

# A Prospective Study of Treatment of Severely Resorbed Maxillae with Narrow Nonsubmerged Implants: Results After 1 Year of Loading

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*The aim of the present study was to evaluate the use of reduced-diameter implants as an alternative to bone grafting for treatment of patients with severely resorbed maxillae. Forty patients (25 females, 15 males, mean age of 57 years, range 19 to 86) with insufficient bone volume for placement of standard-size implants in the maxilla (31 totally edentulous) were treated with 3.3-mm-diameter implants (ITI, titanium plasma-sprayed solid screws). Augmentation was considered for all patients because of lack of sufficient bone volume. Preoperative radiographic examination showed that in all cases, the height of the alveolar crest with a width of 4 mm was less than 10 mm. A total of 182 implants with a length of 8 to 12 mm were placed. All but 3 patients planned for overdenture treatment received fixed prostheses or single crowns (n = 3). One implant (8 mm long) was lost 1 month after placement, providing a survival rate of 99.4% after 1 year of loading. Since 4 implants with peri-implantitis were successfully treated and 1 implant left as a "sleeper" because of malposition, the cumulative success rate was 96.4%. The mean marginal bone resorption at baseline was  $0.14 \pm 0.67$  mm (range 0 to 6 mm). After 1 year of loading the mean resorption was  $0.35 \pm 1.05$  mm (range 0 to 7 mm); 4.8% of the implants had marginal bone resorption of more than 2 mm. (INT J ORAL MAXILLOFAC IMPLANTS 2001;16:731-736)*

**Key words:** bone resorption, clinical study, dental implants, maxilla

A number of recent studies have evaluated bone grafting in the atrophied maxilla as a part of treatment involving dental implants. However, the inclusion criteria have not been clearly defined. The numbers, length, and diameters of implants required for the successful treatment of atrophied maxillae remains in question.

Limited quantities of bone in edentulous maxillae can restrict the placement of long, standard-diameter implants. In some cases, bone augmentation procedures are necessary to enable implant placement. The results from studies on different bone grafting techniques using machined screw-type implants have generally shown that the implant

failure rate is higher<sup>1-8</sup> than for standard treatment procedures.<sup>9-11</sup> It has also been shown that the implant failure rate is higher in situations with poor bone quality<sup>12,13</sup> and when implants shorter than 10 mm are used.<sup>10-16</sup>

There is evidence from animal research that increased surface roughness results in more bone-implant contact as compared to smoother surfaces.<sup>17-19</sup> A higher resistance to removal torque forces has also been demonstrated for rough implant surfaces, which suggests stronger bond between rough implants and bone tissue.<sup>18,19</sup> However, comparative clinical studies have demonstrated no statistically significant differences between titanium oxide grit-blasted and machined screw-type implants, although a tendency toward lower failure rates for rough implants was seen.<sup>20,21</sup> A number of follow-up studies of titanium plasma-sprayed (TPS) hollow-basket and solid-screw implants have demonstrated similar survival rates when compared to machined screw-type implants,<sup>20,22-25</sup> while TPS cylinders have shown lower short-term failure rates but similar

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**Table 1** Distribution of Bone Quality and Quantity by Implant Site (n = 182)\*

	Bone quality				Bone quantity				
	1	2	3	4	A	B	C	D	E
No. of implant sites	0	21	86	75	0	0	109	73	0

\*According to Lekholm and Zarb.<sup>38</sup>

high long-term failure rates as compared to the machined implants.<sup>22</sup> No long-term (> 5 years) radiographic data have been presented for TPS implants, but long-term data on machined screw-type implants generally show minor bone resorption over time.<sup>9</sup> The present lack of evidence for clinical superiority of rough-surfaced implants, in spite of the data from animal studies, may be related to the fact that surface roughness is not as important in good-quality bone. If there are benefits in the use of rough-surfaced implants, these should be evident in clinically compromised bone situations.<sup>26</sup> For instance, it is possible that short and/or narrow rough-surfaced implants can be used in situations of limited bone volume, which would otherwise require bone augmentation for the use of standard-sized implants. If a bone augmentation procedure could be avoided, this would be beneficial in many aspects; for instance, no extraoral donor site is needed, and less surgical and healing time is needed, at least in comparison to a 2-stage augmentation procedure.

This study was designed to evaluate the clinical efficacy of narrow-diameter TPS implants in the reconstruction of severely resorbed maxillae.

