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Abstract

This retrospective study aimed to radiographically assess sinus floor remodeling after using a modified osteotome technique without graft materials or membranes. After pilot drilling, residual bone was fractured and raised with the Schneiderian membrane to the final implant length using osteotomes. Self-tapping implants were placed, and restorations were performed six months later. Twenty-four patients were available for follow-up after a mean ± SD observation period of 17.6 ± 8.4 months. Implant survival rate at that time was 100%. Bone filling around the implants was measured and compared with baseline digital radiographs. New bone formation was 86.3 ± 22.1% mesially and 89.7 ± 13.3% distally. In nine cases, digital volume tomography was used to verify regeneration. Within the limitations of this evaluation, the Schneiderian membrane guided considerable bone regeneration and good clinical success was achieved despite the omission of graft materials.

Introduction

In the posterior maxilla, implant placement is frequently complicated by unfavorable postextraction bone resorption patterns, pneumatization of the maxillary sinus, and the often poor quality of the remaining alveolar bone.[1] In a clinical situation where less than 8 mm of bone is available below the maxillary sinus, a sinus grafting procedure with lateral access is often recommended to provide sufficient support for dental implants.[2-4] In an attempt to augment bone for implant placement in a simpler, less invasive manner, Summers proposed the osteotome technique.[5] In contrast to the more invasive lateral approach, this method uses an internal sinus lift, which is performed using sequentially sized osteotomes to fracture the residual alveolar bone crestal to the floor of the sinus. There are various techniques used to elevate the sinus floor. In most of the reported cases, grafting materials were used. These materials aim to create more bone volume to support the implant and to act as a shock absorber during osteotomy.[6]

Limited data are available regarding the use of the Schneiderian membrane alone to act as biological autologous membrane to enable bone formation supported by the implant only. The aim of this retrospective study was to clinically and radiographically evaluate implants that were placed using an osteotome technique without graft materials or membranes.

Materials & Methods

Patient recruitment

The presents study was retrospective. All procedures were approved by the local ethics committee (StV 05/03).

The computerized patient administration program of the Center for Dental and Oral Medicine of the University of Zurich was used to identify all patients who had received an implant in the Clinic for Preventive Dentistry, Periodontology and Cariology during the years

2001–2004. The clinical histories were searched for patients who received an implant in the posterior maxilla. Only patients treated with the modified osteotome technique described in detail below, with no grafting materials or membranes, were selected. Four patients meeting the criteria did not respond to an invitation for a radiographic reevaluation. Twenty-four patients were identified and evaluated. In cases where two implants were placed into the sinus of the same patient, only the implant with the highest radiographic projection into the sinus was assessed. During the patient identification and recruiting phase, no attempts were undertaken to exclude patients treated with this particular modality.

Implant placement

All patients had been treated with an implant placed in the posterior maxilla using a modified osteotome technique. Before implant placement, pre-surgical measurements of the alveolar height to the sinus floor had been made using digital radiographs (Digora, Jordi Informatik, Wolfhausen, Switzerland). A 5 mm diameter metallic sphere was used for calibration.

All patients had been treated according to the following surgical protocol. Patients rinsed with 0.2% chlorhexidine for 60 seconds before surgery. Under local anesthesia, full thickness flaps were elevated following a mid crestal incision. If necessary, vertical releasing incisions were made to elevate the flap to the mucogingival junction. The location of the implant was marked with a small diameter bur, drilling through the corticalis. An implant bed was prepared 1 mm below the sinus floor with the first 2.2 mm pilot drill (Straumann implant system, Institut Straumann AG, Basel, Switzerland). An osteotome (Institut Straumann AG) of the same diameter was used to fracture the sinus floor and to raise the membrane by careful tapping to the final implant length. Consecutive drills with diameters of 2.8 and 3.5 mm were then used to prepare the site. No osteotome was used between these two steps. Finally, to raise the mobilized membrane to the final implant length, a 3.5 mm osteotome was used for 4.1 mm

implants, and a 4.2 mm osteotome for 4.8 mm diameter implants. At all stages of preparation and osteotome application, Schneiderian membrane integrity was checked either visually or with a blunt indicator (Fig. 1). A self-tapping implant (Institut Straumann AG, Basel, Switzerland) was then placed. No bone graft or membrane was used. Flaps were sutured with 4-0 sutures (Supramid, Aesculap, Tuttlingen, Germany). Healing occurred submerged or semi-submerged. Postoperatively, patients rinsed for 60 seconds with 0.2% chlorhexidine twice daily for 10 days. Mefenamic acid (500 mg, Streuli AG, Uznach, Switzerland) was prescribed as needed for pain control. Implants were allowed to osseointegrate for six months before stage 2 uncovering procedures were performed, if required. After three weeks of soft tissue healing, impressions were made and restorations were cemented. In two patients, screw-retained bridges were inserted.

