Short Implants in the Severely Resorbed Maxilla: A 2-Year Retrospective Clinical Study

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ABSTRACT

Background: Although the predictability of endosseous dental implants is well documented, the restoration of the posterior region of the maxilla remains a challenge. The placement of short implants is one therapeutic option that reduces the need for augmentation therapy.

Purpose: The purpose of this retrospective study was to assess the survival rates of 6 to 8.5 mm–long implants in the severely resorbed maxilla following a surgical protocol for optimized initial implant stability.

Materials and Methods: The study included 85 patients with 96 short (6–8.5 mm) implants (Brånemark System®, Nobel Biocare AB, Göteborg, Sweden) supporting single-tooth and partial reconstructions. The implants had a machined (54) or an oxidized (TiUnite™, Nobel Biocare AB) (42) surface. A one-stage surgical protocol with delayed loading was used. The patients were followed for at least 2 years after loading (average follow-up period 37.6 months). The marginal bone resorption was assessed by radiographic readings.

Results: Five implants were lost during the first 9 months, and four implants were lost to follow-up. The cumulative survival rate was 94.6%. Four of the failed implants had a machined surface, and one had an oxidized surface. The mean marginal bone resorption after 2 years in function was 0.44 ± 0.52 mm.

Conclusion: This study demonstrates that the use of short implants may be considered for prosthetic rehabilitation of the severely resorbed maxilla as an alternative to more complicated surgical techniques.

KEY WORDS: atrophic, initial stability, maxilla, resorption, short implants

The efficacy of dental implant treatment is well documented,[1–6] and emphasis is now placed on simplifying surgical and prosthetic protocols. One area in need of simpler treatment protocols is the posterior maxilla, where bone resorption often precedes or accompanies tooth loss; a deficient posterior alveolar ridge and increased pneumatization of the maxillary sinus result in a minimal hard tissue bed, rendering implant placement difficult. Today sinus bone grafting is an accepted treatment option in such situations and may provide sufficient bone quantity and quality for implant placement and prosthetic support.[7] However, the risk of morbidity and the time and cost of this treatment modality relative to other alternatives should be taken into account when sinus bone grafting is considered. One alternative treatment approach is the use of implant tilting,[8,9] which makes it possible to achieve good implant anchorage by benefiting from remote available dense bone structures; the use of the zygomaticus as an anchor for tilted long implants is one well-documented example.[10]

On the other hand, the use of short implants seems to be an obvious alternative in resorbed jawbones, but, historically, short implants have been associated with low success rates.[11] However, recent studies suggest that the same level of clinical success may be reached for short implants compared with longer implants.[12–14] Furthermore, it has been demonstrated by theoretical analyses that in many situations, the 2 to 3 mm most coronal part of the implant carries the major load transfer to the bone[15]; these findings may be interpreted as a rationale for selecting short implants provided that they are well anchored in the residual bone. In addition, the use of short implants offers a simpler and safer treatment owing to reduced risks of interference with anatomic structures, such as the sinus.

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Based on the above, it is believed that with an optimized implant design and insertion protocol, short implants may play a more important role in the rehabilitation of the severely resorbed maxilla.

The aim of this retrospective study was to evaluate the survival rate of short implants (6–8.5 mm) in the resorbed maxilla when applying a consistent protocol for maximum bone anchorage. The hypothesis tested was that short implants, especially with enhanced osseoconductive surfaces, have a survival rate comparable with longer implants, as previously reported.

MATERIALS AND METHODS

Eighty-five patients (30 men and 55 women; mean age 58.6 years) were selected from a group of patients treated with implant-supported prostheses at one clinic. The inclusion criterion was treatment with one or more 6 to 8.5 mm–long implants without adjunctive bone augmentation. Only implants replacing second premolars (13) or first (54) or second molars (29) were considered in the study. Available pretreatment data included medical history, long-cone periapical radiographs, panoramic radiographs, and, when necessary, computed tomography. Radiographic assessment of bone quantity and quality according to the classification of Lekholm and Zarb[16] was performed at the time of surgery. Seventy-six percent of the treated sites presented type III or IV bone quality (Figure 1).

The patients received 96 short (6–8.5 mm, mean 7.9 mm) implants (Brånemark System®, Nobel Biocare AB, Göteborg, Sweden) placed using a one-stage surgical protocol with delayed loading (3–6 months). The implant types and dimensions are presented in Table 1. Forty-two of the implants had an oxidized surface (TiUnite™, Nobel Biocare AB), and 54 implants had a machined surface. Forty-three implants were used for prostheses supported by short implants only: 15 for single-crown restorations (Figures 2 and 3) and 28 for partial restorations (see Figures 4 and 5 and Table 1). Fifty-three short implants were used together with longer implants to support partial restorations (see Figure 6 and Table 1).

