Short Dental Implants as a Treatment Option: Results from an Observational Study in a Single Private Practice

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Purpose: *The purpose was to evaluate clinical outcome of short (6- and 8-mm) dental implants placed in sites with low bone availability (7 to 11 mm) in a single private practice and to compare their survival with that of longer implants.* ***Materials and Methods:*** *Implants were placed by a single private practitioner in a variety of clinical indications. Exclusion criteria included uncontrolled diabetes mellitus, alcoholism, and systemic immune disorders. Clinical data relating to implant placement and follow-up appointments, including adverse events, were entered into an electronic database. Two-year survival rates were calculated and life table analyses undertaken for implants measuring 6, 8, and 10 to 16 mm.* ***Results:*** *A total of 630 Straumann implants were placed in 264 patients between April 1994 and December 2003. Of these, 35 implants were 6 mm long, 141 were 8 mm long, and 454 were 10 to 16 mm long. Maximum follow-up was 64.6 months, 83.7 months, and 102 months for implants measuring 6 mm, 8 mm, and 10 to 16 mm, respectively. Two-year survival rates were 94.3%, 99.3%, and 97.4% for 6-mm, 8-mm, and 10- to 16-mm implants, respectively.* ***Discussion:*** *The results indicated that the 2-year outcome for 6-mm and 8-mm implants was comparable to that for longer (10- to 16-mm) implants in this patient population.* ***Conclusion:*** *In this study, short (6- or 8-mm) implants were used with good reliability in patients with limited bone availability, without the need for ridge augmentation. Shorter implant length was not associated with reduced survival at 2 years, compared with longer implants.* (Case Series) Int J Oral Maxillofac Implants 2006;21:769–776

Key words: *life table analysis, private practice setting, short dental implants*

In patients with advanced levels of alveolar bone resorption, the provision of dental implants is often problematic and may require additional surgical intervention to augment bone levels. This is particularly the case in the posterior mandibular and maxillary regions, where there is a risk of involving the inferior alveolar nerve or penetrating the maxillary sinus during implant placement when alveolar bone is deficient. This requirement for additional surgery adds considerably to treatment duration and costs and may deter some patients from undergoing prosthetic rehabilitation.

An alternative approach in cases where a limited amount of bone is available is to use short implants, 6 to 8 mm in length, instead of the standard range of 10 to 16 mm. This strategy avoids the need for bone augmentation procedures and simplifies treatment. However, short implants are widely perceived to have a greater risk of failure compared with standard-length implants, because of increased loading of the supporting bone and reduced resistance to lateral forces. A number of publications have lent support to this view, reporting poorer outcomes for shorter machined implants compared with longer ones.[1–4]

In contrast, however, some investigators found that implant length did not significantly influence outcome for implants with textured surfaces.[5–7] For example, in a recent report on 1,030 implants placed in private practice, Nedir and colleagues found that the survival rate for short implants was equal to that for longer implants when used to support single crowns or fixed partial dentures of 2 to 4 units.[7] It was also observed that the use of short implant therapy to avoid the need for advanced surgical intervention gives private practitioners the opportunity to rehabilitate a broader base of patients, including higher-risk individuals such as bruxers, smokers, and those with serious medical conditions.

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The aims of the present study were first, to demonstrate that short implants (6 to 8 mm in length) can produce clinical results comparable to those achieved with longer implants and, secondly, to demonstrate that short implants can be used in situations in which available bone is limited—situations where longer implants could not be used without additional surgical procedures such as bone grafting or bone augmentation.

MATERIALS AND METHODS

All treatment was carried out by a single practitioner in a private dental practice in Toronto, Ontario, Canada, between April 1994 and December 2003.

Patients were treated for a variety of clinical indications, including replacement of single teeth and prosthetic treatment of partially and completely edentulous arches. Exclusion criteria included uncontrolled diabetes mellitus, alcoholism, or systemic immune disorders. Smoking was not considered a contraindication to treatment, but patients were advised that smoking is associated with an increased risk of implant failure.