Radiographic and volume tomographic analysis

After a mean ± SD period of 17.6 ± 8.4 months, patients were recalled and radiographs were taken. The location of the actual sinus floor was compared with the baseline radiographs, which had routinely been taken after implant placement. Two investigators performed all measurements independently.

As the apical aspect of the implant was not flat, a line perpendicular to the midline of the implant was drawn to separate the mesial and distal aspects of the implant from the apex. The amount of new bone formation at the mesial and distal surfaces and the apex of the implants were measured separately (Fig. 2).

In nine patients with a clinical sinus elevation of more than 4 mm, digital volume tomography (3D Accuitomo, Morita Europe, Dietzenbach, Germany) was performed to verify regeneration (exposure time 18 seconds, tube voltage 80 kV and tube current 7.4–8.6). Measurements were made using the "I-view-3D" software (Morita Europe).

Statistical analyses

To compare inter-operator measurements, differences between the recordings of the two raters were calculated and 95% confidence intervals were computed. A difference of less than 0.5 mm was considered good inter-operator agreement, i.e., a clinically non-significant discrepancy.

Radiographic projections of the implants in the sinus at baseline and after the mean observation period of 17.6 months were measured and statistical comparisons performed using the Wilcoxon signed-rank test.

Linear regression was performed to reveal any possible relationship between baseline projection into the sinus and new bone formation.

Results

An overview of the patients and technical baseline data is given in Table 1.

The mean age of the patients was 61.9 ± 10.3 years. Nine men and 15 women were treated. In two cases, there was a small perforation of the Schneiderian membrane, which did not affect the clinical outcome, but altered bone regeneration in one case (see below). Antibiotics were administered to only one patient, in whom epistaxis occurred. No other patient reported discomfort from pain, swelling, bleeding or epistaxis after the operation. Overall, none of the 24 implants assessed in this study failed during the observation period of 17.6 ± 8.4 months.

Fourteen implants were placed in the molar region and 10 implants in the premolar region. The overall initial bone height under the sinus was 5.0 ± 1.5 mm, and the mean length of the implants used was 8.6 ± 1.3 mm.

The clinically performed sinus elevation was 3.6 ± 1.4 mm. Figure 3 depicts the mean length of implants used in the present study with respect to the mean initial alveolar bone height available.

Radiographic evaluation

The inter-operator agreement was good. Differences were not statistically significant at the mesial ($P \leq 0.783$) and distal ($P \leq 0.140$) aspect, with mean differences of 0.04 mm (confidence interval (CI): –0.2,0.28 mm) and –0.2 mm (CI:–0.47,0.07 mm), respectively.

The radiographic baseline projection of the implants into the sinus measured as the distance between the implant apex and the initial sinus floor were 2.6 ± 1.8 mm mesially and 2.8 ± 1.7 mm distally. These values decreased to a mean value of 0.3 ± 0.6 mm mesially and 0.3 ± 0.6 mm distally (Fig. 4). The mean height of the newly formed bone, calculated from the resulting difference, was 2.2 ± 1.7 mm mesially and 2.5 ± 1.5 mm distally, or, as a percentage of new bone formation, 86.3 ± 22.1% and 89.7 ± 13.3%, respectively. The relationship between the formation of new bone (y axis) and the radiographic projection in the sinus (x axis) is given in Figure 5. Linear regression showed a statistically significant correlation between the two tested parameters, with r^2 values of 0.907 ($P \leq 0.001$) mesially and 0.894 distally ($P \leq 0.0001$).

At the apex of the implant, bone formation was less accentuated, with wide variations. Only 45.2 ± 31.8% of the implant apical surface showed bone coverage (minimum 0%, maximum 100%).

Digital volume tomography evaluation

A comparison between radiographic and digital volume tomography examination is shown in Fig. 6. No statistical difference was found between the two methods. The volume tomographic examination, however, led to slightly higher measurement values. The residual sinus projection values (median; interquartile range (IQR) in parentheses) for the nine patients were 0.4 mm (1.2) mesially, 0.8 mm (1.6) distally and 3.5 mm (2.4) apically.

Radiographs showed good bone remodeling around the implants (Fig. 7). The digital volume tomography revealed impressive bone formation at the palatal and buccal aspects, which was also evident in the other cases (Fig. 8).