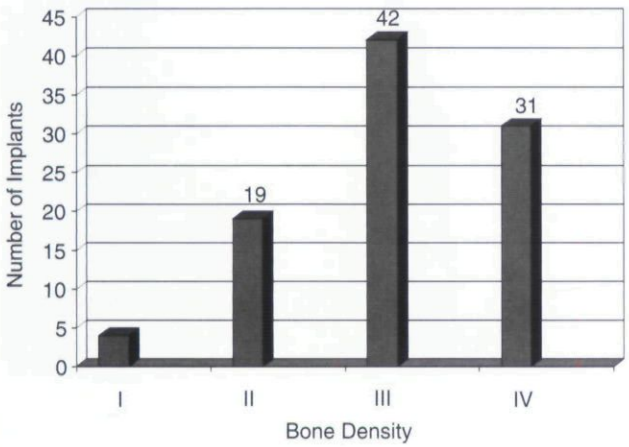

Figure 1 Bone site classification.

Surgical Protocol

The implants were inserted under local anesthesia and using crestal incisions. An adapted surgical procedure was performed to enhance initial implant stability (Figure 7).[13,17] The countersink was used to a minimum, only to facilitate implant insertion. The implants were inserted using a torque controller (OsseoCare, Nobel Biocare AB). A manual torque wrench was used in cases in which implant seating was incomplete. The implant collar was placed supracrestally. Healing or definitive abutments were installed at the time of surgery. The patients were recommended not to wear dentures for a period of 2 to 3 weeks.

Prosthetic Protocol

Healing periods of 3 and 6 months were employed for patients receiving oxidized and machined implants, respectively. Single-tooth restorations were realized on CeraOne abutments (Nobel Biocare AB). Multiple-implant restorations were screw-retained on Esthetic-Cone, MirusCone, or Multi-unit Abutments (Nobel Biocare AB). All of the crowns and bridges were made of ceramic. Attention was paid to reducing the occlusal surfaces and the cusp inclination.

Follow-Up

The patients were recalled 1 week after surgery for removal of sutures and 3 to 6 months postoperatively for delivery of the prosthesis. Thereafter, clinical and radiographic examinations were performed annually by one examiner. Periapical radiographs were obtained at implant placement, at prosthesis connection, and after 2 years of loading in 76 patients (87 implants). The marginal bone level was assessed mesially and distally by identifying the lowest observed point of crestal bone in intimate contact with the implant.[18] A 2.5× magnifying glass was used for the radiographic readings.

Implants were considered survivors when no clinical (suppuration, pain or any subjective sensation, periimplant infection) or radiographic (radiolucency

TABLE 1 Number of Short Implants per Type, Length, and Type of Prosthetic Reconstruction

Implant Dimensions, mm	Implant Surface			Number of Short Implants According to Type of Prosthesis Supported		
	N	Machined	Oxidized	Single Crowns	Short Implant Partial Restoration	Long Implant Partial Restoration
6 × 5	10	10	0	3	4	3
7 × 3.75	2	1	1	0	2	0
7 × 4	14	6	8	2	3	9
7 × 5	7	2	5	3	2	2
8.5 × 3.75	6	3	3	0	3	3
8.5 × 4	32	17	15	3	5	24
8.5 × 5	25	15	10	4	9	12

around the implant) signs of failure were detected at the last evaluation.

RESULTS

All patients were followed for at least 2 years after loading of the implants, the mean follow-up time being 37.6 months after loading (Table 2).

Implant Survival

Five of the 96 implants were lost in five patients, giving a cumulative survival rate of 94.6% (95% confidence interval 0.90–0.99) (see Table 2). Four of the lost implants had a machined surface (4 of 54) and one had an oxidized surface (1 of 42), giving survival rates of 92.6% and 97.6% for the different surfaces, respectively. The difference was not statistically significant.

Failure Analysis

A failure analysis is presented in Table 3. One failure was registered 2 months postsurgery (before loading) for a 7 × 4 mm oxidized implant in type 2 bone. Primary stability was difficult to achieve in this case owing to a very small jaw opening. The implant was replaced 2 months after the failure.

