Crestal Sinus Lift With Sequential Drills and Simultaneous Implant Placement in Sites With <5 mm of Native Bone: A Multicenter Retrospective Study

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Purpose: The aim of this multicenter retrospective clinical study was to evaluate the survival rate of implants placed in the posterior maxilla with a residual bone height of <5 mm.

Materials and Methods: One hundred seventeen patients, recruited from 6 different centers, had 134 implants placed below the maxillary sinus. The patient population consisted of 52 men and 65 women ranging in age from 39 to 78 years (mean age, 53.2 years). Sinus lift procedures were performed following a crestal approach using a specific sequence of drills (Cosci’s technique). All implants were submerged. Periapical radiographs were obtained with a parallel-technique and were digitized. The pattern of bone remodeling was subsequently evaluated.

Results: The average (±SD) follow-up time was 48.2 months (±29.30 months; range, 24 to 120 months). Of the original 134 implants placed, 5 implants (3.7%) failed. The implant survival rate was 96.3%. The average residual bone height was 3.46 mm (±0.91 mm) at baseline. The average height of the alveolar crest in the treated implant sites was 9.94 ± 2.29 mm. The radiographic bone gain was 6.48 ± 2.38 mm.

Conclusion: The investigation suggests that this crestal drill approach can be a successful sinus lifting procedure in a severe atrophic maxilla with <5 mm of crestal bone height. (Implant Dent 2011;20:1–000)

Key Words: crestal approach, lifting drills, residual bone height, sinus augmentation, sinus graft

Implant placement is often complicated in the posterior upper jaw by postextraction bone resorption, pneumatization of maxillary sinuses, and poor quality of alveolar bone. In these situations, the residual vertical bone height is reduced making standard implant placement difficult. In fact, studies have shown higher success and survival rates (SRs) with a fixture length of at least 10 mm.1–4 The elevation of the maxillary sinus floor is one possible solution.5 The sinus floor augmentation technique was first presented by Boyne and James;6 it was based on the lateral window method that was a modification of the known sinus revision procedure according to Caldwell-Luc. Since then and until today, the sinus lift technique using lateral access has been widely documented in the literature and has proved to be a safe and highly predictable method.7–12

A crestal approach for sinus floor elevation was initially suggested by Tatum.13 Summers later proposed the osteotome technique to place implants in a simpler, more conservative, and less invasive manner than the lateral approach.15 In Summers’ technique, an osteotome is inserted through the edentulous alveolar crest at the inferior border of the maxillary sinus floor. This intrusion procedure produces a fracture in the least traumatic way possible and the sinus floor is moved upward. This creates a space for bone graft and simultaneous implant placement. Some years later, some authors16–19 suggested modifications to the Summers’ technique based specifically on the use of different biomaterials and on the expansion and compression of the alveolar crest to lift the sinus floor of the maxilla.

In particular, Cosci and Luccioli17 presented a sinus lift 1-stage crestal approach using a specific sequence of drills (Cosci’s Technique). The shape of the drill tip prevented perforation of the sinus membrane and permitted gentle abrasive removal of the cortical
bone of the sinus floor without fracture. The main limitation of these crestal techniques is the uncertainty of a possible perforation of the sinus membrane. However, an endoscopic study showed that the sinus floor may be elevated up to 5 mm without tearing the membrane.20 This outcome is indirectly confirmed by the study, which compared the crestal approach and the lateral antrostomy for sinus augmentation: the results indicated that the osteotome technique allowed a maximum increase in bone height of 3 to 4 mm, whereas the lateral technique allowed an increase of 10 to 12 mm.21

In a multicentric retrospective study, Rosen et al22 evaluated the outcome of the Summers’ technique in the placement of implants below the maxillary sinus: the SR was 96% when the residual bone height was 5 mm or more, but dropped dramatically to 85% when crestal bone height was 4 mm or less. Existing literature22–24 suggests that residual bone height has a significant influence on the outcome of crestal procedures. Specifically, the success and SRs decrease with reduced residual bone height.

The purpose of this multicenter retrospective study was to evaluate the SRs of implants placed in the posterior maxilla with a residual bone height of <5 mm using a sequential sinus lift crestal approach (Cosci’s technique).