Discussion

The method of localized management of the sinus floor was first described in attempts to augment the sinus floor without bone grafts or membranes.[7] This method, however, used bioabsorbable collagen (CollaCote®) as a plunger. The authors reported on 499 implants (303 patients) with a success rate of 97.5 % after 2–5 years after loading. They recommended using the localized management of the sinus floor technique with at least 5–7 mm of bone under the sinus. Winter and coworkers applied the same technique and evaluated the clinical success of implants in a area with ≤4 mm of alveolar bone in 34 patients with an average vertical height of only 2.87 mm.[8] The sinus was raised by an average of 9.12 mm using a collagen cushion (CollaCote®) without bone grafts or membranes. The success rate after 22 months of loading was 91.4%. Whether the collagen sponge can be considered as graft material or not is controversial; however, this material may be used to assist hemostasis and serve as a shock-absorbing material and space-maker for bone formation.[9] Another study also used this collagen cushion with a residual bone height of ≥7 mm, and a cumulative success rate of 88.6% was reported after a mean observation period of 35 months.[10] None of these studies quantitatively reported the amount of bone formation detected in radiographs. Other studies using the osteotome technique showed an average gain of bone height of 3–3.25 mm.[6] Leblebicioglu and coworkers recently evaluated implants placed in the sinus in 40 patients using an osteotome technique with no graft or cushion materials;[11] the success rate after 25 months was 97.3%. They measured the mean gain of alveolar bone height in scanned panoramic radiographs (3.9 ± 1.9 mm).

An approach without filler materials certainly eliminates the risk of displacing graft

materials into the sinus. This is a great concern, as it can lead to transient or chronic sinusitis in 10%–20% of sinus elevation cases, prompting the need for additional treatment.[12,13] The fate of implants without graft materials and protruding 2–3 mm into the sinus were investigated by Boyne and coworkers in rhesus monkeys. Complete regeneration was shown over the whole surface. In contrast, when protrusion was 5 mm and more, only partial growth of bone occurred at the lateral and apical aspects of the implant.[14] In this study, healing of the two implants with detectable membrane ruptures were in accordance with these results. In one case, bone gain was only 3.2 mm mesially and 4.4 mm distally, compared with an initial projection into the sinus of 5.6 mm and 6.7 mm, respectively: This corresponded to a percentage bone remodeling increase of only 55% and 65%. In contrast, when the projection into the sinus was only 2 mm, as observed in the other case, bone regeneration was not hampered. Within the limitation of the relatively short observation period, both implants showed good clinical success after loading.

Toffler and coworkers suggested a minimal implant length of 8.5 mm or more to be adequate.[15] The relationship between the length of the implant placed and the preoperative residual alveolar bone crestal to the floor of the sinus appears to be significant.[6] Not only microstability, but also blood supply during the regenerative phase may play an important role. Fugazzotto therefore proposed a hierarchy of treatment selection for the augmentation of the posterior maxilla.[6] He suggested the formula $2x - 2$ for determining the maximum length of implants to be placed at the time of osteotome sinus augmentation (x is the amount of preoperative bone coronal to the floor of the sinus). With respect to the initial alveolar bone height and the length of implants used in this study, as represented by the means of the pooled data, this condition appears to be met. However, on closer examination of the data, most of the implants placed in the present study were not placed according to this guideline. Twenty-one implants had an increased implant/initial bone height ratio. For instance, for a residual bone height of 5 mm and a recommended implant length of 8 mm the calculated ratio would

be 1.6:1. This ratio approximates a ratio of 2:1 with higher values. The mean ratio for 8 mm implants in our study was 3.1 (± 1.4):1. Despite this high ratio, the exposed implant surface within the regenerative space under the sinus membrane was within or below the recommended 4–6 mm.[6] A decrease of this unfavorable ratio could only be produced by a reduction of the selected implant length. Whereas there is some evidence that short implants may be successful, there is currently no recommended clinical application for short implants in the less dense bone of the maxilla, especially in combination with a simultaneously augmented sinus.[16]

Despite the limitations of this study, it can be concluded that the described procedure allows for a high survival rate and a considerable amount of newly formed bone around the exposed implant surface.