## MATERIALS AND METHODS

### Patients

Forty consecutive patients (25 females, 15 males) with a mean age of 57 years (range 20 to 86) referred for implant treatment of their partially or totally edentulous maxillae were included in the study. One surgeon performed all surgeries in 2 clinics.

Thirty-one of the patients were completely edentulous and 9 were partially edentulous (3 required single-tooth replacements). All patients were planned for fixed prostheses or crowns, except for 3 patients for whom overdenture treatment was chosen. The inclusion criterion was insufficient bone volume for placement of standard-sized implants as judged from tomographs of the anticipated implant placement area (Table 1). Preoperative radiographic examination showed that the height of the alveolar

crest, with a width of 4 mm, was less than 10 mm in all patients. The exclusion criterion was severe illness; smoking was not regarded as an exclusion criterion. Included patients had originally been planned for augmentation procedures (maxillary sinus floor augmentation, onlay bone grafting, or interpositional bone grafting) depending on location of the atrophy and the maxillomandibular relationship.

### Surgical Procedure

All implants used in this study were TPS solid titanium screws (ITI, Straumann, Waldenburg, Switzerland). Treatment planning and the surgical procedures were performed according to manufacturer instructions and accepted practice.

All patients were treated under local anesthesia of approximately 10 mL 2% lidocaine with 12.5 µg epinephrine (Xylocaine-Adrenalin, Astra, Södertälje, Sweden). All patients received 2 g penicillin (Kåvepenin, Astra) 1 hour preoperatively and 2 g daily for 10 days postoperatively.

All 182 implants were placed using a 1-stage surgery. Of the 182 implants placed, 88% were 3.3 mm in diameter and 8 to 12 mm long (Table 2). The remaining 12% of implants were 4.1 mm in diameter and were placed when bone conditions permitted. In most of the implant sites, some threads were visible as either buccal or palatal fenestrations (Fig 1), although a few sites showed marginal buccal dehiscence defects with exposed threads. In none of the cases were the bone conditions in accordance with the ITI consensus.<sup>27</sup> After implant placement, all patients rinsed with a surface antimicrobial antiseptic solution (chlorhexidine) 2 times daily for 10 days.

### Prosthetic Procedure

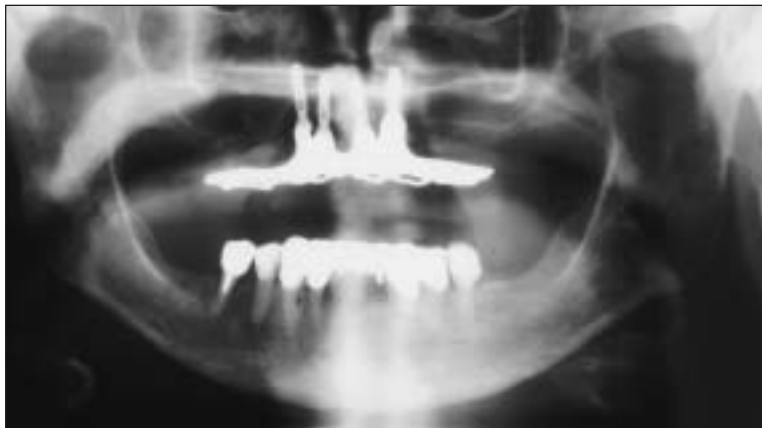
The patients' existing prostheses were modified with resilient liners (Viscogel, Dentsply, York, PA) during the healing period. The liner was replaced every fourth week until the definitive prostheses were seated. The mean healing time prior to loading was 4.6 months (range 3 to 6 months). Octa abutments were used in all cases except the overdenture cases, where ball attachments were used. All patients were rehabilitated with fixed prostheses or crowns, except for 3, who received overdentures. In 5 patients, fixed prostheses were fabricated on 4 implants (Fig 2). Prosthodontic treatment was performed according to the manufacturer's protocol and procedures described in the consensus statement.

No patients had removable mandibular prostheses. Two patients had fixed prostheses and the other patients were dentate, although most were restored

**Table 2** Placed Implants (n = 182)

Dimensions	No. placed	No. lost	No. with peri-implantitis	No of sleepers
3.3 × 8 mm	7	1	—	—
3.3 × 10 mm	26	—	—	—
3.3 × 12 mm	15	—	—	—
3.3 × 8 mm*	10	—	—	—
3.3 × 10 mm*	59	—	4	—
3.3 × 12 mm*	43	—	—	1
4.1 × 8 mm	2	—	—	—
4.1 × 10 mm	1	—	—	—
4.1 × 12 mm	8	—	—	—
4.1 × 8 mm*	3	—	—	—
4.1 × 10 mm*	3	—	—	—
4.1 × 12 mm*	5	—	—	—

\*Esthetic Plus Implants. (The polished neck was 1 mm shorter.)

