Short Implants Placed One-Stage in Maxillae and Mandibles: A Retrospective Clinical Study with 1 to 9 Years of Follow-Up

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ABSTRACT

Background: The use of short implants (7–8.5 mm) has historically been associated with lower survival rates than for longer implants. However, recent clinical studies indicate that short implants may support most prosthetic restorations quite adequately, but still clinical documentation is sparse.

Purpose: The purpose of this study was to report on the placement of short Brånemark implants, testing the hypothesis that short implants in atrophied jaws might give similar long-term implant survival rates as longer implants used in larger bone volumes.

Materials and Methods: This retrospective clinical study included 237 consecutively treated patients with 408 short Brånemark implants supporting 151 fixed prostheses. One hundred thirty-one of the implants were 7-mm long, and 277 were 8.5-mm long. Final abutments were delivered at the time of surgery, and final prostheses were delivered 4 to 6 months later.

Results: One hundred and twenty six of the 7-mm implants (96%) have passed the 1-year follow-up; 110 (84%), the 2-year follow-up; and 88 (67%), the 5-year follow-up. Five implants failed in four patients before the 6-month follow-up, giving a cumulative survival rate of 96.2% at 5 years. The average bone resorption was 1 mm (SD = 0.6 mm) after the first year and 1.8 mm (SD = 0.8 mm) after the fifth year of function.

Two hundred sixty nine of the 8.5-mm implants (97%) have passed the 1-year follow-up; 220 (79%), the 2-year follow-up; and 142 (51%), the 5-year follow-up. Eight implants failed in seven patients before the 6-month follow-up, giving a cumulative survival rate of 97.1% at 5 years. The average bone resorption was 1.3 mm (SD = 0.8 mm) after the first year and 2.2 mm (SD = 0.9 mm) after the fifth year of function.

Conclusions: The cumulative survival rates of 96.2 and 97.1% at 5 years for implants of 7.0- and 8.5-mm length, respectively, indicate that one-stage short Brånemark implants used in both jaws is a viable concept.

KEY WORDS: Brånemark implants, long-term, one-stage protocol, retrospective study, short implants

The use of short implants (7–8.5 mm) has long been associated with low success rates.[1,2] Their use has also been discouraged from a biomechanical point of view, when combined with poor bone quality and high occlusal loads.[3] However, the development of implant design, surface structure, and improved surgical technique has given reason to reevaluate previous results, and recent clinical studies indicate that short implants may support most prosthetic restorations quite adequately. Survival rates around 95% are reported for the rehabilitation of partial edentulism and severely resorbed maxillae,[4,5] and 88 to 100% for the atrophic mandible.[6]

Finite element analysis indicates that maximum bone stress is practically independent of implant length.[1] From studies using an experimental canine model, it was reported that increasing implant length from 7 to 10 mm did not significantly improve the anchorage.[7] Further, no differences were observed

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between short implants and other prosthetic rehabilitation modalities of the severely resorbed mandible (namely, endosseous implants with augmentation and transmandibular implants).[8]

These recent experiences indicate that today's short implants (7.0–8.5 mm), with modified surfaces and adequate implant insertion techniques, might be equally effective as longer implants. However, clinical documentation is still sparse. The purpose of this study was to test the hypothesis that short implants in prosthetic rehabilitation of atrophied jaws might give similar long-term implant survival rates as longer implants used in larger bone volumes.

MATERIALS AND METHODS

This retrospective clinical study was performed in a private clinic, Clinica Maló, in Lisbon, Portugal, and included 237 consecutively treated patients, 68 males and 169 females, with 408 implants (Brånemark System® MkII, MkIII, and Mk IV, and NobelSpeedy Shorty, Nobel Biocare AB, Göteborg, Sweden) supporting 151 prostheses. The same team performed surgery and prosthetic placement. The first implant was placed in July 1996 and the last in October 2004, and the patients were followed between 1 and 9 years. The patients' ages ranged from 27 to 86 years (mean, 55).

Two hundred seventy-two implants had machined surfaces, while 136 implants had oxidized surfaces (TiUnite™, Nobel Biocare AB). Of the 7-mm implants, 16 had 3.75-mm diameter, and 115 had 4-mm diameter, while for the 8.5-mm implants, 75 had 3.75-mm diameter, and 202 had 4-mm diameter.