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References

1. Fugazzotto PA. Immediate implant placement following a modified trephine/osteotome approach: success rates of 116 implants to 4 years in function. Int J Oral Maxillofac Implants 2002;17:113-120.
2. Boyne PJ, James RA. Grafting of the maxillary sinus floor with autogenous marrow and bone. J Oral Surg 1980;38:613-616.
3. Tatum H Jr. Maxillary and sinus implant reconstructions. Dent Clin North Am 1986;30:207-229.
4. Jensen OT, Shulman LB, Block MS, Iacono VJ. Report of the Sinus Consensus Conference of 1996. Int J Oral Maxillofac Implants 1998;13 Suppl:11-45.
5. Summers RB. A new concept in maxillary implant surgery: the osteotome technique. Compendium 1994;15:154-156.
6. Fugazzotto PA. Augmentation of the posterior maxilla: a proposed hierarchy of treatment selection J Periodontol 2003;74:1682-1691.
7. Bruschi GB, Scipioni A, Calesini G, Bruschi E. Localized management of sinus floor with simultaneous implant placement: a clinical report. Int J Oral Maxillofac Implants 1998;13:219-226.
8. Winter AA, Pollack AS, Odrich RB. Placement of implants in the severely atrophic posterior maxilla using localized management of the sinus floor: a preliminary study. Int J Oral Maxillofac Implants 2002;17:687-695.
9. Gray CF, Redpath TW, Bainton R, Smith FW. Magnetic resonance imaging assessment of a sinus lift operation using reoxidised cellulose (Surgicel) as graft material. Clin Oral Implants Res 2001;12:526-530.
10. Cavicchia F, Bravi F, Petrelli G. Localized augmentation of the maxillary sinus floor through a coronal approach for the placement of implants. Int J Periodontics Restorative Dent 2001;21:475-485.
11. Leblebicioglu B, Ersanli S, Karabuda C, Tosun T, Gokdeniz H. Radiographic evaluation of dental implants placed using an osteotome technique. J Periodontol 2005;76:385-390.
12. Block MS, Kent JN. Sinus augmentation for dental implants: the use of autogenous bone. J Oral Maxillofac Surg 1997;55:1281-1286.
13. Doud Galli SK, Lebowitz RA, Giacchi RJ, Glickman R, Jacobs JB. Chronic sinusitis complicating sinus lift surgery. Am J Rhinol 2001;15:181-186.

14. Boyne PJ. Osseous repair of the postextraction alveolus in man. Oral Surg Oral Med Oral Pathol 1966;21:805-13.
15. Toffler M. Osteotome-mediated sinus floor elevation: a clinical report. Int J Oral Maxillofac Implants 2004;19:266-273.
16. ten Bruggenkate CM, Asikainen P, Fiotzik C, Krekeler G, Sutter F. Short (6-mm) nonsubmerged dental implants: results of a Multicenter clinical trial of 1 to 7 years. Int J Oral Maxillofac Implants 1998;13:791-798.

Captions

Fig. 1

Panel A: Osteotome placement in the pre-prepared implant bed (4 mm) prior to osteotome application. The stop indicates the planned distance for elevation (10 mm). Panel B: The final osteotome length of 10 mm has been achieved. The stop has reached the alveolar crest. Panel C: Visual examination of membrane integrity.

Fig. 2

Illustration of the radiographic measurements. Panel A: Preoperative situation. Panel B: Implant placement and raising of the Schneiderian membrane. A line perpendicular to the midline of the implant was drawn to separate the mesial and distal aspects of the implant from the round-ended apex. Projection into the sinus was measured from the mesial (M) and distal (D) aspects to the original sinus borders. The asterisk indicates the screw thread distances for calibration measurements. Panel C: Postoperative measurement of the sinus projection after new bone formation under the Schneiderian membrane (M' and D'). Panel D: Measurement of projection at the round-ended apex pre- (R) and post-operatively (R').

Fig. 3

Mean length of implants used in this study (y axis) with respect to the mean initial available alveolar bone height (x axis). The separation line between red and green area represents the calculation "2x – 2", where x is the amount of preoperative bone coronal to the floor of the sinus.[6] Most implants in this study were longer than recommended, with an increased implant/preoperative bone ratio.

Fig. 4

Radiographic measurement of projection of the implants into the sinus. Bars indicate significant differences ($P \leq 0.05$, Wilcoxon signed-rank test).

Fig. 5

Linear regression to examine the relationship between baseline projection into the sinus and new bone formation.

Fig. 6

Projection of the implants into the sinus as measured from radiographs and comparative values determined from volume tomographic images (nine patients). No significant differences could be detected between the two evaluation methods ($P > 0.05$, Wilcoxon signed-rank test) at the mesial, distal and apical aspects. Measurements of the tomographic volumes in the buccal and palatal sinus regions are also illustrated.

Fig. 7

Radiographic images from a representative case. Panel A: X-ray after pilot drilling with indicators (2.2 mm) in situ. Panel B: Distal implant is placed in the sinus; a reactive swelling of the sinus membrane is visible. Panel C: X-ray after six months. Panel D: Final radiograph after 14 months.

Fig. 8

Radiographic (panels A and B) and volume tomographic (panels C and D) images of a treated patient 22 months after implantation. Panel D shows new bone formation at the buccal and palatal aspects of the sinus. The original sinus floor is still visible.