Prior to surgery, bone availability at the implant site was assessed radiographically by means of orthopantomographs and/or periapical views. The results of this evaluation were used to determine the appropriate implant length, with short (6 or 8 mm long) implants considered suitable for rehabilitation of edentulous sites with 7 to 11 mm of available bone.

All implants were placed according to a standard Straumann protocol, in most cases 6 months or more postextraction, and were loaded 3 to 5 months following surgery. The exact timing was dependent on bone quality. Implants situated in adjacent sites were routinely splinted, regardless of length. Patients were reviewed at 1 week, at 3 to 5 months (for preprosthetic verification of osseointegration), and shortly after prosthetic loading. Patients were then invited for annual follow-up. At review appointments, implants were tested manually for mobility and checked for freedom from infection. Adverse events reported by patients were recorded. All implants were evaluated radiographically with periapical radiographs taken with a nonstandardized long-cone paralleling technique using an XCP positioner (Dentsply Rinn, York, PA). Crestal bone loss greater than or equal to 1 mm apical to the rough/smooth implant junction was recorded. Other assessments made at follow-up appointments included oral hygiene, probing depths, and any alterations in sensation. The results of these assessments were recorded only if they were considered to be outside the normal range.

Data Collection and Statistical Analysis

All clinical data relating to placement of the implants and observations at subsequent review appointments, including adverse events, were entered into an electronic database (Triton DIMS; Martin Lumish, Yorktown Heights, NY) system. This system enables the private practitioner to systematically document and subsequently analyze the numerous clinical variables that may influence implant survival.[8,9] The statistical analysis comprised calculation of 2-year absolute success rates and life table analyses for implants of 6 mm, 8 mm, and 10 to 16 mm in length, according to the method described by Kalbleish and Prentice.[10]

RESULTS

A total of 630 implants (Straumann, Waldenburg, Switzerland) were placed in 264 patients, with an age range of 13.8 to 95.7 years and a median age of 55.5 years. The patient population comprised 131 men (49.6%) and 133 women (50.4%). Maximum follow-up was 64.6 months for 6-mm implants, 83.7 months for 8-mm implants, and 102 months for 10- to 16-mm implants. The maximum follow-up was 8.5 years, with a mean of 31.7 months.

Of the 630 implants placed, 536 (85%) were placed in partially edentulous jaws, while 94 (15.4%) were used in the rehabilitation of completely edentulous jaws. A total of 35 (5.6%) of the implants were 6 mm long, while 141 (22.4%) were 8 mm long and the remaining 454 (72.1%) were 10 to 16 mm in length. The numbers and dimensions of the various types of implants used are shown in Tables 1 and 2.

The numbers of implants placed at different maxillary and mandibular sites are illustrated in Fig 1. Overall, 82.2% of the 10- to 16-mm-long implants and 90.1% of the 8-mm-long implants were placed in the mandible, while all 6-mm-long implants were placed in posterior mandibular sites. The bone quality at the recipient sites, as defined by Lekholm and Zarb,[11] is shown in Fig 2 for implants of different lengths. Although 66.0% of all implants were placed in type 1, 2, or 3 bone, more than half of the 6 mm implants were placed in relatively poor quality (type 4) bone.

Overall, 17 (2.7%) of the 630 implants placed failed, resulting in an absolute success rate of 97.3% for implants of all lengths and types. Absolute success rates for the 3 implant subgroups were 94.3%, 99.3%, and 96.9% for 6-mm, 8-mm, and 10- to 16-mm implants, respectively. The 2-year survival rates for implants of different lengths are shown in Table 3. There were no further losses among the 6-mm implants after 2 years, but only 7 of these short

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Table 1 Distribution of Implants According to Type and Length

