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Minimally Invasive Technique For Transalveolar Sinus Floor Elevation with A Diamond Burr Used in Skull Base Surgery: A Case Series

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Abstract: *When alveolar ridges lack the appropriate bone volume for implant placement, additional surgical procedures are necessary. In the posterior maxilla, the pneumatization of the maxillary sinus reduces the residual crestal height, and to perform implant placement, several sinus floor elevation techniques have been developed. These techniques involve specific instruments that require some experience, especially when performing sinus membrane lifting because of its importance for surgery success. A minimally invasive transalveolar sinus floor elevation technique is presented, in which a diamond burr used in cranial base surgery is employed. Surgery was performed on 10 patients. Panoramic radiographs and computerized tomography (CT) scans were taken before surgery and 1 month and 2 years after surgery, and they were used to measure bone height. The achieved augmentation heights were between 2.18 and 5.93 mm. All of the surgical procedures were conducted without complications. No Schneiderian membrane was perforated, and a vertical augmentation for allowing implant placement was achieved. It represent a good technique for minimally invasive sinus floor elevation.*

Keywords : *Diamond burr, Sinus floor augmentation, Sinus lift, Transalveolar technique.*

I. Introduction

The use of dental implants in the treatment of complete or partially edentulous patients has become an effective and common practice. Surgical planning and implant long-term stability are related to both the quality and the quantity of the available bone tissue [1]. Occasionally, an alveolar ridge may not have the bone support to host a dental implant due to different reasons, including periodontal disease, post-traumatic sequelae, or a tumor resection.

In the posterior maxilla, an additional reduction of the residual crestal height can occur due to the pneumatization of the maxillary sinus. Therefore, the residual crestal height can be insufficient for implant placement. In cases when the residual crestal bone height is 9 mm or less [2], additional surgical procedures are necessary. A variety of sinus elevation methods that depend on the defect size and location have been introduced to reach the necessary and appropriate bone height and volume. Each surgical procedure has advantages and disadvantages. Whenever the clinical situation allows, priority should be given to those procedures that are less invasive and traumatic and that are associated with a lower risk of complications, the lowest economic costs, and the shortest period of time to reach the intended results [3].

For implant placement in the posterior maxilla, sinus floor elevation was introduced [5-7]. There are several conditioning factors that should be taken into account to ensure the feasibility and success of the procedure(e.g., the maxillary sinus anatomy; the present height, location, and morphology of the maxillary sinus septa [8]; the quality, height, and width of the remaining crestal bone; the implant length and diameter [9]; and the grafting material). The application of each existing method depends on the residual bone volume of the alveolar crest.

Classically, this technique involves invasive procedures, such as the opening of a bony window in the lateral sinus wall, through which the sinus membrane is manipulated and a grafting material is placed [10]. This procedure demands a substantial amount of time and money and can result in a high degree of morbidity.

Therefore, transalveolar sinus floor elevation was introduced, which consists of accessing the sinusoidal cavity through the sinus floor [5]. A small and carefully placed osteotomy is made through the remaining alveolar crest, exposing the mucosa of the maxillary sinus after which the sinus membrane is lifted where the bone grafting material is delivered. Once the proper elevation is achieved, the implant is placed in the same osteotomy.

Several techniques and instruments are used daily worldwide to perform sinus membrane lifting and generally involve sinus lift kits of these specific instruments, which are expensive and require experience and

ability of the surgeon. Among the different instruments used, we can mention the elastic balloon that can be placed into the osteotomy, lifting the sinus membrane while insufflating [11, 12]. With the same purpose, hydraulic [13, 14] or gel [13, 16] pressure can be applied to the membrane surface by injecting water or gel into the osteotomy, assuming the risk of perforation and immediate infiltration into the sinus cavity. Metallic instruments with special designs can be used to lift the membrane manually. Some of them are based on piezoelectric oscillations; its vibrations facilitate membrane detachment [17, 18]. The main challenge during a sinus floor elevation is to maintain the integrity of the sinus membrane. Perforation is considered one of the most serious intraoperative complications and can lead to postoperative difficulties (e.g., a sinus infection, hemosinus, sinusitis, an oroantral fistula, and the impediment of grafting material delivery), and thus precluding the implant placement. A postoperative infection represents the main cause of failure (61.4%) [19].

In the present study, a minimally invasive and cost-effective technique for transalveolar sinus floor elevation is presented, in which a diamond burr and special adapted instruments are used [20].