**Fig 1** (Left) Buccal fenestrations after implant placement.**Fig 2** (Below) Postoperative panoramic radiograph of 4 implants retaining a fixed prosthesis.

with crowns. All patients had at least 10 remaining teeth in the mandible. In all patients, the fixed prostheses, including the cantilevers or the crowns in the maxilla, had opposing tooth contacts.

### Follow-up

All patients were followed for 1 year post-loading and were monitored according to research protocol. No drop-outs were experienced, except for 1 patient who died. Clinical recordings of implant stability were carried out at baseline and at the 1-year follow-up examination. All screw-retained prostheses were removed at 1 year to facilitate examination of the implants for stability.

### Radiographic Examination

Tomographic radiographs were obtained preoperatively with the Scanora technique (Soredex Corpora-

tion Ltd, Helsinki, Finland). Six months after implant placement and 1 year after loading, panoramic and periapical radiographs were obtained. Marginal bone levels were measured on the periapical radiographs (measurements were not standardized). The marginal bone level was measured as the distance from the crown/implant border to the most coronal contact between the marginal bone and implant. Measurements were made distally and mesially at each implant and the marginal bone level was calculated as a mean for each implant. All measurements were performed twice by a single examiner, with an interval of 3 months between measurements.

### Life Table and 4-Field Analysis

Implant survival and success were evaluated according to Roos and associates<sup>28</sup> using the following definitions:

- Survival = an implant still in the patient's jawbone
- Failure = a mobile or removed implant
- Success = a stable implant as individually tested with the suprastructure removed and continuously supporting a prosthesis
- Unaccounted for = an unfollowed implant

## RESULTS

Of the 182 implants placed, 176 could be followed throughout the observation period (Table 2). One failure was experienced (an 8-mm-long implant) during the postoperative healing period. One implant was not used and left as a sleeper (not a success) because of malposition. One patient with 4 short implants died 2 weeks after prosthesis placement. The survival rate after 1 year of loading was calculated to be 99.4%. Four implants in 3 patients showed signs of peri-implantitis (designated as failures), giving a success rate of 96.4%. These implants were surgically exposed and cleaned with chlorhexidine gel. In addition, the patients were placed on antibiotics (doxycycline) for 3 weeks. One of the implant sites was also reconstructed using the guided bone regeneration technique and bovine hydroxyapatite (Bio-Gide + Bio-Oss, Geistlich, Wolhusen, Switzerland) because of a large defect. These 4 implants have shown no further symptoms 1 year after treatment. All implants involved with peri-implantitis were in edentulous patients wearing dentures during the healing time. The patient who experienced problems with 2 of her 6 implants was a heavy smoker (more than 20 cigarettes/day). Five implants were malpositioned to the buccal, which resulted in screw holes on the buccal surface of the replacement teeth. In 8 implant sites in 5 patients, the implants were totally or partially covered by overgrown mucosa after the initial healing period. This necessitated surgical soft tissue removal prior to prosthetic treatment.

The mean change in marginal bone height from the time of implant placement to prosthesis placement was 0.14 mm  $\pm$  0.67 mm (range 0 to 6 mm) and from implant placement to 1 year of loading was 0.35 mm  $\pm$  1.05 mm (range 0 to 7 mm); 4.8% of the implants exhibited marginal bone resorption of more than 2 mm.

## DISCUSSION

The patients treated in this study were all candidates for bone grafting procedures. In spite of this, favor-

able outcomes were obtained using narrow-diameter and short TPS implants for anchorage of fixed prostheses and overdentures. Only a few complications were observed. These included loss of 1 implant and peri-implant infection and bone loss around another 4. However, the latter were successfully treated by surgical cleaning and the use of antibiotics.

Several grafting techniques have been described involving implant treatment of severely resorbed maxillae.<sup>1-8</sup> However, the efficacy of bone grafting procedures is difficult to assess, since no studies with ungrafted controls have been performed. It is generally anticipated that in cases of severe atrophy, implant treatment is not possible. Thus, the influence of inclusion criteria has not been examined, and limits for the use of standard protocols are not known. For instance, in some studies, bone augmentation procedures have been performed with good results in situations with a residual bone height of 7 to 10 mm. Shorter implants may have also been successful for these patients.