One hundred thirty implants were placed in the maxilla (27.0 × 7.0 mm and 103.0 × 8.5 mm); and 278 in the mandible (104.0 × 7.0 mm and 174.0 × 8.5 mm). Fifty-eight implants supported single-teeth rehabilitations (15.0 × 7.0 mm and 43.0 × 8.5 mm); 296 implants, small bridges (100.0 × 7.0 mm and 196.0 × 8.5 mm); and 54 implants, complete edentulous rehabilitations (16.0 × 7.0 mm and 38.0 × 8.5 mm). Of the 296 implants placed in small bridge rehabilitations, 185 (68.0 × 7.0 mm and 117.0 × 8.5 mm) were splinted to longer implants.

Inclusion/Exclusion Criteria

The patients were included in the study provided they were in need of implant-supported restorations, had good general health, and had atrophied jawbone but sufficient height to place at minimum a 7-mm-long implant. The concurrent use of longer implants supporting the restorations was accepted.

As exclusion criteria, those generally used when performing implant treatment were followed.[9] Further, patients with the following conditions were excluded: immunodeficiency pathology, bruxism, stress situation (socially or professionally), emotional instability, and unrealistic aesthetic demands.

Surgical Protocol

Prophylactic presurgery and 15-days postsurgery antibiotics (Oraminax® 1 g, Wyeth Laboratories, Azevedos, Algés, Portugal), anti-inflammatory medication (Nimed®, Rhône-Poulenc Rorer, Lda, Mem Martins, Portugal), and analgesics (Clonix®, Janssen-Cilag, Barcarena, Portugal) were used. Some patients were sedated (Valium® 10 mg, Roche, Amadora, Portugal) before surgery, which was performed under local anesthesia (Rapicaine® 2% ep, lidocaine HC1 2% with epinephrine 1 : 100,000, Unipharm, Vera Cruz, Mexico). Postsurgically, a chlorhexidine gel (Elugel®, Pierre Fabre Dermo Cosmetique, Lda, Lisboa, Portugal) was placed over the area around the tooth. The patient was instructed to rinse with chlorhexidine solution (Eludril) daily for 15 days.

The insertion of the implants followed the standard procedures[10] with the following modifications: incision was performed on the palatal side of the crest for maximum tissue repositioning of the papilla, and the flaps were kept as small as possible, to maximize the blood supply to the implant site after surgery.

The drilling sequence was modified in order to achieve maximum apical compression and anchorage. For 3.75-mm implants, sites were initially prepared with 2.0-mm twist drills. The coronal one-half of these sites was then enlarged with 2.8-mm twist drills. For 4.0-mm implants, the sites were prepared with 2.8-mm twist drills. The coronal one-half of these sites was enlarged with 3.15-mm twist drills. Countersinking was eliminated in order to preserve marginal bone.[11] The minimum insertion torque for accepting the implant was 32 Ncm.

The implant platform was aimed to be 0.8 mm above the bone crest, that is, the lower corner of the cylindrical part of the implant flange was placed flush to the bone crest. Bicortical anchorage was established whenever possible. The abutment choice was made

according to the rehabilitation: For single teeth, CeraOne® abutments were used, and for small bridges and complete edentulous rehabilitations, miruscone, estheticone, or multiunit abutments were used (Nobel Biocare AB). Final abutments were attached after the implant placement, and the soft tissues were readapted and sutured back into position with 4–0 nonresorbable sutures. The abutments were protected with healing caps, but in 16 cases (23 implants), a provisional prosthesis was attached directly after surgery for immediate function.

Postoperative Protocol

The patients were instructed not to chew on the implants for 4 months. Ten days after surgery, the sutures were removed, and hygiene and implant stability were checked, a procedure that was repeated after 2 and 4 months. After 4 to 6 months, the final crowns or prostheses were placed. A clinical case is presented in Figure 1.

Dropout

Two patients with five implants died due to unrelated causes, 21 months and 2 years after implant placement; consequently, data related to these cases were withdrawn from the study.

Implant Survival Criteria

To be classified as survival, the implants needed to fulfill the following criteria: clinical stability (bridges removed and implants individually checked), fulfilled purported function without any discomfort to the patient, no suppuration or infection present, and no radiolucent areas around the implants.