Implant type	6 mm	8 mm	10–16 mm
Angled hollow cylinder	0	0	9
Hollow cylinder	0	0	1
Hollow screw	0	0	1
Hollow cylinder esthetic	0	0	1
Narrow neck	0	0	1
Small diameter (3.3 mm)	0	13	64
Small diameter esthetic	0	0	1
Small diameter SLA (3.3 mm)	0	6	22
Solid-screw standard (4.1 mm)	4	21	137
Solid-screw esthetic (4.1 mm)	0	4	9
Solid-screw esthetic SLA (4.1 mm)	1	4	11
Solid-screw standard SLA (4.1 mm)	18	48	102
TE Implants 4 mm	0	17	26
Wide-body implants (4.8 mm)	3	3	20
Wide neck	0	1	1
Wide body SLA	6	14	20
Wide neck SLA	3	10	28
Total	35	141	454

SLA = sandblasted, large-grid, acid-etched; TE = tapered effect.

Table 2 Distribution of Implant Diameter According to Implant Length

Implant length/ implant diameter	No. of implants	% of implants
6 mm		
4.1	23	65.7
4.8	12	34.3
Total	35	100
8 mm		
3.3	21	14.9
4.1	85	60.3
4.8	35	24.8
Total	141	100
10 to 16 mm		
3.3	93	20.5
3.5	11	2.4
4.1	264	58.1
4.8	86	18.9
Total	454	100