II. Materials And Methods

2.1. Study Population

The patients were informed about the details of the surgery, and all of the subjects gave their written informed consent for inclusion prior to the study. The study was conducted in accordance with the Declaration of Helsinki and registered by the Bioimplants Laboratory into the research project, RDP 6120.The protocol was approved by the National University of Entre Ríos, Argentina (Res C.S N° 364/12).

2.2. Inclusion and Exclusion Criteria

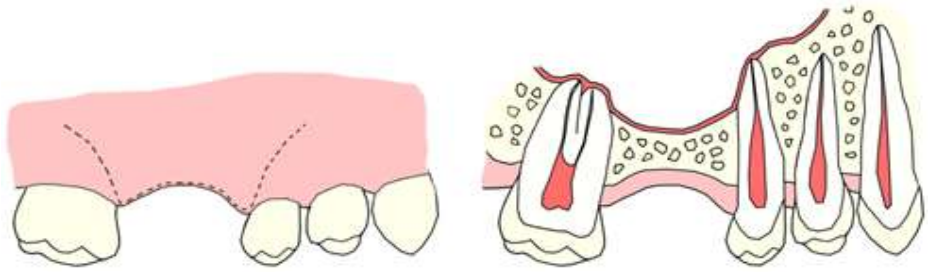
Patients were recruited according to the following inclusion criteria: aged 40–60 years a class B (7–9 mm) or class C (4–6 mm) (according to the consensus conference on sinus lifting [21]) residual bone height (RBH), and at least 5 mm of bone width.

Exclusion criteria were as follows: non-controlled Type I or Type II diabetes, a history of smoking, systemic diseases such as history of anemia, radiation therapy, and the use of unstable dentures.

2.3. Surgical Procedure

Surgery was performed on 10 patients. The presurgical evaluation consisted of clinical tests and the analyses of CT-scans and panoramic and periapical radiographs. The transalveolar sinus floor elevation with simultaneous implant placement was performed under local anesthesia (Totalcain with Carticain Hydrochlorid 4% and l-Adrenaline 1:100.000).

Flap surgery or the flapless approach were used according to individual requirements (Scheme I).



(a) (b)

Scheme 1. (a) Incisions for flap elevation. (b) Sagittal section of the posterior maxilla.

Then, a transalveolar osteotomy was conducted. The initial point was marked with a round drill (Fig. 1, Scheme 2A). After that, a lance pilot drill was used to perform the first perforation (Scheme 2B), and then a sequence of 2.2-mm, 2.4-mm and 2.8-mm diameter drills were used

(Fig. 1, Fig. 2A, Scheme 2C). The bone was penetrated until approximately 2 mm before reaching the sinus floor cortical bone (Scheme 2D). The osteotomy position was corroborated by digital periapical radiographs using a CPITN periodontal probe (Fig. 2B).

