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CASE REPORT

# A simplified approach to the minimally invasive antral membrane elevation technique utilizing a viscoelastic medium for hydraulic sinus floor elevation

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**Abstract**
*Purpose* Maxillary sinus augmentation surgery is frequently employed to provide adequate vertical bony dimensions in posterior maxillary sites. When significant gain in bone height is sought for, an invasive lateral-window approach is routinely used to achieve sinus floor elevation. The minimally invasive antral membrane elevation technique was initially conceived as a surgical improvisation that has been shown to lead to up to, or exceeding, 10 mm of bone height, while enhancing the safety profile of the transalveolar sinus augmentation technique. This approach is based on the use of hydraulic pressure that is applied to the schneiderian membrane via a saline-inflatable balloon. Even though this technique has been shown to be a safe and efficacious treatment modality, the need for specialized equipment, training, and corresponding costs may hinder its widespread application. The purpose of this clinical paper is to introduce a simplified approach to the minimally invasive antral membrane elevation technique.
*Methods* The simplified minimally invasive antral membrane elevation technique is based on the application of hydraulic pressure by a viscous bone graft that acts as an incompressible fluid. The specific clinical steps of this technique will be demonstrated to illustrate how grafting of the maxillary sinus is achieved simultaneously with the atraumatic elevation of the schneiderian membrane, thus resulting in even less operative time.
*Conclusions* This simplified technique may make the minimally invasive antral membrane elevation technique more accessible to implant surgeons as it eliminates the need for purchase of specialized equipment and aids in further decrease of intra-operative time accomplished with the original technique.

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## Introduction

In 2006, a clinical article was published that attracted significant attention introducing a novel improvisation for minimally invasive antral membrane elevation [1]. In this article, a surgical improvisation that utilized standard cardiosurgical equipment was described [1]. This technique aimed in maximizing the height of sinus membrane elevation that could be achieved utilizing a transalveolar approach. Until that time, the management of severe atrophy of maxillary ridges as a result of pneumatization of the sinuses was a contraindication for the use of a transalveolar approach. The work of Nkenke et al. [2] has shown that not more than 3–4 mm of sinus lift can be safely achieved utilizing a conventional indirect sinus lift approach [3].

Maxillary sinus augmentation surgery is frequently employed to provide adequate vertical bony dimensions for the placement of an implant in sites with less than 5 to 6 mm of bone height coronally to the sinus membrane. In such a case, a more invasive lateral-window approach is routinely used to achieve sinus floor elevation [4]. Utilizing the minimally invasive antral membrane elevation technique, Kfir et al. [1] were successful at achieving up to, or even beyond, 10 mm of gain in vertical bone height in a series of published reports [5–8].

The rationale behind the use of a balloon that is slid through the osteotomy is that by filling the balloon with sterile saline, hydraulic pressure will be evenly applied around the Schneiderian membrane. Consequently, the membrane will be atraumatically reflected from the sinus floor. What makes this technique more potent in significantly increasing the bone height using a transalveolar approach is the pattern of distribution of forces.

The use of Summer's osteotomes for the elevation of the sinus floor is based on the initial greenstick fracture of the floor of the sinus that is followed by placement of bone-graft material through the implant bed. Subsequently, osteotomes are inserted that push the graft volume upwards in an attempt to induce lateral forces at the base of the membrane [3]. The pressure is applied in "bursts" and the risk for membrane perforation increases with every additional burst of pressure. The use of osteotomes may lead to a risk of membrane perforation as high as 26 % [9].

To make the transalveolar sinus lift approach more predictable and cost-efficient, an atraumatic and less time-consuming modification to the minimally invasive antral elevation technique that does not require additional equipment has been developed and will be presented in this article.

In this technique, a transalveolar approach is utilized and the implant osteotomy is prepared 1–2 mm below the floor of the antrum. The viscoelastic attributes of a putty alloplastic bone material are exploited in this surgical technique. Recently, bone substitutes displaying a putty consistency are becoming more popular for bone-grafting procedures [10, 11]. The handling characteristics of putty bone substitutes have expanded the available treatment options for bone grafting in narrow spaces, and their physical properties can facilitate an increase in safety and predictability of sinus lift procedures.

In this improvisation, a viscoelastic, calcium phosphosilicate alloplastic putty that is available in cartridge delivery system is utilized. Calcium phosphosilicate alloplastic bone substitutes have been successfully used in various osseous defects, including sinus augmentation in a predictable manner [12–14].

The aim of this article is to present the simplified minimally invasive antral membrane elevation technique that employs hydraulic pressure for sinus membrane elevation.