One machined implant placed in type 4 bone (7 × 3.75 mm) was lost after 1 month. The implant was not

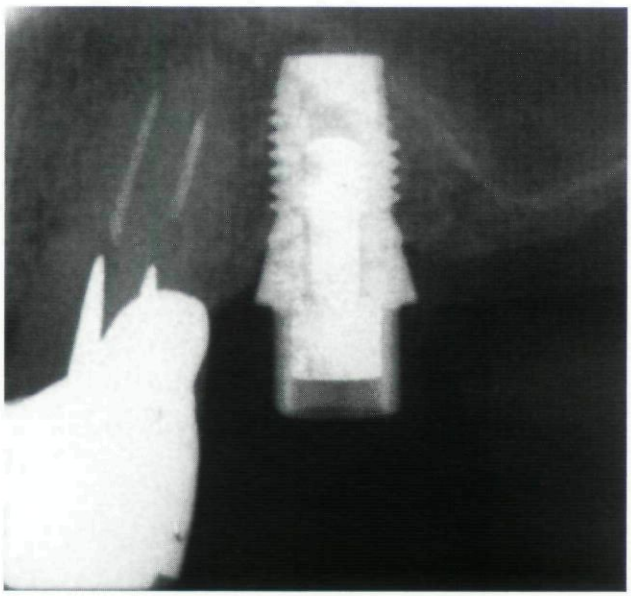

Figure 2 Single-tooth replacement. Radiograph taken at the time of definitive abutment connection.

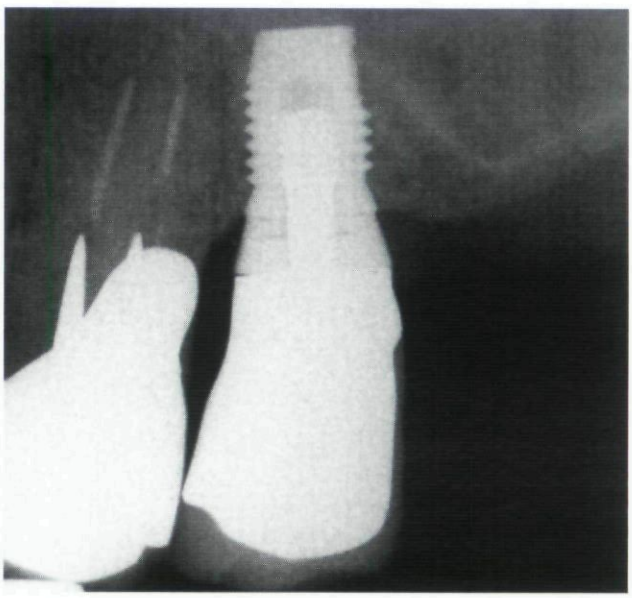

Figure 3 Single-crown restoration. Radiograph taken 5 years after loading in the same patient as in Figure 2. A wide platform implant was used to increase the load-bearing capacity. Bone stability was observed around the implant.

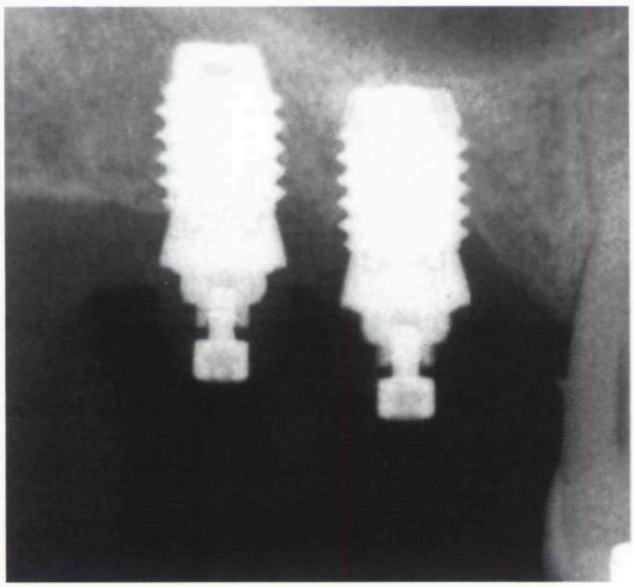

Figure 4 Baseline radiograph taken immediately after surgery showing two 6 mm–long regular platform implants.

