Short Implants: A Descriptive Study of 273 Implants

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ABSTRACT

Purpose: The study aims to assess the performance of short implants in a series of patients with severe alveolar resorption.

Materials and Methods: A review is made of 273 implants measuring 10 mm or less, placed by conventional surgery or using osteotomes, and with a postloading follow-up of between 18 months and 12 years (mean 81 months).

Results: A total of 20 failures were recorded (7.33%), with a global implant survival of 92.67%. The survival rate for 10 mm implants was 92.82%, versus 92.5% in the case of those measuring less than 10 mm. Overall, the failure rate was lowest for the treated surface implants (2.56% vs 4.76%). On considering the implants measuring under 10 mm, the failure rates were similar in both groups (3.77%).

Conclusions: Short implants are a good treatment alternative for patients with severe alveolar resorption of both jaws.

KEY WORDS: bone resorption, dental implants, implant surfaces, short implants

INTRODUCTION

Conservative treatment options in patients with severe alveolar resorption are limited and in many cases, surgery is necessary. Preprosthetic surgical techniques (eg, vestibuloplasties, vestibuloplasty with mucosal or cutaneous grafting, onlay-type bone grafts) were often used in the past to increase alveolar ridge height and thus to improve removable denture retention and stability. However, these techniques are associated with important postoperative complications, limited efficacy, and scant stability over time.[1,2] Because the demonstration that dental implants offer predictable results for both fixed and removable prostheses, preprosthetic reconstructive surgery has evolved from techniques designed to generate sufficient bone and mucosal support to procedures aimed at securing sufficient bone volume to facilitate implant placement in the best position.[1,2]

In patients with severe alveolar resorption, there are different surgical procedures designed to facilitate future implant placement. More complex implant techniques include the use of bone grafts harvested from extra- or intraoral zones and positioned as inlays or onlays, osteogenic distraction, zygomatic implants, transmandibular implants, and transpositioning of the inferior dental nerve. Other less complex implant options include pterygoid implants, guided bone regeneration, monocortical partial grafts, maxillary sinus lift, and short implants.[1,2]

At present, minimally invasive surgical techniques are advocated to improve patient's comfort during the postoperative period, while reducing morbidity and possible complications.[3] The use of short implants aims to avoid aggressive surgical procedures that may be unnecessary in some cases. However, a prior requirement is definition of the predictability and therapeutic limits involved. In an extensive review of 33 studies with 16,344 implants of 7, 8.5, or 10-mm long published between the years 1980 and 2004, the total rate of success

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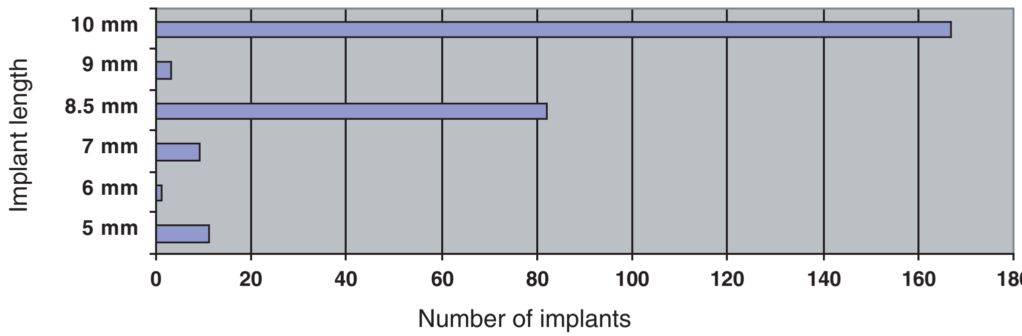

Figure 1 Implant distribution according to length.

was 95.2%.[4] Implants 3.75-mm wide and 7-mm long failed at a rate of 9.7%, compared with 6.3% for 3.75×10-mm implants. Poor bone quality seemed to be relevant to failure but the use of implants 4 mm in diameter appeared to minimize failure in these situations. The authors concluded that short implants should be considered as an alternative to advanced bone augmentation surgeries, as surgeries can involve higher morbidity, require extended clinical periods, and involve higher costs to the patient.[4] In a review of the literature covering the period 1990 to 2005, data of 22 publications reporting an adapted surgical preparation and the use of textured-surfaced implants have shown survival rates of short implants comparable with those obtained with longer ones.[5] In other clinical studies of the performance of short implants, success rates between 92.2 and 95.8% have been reported.[5–8] In recent studies, survival rates of short implants in posterior areas are about 99%.[9,10] The influence of diameter and length of implant on early dental failure was also recently analyzed in a retrospective study of 1,649 implants placed in different areas in 650 patients.[11] The overall early survival rate was 96.2%. The largest losses were observed in narrow implants (5.1%) and in short (6–9 mm) implants (9.9%). In the multivariate logistic regression analysis, short implant ($p = .001$) and anterior installation implant ($p = .001$) were significantly associated with early loss.

