Transcrestal Sinus Floor Elevation: A Retrospective Study of 46 Patients up to 16 Years

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ABSTRACT

Background: The aim of this study was to evaluate the clinical outcomes and radiographic data of transcrestal sinus floor elevation (TSFE) of residual alveolar bone ≤3 mm.

Methods: Forty-six patients, edentulous in one or both maxillary posterior segments, were enrolled in this study. The residual alveolar ridge was measured. TSFE without bone grafting was performed. Three months after the first surgery procedure, 66 implants were placed without grafting material. A presurgical distance from the alveolar crest to the floor of the maxillary sinus and the amount of new radiopacity between the sinus floor and alveolar crest were measured from the mesial and distal surfaces of each dental implant surface.

Results: After a mean follow-up period of 10.43 ± 5.01 years (ranged from 5 to 16 years), a survival rate of 95.45% was reported. Mean bone levels at implant placement were 7.12 ± 0.90 mm and, after 1 year, were 13.28 ± 1.23 mm. They were stable over time, reporting an up to 16 years' value of 13.07 ± 2.63 mm.

Conclusions: The results of this retrospective clinical study confirmed the reliability of the TSFE procedure and the maintenance of bone levels without grafting procedures over time.

KEY WORDS: dental implant, sinus lift, trancrestal sinus floor elevation

INTRODUCTION

The sinus floor elevation is a surgical procedure performed to increase the vertical bone dimension in the posterior maxillary area in order to allow the placement of dental implants. Boyne and James[1] presented maxillary sinus floor elevation techniques with a lateral approach, opening a bone window through the lateral wall of the maxillary sinus in which they filled the sinus cavity with autogenous bone marrow from the iliac crest.

Implants can either be inserted simultaneously, when there is sufficient bone height for primary bone stability >4 mm, or they can be inserted in a second procedure when bone remodeling of the graft has taken place. This two-stage procedure is indicated when the residual bone crest presents a residual height less of 5 to mm.[2–4]

However, this surgical procedure is rather complex and invasive; therefore, alternative method as transcrestal approach was presented by Tatum[5] in 1986. The technique consisted of a "green-stick fracture" of the sinus floor performed by hand tapping the socket former in a vertical direction until a fracture of the sinus floor was obtained. Successively, Summers modified this technique, suggesting the use of a specific set of osteotomes for preparing the implant site and elevating the sinus floor.[6,7]

Several clinical studies[8–10] showed that sinus augmentation procedures using the transcrestal sinus floor elevation (TSFE) approach was associated with considerable long-term implant stability, with an implant survival rate ranging from 93.5 to 98.3% at different follow-up years.

This approach has been so reliable and predictable that some authors extended this surgical

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procedure to residual bone height beneath the sinus by 4 mm.[11]

The procedure consisted of elevating the Schneiderian membrane with osteotomes through a crestal approach, placing simultaneously the bone grafting material and the implant when the stability can be achieved.

Recently, the necessity of placing a filling material for sinus elevation procedures has been questioned in crestal approaches.[12–17] These studies demonstrated the bone formation beyond the original limits of the sinus since the bone filled the graft-free volume.

However, it is more difficult to successfully treat the cases in which the residual bone crest below the sinus floor is less then 3 mm. With this limited quantity of primary bone, it is very difficult to achieve primary implant stability that is of paramount importance to provide osseointegration.

The aim of this study was to evaluate the clinical and radiographic assessments of TSFE procedure in the maxillary posterior alveolar bone ≤3 mm. All implants were placed following a two-stage protocol (sinus floor elevation at the first time, and implant placement after 3 months) without the use of bone grafts.

MATERIALS AND METHODS

Patient Selection

Between October 1993 and November 2004, 46 patients from a private practice setting were restrospectively enrolled in the study.

Patients were 29 females and 17 males; the mean age was 55.4 ± 27.1 years, varying from 26 to 83 years.

The following inclusion criteria were adopted: good general health and without chronic systemic diseases. All patients included in this study were in one or both maxillary posterior segments edentulous. Based on periapical radiographs obtained with the paralleling technique, the residual alveolar was judged to be less than 3 mm until 1 mm. Exclusion criteria were the presence of chronic systemic disease, smoking of more than 10 cigarettes, bruxism habits, uncontrolled diabetes, coagulation disorders, alcohol or drug abuse, and poor oral hygiene.