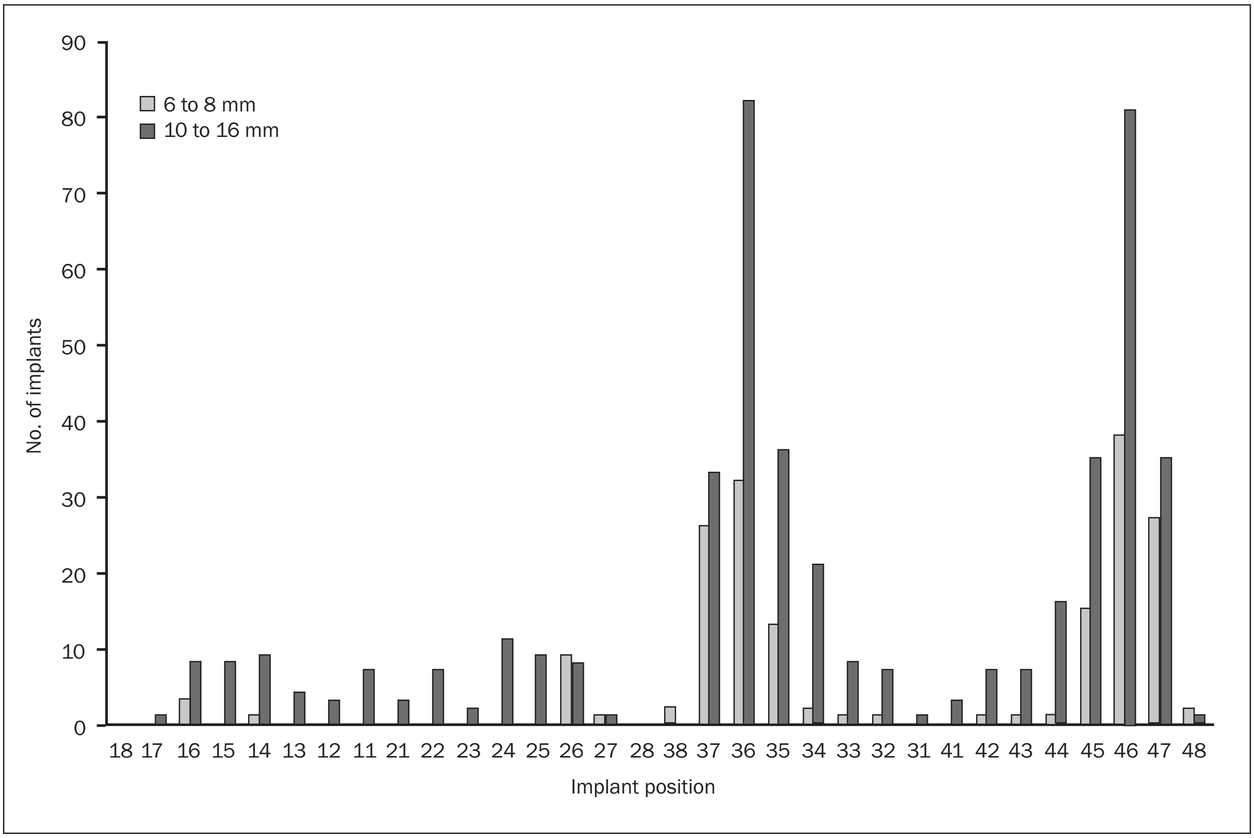

Fig 1 Distribution of implants of different lengths (FDI numbering system).

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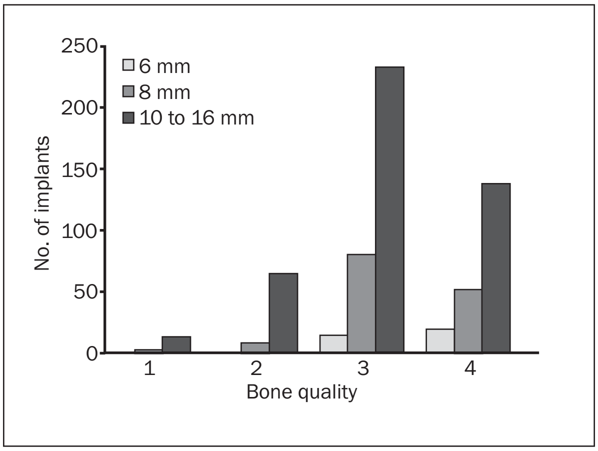

Fig 2 Frequency of implants of different lengths accordingly to bone quality.[11]

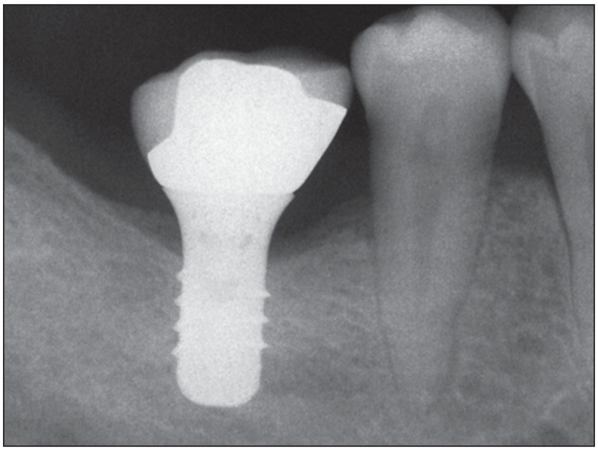

Fig 3 Periapical radiograph of an 8-mm-long wide-neck implant supporting a single posterior tooth, obtained 36 months following prosthetic restoration and 40 months after implantation.

Table 3 Success Rates After 2 Years According to Implant Length

Implant length	No. placed	No. failed	Success rate (%)
6 mm	35	2	94.3
8 mm	141	1	99.3
10 to 16 mm	454	12	97.4

Table 4 Life Table for All Implants

Time (y)	No. of implants at start	No. not completing interval	No. exposed to risk	No. lost	Implant survival rate (%)	Cumulative survival rate (%)
6-mm-long implants						
0*	35	1	34.5	2	94.2	94.2
0–1†	32	16	24.0	0	100.0	94.2
1–2	16	9	11.5	0	100.0	94.2
2–3	7	2	6.0	0	100.0	94.2
3–4	5	3	3.5	0	100.0	94.2
4–5	2	2	1.0	0	100.0	94.2
8-mm-long implants						
0*	141	22	130.0	1	99.3	99.2
0–1†	118	48	94.0	0	100.0	99.2
1–2	70	35	52.5	0	100.0	99.2
2–3	45	21	34.5	0	100.0	99.2
3–4	24	9	19.5	0	100.0	99.2
4–5	15	7	11.5	0	100.0	99.2
5–6	8	5	5.5	0	100.0	99.2
6–7	3	3	1.5	0	100.0	99.2
10- to 16-mm-long implants						
0*	454	19	444.5	9	98.0	98.0
0–1†	426	97	377.5	1	99.7	97.7
1–2	328	67	294.5	2	99.3	97.0
2–3	259	55	231.5	0	100.0	97.0
3–4	204	38	185.0	0	100.0	97.0
4–5	166	68	132.0	1	99.2	96.2
5–6	97	32	81.0	0	100.0	96.2
6–7	65	28	51.0	0	100.0	96.2
7–8	37	19	27.5	1	96.4	92.7
8–9	17	17	8.5	0	100.0	92.7

