

The literature documents how these various techniques have been repeatedly and successfully employed even when the apicocoronal dimension of the residual bone is less than 6 mm and even when the amount of sinus elevation desired approaches or exceeds that expected with a lateral window approach. In the experience of these authors, the CAS kit can be used for poor osseous conditions. With judicious use, success can be maximized while minimizing surgical trauma and the number and duration of procedures.

Case Report

A 39-year-old man presented for treatment of an edentulous site at the maxillary right first molar (No. 3). The patient lost the tooth 8 years prior because of complications related to endodontic therapy. Following a clinical and radiographic examination, and after finding an unremarkable medical history, the patient expressed a reluctance to accept any treatment that would be considered invasive, such as lateral window sinus augmentation. Cone-beam computerized tomography (CBCT) evaluation revealed no sinus pathology and 1.7 mm of subantral bone height at the No. 3 site. The following treatment plan was proposed: transcrestal sinus lift with simultaneous implant placement (if conditions permitted) to provide a minimally invasive treatment plan with a reduction in surgical visits (Figures 1 and 2). Despite the minimal height of bone present, simultaneous implant placement was presented as the recommended treatment based on the previous experience of the surgeon and was accepted by the patient. The patient was informed of all reasonable risks and provided informed consent.

Using the DDS-Pro digital planning software (Digital Dental Service Ltd), a 4.5- × 11-mm implant (SPI, Thommen Medical) was treatment planned. To ensure sufficient primary stability in



Figures 2–5. Figure 2. Preoperative measurements. Subantral bone dimension measured as 1.7 mm in the apicocoronal dimension relative to the proposed drilling angle (faciopalatal dimension was measured as 6.9-mm wide, although not shown here so as not to obscure the image). A consequential yet often overlooked point is that this calculated apicocoronal dimension of the subantral bone represents the center of the proposed osteotomy, which may differ significantly from the apicocoronal dimension of bone at the periphery of the osteotomy. It should be noted that multiple measurements (ie, center of the osteotomy, as well as both mesial and distal peripheries) should be calculated because the subantral bone is not necessarily of uniform height for the entire osteotomy footprint. It is important to drill all the way through to the membrane (allowing some bone to remain can complicate membrane elevation and implant placement) but not through the membrane (which would introduce a perforation that would interfere with membrane elevation, introduction of graft material, and subsequent implant placement). **Figure 3.** Palatalized midcrestal incision with sulcular incisions placed at adjacent teeth for a

the amount of native bone, underpreparation of the osteotomy was planned.

After achieving local anesthesia with two 1.8-mL cartridges of 4% articaine with epinephrine 1:100 000 (Septanest), a crestal incision 2 mm palatally from the midcrestal and sulcular incisions around the distal aspect of tooth No. 4 (upper right second premolar) and mesial aspect of tooth No. 2 (upper right second molar) were made with a No. 15c scalpel blade. A full-thickness flap was elevated toward the facial, exposing the crestal bone (Figure 3). A CAS drill 2.8 mm in diameter with the stopper (included in the kit) set at 2 mm (Figure 4) was used to prepare an osteotomy at the appropriate position within the edentulous site, reaching the Schneiderian membrane with the safety drill tip (Figure 5). A hydraulic elevation device (Figure 6) was then used to introduce 2 mL of sterile 0.9% NaCl solution directly against the Schneiderian membrane, elevating it to create space for the bone graft material and fixture. As per the manufacturer's instructions, the rubber valve was placed slightly into the osteotomy (Figure 7), and with finger pressure, a seal was formed and the syringe piston was pressed to gently inject NaCl solution under the sinus membrane to softly elevate it from the sinus floor and walls. A gradually increasing volume of fluid was introduced with multiple cycles of plunging and aspiration to best prevent damage to the membrane (Figure 8). During aspiration, the operator observed blood mixed with saline solution; a lack of air bubbles indicates that the Schneiderian membrane has not been torn. One gram of particulate bovine xenograft bone (Bonefill Porous, Bionnovation Biomedical) was mixed with sterile NaCl solution and introduced through the osteotomy, followed by an SPI Element 4.5- $\times$ 11-mm fixture with a 0.5-mm polished collar (Thommen Medical) to be placed supracrestal, as per the manufacturer's specifications. A primary stability of 30 Ncm (Figure 9) was achieved with insertion at 30 rpm. A healing abutment was connected to the fixture with a hand driver, and 6-0 nylon sutures (Atramat, Mexico) were used to stabilize the soft tissue around the healing abutment. Postoperative CBCT revealed an intact elevation of the sinus membrane of approximately 14-mm high (Figure 10). After 7 days, the patient presented with asymptomatic satisfactory healing, and sutures were removed (Figure 11). The restorative portion of treatment (Figure 12) was commenced after 6 months of healing, and a single-piece screw-retained crown was fabricated and placed (Figure 13). After 24 months from implant placement and sinus lift, and 18 months from implant restoration, clinical and radiographic examination (Figure 14) revealed a satisfactory volume of bone surrounding the fixture and healthy soft tissue around the crown, along with an assessment of proper function of the restoration.

