

Indirect Osteotome Maxillary Sinus Floor Elevation: An Update

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The objective was to review publications on indirect osteotome maxillary sinus floor elevation (OMSFE) procedures. Studies published between 1999 and 2010 on patients with a minimum of 1 year of follow-up were analyzed. Fourteen studies were included. Indirect OMSFE is indicated for a bone height of 6–8 mm. More bone height was gained when graft material was used. Schneiderian membrane perforation was the most frequent complication. Survival rates varied between 93.5% and 100%. Osteotome sinus membrane elevation is a predictable and effective procedure for placing implants in areas of the posterior maxilla with low bone height.

Key Words: *indirect sinus elevation, osteotome technique, osteotome sinus floor elevation*

INTRODUCTION

Atrophy of the alveolar crest and pneumatization of the maxillary sinus limits the quality and quantity of residual bone, therefore complicating the placement of implants in the posterior maxillary area.^{1,2} Various classifications have been established to determine the most appropriate treatment based on the pattern of alveolar resorption: Misch³ established 4 groups in function of the bone height existing between the free margin of the alveolar process and the floor of the maxillary sinus. In 2009, Chiapasco and Zaniboni⁴ established another classification according to the height and width of the alveolar ridge and the intermaxillary relationship of the patient. The need to increase bone volume has led to the development of maxillary sinus augmentation procedures,⁵ although other therapeutic options are available to resolve this anatomic limitation, such as the use of angulated, zygomatic, or pterygoid implants.^{6–9}

Indirect osteotome maxillary sinus floor elevation (OMSFE) is generally employed when the

residual bone height is equal to or greater than 6 mm¹⁰; in cases with higher resorption, the direct sinus elevation technique is used.^{2,11,12} The indirect osteotome technique offers a number of advantages: the surgery is more conservative, sinus augmentation is localized, there is a low rate of postoperative morbidity, a shorter time to implant loading is possible than with the direct technique, and high survival rates of around 90% are obtained.^{5,13}

The aim of this study was to review publications reporting on indirect OMSFE and to evaluate the influence of the graft material, the gain in bone height, and the amount of bone resorption. Likewise, the aim was to assess the complications of this surgical technique and the survival rates of implants placed in these areas.

MATERIALS AND METHODS

Inclusion criteria and search strategy

Studies indexed in PubMed published between January 1999 and January 2010 on patients treated by OMSFE were analyzed. Only human clinical studies using the indirect osteotome technique with simultaneous placing of implants, a minimum of 10 patients, and at least 1 year of follow-up were included. Clinical studies in which the maxillary

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TABLE 1
Studies included in the review

Studies	Patients, N	Implants, N	Follow-Up Period, mo	Graft Material
Rosen et al ¹⁴	101	174	20.2	Autografts, allografts, xenografts, or combinations
Toffler ¹⁵	167	276	12	Xenografts + autografts
Brägger et al ¹⁶	19	25	12	Xenografts + autografts
Nedir et al ¹⁷	17	25	12	No graft
Ferrigno et al ²	323	588	59.7	Xenografts + autografts
Krennmair et al ¹⁰	14	14	44.5	Xenografts
Diss et al ¹⁸	20	35	12	Platelet-rich fibrin
Kermalli et al ¹⁹	45	57	18.7	Xenografts
Fermergård and Astrand ²⁰	36	53	12	No graft
Juriscic et al ¹	33	40	36	Xenografts
Nedir et al ¹¹	32	54	12	No graft
Nedir et al ²¹	17	25	36	No graft
Pjetursson et al ²²	181	252	38.4	No graft and Xenografts
Pjetursson et al ²³	181	252	38.4	No graft and Xenografts

sinus elevation was made immediately after dental extraction were excluded.

The PubMed database was searched using the keywords: *indirect sinus lift*, *osteotome sinus floor elevation*, and *osteotome technique*. Articles were found from the following journals: *The International Journal of Oral & Maxillofacial Implants*; *Journal of Periodontology*; *Clinical Oral Implants Research*; *Oral Surgery*, *Oral Medicine*, *Oral Pathology*, *Oral Radiology*, and *Endodontics*; and *Clinical Implant Dentistry and Related Research*.