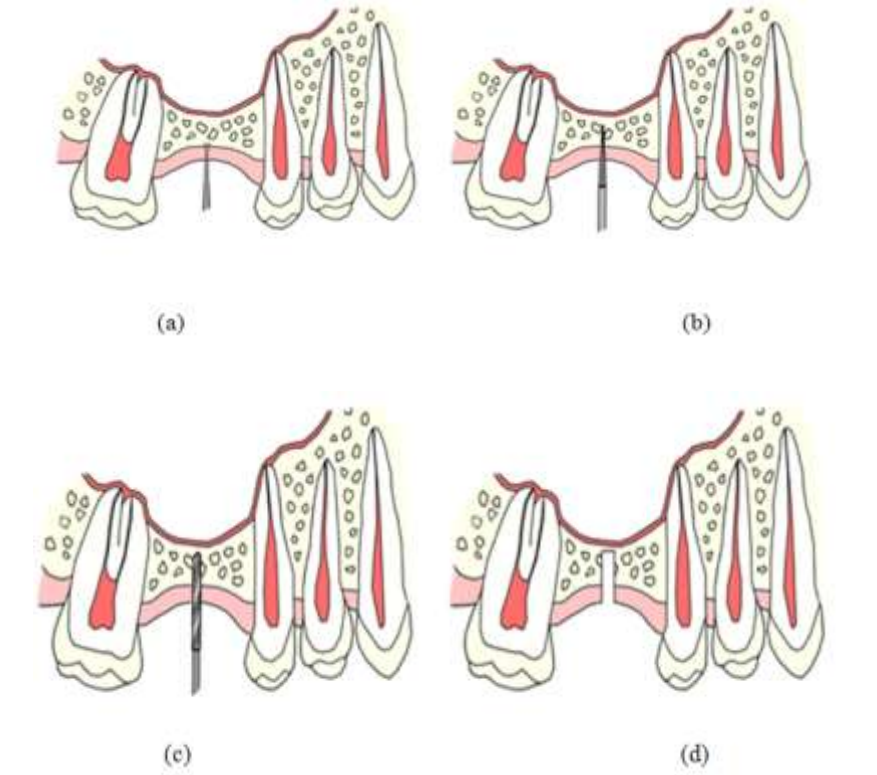
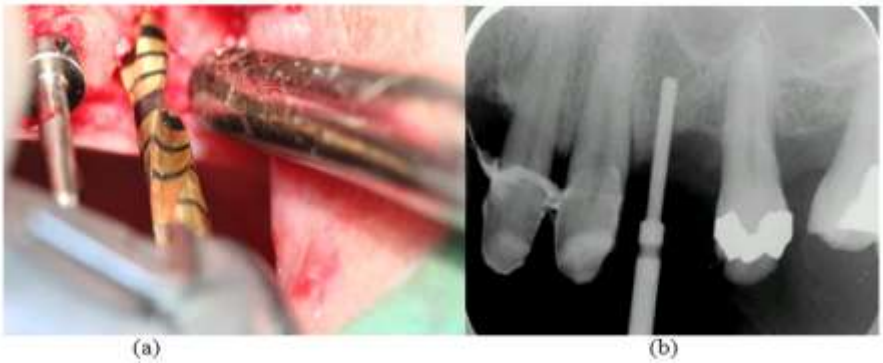
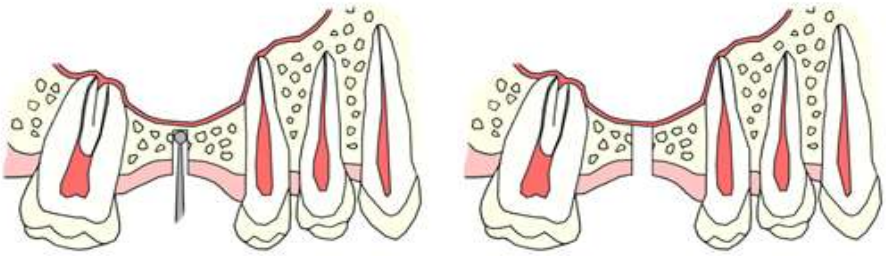


Figure 1. Drills and diamond burr used for osteotomy.

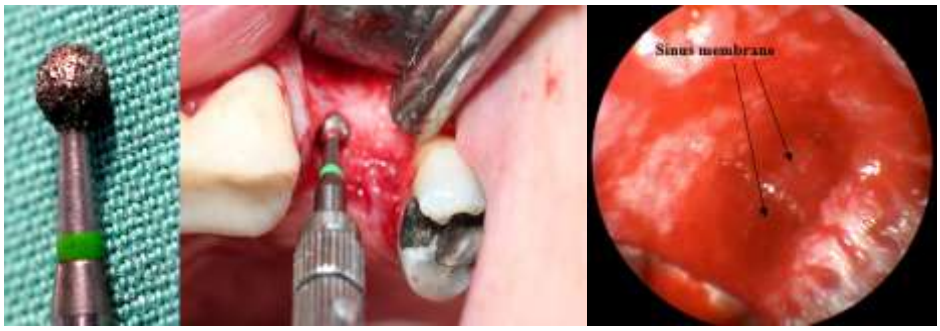


After drilling, a 3-mm diameter diamond burr for a contra-angle was used (speed range: 800-1000 rpm, reduction: 1:20) (Fig 3, Scheme 3A). The last portion of the sinus floor bone was removed by circular soft movements. Alternatively, periapical radiological images were taken until the sinus floor was opened (Scheme 3B).



(a) (b)

Scheme III. (a) Diamond burr inside osteotomy. (b) Osteotomy completed.

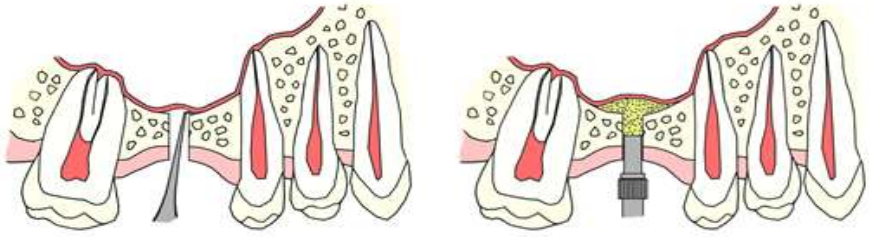


(a) (b)

Figure 3. (a) Diamond burr. (b) Endoscopic view of osteotomy finished.