The patients included in this clinical study were treated by a single operator (G.B.B.) in private practice office.

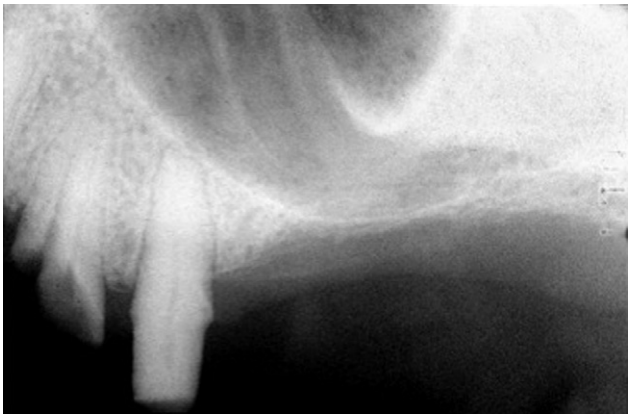

Figure 1 The distance between the ridge crest and the floor of the sinus is measured on a preoperative periapical radiograph.

All patients gave their consent to carry out the treatment according to the described protocol.

At the first stage, TFSE procedure was performed utilizing a collagen used to fill the cavity created, opening the bone crest after the detachment of Schneiderian membrane. Three months after the first sinus lift procedure, 66 implants were placed without grafting material.

Surgical Procedure

At the first stage, local Xylocaine anesthesia (Astra, Milan, Italy) was used in all patients. All were premedicated with a nonsteroidal anti-inflammatory drug (Naprosyn, 1.5 g; Recordati, Milan, Italy) and an antimicrobial agent (Ciproxin, 1 g; Bayer, Milan, Italy) 1 hour before surgery. Antibacterial and anti-inflammatory medications were continued for 5 days after surgery.

According to the prosthetic treatment planning, the location for implant placement was established, and the residual bone height at such locations was first measured on periapical radiographs as the distance from the bone crest to the sinus floor (Figure 1).

The bone crest that needed implant was exposed with a modified partial thickness flap.[18] The first incision started on the palatal surface of the masticatory mucosa with a long bevel that extended buccally within the suprabony connective tissue and continues over the edentulous crest and toward the fornix. This first incision included all the masticatory mucosa that covered the occlusal part of the edentulous crest. The second incision was complementary to the first; it began on the buccal border of the bevel and continued within the connective tissue on the palatal aspect of the ridge (Figure 2).