## Materials and methods

A transalveolar sinus floor elevation (TSFE) technique is utilized, and the osteotomy site is prepared to the size of the final implant diameter and stopped 0.5–1 mm short of the sinus floor. A small amount of putty graft (~0.25 cc) is delivered in the osteotomy to act as a "protective cushion" prior to the use of the osteotome for infracture of the sinus floor. This approach serves a dual purpose; it minimizes the risk of membrane perforation during percussion of the sinus floor and minimizes the risk of adverse events associated with the traditional osteotome technique, such as benign paroxysmal positional vertigo by reducing the propagation of forces to the neighboring tissues.

Following fracture of the sinus floor and verification of the integrity of the membrane with the use of a sinus probe, the bent cannula of the graft's cartridge delivery system is placed in the osteotomy site. The width of the cannula is narrow enough to allow it to be inserted into the osteotomy following the use of a 2.0-mm pilot drill. The putty is then injected into the site via the cartridge dispensing system. As the cartridge is directing the flow of the putty towards the schneiderian membrane, pressure is caused on the surface of the membrane by the putty's viscosity. In contrast to Summer's osteotome technique [3], the pressure distribution is even across the membrane as the putty acts as an incompressible fluid [15]. As the molecules of the putty interact with the edges of the membrane, the pressure force arises and the membrane is atraumatically reflected [16, 17]. The continuous flow of the viscous biomaterial results in the gradual and continuous elevation of the membrane. The rheological mechanism that aids in the expression of lateral forces that reflect the membrane, instead of vertical forces that could potentially lead to perforation of the membrane, is the establishment of a stagnation point at the point where the infractured bony floor of the sinus comes in contact with the viscous putty [18].

When the putty "meets" this solid bony floor, its flow speed is equal to zero adjacent to it and the flow is directed laterally to the point of less resistance, the interface between the membrane and the bony floor of the sinus. After slight elevation of the membrane has occurred, the stagnation point is further apically positioned as the sinus floor is elevated and the flow of the putty is continued until the desired amount of gain in bone height is obtained [19].

The putty is delivered in 0.5- or 1-cc increments depending on the selection of cartridge size. The selection is based on the desired amount of sinus lift. The amount of elevation that can be achieved is significant because of the atraumatic and gradual lift of the membrane from the wall of the sinus cavity. When the membrane has been elevated adequately with the aid of hydraulic pressure, the gap present between the initial position of the sinus floor and the elevated membrane is

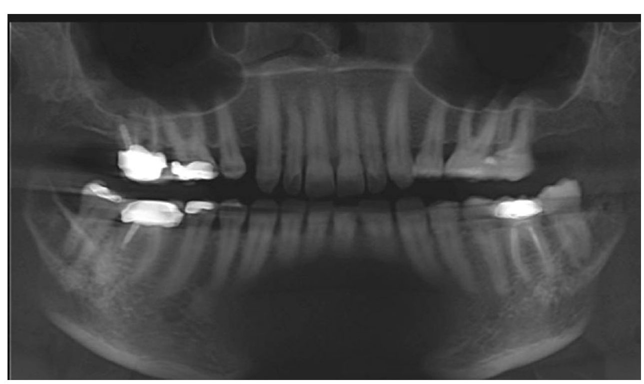

**Fig. 1** Panoramic radiograph taken prior to the extraction of the involved second molar

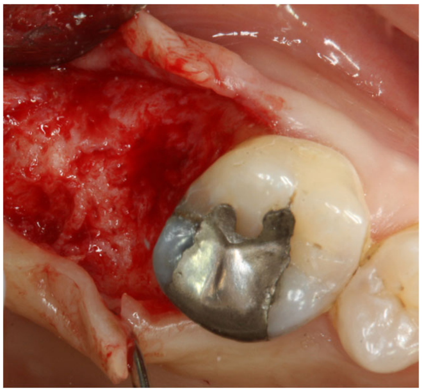

**Fig. 2** Crestal incision and full-thickness mucoperiosteal flap

already filled with the graft material. This represents a time-saving step in comparison to the balloon elevation technique. In the latter, following deflation and removal of the balloon, grafting using a specialized graft delivery system must be performed to fill the void.

## Representative case

A 56-year-old female patient presented with an edentulous site in the maxillary second molar area (no. 2) due to the recent extraction of a root canal-treated second molar. The patient also had a very narrow edentulous site (~2.5 mm) between her second premolar and her canine that was non-restorable due to inadequate edentulous span. A panoramic radiograph that was taken prior to the extraction of the involved second molar revealed significant pneumatization of the maxillary sinus with approximately 5 mm of residual bone height (Fig. 1).