The sinus membrane was detached from the underlying bone using a special instrument with a rounded non-sharp edge (Figure 4, Figure 5A). The instrument tip was introduced between the sinus membrane and the osseous sinus floor (Scheme 4A).Through horizontal movements, the sinus membrane was detached; through subtle pressure, the membrane was elevated. During this procedure, the periosteum was removed.

The sinus membrane integrity was verified through two methods: the Valsalva maneuver [22] and via a Storz Hopkins support endoscope (2.7-mm diameter, Karl Storz ®, Tuttlingen, Germany) [23]. After that, a FRIOS® Algipore® (Dentsply Friadent, Mannheim, Germany) composite was mixed with an antibiotic (Tetracyclin 250 mg) and physiological solution and was placed through the osteotomy using a specially adapted instrument (Fig. 4, Scheme 4B). A bone substitute was placed between the membrane and the sinus floor, raising the Schneiderian membrane and generating an additional detachment that generated an augmentation of the sinus floor.



(a) (b)

Scheme 4. (a) Sinus membrane elevation. (b) Bone substitute delivery into the osteotomy.

Figure 4. Rounded non-sharp edge instrument for detaching the membrane (above) and instrument

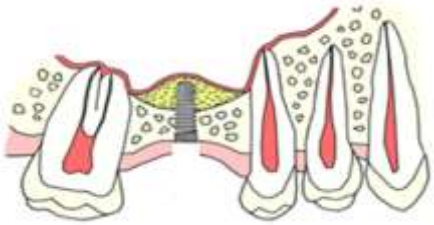
adapted for delivering bone substitute (below).

(a) **(b)** **(c)**

Figure 5. Use of: (a) Rounded non-sharp edge instrument. (b), (c) Instrument adapted for delivering bone substitute.

At this point, the maxillary sinus floor elevation was completed, allowing implant placement (Fig. 6, Scheme 5). The primary stability was checked and confirmed with oblique pressure applied on the abutment using fingertips. After that, a suture was made to close the site.

Digital periapical and panoramic radiographs were taken after the surgery.



Scheme 5. Implant placement.

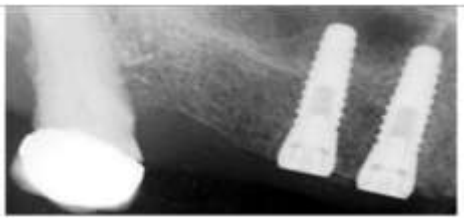


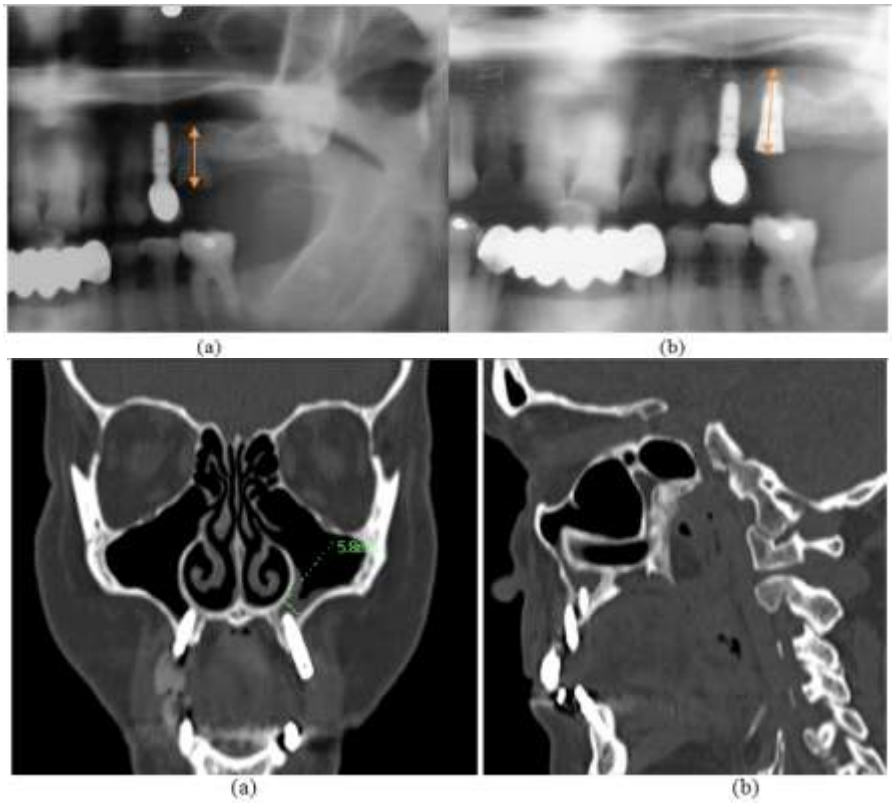
Figure 6. Periapical radiograph of implant in situ.