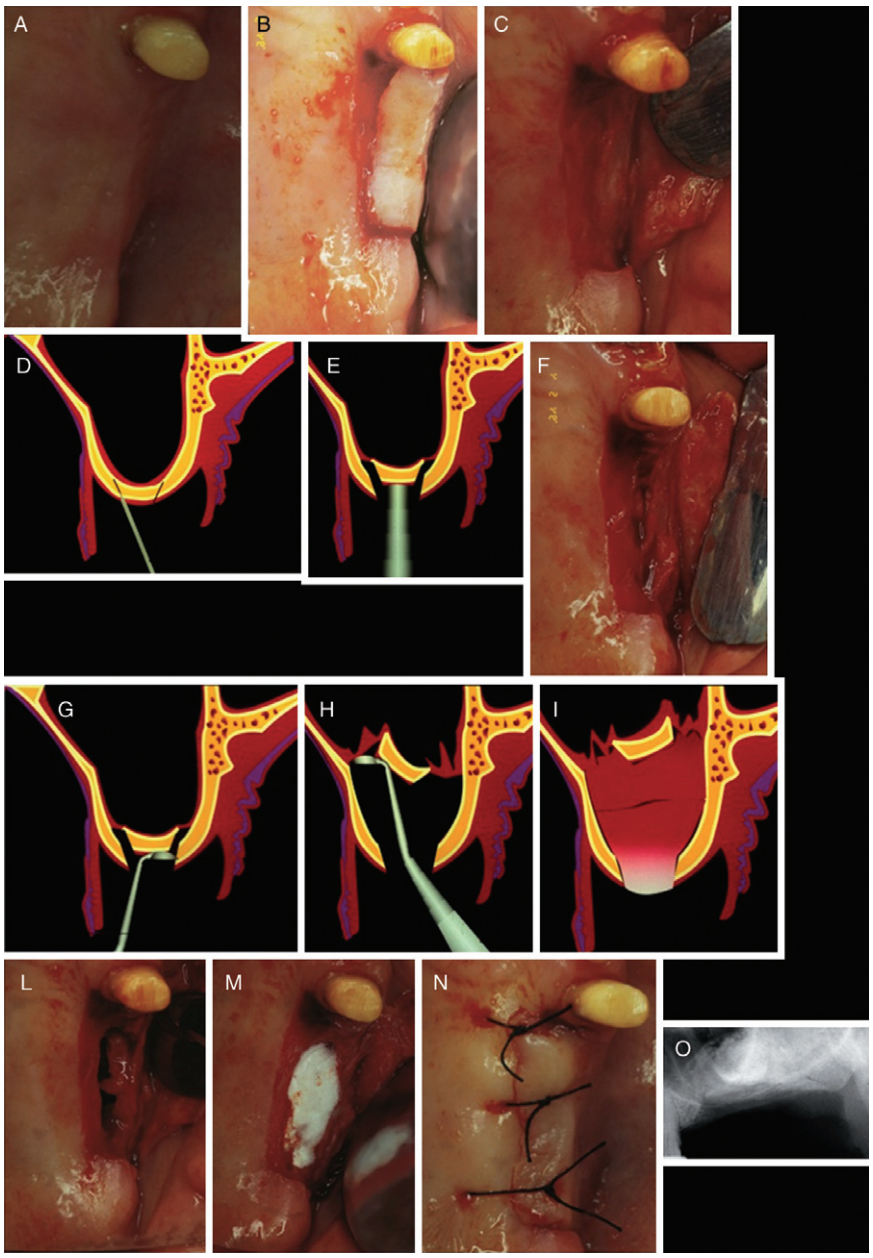

Figure 2 Clinical photograph showing the edentulous ridge of the maxilla before surgery (A). Exposure of the crest with the partial-thickness flap. The first incision starts on the palatal surface of the masticatory mucosa with a long bevel that extends buccally within the suprabony connective tissue and continues over the edentulous crest and toward the fornix. The second incision begins on the buccal border of the bevel and continues within the connective tissue on the palatal aspect of the ridge (B and C). An intrabony fissure is impressed within the bone crest with a no. 64 Beaver blade, and it is deepened almost to the level of the maxillary sinus floor (D). When all the occlusal portion of the edentulous crest was marked the tip of the corresponding, in size, bone expander was used. The selected instrument (normally 4.5 × 13-mm instrument) was gently tapped with a surgical mallet to make totally mobile this carved bone crest internally to the sinus cavity (E). Clinical photograph showing totally mobile bone crest internally to the sinus cavity (F). Schematic view of gentle detachment of the Schneiderian membrane, using the no. 2 De Marco curette, from the laterals and mesio-distal walls. Collagen sheets are placed in the created cavity to maintain in its position the bone crest apically displaced (G–I). Clinical view of surgical procedure with final sutures of gingival margins (L–N). Postoperative periapical radiograph immediately after the transcrestal sinus floor elevation procedure. The shadow of the fractured sinus floor can be seen (O).

A rectangular portion of the edentulous bone crest was performed with the tip of the no. 64 Beaver blade (Becton Dickinson Acute Care, Franklin Lakes, NJ, USA) avoiding sinus membrane perforation. The edentulous bone crest was covered by the preserved suprabony connective tissue and the underlying periosteum. The tip of the blade was oriented palatally to perform the palatal bone incision, and buccally for the buccal bone incision.