RESULTS AND DISCUSSION

Ninety-seven articles were identified, of which 83 studies were excluded; 21 because they did not use the osteotome technique, 33 were not human clinical studies, 11 involved fewer than 10 patients, 15 had a follow-up period of less than 1 year, and 3 studies used the indirect sinus lift with osteotomes immediately following dental extraction. Fourteen studies were included (Table 1).^{1,2,10,11,14-23}

Indications for indirect sinus elevation

Residual ridge height is the principal factor in determining the type of maxillary sinus elevation procedure used.¹⁰ In the majority of the articles published, indirect OMSFE is generally employed when the residual bone height is equal to or greater than 6 mm^{1,2,10,11,16-20,22,23}; however, some of the reviewed studies included cases of sinus elevation made with less than 6 mm of residual bone.^{11,14-19,21,22} Rosen et al¹⁴ and Diss et al¹⁸ excluded patients with

the following conditions: uncontrolled diabetes, immunologic disease or systemic conditions that contraindicated surgery, radiation therapy in the head and neck region or chemotherapy during the 12 months prior to surgery, uncontrolled periodontal disease, active infection of the maxillary sinus, or psychological problems. Also excluded were patients who smoked 1 or more packs of cigarettes per day or who were uncooperative or unwilling to carry out the maintenance program. Ferrigno et al² further excluded other conditions such as poor oral hygiene, severe intermaxillary skeletal discrepancy, bruxism, and alcohol or drug abuse.

Surgical procedure

A similar surgical procedure was used in all of the reviewed studies, carried out in a single clinical session in which a supracrestal incision is made and a full thickness flap is raised. The implant bed is prepared to approximately 1 mm below the floor of the maxillary sinus. The osteotomes are chosen to extend the preparation area both horizontally and vertically until elevating the Schneiderian membrane without perforation. The graft material is placed where indicated, the implant is inserted, and the wound is closed.

Bone graft material

The sinus elevation was made using deproteinized bovine bone in 5 studies,^{1,10,19,22,23} a combination of autologous bone with xenograft and or allograft in 4 studies,^{2,14-16} platelet rich plasma in 1 study,¹⁸ and no material at all in 6 studies^{17,11,20-23} (Table 1).

Survival Implants, %	Treated Sites With Perforation of the Membrane	Other Complications	Healing Time, mo
95.4	-	-	+ 6
93.5	4.7	Nasal bleeding	5-6
96	4	-	5-6
100	16	Nasal bleeding and sensation of a blocked up nose	3-4
94.8	2.2	-	3-4
100	21.42	-	5-6
97.1	11.42	Nasal bleeding and sensation of a blocked up nose	3-4
96.5	3.5	Postoperative infection and sinusitis	5-6
96	-	-	3-4
100	-	-	5-6
100	9.25	Postoperative inflammation	3-4
100	16	Nasal bleeding and sensation of a blocked up nose	3-4
97.4	10.71	Excessive hematoma	5-6
97.4	10.71	-	5-6

In the 4 studies that used autogenous bone, this was obtained during drilling or from the tuberosity, maxillary edentulous ridge, or the posterior mandible.^{2,14-16}

Only 1 of the studies included in this review¹⁴ related implant survival to the type of bone graft material used, finding no statistically significant differences. In 2 of the studies,^{22,23} implant survival was compared with and without bone graft material, obtaining no significant differences between the 2 groups.