Fig. 1

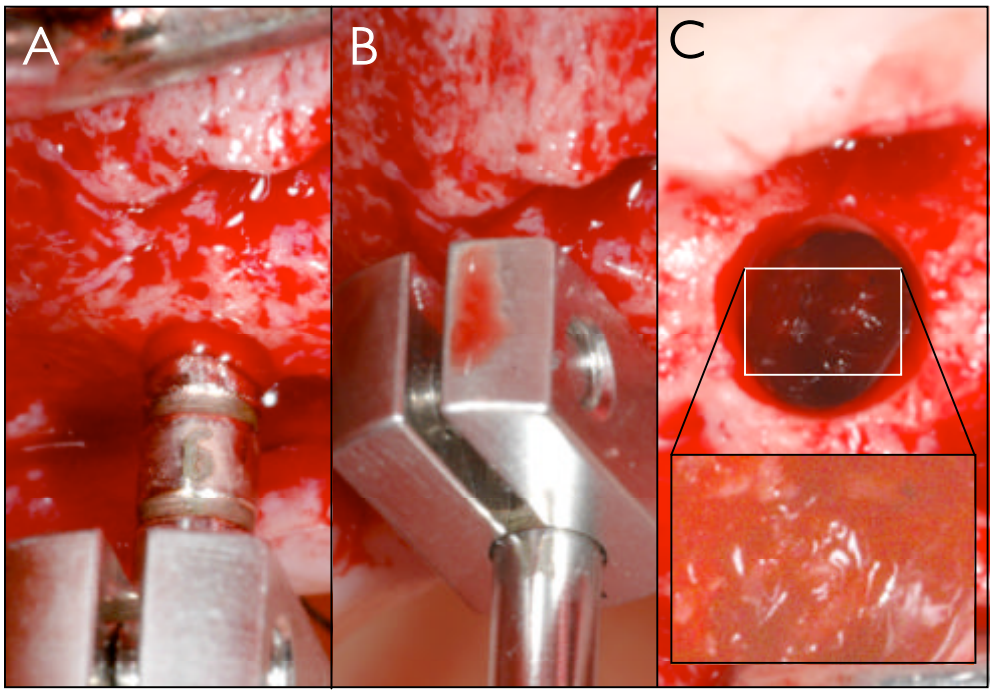


Fig. 2

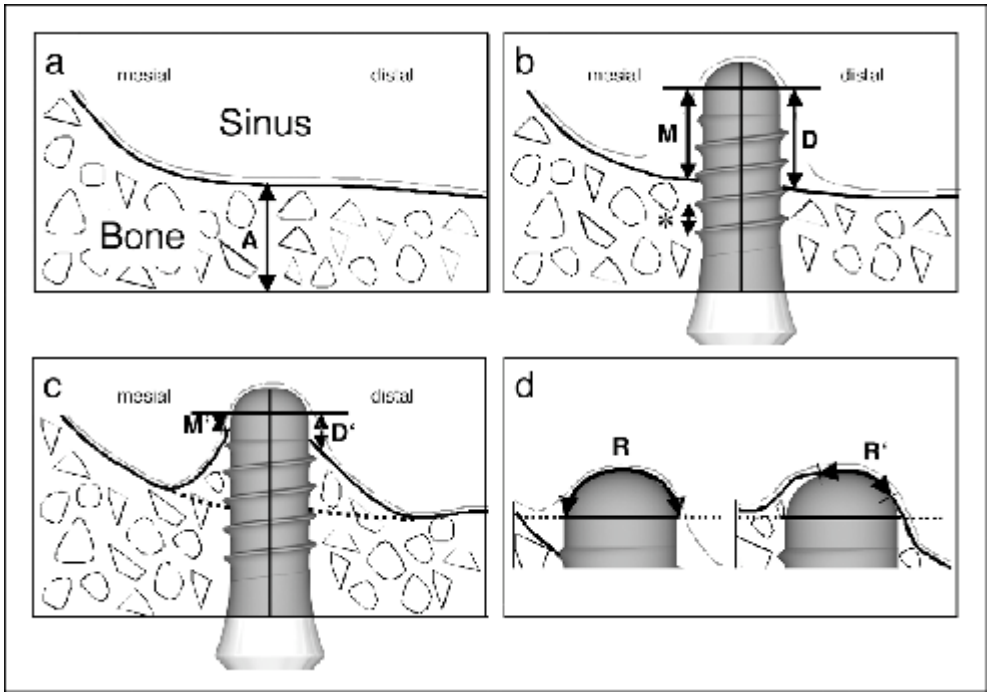

a
mesial
distal
Sinus
Bone
A
b
mesial
distal
M
D
*
c
mesial
distal
M'
D'
d
R
R'