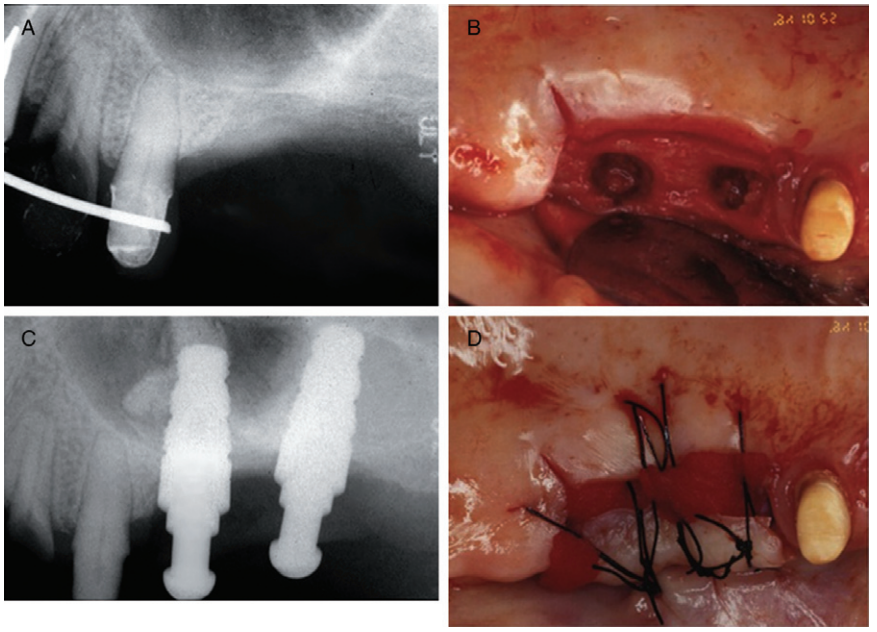

Figure 3 Periapical radiograph at the time of stage 2 surgery, performed as usual 3 months later. The modified profile or the cortical bone lining the floor of the maxillary sinus can be identified. The transformation is evident when this radiograph is compared with Figure 1, using the apex of the second bicuspid as a reference point (A). The implant site was created, expanding the tissue that filled up the cavity created with the stage 1 in all directions, and means laterally against the preexisting lateral walls and apically moving up and compressing with a series of progressive increase in the diameter of bone expanders (B). Periapical radiograph of implants during surgical procedure (C). The buccal flap was apically repositioned and stabilized with sutures tied to the margin of the lingual/palatal flap and anchored buccally with a loose loop to the periosteum at the level of the alveolar mucosa (D).

The final shape of the crestal bone portion presented a trapezoidal shape, as the external part of the carved bone crest resulted smaller than that in the internal one.

When all the occlusal portion of the edentulous crest was marked, the tip of a bone expander (Friadent Gmbh, Mannheim, Germany) was used. The selected instrument (normally 4.5×13 mm) was gently tapped with a surgical mallet to make totally mobile this carved bone crest internally to the sinus cavity. The Schneiderian membrane was carefully and totally detached, using the no. 2 De Marco curette (Hu-Friedy PGF-GFS, Hu-Friedy, Chicago, IL, USA), from the laterals and mesio-distal walls to create an empty space height. The result was a creation of a new space between the two lateral walls and the mesio-distal as well. Once the space obtained with the probes was sufficient, a 1×1 cm collagen sheet was placed in the created cavity to maintain the bone crest apically displaced; the remaining cavity was filled with two or three collagen sheets.

A final intraoral Rx was performed to check the space obtained.

Sutures were placed, obtaining a primary wound closure, and were removed after 1 week. Removable prostheses were always adapted postoperatively to treated crest.

Three months later, the same surgical procedure was followed for stage 2 (Figure 3).

The implant site was created, expanding the tissue that filled up the cavity created at stage 1, both laterally against the preexisting lateral walls and apically moving up and compressing with a progressive series of bone expanders. The implants used for two-stage TSFE were from two manufacturers: Frialit (Friadent Gmbh, Mannheim, Germany) for the first type (Group A), diameter 4.5, 5.5, and 6.5 mm, length 13 and 15 mm; and PILOT (Sweden-Martina, Padova, Italy) for the second type (Group B), diameter 4.7, 5.7, and 6.7 mm, length 13 mm. In total, 42 implants were placed for Group A and 24 implants were placed for Group B (Table 1). Implant dimensions and positions are shown, respectively, in Tables 1 and 2.