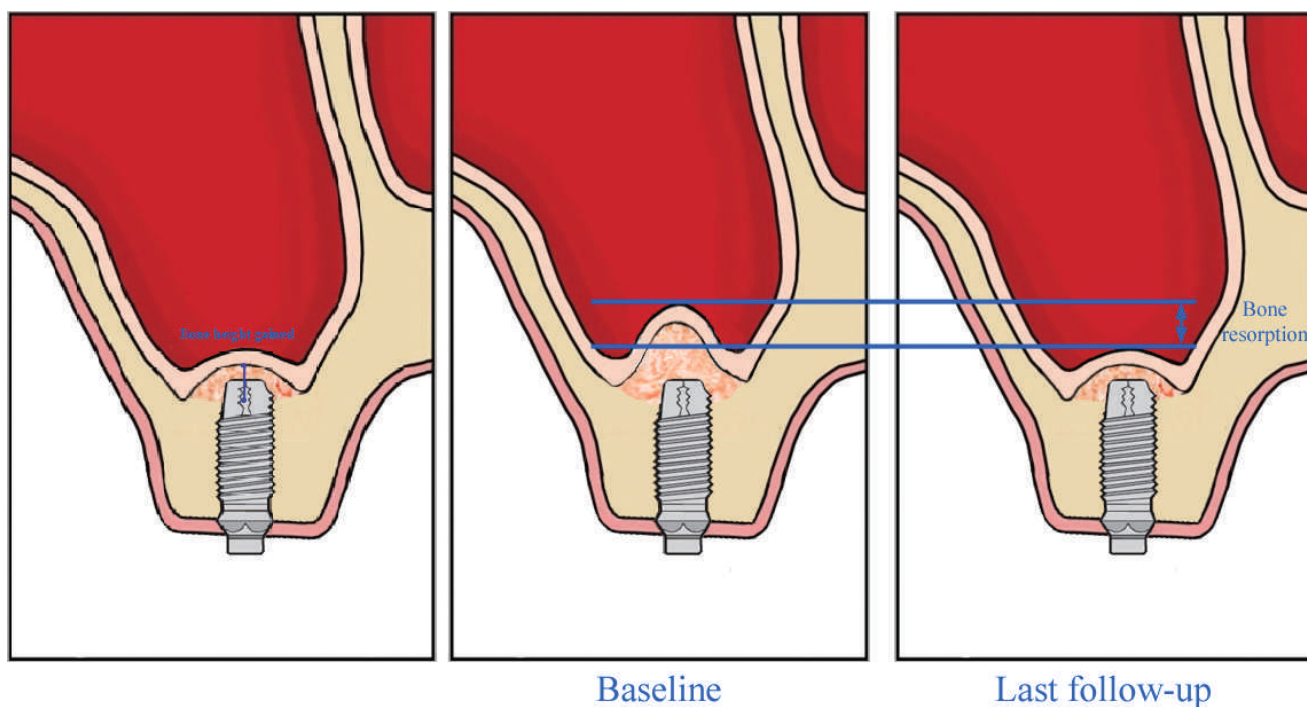
Bone height gained and bone resorption

Seven of the articles reviewed^{11,15,17,18,20,21,23} (Table 2), reported the amount of bone height gained following indirect maxillary sinus elevation. In Figure 1, a schematic drawing of bone height gained following indirect maxillary sinus elevation is presented. Table 2 shows that with no bone graft material a mean gain of 2.86 mm was achieved

(range 1.7–4.4 mm), and with bone graft material the mean was 3.7 mm (range 3.2–4.1 mm). Only 1 of the studies²³ evaluated the bone height gained in the sinus with and without the use of graft material; in this study, the probability of gaining 2 mm of new bone was 39.1% when no graft material was used, and the probability of gaining 2 mm or more of the new bone increased to 77.9% when the implants were installed with grafting material.

With respect to bone resorption of the bone graft after the OMSFE procedure, Figure 2 shows a schematic drawing of the apical remodelling of the graft at the apex of the implant. In order to evaluate whether the new sinus floor or the graft margin was moved apical (bone gain) using this technique, the distance from implant shoulder to the sinus floor at baseline was compared with the distance from implant shoulder to the new sinus floor or the graft margin at the last examination. Eight studies^{1,10,11,16,17,19,21,23} considered this aspect: when

Studies	Implants, N	Grafting Material	Bone Gain, mm	Average Bone Gain, mm
Nedir et al ¹⁷	25	No graft	2.5 ± 1.2	2.86
Fermergård and Astrand ²⁰	53	No graft	4.4 ± 0.2	
Nedir et al ¹¹	54	No graft	2.6 ± 1.7	
Nedir et al ²¹	25	No graft	3.1 ± 1.5	
Pjetursson et al ²³	252	No graft	1.7 ± 2	
Toffler ¹⁵	276	Xenografts	4.1 ± 2.4	3.7
Diss et al ¹⁸	35	Xenografts + autografts	3.8	
		Platelet-rich fibrin	3.2 ± 1.5	



FIGURES 1 AND 2. FIGURE 1. A schematic drawing of bone height gained following indirect maxillary sinus elevation. **FIGURE 2.** A schematic drawing of the apical remodelling of the graft following indirect maxillary sinus elevation.

no graft material was used, a mean resorption of 0.7 mm was recorded at 1 year (range 0.2–1.2 mm) and 1.4 mm at 3 years (range 0.7–2.1 mm); when graft material was used, resorption was 0.91 mm (range 0.6–1.23 mm) at 1 year and 1.75 mm (range 0.9–2.3 mm) at 3 years (Table 3). In the study published by Pjetursson et al,²³ in 88 implants bone graft was used, and in 164 no grafting material was used for indirect sinus floor elevation. In the group of no grafting material, in 55% of the implants no visible structure was demonstrated apical to the implants after insertion; in 26.3% a radio-opaque structure was visible but no radio-opaque structure was visible after 1 year. For implants inserted with grafting material, only 23.5% showed no visible radio-opaque structure apical to the implants after implant installation. For the remaining implants, the graft height was reduced from 2.7–2.1 mm.