**Materials and Methods**

During the period from 1999 to 2009, 117 patients, recruited from 6 different centers, had 134 implants placed below the maxillary sinus. The patient population consisted of 52 men and 65 women ranging in age from 39 to 78 years (mean age, 53.2 years). All of the selected patients were in a good state of health, absence of diseases that affects bone metabolism or wound healing, and no regular medications consumption for >3 months. All the authors’ patients who underwent bone regeneration techniques were non-smokers.25,26 Hence, smokers were excluded from the study.

These patients presented a residual bone height of <5 mm, making implant placement impossible without a sinus lift procedure. Pretreatment residual bone height was determined for each site by using a periapical radiograph.

**Radiographic Analysis**

Endaural digital images (RVG Kodak system & CSN system) were obtained after implant placement (baseline) and during control examinations with a paralleling technique using a Rinn film holder. To obtain real and accurate measurements, digital images were always calibrated with a specific software application, taking the known length of the inserted implant as a reference for measurement. No attempts were made for further standardization.

The following radiographic linear measurements were made:

1. Residual bone height from the alveolar crest (coinciding with the implant shoulder) to the floor of the maxillary sinus mesial and distal to the inserted implant at baseline (Fig. 1, A).
2. Distance from sinus floor to alveolar crest in treated sites at the follow-up appointment (Fig. 1, B).
3. Radiographic bone gain (G) was calculated: the distance from implant shoulder to the sinus floor at baseline was compared with the distance from implant shoulder to the edge of the graft (or new bone) as revealed in the control x-ray. Reduction of the graft (R) is the difference between the height of the graft measured from the implant shoulder to the edge of the graft (or new bone) as revealed in the control x-ray and the height measured from the implant shoulder to the sinus floor in the baseline x-ray. G = B1 − B0 in the figures. Reduction of the graft (R) is the difference between the height of the graft measured from the implant shoulder to the edge of the graft (B0 + H) in the baseline x-ray and the height of the graft (or new bone) measured from the implant shoulder to the edge of the graft in the control x-ray. R = (B0 + H) − B1 in the figures.

![Fig. 1. Linear measurements made on the periapical radiographs. A, Baseline radiograph. B, Control radiograph. Radiographic bone gain (G) is the difference between the height of the graft (or new bone) measured from the implant shoulder to the edge of the graft (or new bone) as revealed in the control x-ray and the height measured from the implant shoulder to the sinus floor in the baseline x-ray, G = B1 − B0 in the figures. Reduction of the graft (R) is the difference between the height of the graft measured from the implant shoulder to the edge of the graft (B0 + H) in the baseline x-ray and the height of the graft (or new bone) measured from the implant shoulder to the edge of the graft in the control x-ray. R = (B0 + H) − B1 in the figures.](image1)

![Fig. 2. Lifting drills with a small cutting angle of 30 degrees.](image2)
the new sinus floor at the time of last examination (Fig. 1, A and B).

4. Height of the graft (or new bone, in the control x-ray image) from the floor of the sinus to the edge of the graft mesial and distal to the implant (Fig. 1, A).

5. Reduction of the graft ($R$) was calculated: the difference between the height of the graft measured from the implant shoulder to the edge of the graft in the baseline x-ray and the height of the graft (or new bone) measured from the implant shoulder to the edge of the graft in the control x-ray (Fig. 1, A and B).

When no visible radio-opaque grafting materials were used, it was impossible to measure the graft height and therefore to calculate the reduction of the graft. In these cases, only the radiographic bone gain was calculated. Every linear measurement was reported as a mean between the mesial and the distal measurement. A difference of $<0.5$ mm was considered as good interoperator agreement, ie, a clinically nonsignificant discrepancy.

At the clinical and radiographic examination after functional loading, the following parameters were also evaluated: survival of implants and restorations; pocket probing depth in millimeters; periimplant radiographic bone loss measured from the implant shoulder to the first bone-to-implant contact. It was calculated as an average of mesial and distal bone changes from the preoperative values. The final value was calculated by averaging the average bone loss per patient. The standard of success for implant function established by Albrektsson et al$^{27}$ was applied.

### Surgical Procedure

All patients had been treated with implants placed in the posterior maxilla using the specific sequence of lifting drills$^{16}$ (Fig. 2). The set of drills included 11 pieces with the same diameter (3.1 mm) but with increasing length (2, 3, 4, 5, 6, 7, 8, 9, 10, 11, and 12 mm). All patients were treated according to the following surgical protocol. Patients rinsed 0.12% chlorhexidine for 1 minute before surgery. Under local anesthesia, a full-thickness flap was opened. If necessary, vertical releasing incisions were made. The location of the implant was marked with a small-diameter pilot-drill of 1 mm in length working through the cortical bone. Then a larger-diameter intermediate drill was used. An implant site was prepared about 1 mm below the sinus floor using a lifting drill that was 1 mm shorter than the height of the alveolar crest.