Coincidentally, a CBCT scan was taken 30 months after surgery (24 months after restoration) for reasons unrelated to this site. This image confirmed the presence of adequate bone around the fixture (Figures 15 and 16).

Discussion

Elevation of the maxillary sinus floor is a commonly performed preprosthetic procedure in implant dentistry.[13] Various methods of obtaining access to the sinus have been described, such as open (often referred to as the lateral window approach) and closed method (often referred to as the transcrestal approach).[19] The former method is universally recognized as being more invasive than the latter.

When employing a lateral window approach, the membrane is generally lifted directly via instrumentation, whereas when performing a transcrestal approach, it is generally the case that the membrane is lifted indirectly by the introduction of bone graft material. Various materials can be introduced through the osteotomy and used to elevate the membrane, including bone from autogenous, allogeneic, and xenogeneic sources or alloplastic materials.[20–30] It is also possible to insert fixtures without the introduction of graft material.[24,31,32]

The gentle nature of the presented technique as compared with alternative methods constitutes an advantage for safety. As with any surgical technique, it requires proper technique by the operator. It is most prudent to administer the fluid slowly and gradually, applying only 0.2 mL of fluid at first and then cycling through delicate pushing and aspiration of greater amounts of fluid. Excessive addition or removal of fluid, either in speed or volume, can more readily lead to perforation of the membrane. In such a circumstance, implant placement may be abandoned or a shorter fixture may be used if sufficient native bone exists. Alternatively, a lateral window approach may be performed, to include a more elaborate elevation of the membrane along with its repair, which may include simple placement of a large enough adsorbable membrane or more advanced procedures, such as sutures or surgical glue.

According to the literature, the transcrestal approach has limited capability to increase bone volume. A recent systematic review supports the assertion that transcrestal elevation simultaneous to implant placement contributes to greater implant failure in the presence of less than 4 mm of subantral bone height,[33] but it should be recognized that the focus was