Complications arising from the osteotome technique

The most frequent complication was perforation of the Schneiderian membrane; this was present in almost all of the articles with a range of 2.2%–21.4% (Table 1). However, there is no standard procedure described in the literature to be followed in the case

of membrane perforation during an indirect OMSFE. The reviewed studies used a variety of approaches: Ferrigno et al² stopped the surgery, allowing a healing period of at least 3 months before repeating. Nedir et al¹⁷ used shorter-than-planned implants (6–8 mm) to avoid intrusion of the implant into the sinus. Toffler¹⁵ placed collagen sponges at the end of the osteotomy above the implant. Brägger et al¹⁶ and Pjetursson et al²³ placed the implants without graft material.

In addition to perforation of the Schneiderian membrane, a small number of other complications appear: nasal bleeding,^{15,17,18,21} a sensation of a blocked-up nose,^{17,18,21} postoperative inflammation,¹¹ and excessive hematoma,²² all of which resolved a few days after surgery. In 1 of the reviewed studies¹⁹ an infection produced sinusitis and the loss of the implant; after a 4-month healing period, the sinus elevation was repeated and 7 months later a new implant was placed without complications (Table 1).

Implant survival

The survival rate of implants varies between 93.5% and 100% in the various studies over a minimum follow-up period of 1 year (Table 1).

TABLE 3

Height reduction graft

Studies	Implants, N	Grafting Material	Height Reduction Graft to 1 Year, mm	Height Reduction Graft to 3 Years, mm
Nedir et al ¹⁷	25	No graft	1.2 ± 0.7	-
Nedir et al ¹¹	54	No graft	0.2 ± 0.8	-
Nedir et al ²¹	25	No graft	1.2 ± 0.7	2.1 ± 0.8
Brägger et al ¹⁶	25	Xenografts + autografts	1.23	-
Krennmair et al ¹⁰	14	Xenografts	-	2.3 ± 1.2
Kermalli et al ¹⁹	57	Xenografts	-	1.90
Jurasic et al ¹	40	Xenografts	-	1.9 ± 1.6
Pjetursson et al ²³	252	No graft	0.5	0.7
		Xenografts	0.6	0.9

With respect to *residual bone height*, Toffler¹⁵ obtained a survival rate of 73.3% with a bone height of 4 mm or less, 94.9% with 5–6 mm, and 94.5% with 7 mm or more. Similarly, Rosen et al¹⁴ obtained a survival rate of 85.7% with a bone height of 4 mm or less, 96% with 5 to 6 mm, and 96.4% with 7 mm or more. In contrast, Pjetursson et al^{22,23} recorded a survival rate of 91.3% when the residual bone height was 4 mm or less, 90% at sites with residual bone height between 4 and 5 mm, and 100% when the height was above 5 mm. In 4 publications,^{14,15,22,23} greater residual bone height was significantly associated with higher survival rates.

Regarding *implant length*, Ferrigno et al² recorded a 93.4% survival rate for implants of 12 mm, 90.5% for those of 10 mm, and 88.9% for lengths of 8 mm. Likewise, Pjetursson et al²² obtained a survival rate of 47.6% for 6-mm implants, 98.7% for implants of 8–10 mm, and 100% for those of 12 mm. Toffler¹⁵ recorded a lower survival rate in shorter implants (8.5–10 mm), without specifying percentages. Three studies^{2,15,22} obtained significantly higher survival rates with longer implants.

With respect to *implant surface*, Toffler¹⁵ obtained a survival rate of 87.0% for implants with a machined surface, 94.7% with acid-etched surface, 93.7% for titanium oxide-blasted surface, and 90.0% for sandblasted/acid-etched surface. Rosen et al¹⁴ obtained a 93.3% survival rate for implants with a machined surface, 97.1% with titanium plasma-sprayed surface, and 100% with hydroxyapatite surface. Kermalli et al¹⁹ compared 2 types of surface, obtaining a survival of 96.6% for acid-treated implants and 96.4% for sintered implant surfaces. The type of surface was not statistically related with survival of implants placed after indirect OMSFE in any of these studies.^{14,15,19}

Prosthetic loading

Only 1 study¹⁷ delayed more than 6 months before prosthetic loading; in the remaining studies implants were all loaded within 6 months.^{1,2,10,11,14–16,18–23}

CONCLUSION

Maxillary sinus elevation using the osteotome technique is a predictable and effective procedure for correcting limited bone resorption in posterior areas of the maxilla, independent of the bone graft material used. The technique results in few complications, and the survival rate for implants placed in these areas varies between 93.5% and 100%.

ABBREVIATION

OMSFE: osteotome maxillary sinus floor elevation

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