Fig. 3

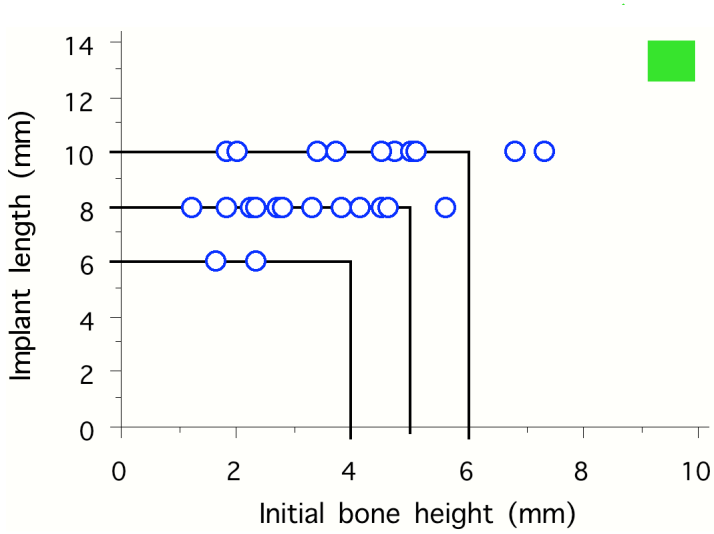

14
12
10
8
6
4
2
0
Implant length (mm)
0
2
4
6
8
10
Initial bone height (mm)

Fig. 4

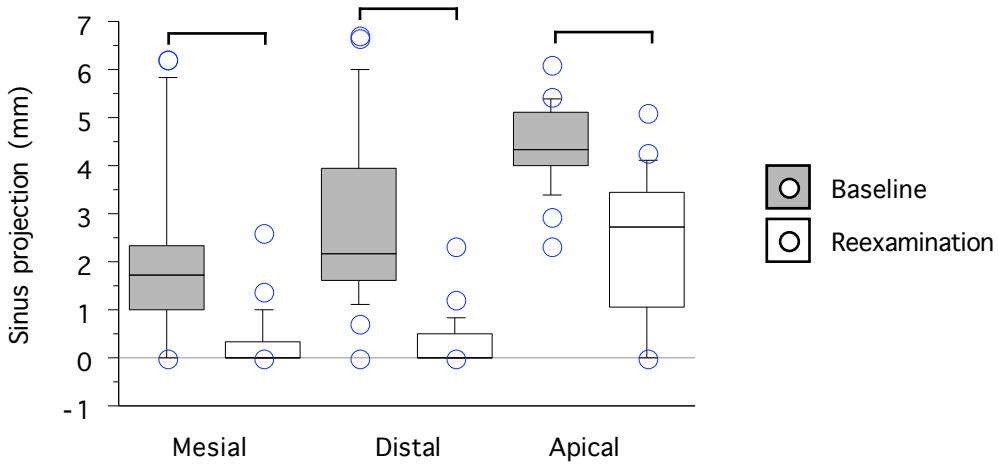
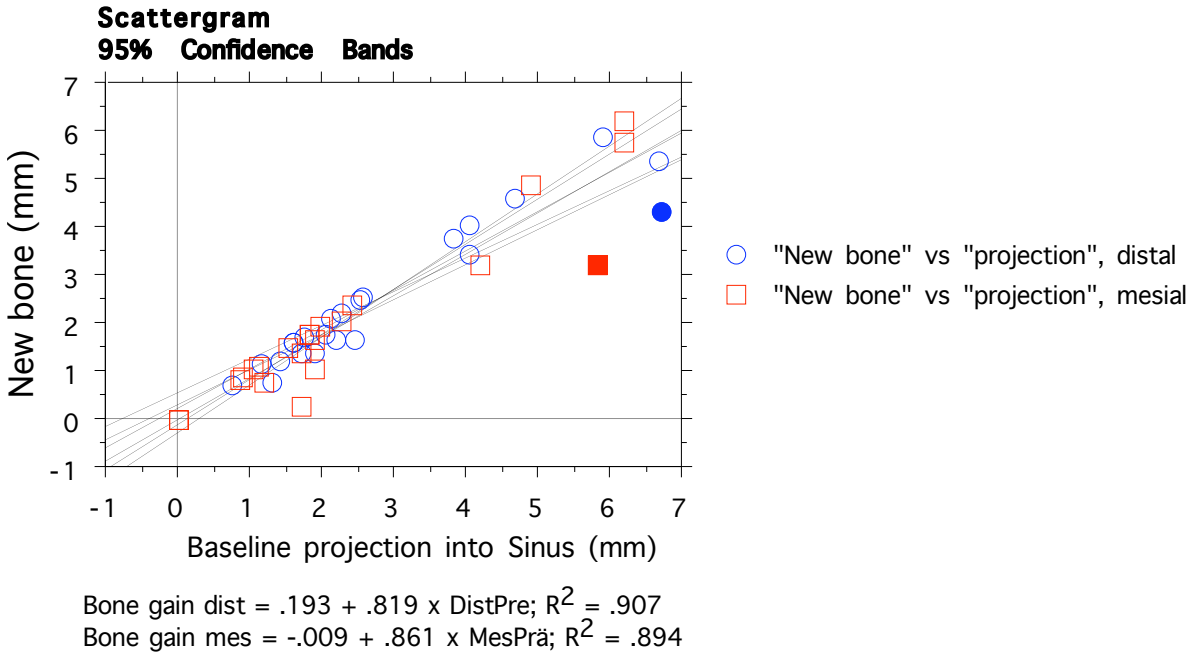