Marginal Bone Evaluation

Periapical radiographs were taken at implant insertion, at 6 months, 1 year, and thereafter each year. A conventional radiograph holder was used, and its position was manually adjusted for an estimated orthognatic position of the film. The reference point for the reading was the implant platform (the horizontal interface between the implant and the abutment), and marginal bone remodeling was defined as the difference in marginal bone level relative to the bone level at the time of surgery. The radiographs were grouped as follows: implant insertion, 1-year follow-up, and 5 years and longer follow-up.

Complications

The following complication parameters were assessed: fracture of loosening of mechanical and prosthetic components (mechanical complications); soft tissue inflammation, fistula formation, pain, or infection (biological complications); and esthetic complaints of the patient or dentist (esthetic complications).

RESULTS

All implants were successfully inserted into the desired positions, achieving good primary stability. In total, 14 implants of the 408 implants placed failed, giving an overall 5-year survival rate of 96.6%.

Cumulative Implant Survival Analysis

One hundred twenty-six of the 7-mm implants (96%) have passed the 1-year follow-up; 110 (84%), the 2-year follow-up; and 88 (67%), the 5-year follow-up. Five implants failed in four patients before the 6-month follow-up, giving a cumulative survival rate of 96.2% at 5 years (Table 1).

Two hundred sixty-nine of the 8.5-mm implants (97%) have passed the 1-year follow-up; 220 (79%), the 2-year follow-up; and 142 (51%), the 5-year follow-up. Eight implants failed in seven patients before the 6-month follow-up, giving a cumulative survival rate of 97.1% at 5 years (Table 2).

One hundred thirty-one implants were placed in the maxilla (7.0 mm = 27; 8.5 mm = 104) with 10 implant losses (7.0 mm = 3; 8.5 mm = 7), giving a 92% overall survival rate (7.0 mm = 89%; 8.5 mm = 93.3%); 277 implants were placed in the mandible (7.0 mm = 104; 8.5 mm = 173) with three implant losses (7.0 mm = 2; 8.5 mm = 1), giving a 98.9% overall success rate (7.0 mm = 98.1%; 8.5 mm = 99.4%) (Table 3).

Failure Analysis

All implant losses occurred during the first 6 months of healing, before prosthetic loading, all had machined surfaces and in most cases, the bone was rather soft, being in the maxilla. The higher survival rate for the oxidized surface implants (100%) was statistically significant (chi-square tests, $p = .008$). The failed implants were replaced after 3 to 4 months and were successful in all cases. These implants were not included in the study.

Three of the lost 7.0-mm implants were part of small bridge therapy in three patients, one in the poste-