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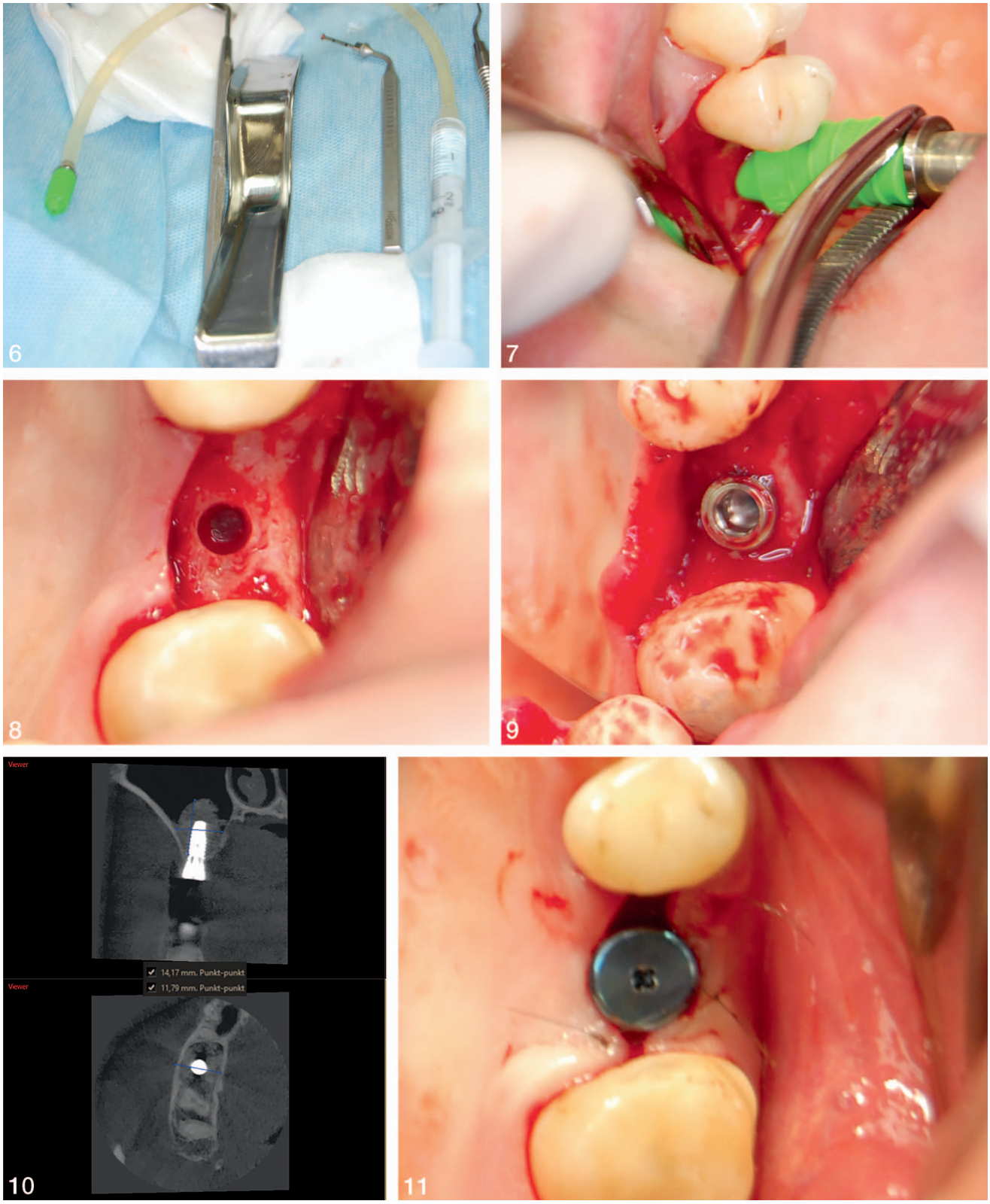
full-thickness flap toward the facial. The palatalized incision puts the eventual palatal soft-tissue margin up against the eventual healing abutment and preserves valuable keratinized tissue from the occlusal aspect of the ridge. The eventual facial soft-tissue margin can then be placed up against the facial aspect of the healing abutment, thus providing an increased zone of keratinized tissue. **Figure 4.** A 2.8-mm crestal approach sinus (CAS) drill with 2-mm safety stopper. The 2.8-mm-diameter CAS drill with the color-coded drill stopper, both off the drill (at left) and on (at right). The kit includes CAS drills in various diameters and stoppers that permit the drill to extend from 2 to 12 mm. **Figure 5.** Intact Schneiderian membrane immediately after osteotomy formation with 2.8-mm-diameter CAS drill fitted with a 2-mm stopper. This point in the surgery is a good opportunity to clinically visualize the potential discrepancies between the heights of the subantral bone around the osteotomy and in relation to the center of the osteotomy as measured on the cone-beam computerized tomography. Care should be taken to not perforate the membrane with a perio probe during this undertaking.



Figures 6–11. Figure 6. Hydraulic elevation tool. The rubber valve (green tip) connects via a tube to a syringe. Although the device is provided by the manufacturer with a 1-mL syringe, a larger syringe can be fitted to the tube, such as this 2-mL syringe. Depending on the length and diameter of the tube, the amount of fluid that remains within the tube during injection can vary, but it is certain that the entire volume of fluid that leaves the syringe will not enter the osteotomy to contribute to membrane elevation. To calculate how much fluid is needed to fill the tube and is never seen by the membrane, the tube can be filled prior to inserting the tip into the osteotomy and the measurement markings on the syringe noted. **Figure 7.** The rubber tip is placed just slightly into the osteotomy for introduction of NaCl

entirely on implant survival and not on the success of the sinus elevation procedure as a standalone. In the authors' experience, it is possible to successfully and reproducibly elevate sinus membranes via a transcrestal approach, such as in this case. In a study performing sinus elevation using hydraulic fluid elevation in sheep, the technique was said to only be able to provide a capacity to lift the membrane by only 5 mm.[34] Because other publications demonstrate much greater lift potential for hydraulic lift techniques, the authors were contacted to provide clarity. In personal communication with these authors, they suggested that their limitation was likely due to lack of a proper seal of the rubber tip. If the minimal height of the initial subantral bone is a concern because of the available stability for simultaneous implant placement, transcrestal sinus elevation may be performed in preparation for a second surgery after osseous healing, during which the implant can be placed. Although this method may not limit the number of surgeries or the overall duration of treatment, the more minimal invasiveness of the transcrestal approach may still be appreciated by both clinician and patient.