Sinus projection (mm)
7
6
5
4
3
2
1
0
-1
Mesial
Distal
Apical
Baseline
Reexamination

Fig. 5



Bone gain dist = .193 + .819 x DistPre; R^2 = .907
Bone gain mes = -.009 + .861 x MesPrä; R^2 = .894

Fig. 6

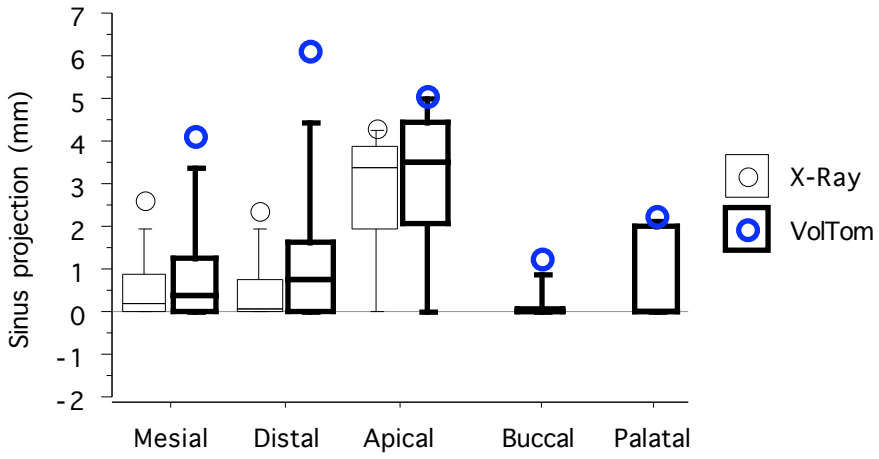

Sinus projection (mm)
7
6
5
4
3
2
1
0
-1
-2
Mesial
Distal
Apical
Buccal
Palatal
X-Ray
VolTom