The purpose of this study was to describe the performance of a series of short implants inserted in patients with severe alveolar bone resorption. A secondary objective was to assess factors influencing the survival of these implants.

MATERIALS AND METHODS

A retrospective study of 273 short implants (measuring 10 mm or less in length), placed in 136 patients, was made. No patient presented absolute contraindications for dental implant placement. Patients who smoked less than five cigarettes a day were also included in the study. The conventional surgical technique or osteotome procedure described by Summers was used.[12] The implants measured 5, 6, 7, 8.5, 9, and 10 mm in length (Figure 1), and the implant types were: MkIII®, MkIII Ti Unite®, MkII®, Replace Select Tapered (RST) Ti Unite®, Branemark Standard®, and Replace Select Straight (RSS) Ti Unite® (NobelBiocare, Göteborg, Sweden); Endopore® (Innova, Toronto, Canada); and TSH Defcon® (Impladent, Barcelona, Spain) (Table 1). Table 2 shows the distribution of implants according to their location.

All implants were prosthesis-loaded, with a waiting interval of 4 months for implants placed in the mandible, and of 6 months for those located in the maxilla. The postloading follow-up period ranged between 18 months and 12 years (mean 81 months). Failed implants were those that showed no osteointegration at follow-up or which were lost after loading. The following variables were recorded: type of implant, type of implant surface, implant location, and length. The SPSS version 14.0 statistical package (SPSS Inc., Chicago, IL, USA) (license of the University of Barcelona, Spain) was used for the descriptive statistical study.

RESULTS

After a postloading follow-up period of between 18 months and 12 years (mean 81 months), the implant survival rate was 92.7%. Of the 273 implants evaluated, 20 failed (7.3% of the total). Implant failure was assessed according to the type of implant involved (Table 3), the type of implant surface (Tables 4 and 5), and implant location (Tables 6 and 7).

Figure 2 shows that the number of implants placed in the mandible more than doubled the number placed in the molar region of the maxilla. This difference is

TABLE 1 Distribution According to Implant Type

Type of Surface	Type of Implant	No. of Implants	% of Total
Machined	MkIII®	102	37.4
	MkII®	40	14.6
	Branemark Standard®	12	4.4
Rough surface	MkIII Ti Unite®	55	20.1
	Endopore®	22	8.1
	Replace Select Tapered® (RST)	21	7.7
	TSH Defcon®	17	6.2
	Replace Select Straight® (RSS)	4	1.5
Total		273	100

because of the fact that in many cases, lifting of the maxillary sinus floor was decided – particularly in the case of young patients – while in contrast the results of bone regeneration in the mandible are less predictable.

Table 3 shows failure distribution according to the type of implant. No significant data are observed, because of the discrepancy between the samples in relation to the number of implants of each type positioned.

TABLE 2 Number and Total Percentage of Implants Placed According to Location

Location	No. of Implants		% of Total	
37–47	34	12.5	Lower molar zone	45.7
36–46	91	33.3		
16–26	46	16.8	Upper molar zone	20.5
17–27	10	3.7		
35–45	38		13.9	
15–25	22		8.1	
Intermental	22		8.1	
Upper anterior sector	10		3.7	
Total	273		100	
Mandible/Maxilla	185/88		67.8/32.2	

TABLE 3 Absolute Number of Failures, Relative Percentage Failures, and Percentage Failures

Type of Implant	No. of Failures	Relative %	% of Total
MkIII®	8/102	7.84	2.93
MkIII Ti Unite®	6/55	10.9	2.2
MkII®	3/40	7.5	1.1
Endopore®	1/22	4.5	0.37
RST®	0/21	—	—
TSH Defcon®	0/17	—	—
Branemark Standard®	2/12	16.6	0.73
RSS®	0/4	—	—
Total	20/273		7.33/100

TABLE 4 Distribution of Failures According to the Type of Implant Surface

Type of Implant		No. of Failures	Relative %	% of Total
Machined	MkIII®	13/154	8.4	4.8
	MkII®			
	Branemark Standard®			
Rough surface	MkIII Ti Unite®	7/119	5.9	2.6
	Endopore®			
	RST®			
	TSH Defcon®			
	RSS®			
Total		20/273		7.3/100

When the different types of implants were compared, the TSH Defcon®, RST®, and RSS® implants showed no failures (see Table 3). In our series, the largest number of failures (in absolute terms) corresponded to the machined surface MkIII® implants. However, it seems evident that this observation is because of the fact that the sample corresponding to this type of implant was larger than the rest, as 8 failures out of 102 positioned implants yield a 92.2% survival rate – the latter being greater than the 83.4% survival rate recorded for the Branemark Standard® implant (2 failures out of only 12 positioned implants).