The patient's medical history was non-contributory and the patient was not a smoker.

Different treatment options were discussed with the patient including the option of no treatment, orthodontic treatment for space management of the edentulous sites, or implant rehabilitation. The patient opted to proceed with implant rehabilitation as she wanted treatment to be completed as soon as possible and she was worried about her limited masticatory ability following extraction of the second molar. Following discussion, it was decided to proceed with the placement of two implants distal to the first molar for restoration of the second molar and a smaller third molar that would compensate functionally for the missing first premolar. The procedure was discussed with the patient and informed consent was obtained. The patient was pre-medicated with 1 g amoxicillin an hour before the surgery.

Following rinsing with 0.12 % chlorhexidine solution for one 30 s, local anesthesia was administered, a crestal incision was traced, and a full-thickness mucoperiosteal flap was raised (Fig. 2). The abovementioned sinus-osteotomy drill was used to drill the osteotomies to approximately the sinus floor utilizing a drill stop to verify that inadvertent perforation of the sinus floor could be avoided (Figs. 3 and 4). Subsequently, putty graft was injected into the osteotomy site to

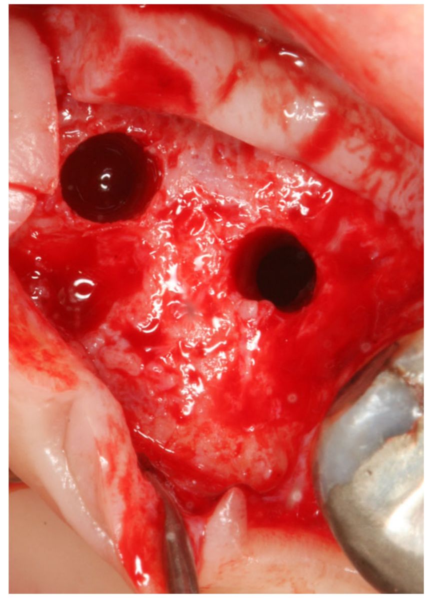

**Fig. 4** Initial osteotomies prepared for insertion of the cartridge tip

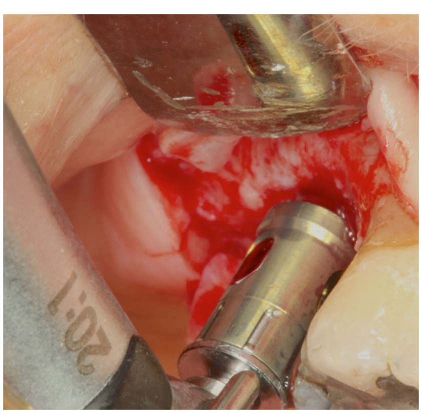


**Fig. 3** Non-end cutting drill utilized to reach the floor of the sinus


**Fig. 5** Device used for hydraulic pressure

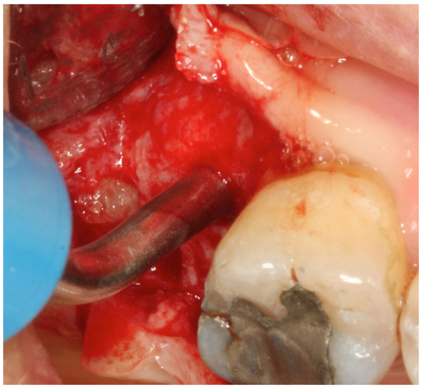

**Fig. 6** Narrow-ended tip of the cartridge delivery system inserted into the osteotomies

initiate the elevation of the sinus membrane via application of hydraulic pressure (Fig. 5). The narrow-ended tip of the cartridge delivery system was inserted into the osteotomies, and putty was injected continuously until the hydraulic pressure from the viscous biomaterial caused atraumatic elevation of the sinus membrane to the desired height (Fig. 6). Approximately 0.5 cc CPS putty were gradually injected into each osteotomy area to elevate the membrane. Two implants were placed simultaneously with the sinus augmentation procedure and achieved optimal primary stability. Radiographically, 7–9 mm of increase in bone height were estimated (Fig. 7). The healing process was uneventful and the patient was recalled at 2 weeks for suture removal. The patient was sent back to his referring dentist to follow-up treatment and was recalled at 18 months following implant loading for evaluation. Intraoral assessment revealed two clinically stable implants in function with no signs of inflammation of the peri-implant mucosa, while radiographic assessment showed newly formed radiopaque tissue surrounding the implants and stopping at the apex of each implant (Figs. 8 and 9). The patient had no subjective symptoms either from the implant areas or from the sinus and was very satisfied with the treatment.