Fig. 7

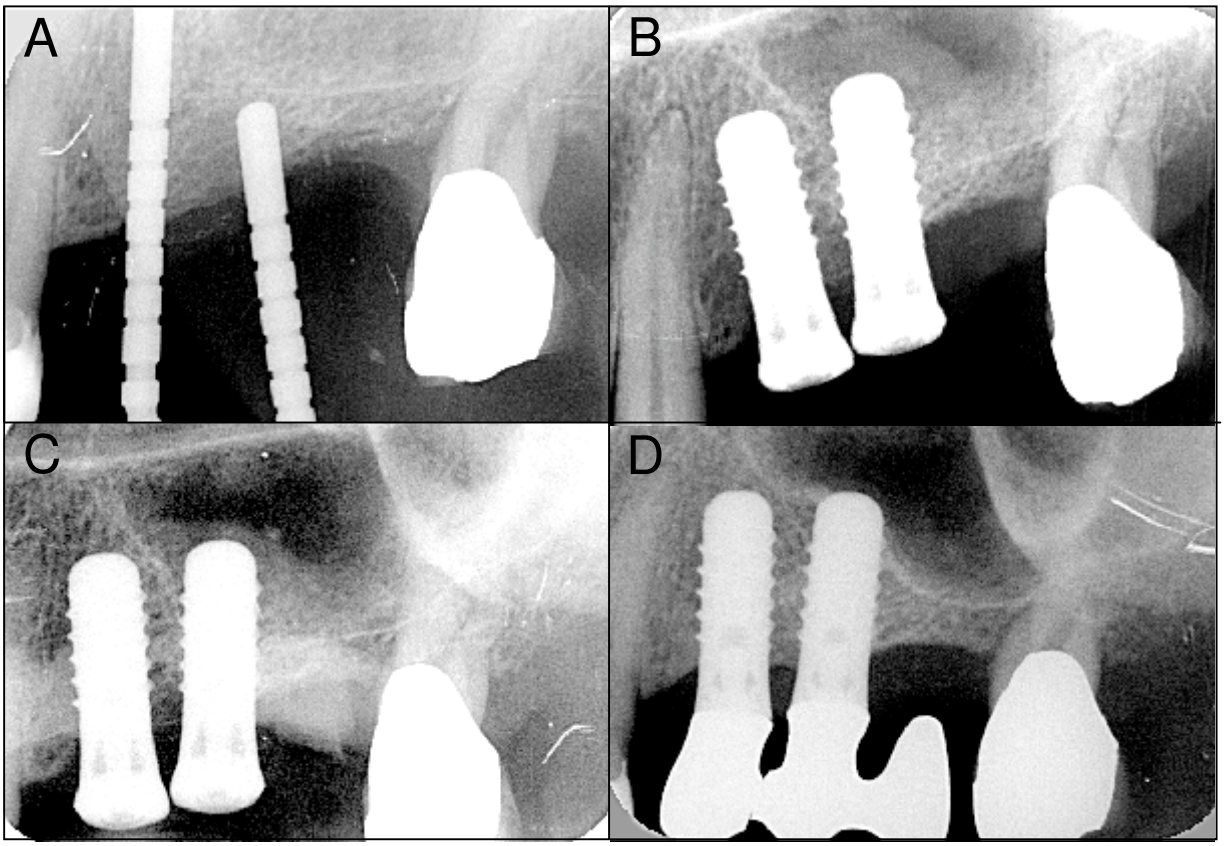


Fig. 8

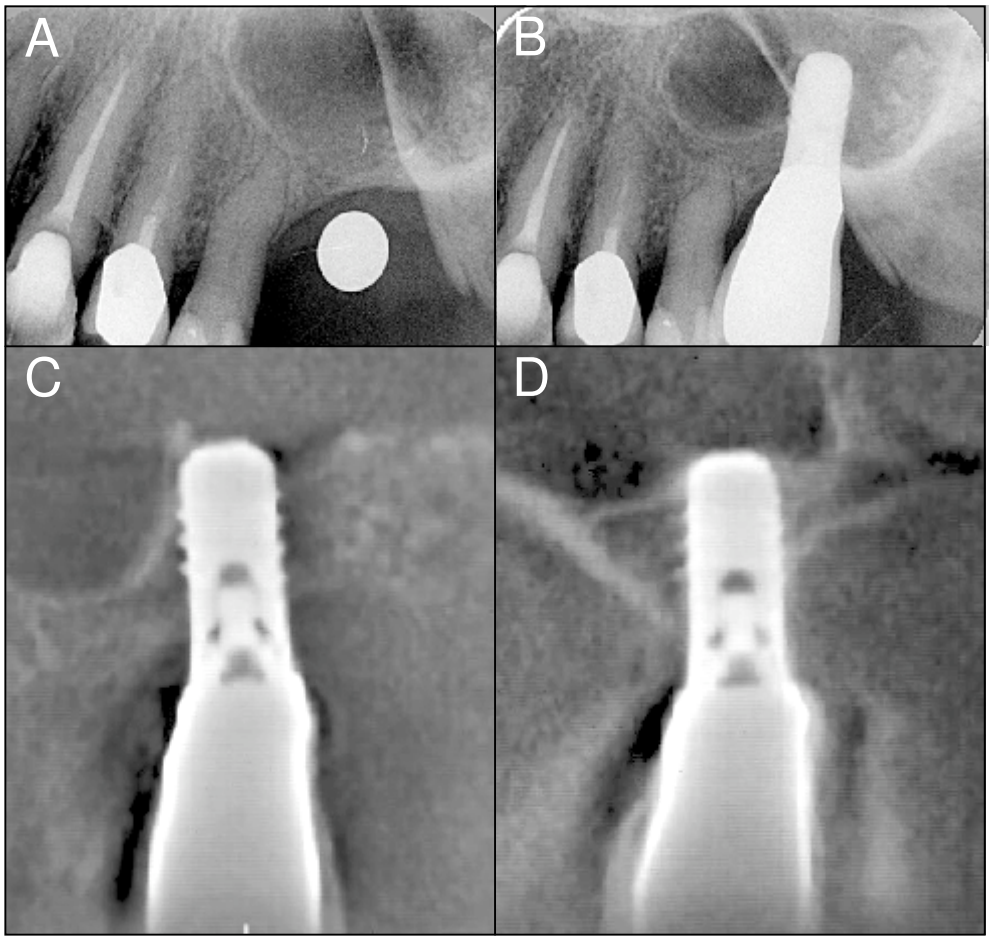


Table 1 Overview of the patients and technical baseline data.

Gender	
Female (N)	15
Male (N)	9
Age (years)	61.9 ± 10.3
Number of implants	24
Implant diameter (mean, mm)	4.4 ± 0.4
4.1 mm implants (N)	13
4.8 mm implants (N)	11
Implant length (mean, mm)	8.6 ± 1.3
10 mm (N)	9
8 mm (N)	13
6 mm (N)	2
Initial alveolar bone height (mm)	5.0 ± 1.5
Clinical osteotome sinus elevation (mm)	3.6 ± 1.6
Observation period (months	17.6 ± 8.4