The analysis of implant distribution according to the type of surface involved, showed that machined

TABLE 5 Failure of Implants under 10 mm in Length According to the Type of Surface

Type of Implant		No. of Failures	Relative %	% of Total
Machined	MkIII®	4/59	6.8	3.8
	MkII®			
	Branemark Standard®			
Rough surface	MkIII Ti Unite®	4/47	8.5	3.8
	Endopore®			
	RST®			
	TSH DEFCON®			
	RSS®			
Total		8/106		7.6/100

TABLE 6 Distribution of Failures According to Implant Location

Location		No. of Failures	Relative %			% of total
Upper anterior sector		0/10				
15–25		1/22		4.5		0.4
Upper molar zone	17–27	1/10	10		8.97	2.2
	16–26	5/46	10.9	9.5		
Lower molar zone	36–46	8/91	8.8		7.98	3.3
	37–47	1/34	2.9			
35–45		4/38		10.5		1.5
Intermental		0/22				
Total		20/273				7.4/100

TABLE 7 Failure According to Location and Type of Implant

Type	Machined			Nonmachined			
Location	MkIII®	MkII®	Brk®	MkTU®	Endop®	Total	Relative %
35–45	3	1	—	—	—	4/38	10.5
36–46	1	2	2	3	—	8/91	8.8
37–4.7	1	—	—	—	—	1/34	2.9
15–25	1	—	—	—	—	1/22	4.5
16–26	1	—	—	3	1	5/46	10.9
17–27	1	—	—	—	—	1/10	10
Intermental	—	—	—	—	—	0/22	—
Upper anterior	—	—	—	—	—	0/10	—
Total	8/102	3/40	2/12	6/55	1/22	20	
Relative %	7.8	7.5	16.6	10.9	4.5		

surface implants yielded a greater relative failure rate compared with the nonmachined surface implants (8.4% vs 5.9%, respectively) (see Table 4). However, when only implants measuring less than 10 mm in length were considered, failure rates were similar for machined and nonmachined implants (see Table 5).

The relative percentage of failure in the upper molar zone was slightly higher than in the mandibular molar region (8.97% vs 7.98%) (see Table 6). When the implants located in the position of the first upper and lower molars were only considered, the failure rate increased to 9.5%. The failure rate recorded in the region of the lower premolars doubled the rate in the region of the upper premolars. Failures in the anterior sector and in the intermental region were not recorded, although it may be because of the small sample size and to the higher bone quality in this anatomical area (see Tables 6 and 7).

As shown in Table 8, the survival rate of implants measuring less than 10 mm in length was 92.5%.

DISCUSSION

Implant success is assessed according to the criteria of Albrektsson and colleagues[13] which include implant immobility, absence of periapical translucency, vertical bone loss of less than 0.2 mm per year after the first year of implant loading, and absence of persistent signs and symptoms including pain, infection, neuropathy, paresthesia, or invasion of the inferior dental canal. Most of the criteria defining implant success were met in our study, although peri-implant crest bone levels were not measured.[6]

Short implants offer clear advantages over the different surgical techniques used to afford sufficient bone for placing longer implants. The option considered in the present study requires only minimally invasive

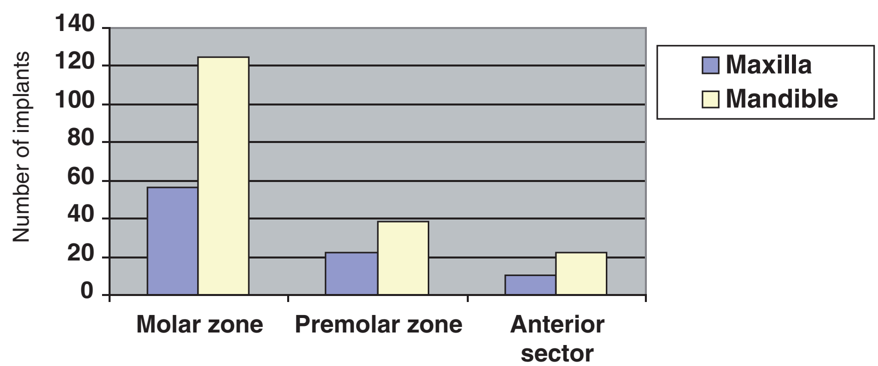

Figure 2 Implant distribution according to location.