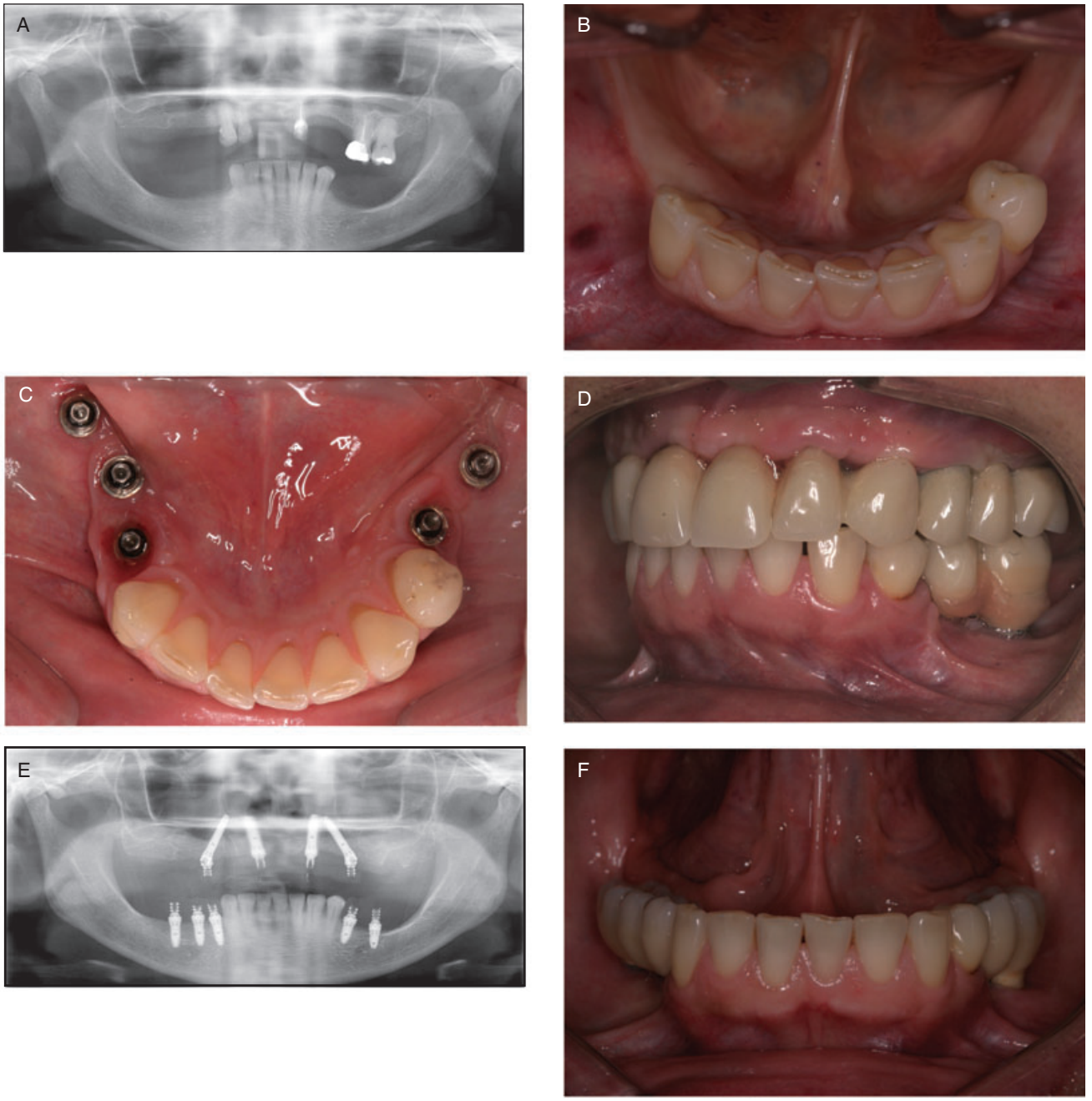

Figure 1 A small bridge rehabilitation in the posterior area of the third quadrant with two implants (4 × 8.5 mm and 4 × 7 mm) in one-stage surgery (prosthesis performed by Dr. Joana Lima). Preoperative panoramic x-ray (A), preoperative intraoral view (B), postoperative intraoral view (C), lateral view after provisional bridge connection (D), panoramic x-ray after provisional bridge connection (E), frontal view after final bridge connection (F).

rior maxilla and two in the posterior mandible. One of the losses in the mandible was an immediate function case. Two 7.0-mm implants were lost in one patient with a complete edentulous rehabilitation in the maxilla, together with the loss of the rest of the implants, in a total of five implants.

Four of the lost 8.5-mm implants in three patients were part of small bridge rehabilitations in the posterior maxilla. Two of these implants in one patient were placed in a periodontal compromised area, and two other implants were immediate function cases. Four 8.5-mm implants failed in four patients with complete