The buccal flap was apically repositioned and stabilized with sutures tied to the margin of the lingual/palatal flap and anchored buccally with a loose loop to the periosteum at the level of the alveolar mucosa. This suture design avoided tissue traction in the repositioned

TABLE 1 Implant Dimensions (n = 66 = Implants)

	Length (mm)	
Diameter (mm)	13	15
4.5	4	4
5.5	10	9
6.5	9	6
4.7	6	0
5.7	14	0
6.7	4	0
Total	47	19

buccal flap. The gap between the superficial margin of the buccally repositioned tissue and lower part of the palatal tissue healed by secondary intention in order to increase the size of keratinized mucosa. A collagen sheet was used to cover the resulting crestal bone gap. The collagen was placed under the buccal flap and covered the bone crest for a coagulum pattern.

Radiographic Assessments

The periapical radiographs were made at baseline, 3 months after the first-stage surgical procedure (at implant placement) and every year after implant placement. They were taken perpendicularly to the long axis of the implant with a long-cone parallel technique using an occlusal template. A radiologist measured bone height over time. He marked the reference points and measured lines on the screen interactively. Outcome variables were recorded on the radiographs using a digital ruler.

The following parameters were assessed from the periapical radiograph:

- a presurgical distance from the alveolar crest to the floor of the maxillary sinus (Figure 1)
- the amount of new radiopacity between the sinus floor and alveolar crest measured from the mesial and distal surfaces of each dental implant surface (Figure 4)

A mean for initial and gained alveolar bone height was obtained from the radiographic evaluations; they were measured at baseline, at temporary prosthesis placement, 1-year, 3-year, and at long-term follow-up.

TABLE 2 Implant Positions (n = 66 = Implants)

Teeth	1.4	1.5	1.6	1.7	2.4	2.5	2.6	2.7
Implants	2	1	12	8	1	4	25	13

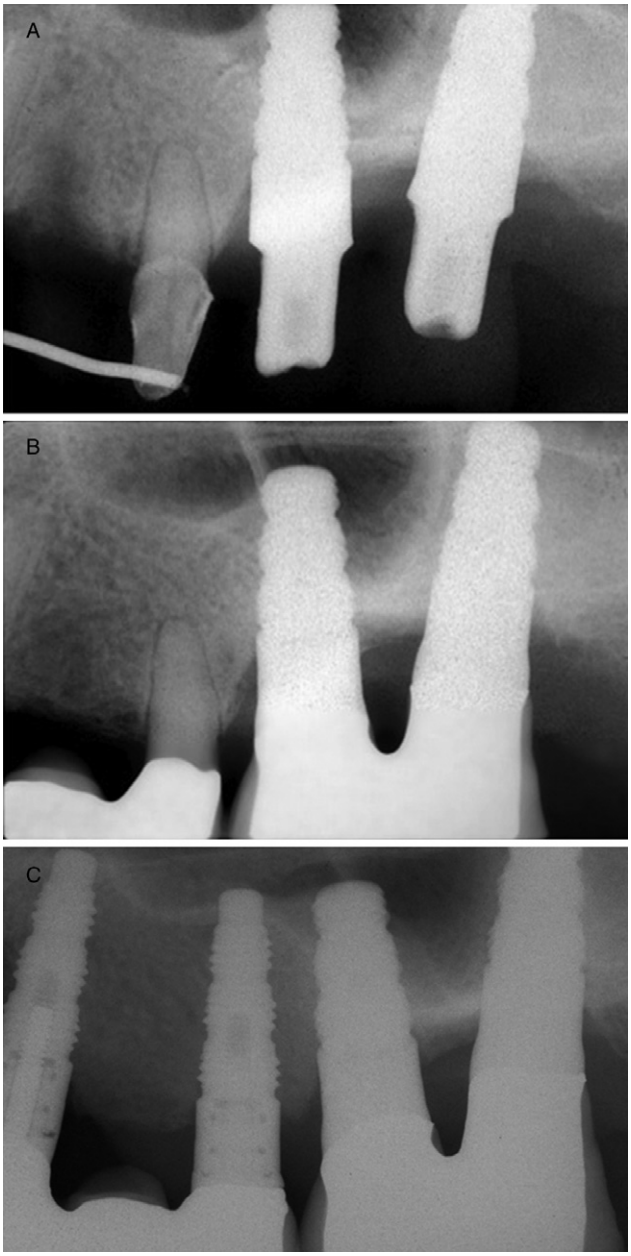

Figure 4 Periapical radiograph performed as usual 4 months later in stage 2 surgery. The modified profile or the cortical bone lining the floor of the maxillary sinus can be identified above the implant. The transformation is evident when this radiograph is compared with Figure 1, using the apex of the second bicuspid as a reference point (A). Follow-up at 6 years (B). Follow-up at 16 years (C). The second bicuspid was removed and implants were positioned.