2.4 Measurements

NIH ImageJ was used to measure the ridge height on the panoramic radiographs taken before the surgical procedure and 1 month after the surgery. The radiographic distortion (1:1.3) was corrected before the measurement.

The vertical augmentation was determined according to Cordioli et al. (2001) [24]. The implant axis was taken as a reference, and the measurements were made on its direction as shown in Fig. 7.

Based on the findings of Peleg (1999) [25], computerized tomography (CT) scans (Fig. 8) were taken 1 month and 2 years after surgery since they are the best option to control de integrity of the Schneiderian membrane and the sinus bone elevation and to evaluate the clinical evolution of sinus lift and amount of newly formed bone.



III. Results

For the 10 clinical cases under consideration, all of the surgical procedures were conducted without complications, and no Schneiderian membrane was perforated. The achieved augmentation heights are shown in Table 1.

Table 1.Augmentation achieved in all 10 clinical cases under consideration.

Patient number	Initial height [mm] ±SD	Augmented height [mm] ±SD	Augmentation [mm] ±SD	Percentual augmentation[1]
1	8.53±0.44	10.71±0,17	2.18±0.47	25.56%
2	5.11±0.18	10.04±0.36	5.93±0.40	116.05%
3	6.12±0.41	10.71± 0,27	4.59±0.49	75%
4	7.81±0.13	13.03±0,21	5.22±0.25	66.84%
5	5.9±0.38	10.39±0,33	4.49±0.50	76.1%
6	4.32±0.14	9.26±0.09	4.94±0.17	114.35%
7	5.84±0.10	8.35±0.37	2.51±0.38	42.98%
8	4.82±0.44	9.75±0.32	4.93±0.54	102.28%
9	5.11±0.34	10.37±0.28	5.26±0.44	102.94%
10	6.42±0.20	9.69±0.30	3.27±0.36	50.94%

1 (height difference/initial height)*100%

Measurements were taken five times for each patient. The mean crestal bone height at the beginning of the study was 5.99±0.14 mm and it was 10.23±0.09 mm after the sinus floor elevation. The mean augmentation was 4.33 mm (77.3% on average).

IV. Discussion

Conventional strategies for a sinus floor elevation involve a variety of methods and medical instruments since their first use for maxillary implant placement more than 3 decades ago. The opening of a bony window in the lateral wall of the maxillary sinus can be performed by the traditional method presented by Tatum [6] in 1977 and published by Boyne and James in 1980 [7]. The crestal bone height can be elevated by the grafting of the maxillary sinus with intraorally harvested autogenous bone or other grafting material [26].

Since the beginning, the aim of surgeons and researchers was to find better patient rehabilitation, in addition to reducing patient morbidity. The technique introduced by Summers (1994) [27] is the most common transalveolar technique; however, the utilization of ostetotomes becomes less predictable with the decreasing of the residual crestal bone height [28]. It is a good technique if the conditions allow its use [27], but when it is not possible, other methods are more appropriate. Osteotomes can be used to lift the maxillary sinus floor, detaching the sinus membrane with it [5, 27]. Furthermore, several studies have demonstrated an incidence of 3% of benign paroxysmal positional vertigo when percussions are performed, in addition to causing the patient discomfort [29-31]. Other techniques require a deeper osteotomy that reaches the sinus membrane surface, increasing the risk of perforation [5, 32].

Unlike the classical techniques described, the transalveolar approach is considered minimally invasive, produces a low morbidity in the patient, and allows immediate implant placement [33]. Generally, minimally invasive surgeries allow a better recovery of the tissue, minimize scars and trauma, and prevent bone loss caused by resorption, which is especially important in techniques that implicate bone grafts [26, 34].