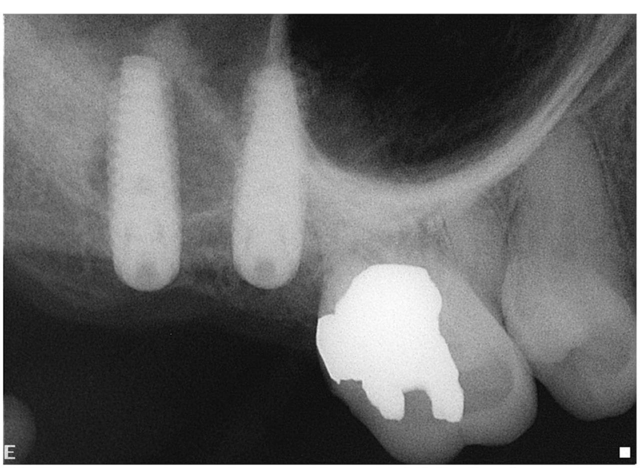

**Fig. 7** Periapical radiograph showing increase in bone height

**Fig. 8** Clinically stable implants in function with no signs of inflammation of the peri-implant mucosa

## Discussion

The use of the minimally invasive antral membrane elevation technique has a well-documented history of success and has been shown to yield success rates ranging from 95.2 to 100 % for 6 to 18 months of follow-up [19, 20]. These results are comparable, yet slightly higher than those reported in a large-scale survival analysis of implants placed with the osteotome technique for indirect sinus lift [21].

Results from the work of Kfir et al. and Mazor et al. are well within the range of 92.7–96.9 % survival reported by a systematic review for sinus lift using the transalveolar approach [5, 6, 20, 22].

The most significant benefit from the use of this technique is that it can achieve gain in bone height comparable with that achieved with the use of the lateral-window approach, while maintaining the benefits of the less-invasive transalveolar approach. In general, the transalveolar sinus lift approach is employed for sites with more than 6 mm of bone height preoperatively [23]. The current technique extends the

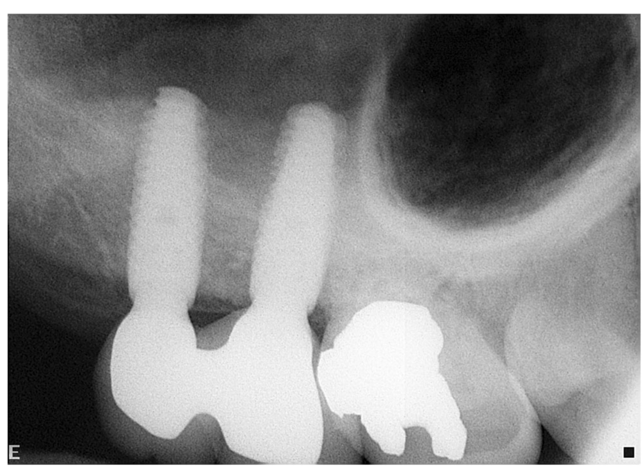

**Fig. 9** Newly formed radiopaque tissue surrounding the implants and stopping at the apex of each implant

application of the transalveolar approach to cases with significantly less bone height.

In this technique article, a simplified minimally invasive transalveolar technique for sinus augmentation was conceived by exploiting the viscous consistency and flow characteristic of a new-generation putty graft. The presented technique serves a dual purpose: (1) eradicates adverse events associated with the use of osteotomes and (2) provides an inexpensive technique for predictable elevation of the sinus membrane.

The consistency of the putty helps in minimizing membrane perforations and associated adverse events during percussion with osteotomes. The technique also attempts to overcome the need for the purchase of specialized equipment needed to apply hydraulic pressure for the elevation of the Schneiderian membrane while simultaneously with sinus floor elevation, adequate graft volume is placed in the site to allow for placement of the implants. Additional advantages of this technique are reduced chair-side times and minimal graft wastage.

The presented technique that utilizes a cartridge system for sinus floor elevation may offer a more conservative procedure, localized augmentation of sinus, and less postoperative morbidity. This technique can be successfully used for sinus augmentation with immediate implant placement, as it offers key primary stability to the implant. These advantages make this simplified approach to the minimally invasive antral membrane elevation technique a viable option for transalveolar sinus augmentation. Controlled clinical studies are required to assess the efficacy of this surgical improvisation.

This simplified approach may make the minimally invasive antral membrane elevation technique more accessible to implant surgeons as it eliminates the need for purchase of specialized equipment and aids in further decrease of intraoperative time accomplished with the original technique.

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