Regretfully, there is limited documentation of such success, and further study ought to be forthcoming. A review by Kim et al[35] revealed high or very high satisfaction with the CAS kit system based on surveys of 28 dentists who placed a combined 924 implants, with elevation of the sinus floor. A recent investigation in a sheep model comparing different techniques for the transcrestal approach favored the CAS kit followed by fluid introduction to hydrostatically lift the membrane over the more traditional osteotome technique, although it took more time to perform. However, to achieve a significantly decreased potential for introducing perforations, an average 5-minute increase in surgical time (8.5 vs 3.1 minutes) might be justifiable.[34]

The presented technique may constitute a reliable method for sinus lift procedures. The additional possible intraoperative complication that can occur while employing this method is that of the introduction of fluid into the sinus secondary to a tear in the membrane. This occurs less frequently than the introduction of bone graft material into the sinus when perforation occurs during the transcrestal sinus elevation approach. This can be alleviated by raising the patient into a seated position and suctioning excessive leaked fluid from the sinus through the osteotomy, although this may contribute to further tearing of the membrane and should be considered judiciously by a clinician of advanced skill.

The advantages of the presented technique include decreased invasiveness, which can result in reduced postoperative pain and swelling, as well as obviating the use of traditional osteostomes and mallets, which have, on occasion, been reported to introduce complications to the visual, auditory, and balance systems.[36,37] This technique can be employed for single or multiple adjacent sites and so can be employed even when more extensive reconstruction is planned.

Conclusion

The experience of those authors involved in the surgical case presentation validates the high efficiency of the CAS kit system in difficult conditions due to minimal subantral bone height. In conditions with less than 2 mm of bone, the osteotomy should be further undersized than usual to achieve substantial primary stability. To prevent premature failure of the implant and loss of the implant into the sinus cavity, wider healing abutments can be placed, with explicit instructions to the patient to avoid all forces due to chewing and biting for the duration of healing.

Thus far, case documentation of a crestal approach for sinus elevation with less than 3 mm of subantral bone is rare in the literature. This case demonstrates that with the use of judicious planning, suitable instrumentation, and advanced experience and skill, sinus floor elevation can be achieved with minimal invasiveness despite minimal native bone height. However, it must be recognized that this is merely a single case published retroactively after seeing success. More powerful data must be forthcoming, including study of larger patient populations, to substantiate the generalizability of this conclusion to the general population.

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Note

Dr Łukasz Zadrożny is a course director for Osstem AIC, which is administered by Osstem Implant Co, Ltd, the manufacturer of the kit used in this case. This relationship began after the final draft of this article was written and had no impact on any aspects of this surgery or case report.