*0 = placement to second stage (prior to loading).
†0–1 = second stage to 1 year.

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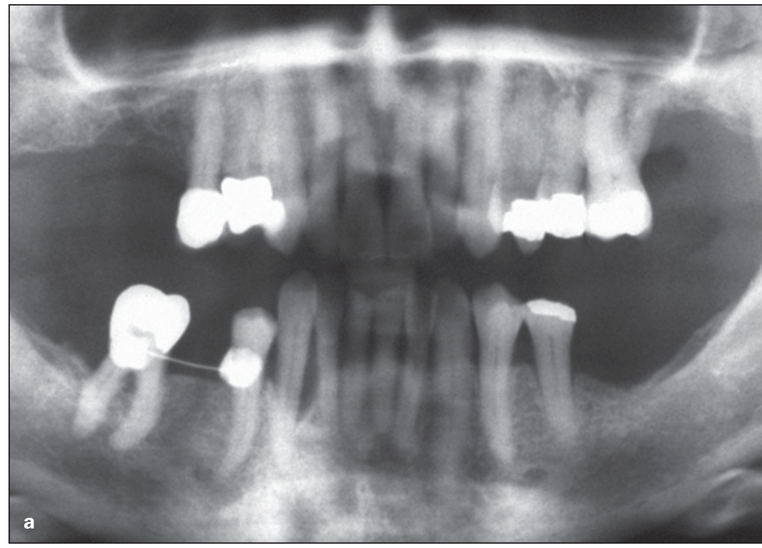
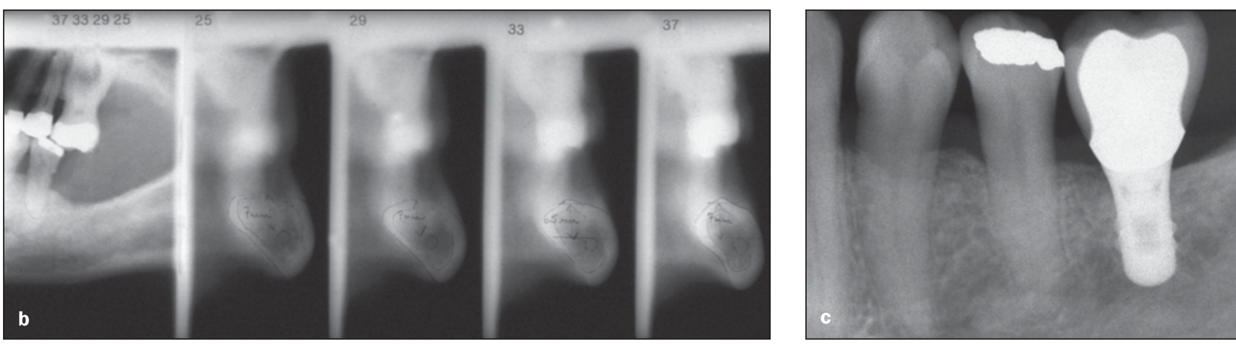
Fig 4 *This case demonstrates what can be achieved with short implants in what would traditionally be considered clinically unfavorable conditions for implant placement.*

Fig 4a Orthopantomograph showing minimal bone availability superior to the inferior alveolar canal in the edentulous mandibular left molar region.