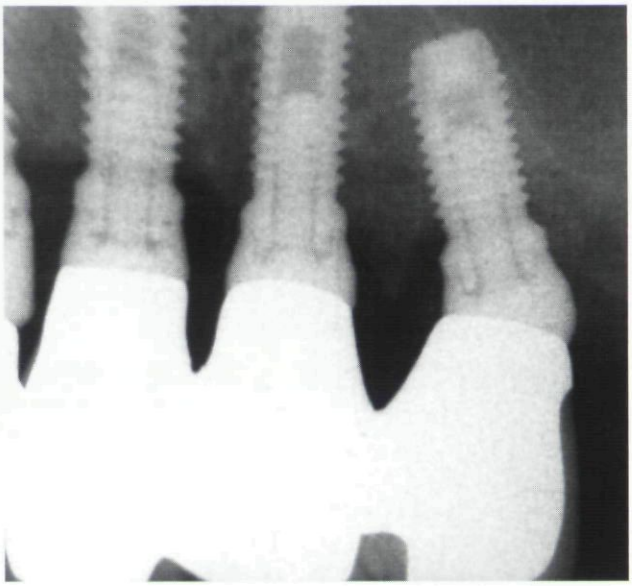

Figure 6 Radiograph taken 6 years after loading. One 8.5 mm implant is connected to longer implants placed anteriorly. The short implant has a slight mesial inclination in order to avoid the sinus cavity.

replaced, and the prosthetic treatment was successfully accomplished with a conventional fixed partial denture.

The loss of a 7 × 5 mm machined implant in a type 2 bone was observed 6 months after surgery. This implant was not replaced because satisfactory function was restored with a shortened prosthesis.

Two machined implants (8.5 × 5 mm) in type 2 and 3 bone were lost after 8 and 9 months, that is, 2 and 3 months after loading. The lost implants were not replaced, and the patients were left with shortened arcades.

Radiographic Analysis

The radiographs taken at implant placement and after 2 years in function revealed a mean marginal bone loss of 0.44 mm (Table 4). The bone loss was similar at the mesial and distal surfaces: 0.45 ± 0.51 mm and 0.43 ± 0.53 mm, respectively. Most implants ($n = 79$) showed bone resorption of 0.5 mm or less; only four implants experienced bone loss of more than 2.5 mm (see Table 3).

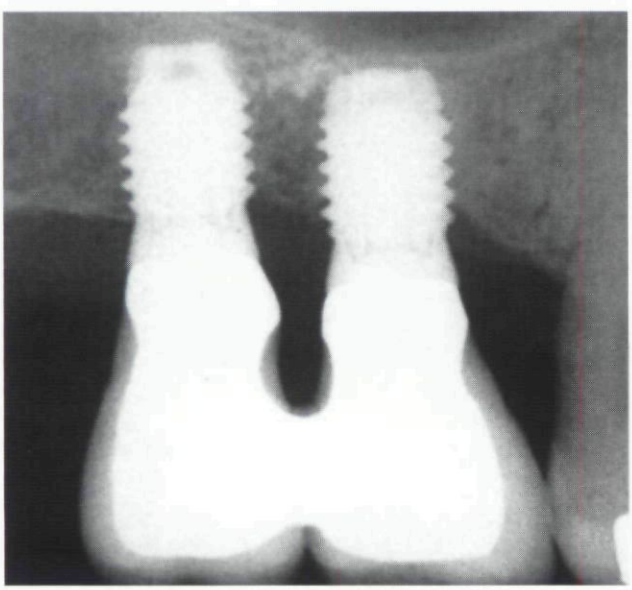

Figure 5 Partial restoration. Implants have been loaded for 4 years. Same patient as seen in Figure 4.

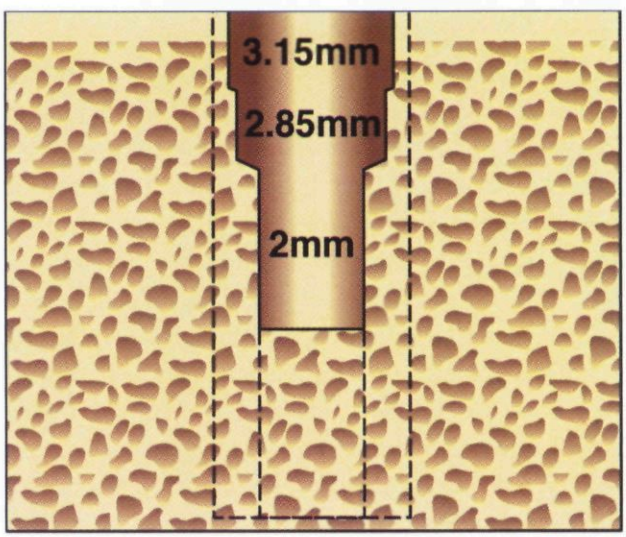

Figure 7 Drawing showing the drilling protocol used to increase implant stability. The conical or pyramidal preparation is particularly indicated in soft bone. In cases of extremely poor bone density, the 2 mm twist drill is not used on the total length.