Statistics

A dedicated software was used for all statistical analyses (SPSS 11.5.0, SPSS Inc., Chicago, IL, USA). All data were

TABLE 3 Baseline Alveolar Bone Crest Height ($n = 46$ = Patients)

	Alveolar Bone Crest
Group A (mm)	2.04 ± 0.72
Group B (mm)	2.17 ± 0.93
Mean (mm)	2.11 ± 0.89

reported as mean ± standard deviation. The two-sample *t*-test was used to compare marginal bone loss between the two groups ($p < .05$ was considered the threshold for statistical significance).

RESULTS

Baseline mean alveolar crest bone height was 2.11 ± 0.89 mm ($n = 46$ = patient) (Table 3).

After the TSFE procedure and implant placement, no pain or final prosthesis mobility was recorded. There was a suitable wound healing around temporary abutments, with a fine adaptation to the temporary crown. Minor swelling of gingival mucosa was present in the first days after surgical procedures; no mucositis or flap dehiscence with suppuration were found. The final prosthetic restorations were cemented 5 months after implant placement.

After TSFE procedure, four patients experienced minor nasal bleeding, which disappeared within the first 24 to 48 hours.

After a mean follow-up period of 10.43 ± 5.01 years (ranged from 5 to 16 years), a cumulative survival rate of 95.45% after up to 16 years was reported (Table 4). Three implant failures occurred within 1 year from implant placement, in three smoker patients. Their dimensions were 5.7 × 13, 5.7 × 13, and 5.5 × 13, and their positions were, respectively, 2.6, 2.6, and 1.6. Furthermore, when implant failure occurred, as in one patient with periimplantitis, the regenerated apical bone was preserved even after years of occlusal function.

Radiographic bone height measurements are reported in Table 5.

No statistically significant differences were found between groups and bone height values over time ($p > .05$).

TABLE 4 Life Table Analysis for All Implants, Group A and Group B

	Implants	Failed Implants	Cumulative Survival Rate (%)
All implants			
Implant placement – Prosthesis delivery	65	1	98.49
Prosthesis delivery – 1 year	63	2	95.45
1–5 years	63	0	95.45
5–10 years	41	0	95.45
10–15 years	22	0	95.45
16 years	18	—	—
Group A			
Implant placement – Prosthesis delivery	42	0	100
Prosthesis delivery – 1 year	41	1	97.62
1–5 years	41	0	97.62
5–10 years	26	0	97.62
10–15 years	13	0	97.62
16 years	11	—	—
Group B			
Implant placement – Prosthesis delivery	23	1	95.83
Prosthesis delivery – 1 year	22	1	91.67
1–5 years	22	0	91.67
5–10 years	15	0	91.67
10–15 years	9	0	91.67
16 years	7	—	—

TABLE 5 Mean Vertical Bone Heights for Group A, Group B, and All Implants (Mean Follow-Up 10.43 ± 5.01 Years, Ranged from 5 to 16 Years) (*n* = 66 = Implants)

Bone Height	Implant Placement	1 Year	5 Years	10 Years	16 Years
Group A (mm)	7.14 ± 1.01	13.55 ± 1.89	13.11 ± 2.98	13.12 ± 2.20	13.15 ± 2.68
n	42	41	41	26	11
Group B (mm)	7.09 ± 0.79	13.11 ± 1.01	12.91 ± 1.89	12.90 ± 1.94	12.95 ± 2.50
n	23	22	22	15	7
All implants (mm)	7.12 ± 0.90	13.28 ± 1.23	13.02 ± 2.46	13.04 ± 2.01	13.07 ± 2.63
n	65	63	63	41	18

The observation period of 66 implants in 46 patients, up to 16 years, confirms the preservation of the vertical bone height without grafting procedures over time.