Fig 4b Tomograph with tracing revealing 7 mm of bone height superior to the inferior alveolar canal.

Fig 4c Periapical radiograph of the completed single crown restoration, supported by a 6-mm-long implant. After 7 years in function, there are no signs of crestal bone loss or any other pathologic change.





implants were followed for more than 2 years. Similarly, no additional failures were observed among the 8-mm implants after 2 years, and thus the survival rate was unchanged at 3 years (n = 45) and at 5 years (n = 15). For the larger group of 10- to 16-mm implants, survival rates after 5 years and 9 years were 97.1% and 96.9%, respectively.

The 17 implant failures were observed in a total of 12 patients. The reasons for failure included implant mobility, persistent inflammation and infection, bone loss exceeding 5 mm at the last examination, and periapical pathology. Three individuals experienced multiple implant failures; in 1 male patient, 4 implants in the mandibular right quadrant were lost within the first month, 1 of which accounted for the single 8-mm implant failure in the study. In addition, 2 female patients each lost 2 implants 10 to 16 mm in length. Failed implants were almost all located in mandibular sites, with only 1 maxillary implant failure occurring at a maxillary first molar site. Failures occurred in all types of bone (types 1 to 4), with 11 of the 17 losses located in bone of types 3 or 4. Both 6-mm implant losses were observed in sites with type 4 bone.

In all, 9 of the 17 failed implants were of the solid-screw standard-diameter type, and an additional 4 were solid-screw implants with SLA surfaces. The remaining losses comprised 2 small-diameter implants, 1 wide-body implant, and 1 wide-neck SLA implant.

Life Table Analysis

Life table analysis showed that 6-mm implants placed in this patient population had a cumulative success rate of 94.2% at 2 years. This figure was unchanged at 5 years; however, it should be noted that only a small number of 6-mm implants were followed up to 3 years (n = 7) and 5 years (n = 2). Only 2 failures, both very early, were observed in the 6-mm subgroup. The 8-mm implants suffered a single failure within the first month and showed a 99.2% cumulative survival, while implants of 10 mm or greater length had a cumulative survival rate of 97.0% at 2 years and 92.7% at 9 years (Table 4). As in the shorter implant groups, most of the failures (9 of 14) in the long implant group occurred within the first 3 months following implantation, prior to prosthetic loading.

Two examples of short implants that have shown good long-term performance are presented in Figs 3 and 4.

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Adverse Events

There was a low frequency of peri-implant infection (approximately 1%). All affected sites were treated with debridement and, in some cases, systemic antibiotics or locally applied doxycyclin hyclate (Atridox, Collagenex Pharmaceuticals, Newton, PA). Implant sites that responded to antimicrobial treatment were considered to fulfill the success criteria, whereas those with recurrent or continuous infection were categorized as failures. No neurosensory changes or other complications were reported.

DISCUSSION

In the present analysis of treatment, the cumulative success rates calculated for implants are at least as favorable as those reported by a number of other investigators in different clinical settings.[6,12–18] It is noteworthy that the majority (76.5%) of implant failures occurred within the first year, and that 92% of these early losses were observed prior to prosthetic loading. Only 2 of the 17 failures occurred after 2 years. This pattern of implant failure is consistent with the results of other long-term studies and suggests that one might expect a low frequency of additional implant failures over the long term.[7,12,16] However, continued long-term follow-up is required to confirm this supposition.

One significant potential confounding factor in studies assessing implant survival is the presence of multiple implants in individual patients, as such implants cannot be considered to be statistically independent from one another. No specific measures were taken to analyze or correct for a cluster effect in this observational study, as would be usual in a prospective, randomized clinical trial, and thus the results presented should be interpreted descriptively.

A further factor that could potentially influence the relative survival rates of short and long implants is the use of splinting. In this study, splinting was applied to implants placed in adjacent sites, irrespective of implant lengths. The relative number of short versus longer implants that were splinted has not been analyzed, and it is likely that much larger sample sizes than those in the current report would be required to determine the presence and size of a splinting effect. From a more pragmatic, clinical perspective, the results of this study show that, whether or not the particular clinical situation dictated the use of splinting, successful osseointegration was achieved with both 6- and 8-mm implants, despite their short length, in a short observational period.