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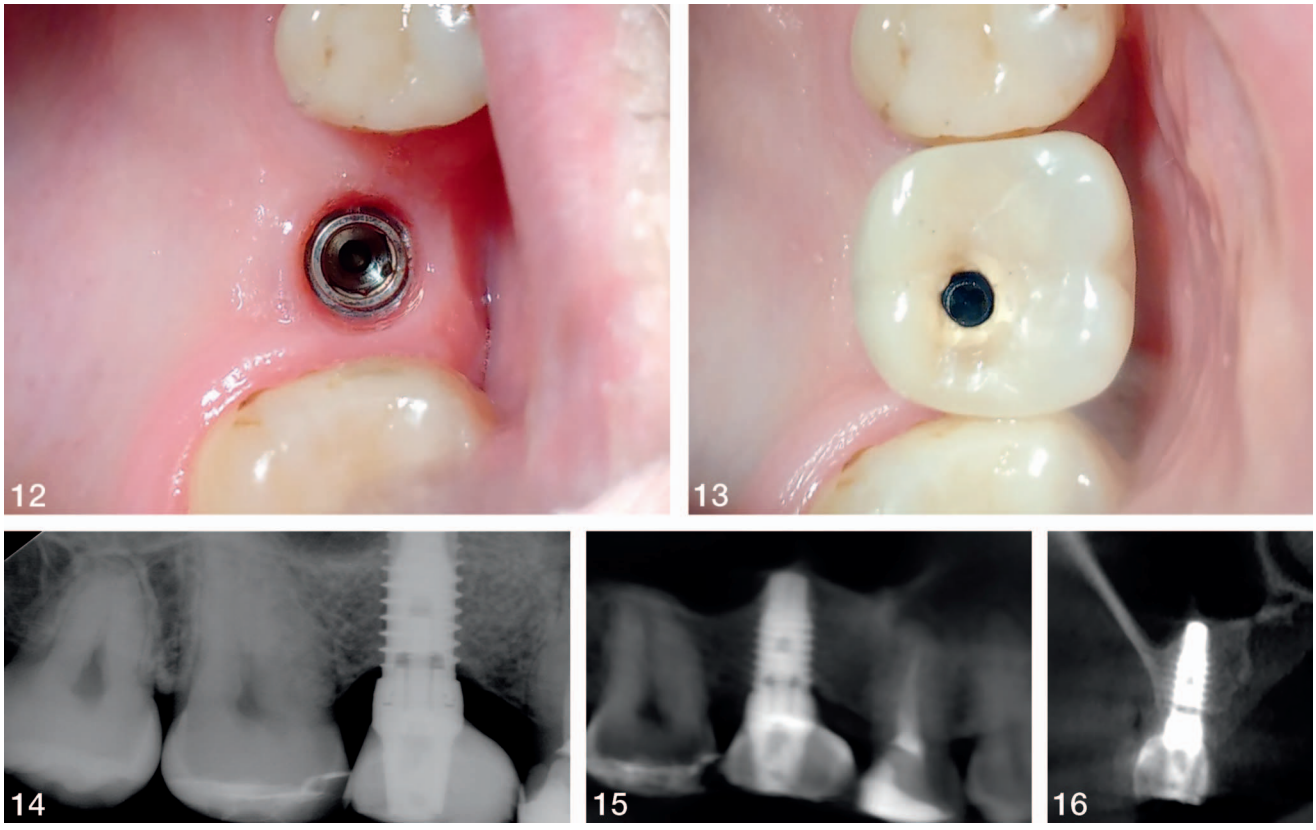
under the sinus membrane. The rubber tip can be secured either by hand or with the aid of an instrument such as a hemostat. A metal tip inserts into the rubber safety tip to prevent the hemostat from clamping the rubber tip and interfering with the flow of fluid. **Figure 8.** Elevated membrane, with displacement of the membrane visible through the osteotomy. Although the membrane appears different than it did before elevation, visualization of an apparently intact membrane confirms neither a favorable elevation nor a lack of tears in another portion of the membrane. **Figure 9.** Placement of the fixture. A Thommen SPI Element 4.5- × 11-mm fixture with external hex connection was placed (with its 0.5-mm polished collar remaining supracrestal) into a 2.8-mm-diameter osteotomy with 1.7-mm high native subantral bone. Initial stability was 30 Ncm. **Figure 10.** Postoperative measurements. The grafted area measures 14-mm high and 12-mm wide and appears well contained within the elevated Schneiderian membrane. **Figure 11.** Surgical site immediately postoperative. The soft tissue was stabilized with 6-0 nylon sutures around the 3.2-mm-tall healing abutment.



Figures 12–16. Figure 12. Soft tissue at 6 months postoperatively, after removal of the healing abutment. The photo was taken just before placement of the impression coping for restorative impression. Keratinized tissue is abundant and healthy. **Figure 13.** Final restoration: single-piece screw-retained crown immediately after placement. **Figure 14.** Periapical follow-up radiograph. This radiograph was taken 24 months after sinus elevation and implant surgery and 18 months after implant restoration. It reveals what appears to be ideal bone formation around the fixture where the sinus elevation and bone grafting occurred. It also demonstrates approximately 1.5 mm of crestal bone loss from the rough/smooth border, which must have occurred late enough for the fixture to have retained primary stability during healing. **Figure 15.** Radiographic follow-up. Sagittal section of cone-beam computerized tomography (CBCT) taken 30 months after sinus elevation and implant surgery and 24 months after implant restoration. It reveals no more crestal bone loss compared with the radiograph taken 6 months earlier. **Figure 16.** Radiographic follow-up. Axial slice (cross section) of the CBCT taken 30 months from sinus elevation and implant surgery and 24 months after implant restoration. It reveals 3-dimensional bone formation to the implant apex but slightly less on the facial aspect.

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