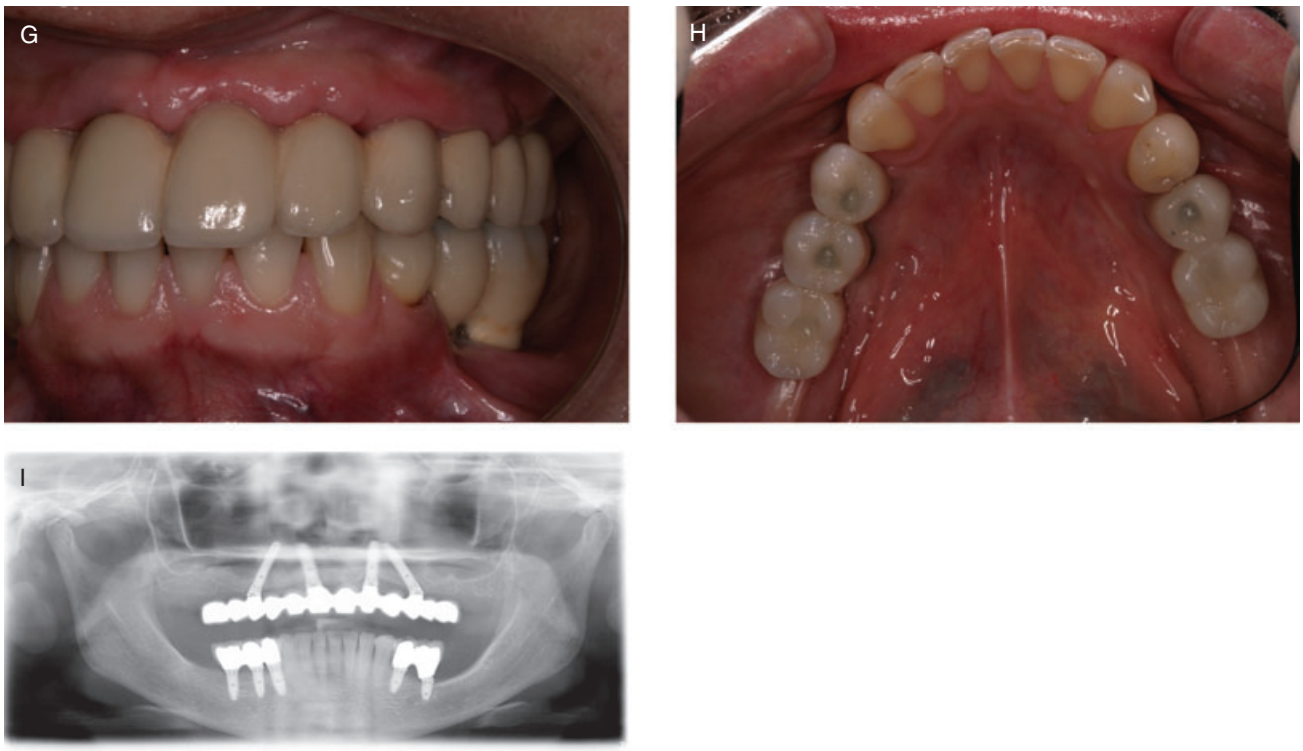

Figure 1 (*continued*) Lateral view after final bridge connection (G), occlusal view after final bridge connection (H), panoramic x-ray after final bridge connection (I).

edentulous rehabilitations (two in the anterior maxilla in two patients submitted to bone graft, one in the posterior maxilla, and one in the posterior mandible).

Marginal Bone Loss

Forty-nine percent of the 7-mm implant radiographs were readable for marginal bone level. The average bone resorption was 1 mm after the first year (SD = 0.6), and 1.8 mm after 5 years of follow-up (SD = 0.8) (Table 4). Fifty-eight percent of the 8.5-mm implant radiographs were readable for marginal bone level. The average bone resorption was 1.3 mm after the first year (SD = 0.8), and 2.2 mm after 5 years of follow-up (SD = 0.9) (Table 5).

TABLE 1 Life Table Analysis Regarding Implant Survival (7-mm Implants)

	Number of Implants				
Duration	Total	Failed	Withdrawn	Not Yet Due	CSR (%)
Placement–6 months	131	5	0	0	96.2
6 months–1 year	126	0	0	0	96.2
1–2 years	126	0	2	14	96.2
2–3 years	110	0	0	11	96.2
3–4 years	99	0	0	11	96.2
4–5 years	88	0	0	38	96.2
5–6 years	50	0	0	30	96.2
6–7 years	20	0	0	18	96.2

CSR = Cumulative survival rate.

TABLE 2 Life Table Analysis Regarding Implant Survival (8.5-mm Implants)

	Number of Implants				
Duration	Total	Failed	Withdrawn	Not Yet Due	CSR (%)
Placement–6 months	277	8	0	0	97.1
6 months–1 year	269	0	0	0	97.1
1–2 year	269	0	3	46	97.1
2–3 year	220	0	0	28	97.1
3–4 year	192	0	0	50	97.1
4–5 year	142	0	0	60	97.1
5–6 year	82	0	0	43	97.1
6–7 year	39	0	0	25	97.1
7–8 year	14	0	0	5	97.1
8–9 year	9	0	0	8	97.1

CSR = Cumulative survival rate.