A parallel pin was inserted into the surgical site and an intraoperative x-ray revealed the exact length of the alveolar ridge below the sinus floor. The first lifting drill that was 1 mm longer than the length of the measured alveolar crest was then used and pushed into the site until the shoulder stop reached the ridge. With a special rounded probe, a check was made of the alveolar bone to determine that it was perforated and that the sinus membrane was ready to be lifted: the Valsalva maneuver (nose-blowing test) showed no perforations (Fig. 3).

Then, the graft was gently pushed into the site using a particular instrument called “body-lifting”; this step was repeated until the site was filled with the graft. Another x-ray was taken to check the lift and its height. A self-tapping implant was then inserted. The type of implants placed had a variety of surfaces (microtexture and hydroxyapatite) and designs: Spline, Screw-Vent, and Screw-Vent Tapered (Zimmer Dental, Carlsbad, CA). All implants were submerged. The time between implant placement and their exposure was approximately 6 months. Subsequent prostheses included single-tooth restoration, multiple-unit implant supported restorations, and overdentures. All implants had to be in function for a minimum of 24 months (Fig. 4).

### Statistical Analysis

The quantitative data were expressed as average ± SD. The Student
The statistical significance was set at $P < 0.05$. Implant survival was expressed as the percentage of lost implants in relation to the total number of implants inserted. The data were subjected to Kaplan-Meier analysis to provide a cumulative SR.

RESULTS

Over the 10-year period (1999–2009), 134 implants were inserted in 117 patients. The average follow-up time was 48.2 months ($\pm$ 29.30 months; range, 24–120 months). Sixty implants used in this study were Spline (Zimmer Dental); 10 implants were Screw-Vent (Zimmer Dental); and 64 implants were Tapered Screw-Vent (Zimmer Dental). The majority of those (50.7%) were standard implants with a diameter of 3.7 or 3.75 mm; 18.7% were implants with a diameter of 4.1 mm; 20.9% were wide-body implants with a diameter of 4.7 mm; 9.7% were implants with a diameter of 5 mm. The most frequently placed implant length was 11.5 mm (placed in 46.3% of cases) followed by 13 mm implants that were placed in 28.3% of cases. Ten-millimeter long implants were used in 23.2% of cases, whereas 15-mm long implants were used in only 2.2% of cases (Table 1).

Fifty percent of the implants placed with this crestal approach were inserted in the position of the first molar; the second most common position was the second bicuspid in 38% of cases; and the third most common position was the second molar in 12% of cases. The cumulative SR of the implants was 96.3% (95% CI) (Fig. 5).

Table 1. Demographic Information of Implants Placed

<table>
<thead>
<tr>
<th>Diameter (mm)</th>
<th>10</th>
<th>11.5</th>
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<td>11</td>
<td>6</td>
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<td>3.75</td>
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<td>22</td>
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<td>4.1</td>
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<td>4.7</td>
<td>8</td>
<td>13</td>
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<td>5.0</td>
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Of the original 134 implants placed, a total of 5 implants (3.7%) failed. Four implants were lost before loading: 1 implant was lost due to acute infection after 35 days. In 2 cases, the implants did not osseointegrate and were removed after approximately 2 months. The fourth implant that was lost before loading was removed after 6 months when the implant was exposed. The fifth implant was lost after a loading time of 63 months due to periimplantitis.

The perimplant bone loss of each of the 129 implants placed successfully was measured mesially and distally. The range of marginal bone loss was 0 to 2 mm both mesially and distally in 128 implants showing an average value of 1.07 mm ($\pm$ 0.40 mm) mesially and 1.20 mm ($\pm$ 0.51 mm) distally. Only one implant showed a greater marginal bone loss, measuring 3.5 mm mesially and 4 mm distally, due to periimplantitis occurring during the healing period. The periimplantitis was treated according to the implant maintenance and treatment protocol cumulative interceptive supportive therapy. Thirty-eight months after supportive therapy, the implant was normally in function with no further bone loss. No other complaints or adverse effects were observed during the follow-up time.