A minimally invasive technique for a transcrestal sinus floor elevation was described in this study, in which instruments widely used in oral surgery and a diamond burr typically used in cranial base surgery were employed [20]. The cases under treatment showed a residual crestal height between 4.32 mm and 8.53 mm (5.99 mm on average) before the surgical procedure. The immediate implant placement was successful. The final bone elevations were between 2.18 mm and 5.93 mm (4.33 mm on average), and they were to be loaded at 6 months on average.

A lack of visual control of the site characterizes almost all of the transalveolar techniques. Therefore, while performing an osteotomy, a surgeon must be experienced in detecting the changes on the bone quality and the resistance to penetration during the osteotomy. The use of piezoelectric instruments to reach the sinus floor does not consume more time than conventional surgical techniques. These instruments are safe and involve less risk of membrane perforation after a "learning curve" in handling the instruments; however, they are expensive and training dependent [17, 18]. So, the complementary use of digital periapical radiographs is suitable to control osteotomy progress. To obtain a better visualization, an endoscopy system could be used; however, it makes the procedure more complex and costly and obviously requires practice and skill that surgeons develop through experience and clinical supervision.

The main challenge during a maxillary sinus floor elevation is to maintain the integrity of the sinus membrane [19]. Membrane perforation is considered one of the biggest intrasurgical complications and can lead to a postoperative sinus infection, which is the principal cause of failure [19].

Therefore, in the presented technique, the first precaution taken to preserve the integrity of the sinus membrane involved the strategy implemented to perform an osteotomy. Drills were used, reaching a depth 2 mm shorter than the cortical bone of the sinus floor. Then, a diamond burr was used. The diamond burr, which is commonly used in skull base surgeries, rhinoplasties [20], and treatments of recurrent corneal diseases [35], has been used for maxillary sinus floor elevation for many years [26], accessing the sinus by making a bone window on the lateral sinus wall with the aim of maintaining the integrity of the Schneiderian membrane. The operation of the burr by an experienced surgeon involves a low risk of perforation because the burr is able to abrade osseous tissue without significantly hurting the surrounding soft structures and, in the worst cases, may only cause macro and/or micro lacerations [20, 36, 37]. Aimetti et al. (2002) [37] affirm that the eventual lacerations of a sinus membrane do not cause significant consequences or implicate complications in healthy membranes [38]. No Schneiderian membrane was perforated since it has been corroborated by the Valsalva maneuver [22] and an endoscopic view [23].

Del Fabbro et al. (2012) [39] have suggested that only the elevation of the Schneiderian membrane may be sufficient to obtain new bone formation in the newly created space between it and the sinus floor, so the placement of the grafting material has been questioned. However, the time between the Schneiderian membrane detachment and the complete bone formation is large, and it does not allow immediate implant placement. Thus, another important factor for a successful surgery involves the correct detachment of the sinus membrane from the subjacent sinus floor bone and the graft material placement. Several surgical procedures in which special instruments are used have been introduced (e.g., the use of balloon catheter [11, 12], piezoelectric instruments [17, 18], hydraulic or gel pressure [13-16], and nasal suction [40]). These procedures involve diverse complications already described and their use depends on the acquisition of an expensive surgery sinus lift kit. In the presented technique, the instrument used for detaching the membrane was a special design, which has a rounded non-sharp edge. The instrument used for the bone substitute delivery was a specially adapted instrument based on the "piston" operating principle.

V. Conclusion

In the presented technique, a diamond burr used for skull base surgeries and other sinus lift techniques was used to access the sinus and, principally to protect the Schneiderian membrane; however, experienced

surgeons are required. Since the diamond burr diameter is 3 mm, the implant has to be conical shaped and the implant diameter must be 3.5 mm or greater to reach the primary stability in the sinus cortical floor.

Furthermore, a cost-effective instrument was used; this design allows an atraumatic exposure and sinus membrane elevation. A bone substitute was placed using a specially adapted instrument, which allowed for comfortable work and precise control on the amount of used material.

In all of the cases, a satisfactory augmentation and bone volume were achieved, allowing immediate implant placement. The range of bone height achieved was between 25.56% and 116.05%, depending on the patient clinical situation. The final volume should not exceed 2-3 mm above the implant apex.

Indication of this transalveolar minimally invasive technique with immediate implant placement refers to situations of moderate bone reabsorption. The use of a bone substitute should not be excessive.

This technique overcomes the classical drawbacks in favor of sinus membrane preservation.

The present preliminary study requires a greater number of cases. More patients, along with long-term controls and evaluations would help to better determine success of the presented technique.

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