TABLE 3 Implant Distribution Per Jaw (Maxilla/Mandible) and Per Site (Anterior/Posterior)

	7.0-mm Implants			8.5-mm Implants		
	Total (Lost)	Anterior (Lost)	Posterior (Lost)	Total (Lost)	Anterior (Lost)	Posterior (Lost)
Maxilla	27 (3)	5 (2)	22 (1)	104 (7)	13 (2)	91 (5)
Mandible	104 (2)	0 (0)	104 (2)	173 (1)	0 (0)	173 (1)
Total	131 (5)	5 (2)	126 (3)	277 (8)	13 (2)	264 (6)

Complications

Regarding mechanical complications, seven patients and nine implants were assessed having healing cap loosening during the implant healing period. These were due to the patients having chewed on the implants while ingesting food. They were reinstructed not to chew on the implants, and the complication was solved. Regarding biological complications, four patients and four implants presented a soft-tissue inflammation during the implant healing period due to plaque accumulation. This was solved by removing the healing cap from the abutment, debriding, polishing with a chlorhexidine gel, and placing the healing cap again. No esthetic complaints were registered.

DISCUSSION

The 96.2 and 97.1% 5-year survival rates for 7.0- and 8.5-mm implants, respectively, are comparable to results with longer implants and with results from recent clinical studies of short-length implants.[4,5] It supports the hypothesis that short implants (7.0–8.5 mm) in prosthetic rehabilitation of atrophied jaws might give similar long-term implant survival rates as longer implants used in larger bone volumes.

All failures occurred with machined surface implants, which support earlier findings that the oxidized surface improves implants' survival compared to results with machined surfaces.[12,13] There was also a tendency of lower survival rates in maxillae (92%) compared with the mandible (99%), probably due to softer maxillary bone, that is the same tendency as for longer implants.[12,14]

All failures occurred before prosthesis attachment. This could be due to the fact that there was some load on the implant healing caps. As a matter of fact, wear marks were often observed on the plastic healing caps at the time of prosthesis attachment. This indicates that implants with questionable prognosis might have failed before the prosthetic procedure. Further, one may speculate that some of the failures should have been avoided with greater initial implant stability and/or oxidized implant surfaces. A side remark worth mentioning is that splinting of the implants was a nonissue with regard to survival, as all failures occurred before prostheses attachment.

The mean marginal bone resorption after 1 year is comparable to other studies on short implants[5] and results for longer implants.[15] The marginal bone level measured after 5 years (not exceeding 0.2 mm/year of bone loss after the first year) is within the success criteria for the two-stage technique.[16] However, the marginal bone level changes affects a relatively larger portion at short implants and represented one-fourth of the

TABLE 4 Marginal Bone Resorption (7-mm Implants)

	Baseline–1 Year		Baseline–5 Years	
	Mesial	Distal	Mesial	Distal
Number of implants	63	63	16	16
Mean bone resorption	1.1	0.8	1.9	1.6
SD	0.7	0.5	0.8	0.9

TABLE 5 Marginal Bone Resorption (8.5-mm Implants)

	Baseline–1 Year		Baseline–5 Years	
	Mesial	Distal	Mesial	Distal
Number of implants	159	159	15	15
Mean bone resorption	1.3	1.3	2.3	2.0
SD	0.8	0.8	0.9	0.9

implant surface at 5 years. Still no late losses occurred on long term. This supports the understanding that the major part of the load transfer to the bone occurs within a few millimeter length of the implants, and that there is no need for long implants per se if osseointegration has taken place.

All failed implants were successfully replaced, and the number of complications was small and did not differ from that normally encountered during implant treatment; therefore, this study indicates a favorable advantage/risk ratio for the proposed protocol. The result, therefore, supports the use of short implants in small bone volume situations where otherwise the use of longer implants would have required bone grafting.

CONCLUSIONS

The cumulative survival rate of 96% for 7-mm implants and 97% for 8.5-mm implants after 5 years indicates that short implants used in both jaws may be a viable concept with comparable survival rates to longer implants, especially when oxidized implant surfaces are used.

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