Jensen and Geer<sup>29</sup> reported on a relationship between the height of the residual alveolar crest and the implant survival rate in maxillary sinus augmentations. More than 7 mm of bone resulted in low failure rates, and with less than 3 mm of bone the failure rate was about 74%, in spite of the augmentation procedure. Jemt and Lekholm<sup>11</sup> demonstrated a similar failure rate for short implants placed in severely resorbed maxillae as compared to similar but grafted cases after 5 years, which indicates that perhaps the grafting procedure was unnecessary from the point of view of implant survival. The results from the literature and the present study indicate that adaptation of the implants to the bone anatomy, rather than adaptation of the bone anatomy to the implants, is one way to resolve problems with severe resorption. However, this would not be an appropriate approach in sites with esthetic concerns.

The implant survival rates for machined screw-type implants in conjunction with different bone grafting techniques are generally lower<sup>30</sup> than those seen using standard protocols.<sup>13,31</sup> In this study, the success rate based on defined criteria was 96.4% after 1 year of loading. Studies concerning treatment of edentulous maxillae with TPS implants have not yet been published. The results of this study indicate that rough-surfaced implants may perform better than smoother machined implants in the restoration of the nongrafted maxilla.

In this study, only 1 implant was lost prior to prosthesis placement. This is in accordance with other studies using TPS implants.<sup>22,32,33</sup> In studies of machined implants, 3% to 7% of the implants have

been commonly lost before loading,<sup>11,14,34,35</sup> although several studies have shown much lower failure rates.<sup>11,14</sup> In a review article, Esposito and coworkers<sup>36</sup> stated that most TPS implant losses were mainly the result of peri-implantitis, while mechanical factors such as bone quality and loading were the major cause for the loss of machined implants. In the present study, 1 implant was lost because of lack of integration. Another 4 implants showed signs of peri-implantitis prior to loading. The long-term health of these implants, as well as those implants that showed marginal bone resorption but no clinical signs at the first annual check-up, is not known. If marginal bone resorption continues, this will probably be the main reason for failure, in accordance with the conclusions of Esposito and coworkers.<sup>36</sup> However, in the present study only 1 implant has been lost, in spite of the compromised bone conditions. After 1 year of loading the marginal bone resorption demonstrated a mean of 0.35 mm, which is in accordance with results using machined screw-type implants.<sup>11,31</sup>

The ITI clinical recommendation concept and consensus<sup>27</sup> described bone widths over 6 mm for standard treatment (standard implant, 4.1 mm diameter), and the majority of treated patients documented in the literature have been partially edentulous. For example, in the study of Buser and colleagues,<sup>22</sup> long-term results for maxillary implants were specified only by mean distribution with respect to anterior or posterior maxilla. The long-term results for these implants are around 87%; however, only 100 implants were followed for more than 4 years. These results indicate a long-term perspective similar to results with machined screw-type implants. Another point in this study was that 81 implants in 23 patients were placed in totally edentulous maxillae; however, only 3 of the patients were treated with a full-arch fixed prosthesis. It appears that TPS implants may give a better result than machined-surface implants in a short-term perspective.

Studies with machined screw-type implants have indicated the need for primary implant stability to minimize failures. In most studies,<sup>11,37</sup> implants were bicortically anchored to secure stability, and in grafting studies,<sup>7,38</sup> the implant lengths have often been 13 to 15 mm. In this study, most of the implants were narrower (3.3 mm) and shorter (all implants were 8 to 12 mm), and in 3 edentulous patients only 2 implants were placed to anchor an overdenture prosthesis. In 5 patients, 4 implants supported a fixed prosthesis, and the stability was apparently appropriate to tolerate loading forces in the short term.

The short-term results of this study imply that narrow and short TPS implants may be considered as a treatment alternative to bone grafting in patients with severe atrophy of the maxilla.

## CONCLUSION

The results of this study indicate that treatment with fewer, shorter, and narrower implants than for the standard procedure may be possible if using TPS (ITI) implants and may be considered in treatment planning as a good alternative to bone grafting. This treatment can involve lower morbidity for the patient and better implant survival rates than what might be expected in the short term with machined surfaces after different grafting procedures.

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