TABLE 2 Life Table Analysis

Time Interval	Number of Implants	Failures	Withdrawn	Cumulative Survival Rate, %
Healing–loading	96	3	1	96.8
Loading–1 yr	92	2	3	94.6
1–2 yr	87	0	0	94.6
2–3 yr	55	0	0	94.6
3–4 yr	40	0	0	94.6

TABLE 3 Failure Analysis of the Five Failed Implants

Failure	Implant Position	Time of Removal, mo	Bone Quality	Implant Surface	Implant Platform	Length, mm
Primary	15	1	3/4	Machined	RP	7
	16	2	1/2	TiUnite	RP	7
	16	6	2	Machined	WP	7
Secondary	26	8	3	Machined	WP	8.5
	27	9	2	Machined	WP	8.5

RP = regular platform; WP = wide platform.

DISCUSSION

The 94.6% survival rate obtained for 96 short implants, 6 to 8.5 mm in length, in the atrophic maxilla is comparable with results reported for longer implants.[19] Other authors have previously reported similar results. Fugazzotto and colleagues obtained an overall cumulative success rate of 95.1% with implants of 7 to 9 mm in length replacing missing maxillary molars.[12] A 100% success rate was reported by Deporter and colleagues for short implants (mean implant length 6.9 mm) and simultaneous indirect sinus elevation in the posterior maxilla (mean functional time 11.1 months).[14]

Further analysis of the present data indicated somewhat inferior results for the machined implants in comparison with the oxidized implants, although the difference was not statistically significant. Experimental research and clinical histology have shown a stronger bone response to oxidized implants when compared with implants with a machined surface.[20] The results from this and other studies[21–23] indicate that surface modifications may be of importance for better treatment outcomes in demanding situations. In the studies by Fugazzotto and colleagues and Deporter and colleagues, reporting high survival rates, the implants used had a rough-surface design.[12,14]

The surgical protocol of the present study paid special attention to the achievement of high initial stability and to the effective use of the residual bone volume with maximum thread engagement in dense bone structures. This approach may have contributed to the achievement of somewhat better results than what has often been reported.[11]

The marginal bone resorption around the short implants was low (mean 0.44 mm),[24] indicating a long-term stable condition. This result also supports the surgical concept of placing the implants with little or no countersinking and leaving the head of the implant supracrestally. In this way, the implant threads have a good possibility of engaging the dense bone crest at surgery and maintaining the bone level during the healing process.

It can be argued that the 5.4% failure rate obtained in this study is significant. This result must, nonetheless, be placed in relation to the global failure rate for treatments involving bone reconstruction techniques fol-

TABLE 4 Marginal Bone Loss as Measured by Radiographic Measurements

Bone Loss, mm	Mesially	Distally
None	30	34
0–0.5	49	45
1.5	5	4
2.5	3	4
Mean	0.45	0.43
SD	0.51	0.53

lowed by placement of long implants. In a retrospective study, Raghoebar and colleagues evaluated the long-term (a mean follow-up after implantation of 58 months) clinical and radiographic outcomes after augmentation of the maxillary sinus floor with autogenous bone grafts and obtained an overall success rate of 90.8%.[25] In a systematic review realized by Wallace and Froum, the survival rates for implants placed in sinuses augmented with the lateral window technique ranged between 61.7 and 100%, with an average survival rate of 91.8%.[7]

One argument against short implants has been the unfavorable ratio of implant length to crown complex height, which may lead to vertical bone resorption. Despite a general agreement that longer implants improve the biomechanical prognosis of a restoration, this supposition contradicts the results of studies showing that increased diameter, rather than increased length, is required for improved implant anchorage.[26,27] Recently, Pierrisnard and colleagues suggested that the use of short implants may even be beneficial for the long-term biomechanical prognosis.[15] By means of finite element analyses, the authors showed that the stress intensity measured in the implant increased with the length of the implant. They also showed that short implants subjected to lateral forces tend to move within the bone, whereas longer implants with the apical portion fixed have a tendency to fold when subjected to this type of stress.

The results of the present study are encouraging and suggest further development and documentation of the use of short implants because they may offer greater simplicity and safety compared with bone augmentation procedures.

CONCLUSION

This study demonstrates that the use of short implants may be considered for prosthetic rehabilitation of the severely resorbed maxilla as an alternative to more complicated surgical techniques.

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