The decision to use short implants, rather than a combination of ridge augmentation and longer implants, was made after detailed consultation with the patient. A key advantage of placing short implants in patients with extensive alveolar resorption is that it obviates the need for additional surgery, particularly, inferior alveolar nerve transposition, which carries a risk of neurosensory dysfunction resulting from epineurial damage or ischemic stretching.[19–21] Treatment is simplified, with the patient undergoing a single surgical procedure, The patient remains under the care of a single surgeon, and the number of visits to the practice and the cost of treatment are substantially reduced. Because of these benefits, short implants have the potential to make implant therapy more accessible to greater numbers of patients and dental surgeons, providing their reliability can be well established.

There has been some debate about the reliability of short dental implants in the literature, with a number of studies concluding that shorter implants are more prone to failure.[3,22–24] In particular, several investigations into the long-term survival of Brånemark System implants (Nobel Biocare, Göteborg, Sweden) have shown better outcomes for longer implants compared with shorter ones.[2–4] A more recent study, however, found no significant difference between survival rates of short (6- to 8.5-mm-long) versus 10-mm-long Brånemark System implants.[25] When reviewing these reports, it is important to recognize that Brånemark System implants are measured from the implant apex to the top of the restored platform, whereas Straumann implants are measured from the implant apex to the rough-smooth junction. Thus, the shortest Brånemark System implants used in these studies (7 mm) had a corresponding integratable surface of less than 5.5 mm. It also follows that the 6- and 8-mm Straumann implants used in the present study are equivalent, in terms of integratable surface, to Brånemark implants measuring 8.8 and 10.8 mm. Results from studies of Straumann implants do not suggest that length is a determining factor in implant loss, although the investigations did not test implants with integratable surfaces equivalent to that of the shortest Brånemark System implants.[6,14,16] For example, in a large study of 2,359 implants in 1,003 patients, Buser and associates[6] found no significant differences in 8-year cumulative survival between implants measuring 8 mm, 10 mm, and 12 mm. However, the fate of the smaller group of 6-mm implants (n = 39) was not reported.

Short implants have been used with moderate to good success in the treatment of patients with extremely resorbed edentulous mandibles.[11,26] Stellingsma and colleagues concluded that the provision of short implants in this patient population

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was justified because of the relative simplicity and low morbidity.[26]

A number of investigators have specifically studied the predictability of short implants.[7,27,28] In a multicenter study with a 1- to 7-year follow-up, ten Bruggenkate and coworkers reported an absolute survival rate of 97% for 253 short (6-mm) Straumann implants, with a cumulative survival rate of 94% after 6 years (n = 218).[27] Hagi and associates reviewed outcomes from 12 studies of short (≤ 7 mm) implants in partially edentulous patients and concluded that surface geometry has a major influence on performance.[28] Whereas threaded implants are significantly less reliable in short versus longer lengths, the data showed that sintered, porous-surfaced implants perform equally well in short or longer lengths.

This analysis was greatly facilitated by the use of a specialized electronic database.[8] Increased use of this type of user-friendly software in private practice, coupled with standardized protocols for treatment and data collection, has the potential to yield a wealth of useful information and enhance the evidence-based approach to implant therapy. The present analysis included a sample of thirty-five 6-mm-long implants followed for up to 5 years, but it would be desirable to analyze long-term outcomes from larger numbers of unsplinted implants to corroborate the results of this study. Pooling of databases from multiple private practices is one potential way of generating large volumes of reliable information and achieving robust statistical results.

CONCLUSIONS

For patients with limited bone availability, 6-mm and 8-mm implants can be a predictable treatment option. Furthermore, compared with ridge augmentation and placement of longer implants, placement of short implants can be a simpler, less time-consuming, and less costly treatment, with low patient morbidity.

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