DISCUSSION

This retrospective clinical study presented a crestal approach for sinus lift procedure with residual alveolar bone less than 3 mm. The results showed a 95.45% success rate up to 16 years.

Radiographic analysis reported an increase of 10 to 14 mm of available bone, and these values remained up to 16 years.

The careful apical displacement of cortical bone and Schneiderian membrane into the sinus cavity was performed to create a new vertical intraosseous spaces with complete preservation of the original bone. The biologic basis for the healing process of TSFE tecnique is similar to classic "socket" healing,[19,20] in which the blood clot induces the migration, proliferation, and differentiation of various types of cells, stimulating angiogenesis.[21] Neovascularization of the blood clot and subsequently new bone formation appeared to start from released bone marrow spaces of the adjacent defect borders.

It can be argued that it may not be the size of the marginal gap per se, but rather the formation of a coagulum in the defect, its retention and replacement with a bundle bone matrix, which determine whether defect resolution will occur.

Also, human maxillary sinus membrane tissue is considered a potential source of multipotent mesenchymal stem cells that may differentiate into osteoblasts under osteogenic induction and consequently promote a natural healing process.[22]

Because bone graft materials are not recommended when performing the TSFE technique, the healing process proceeds more rapidly than with other augmentation techniques that utilize an assortment of autogenous grafts, allografts, or xenografts.

Furthermore, several studies have explained the capability of forming bone without grafting material when the Schneiderian membrane has been lifted beyond the anatomical limits of the sinus floor, either crestally[17] or laterally.[23–26]

Nedir and colleagues[27] confirmed that the osteotome sinus floor elevation procedure without grafting material was sufficient to create bone beyond the natural limit of the sinus. The 100% survival rate of implants included in the study showed that the osteotome approach can be relevant even when the residual bone height is <5 mm. This is in line with other papers of the literature. Shalabi and colleagues[28] reported the overall survival rate for implants placed with the osteotome procedure to vary from 99% after 6 months to 94% after 42 to 56 months. The osteotome procedure without grafting material was effective for all implants, inducing new bone beyond the original limits of the sinus when the residual bone height was <5 mm. Implants gained endo-sinus bone despite the lack of grafting material, without shrinkage of the augmented area.

A critical difference between the lateral and the crestal approaches is that by the end of the osseointegration period, implants placed with the lateral approach are embedded in a larger bone volume and it is important for a certain rate of resorption at the expense of the sinus cavity as it has been documented to occur over time with grafting materials. Indeed, partial resorption of the grafted area has been reported when the sinus is augmented either with a limited volume via the osteotome technique[29] or with a large volume of grafting material via the lateral approach.[30] In a 10-year survey,

Hatano and colleagues[30] found on radiographs that the height of the embedding bony material measured at implant placement decreased substantially during the first 3 years.

The shrinkage of the novel bone was not observed and remained stable during 3 years,[27] and in the present study, the bone height gained after sinus lift procedure did not shrink over 16 years as reported with grafted materials.[29,30] The newly elevated sinus floor was also better delimited and maintained at level with the implant apices.

A reduction of the grafted volume below the implant apices has been reported during the first 3 years and then stable over time, up to 10 years.[30]

The fact that all implants have functioned successfully demonstrated that the newly formed bone provided adequate support to occlusal loading, maintaining a stable level along implant apex.

The TSFE procedure, when properly performed, is simple, and, in practice well tolerated. Four patients experienced minor nasal bleeding, which disappeared within the first 24 to 48 hours. This was the only postoperative complication experienced.

The results of the present study demonstrated that the TSFE procedure allows the expansion of the dimensions of resorbed posterior maxillary alveolar bone both vertically and horizontally, with a success rate of 95.45% of implant osseointegration over time. Moreover, the implants can be large enough to replace the lost maxillary molars, sustaining the occlusal forces of this anatomic area.

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CONFLICT OF INTEREST STATEMENT

We certify that we have no affiliation with or financial involvement in any organization or entity with direct financial interest in the subject matter or materials discussed in the manuscript, and that the material is original and has not been published elsewhere.

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