The average residual bone height was 3.46 mm ($\pm$ 0.91 mm) at baseline. The average height of the alveolar crest in the treated implant sites was 9.94 mm ($\pm$ 2.29 mm) at the time of follow-up examination. The measured mean radiographic bone gain using this technique was 6.48 mm ($\pm$ 2.38 mm) (Table 2).

In this study, 7 different types of grafting materials were used (autoge-
nous bone, deproteinized bovine bone mineral, collagen, hydroxyapatite, de-mineralized freeze-dried bone allograft, tri-calcium phosphate, and mineralized human bone allograft) alone or in various combinations. Because of the heterogeneity of the grafting materials, no comparative statistical analysis could be performed with regard to the 7 individual materials.

It was however possible to calculate the reduction of the graft for 79 of the 129 successfully inserted implants. In these cases, a radio-opaque grafting material was used. Immediately after implant insertion, the height of the graft was 9.40 mm (±1.63 mm). At the follow-up examination, this height had reduced by 1.82 mm (±1.03 mm) to 7.58 mm (±2.03 mm) (P < 0.05) (Table 3).

**DISCUSSION**

Since their introduction into clinical practice, different sinus augmentation procedures have demonstrated their effectiveness regarding the enhancement of native bone in maxillary areas with atrophic ridges and pneumatized sinuses. Boyne and James in 1980 proposed a lateral approach for sinus lifts. The access to elevate the sinus floor. During the 1980s, less invasive clinical practice techniques using a crestal approach were introduced. These procedures were based on the use of osteotomes or sequential drills and allowed simultaneous implant placement and sinus floor elevation obtained by graft insertion. Additionally, this drill technique eliminated hammering and therefore proved to be more acceptable to patients.

Evidence available today indicates that crestal techniques with simultaneous implants insertion are predictable and safe with excellent SRs. However, it is generally considered that the crestal approach requires a minimum of 5 mm of residual bone height due to the risk of tearing the membrane and the difficulty of obtaining primary implant stability in thin ridges. For this reason, an osteotome-staged approach with 6 months delayed implant insertion has recently been proposed with encouraging results.

Because osteotome techniques enabled a maximum increase in bone height of 3 to 4 mm, some authors proposed the use of short, porous-surfaced implants, with or without sinus floor elevation, in extremely atrophic ridges. The results are undoubtedly encouraging (97%–99%) but are still based on limited cases and supported only by short-term follow-up. In the present multicenter retrospective report, the 134 implants immediately inserted into sites with <5 mm (average height, 3.46 ± 0.91 mm) showed an excellent SR (96.3%) (Fig. 8) calculated on a significant follow-up period (48 months).

This result is better than an analogous retrospective report based on an osteotome technique that showed a lower SR in atrophic ridges (85.7%). This result can be explained by a reduced risk of damaging the sinus membrane by using sequential drilling. This outcome is confirmed by the gain in bone height obtained in this study (6.48 ± 2.38 mm) (Table 2), which is greater than the increase observed using the osteotome technique (3–4 mm). This difference may also be attributed to the fact that only non-smokers were selected in this investigation due to the fact that nicotine has a negative impact on bone healing and sinus augmentation procedures.

Another report showed 9.12 mm of bone gain but with a lower SR (91.4%) and in a shorter follow-up period (22 months) with localized management of the sinus floor, a modified osteotome technique without graft insertion. Other studies using the osteotome technique with no graft showed an average gain in bone height of between 1.7 and 3.5 mm. The average length of implant used was approximately 11 mm and the average diameter was 4 mm (Table 1). These data confirm that the crestal sequential drill approach enables the development of a satisfactory bone height for simultaneous insertion of implants of adequate length and diameter as suggested in the literature.

Despite the heterogeneity of grafting materials, it was possible to calculate the contraction of the graft in 79 of the 129 successfully inserted implants in which a radio-opaque grafting material was used. In these cases, immediately after implant insertion, the height of the graft was 9.40 ± 1.63 mm and, at the time of follow-up examination, this height had reduced by 1.82 ± 1.03 mm to 7.58 ± 2.03 mm (Table 3), ie, approximately 20%, which is similar to the data available in another report.

**CONCLUSION**

This retrospective investigation suggests that the crestal sequential drill approach (Cosci’s technique) can be a successful sinus lifting procedure in a severely atrophic maxilla with <5 mm of crestal bone height.

**DISCLOSURE**

The authors claim to have no financial interest in any company or any of the products mentioned in this article.

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**REFERENCES**


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