TABLE 8 Distribution of Failures with Implants Measuring under 10 mm in Length, According to Type

Type of Implant	No. of Failures	Relative %	% of Total
MkIII®	1/35	2.9	0.9
MkIII Ti Unite®	3/22	13.6	2.8
MkII®	1/13	7.7	0.9
Endopore®	1/22	4.5	0.9
Replace Select Tapered®	—	—	—
TSH Defcon®	0/2	—	—
Branemark Standard®	2/11	18.18	1.9
Replace Select Strait®	0/1	—	—
Total	8/106		7.4/100

surgery, and avoids the need for more complex and traumatic surgical procedures, thus saving treatment costs and time, with few complications, lower risk of maxillary sinus or inferior dental canal invasion, and relatively high survival rate. Moreover, the bone-implant interface is stable, more favorable implant angulation is allowed, and the patients can be treated on an out-hospital basis.[1,5,6,14] The surgery for placing short implants is very simple, particularly compared with the bone augmentation techniques. Moreover, because of the scant depth of implantation and the easy and direct irrigation access,[14] the risk of bone overheating is lower. Some disadvantages of short implants include an unfavorable crown/implant ratio, supporting of excessive forces, and a lesser implant surface amenable to osteointegration. The risk of mandibular fracture in a case of edentulous patient with very severe resorption has been reported as a major complication of short implants.[1]

Techniques for maxillary sinus lifting are indicated when the maxillary sinuses are highly pneumatized, allowing the placement of implants in posterior areas of the maxilla when the existing bone crest height proves insufficient. The most frequent intraoperative complications is perforation of the sinus membrane (7–44%), in which percentage bone formation may be very limited (14.2 ± 7.1%).[15] Another inconvenience is that in some cases of severe alveolar crest, resorption surgery may have to be performed in two steps: the first to regenerate the bone and the second to position the implants because a single step procedure would be unable to secure the necessary primary implant stability. In addition, sinusitis secondary to graft infection must be also considered.[15]

Peleg and colleagues[16] reported a cumulative survival rate of 97.9% after 9 years in 2,132 rough surface implants placed simultaneously to maxillary sinus graft in patients with 1–5 mm of residual alveolar bone height. In the study of Herzberg and colleagues,[17] the cumulative implant survival rate was 95.5%, with an 83.7% radiological success rate over a period of 4.5 years. McDermott and colleagues[18] compared the percentage of success between implants placed in grafted maxillary sinuses versus nongrafted sinuses. The survival after 5 years was 88% in the posterior zones of the maxilla without grafting, and 87.9% in the case of the grafted maxillary sinuses.

A total of 56 implants were inserted in the area of the upper first and second molars and 125 in the same molar area of the mandible. Failure rate in the upper molar zone was 10.7% (6 out of 56), and was compared with 7.2% (9 out of 125) in the mandible. The relative higher percentage of failure in the upper molar area may be associated with poorer primary stability and more deficient bone quality of the maxilla. Although the success rate of implants placed in grafted sinuses is higher,[19,20] short implants avoid the need of sinus lift procedures. The cumulative graft survival obtained in our study (92.7%) without morbidity and in a short period of time is acceptable and similar to rates reported by others.[17] Short implants are associated with survival rates between 88 and 100%.[1,5]

There is no consensus regarding the length defining a "short" implant. In the different series, lengths of 12 to 7 mm or less have been considered.[6,14,21–24] Although we included implants of up to 10 mm in length, an independent analysis of implants measuring less than

10 mm was performed. However, the success rate of these implants (92.5%) was similar to that of the overall series (92.7%). This appears to indicate that in this range of implant lengths, the millimeters of difference between the two groups exert no significant influence upon implant survival. Indeed, it should be pointed out that in 17 implants located in the upper first and second molar region measured 5 mm in length and 5 mm in diameter, with a porous surface, no failures were recorded. These implants, however, were inserted in only 22 patients (8.1%) and were used splinted to others of greater length, forming part of an implant-supported bridge, and in no case were they applied in edentulous patients or as unit implants.

Gentile and colleagues[7] also reported comparable survival rates between Bicon® implants (Bicon Dental Implants, Boston, MA, USA) measuring 6 × 5.7 mm and other implants of the same type but with different lengths and diameters. In a prospective multicenter study, Testori and colleagues[25] even reported similar percentage success rates with implants measuring 10 mm or less and longer implants. However, a literature review by Misch[14] showed that implants of less than 10 mm in length tended to yield higher failure rates than longer implants. A number of factors as possible explanations for these results were suggested, including lower bone density in the areas where the implants are inserted, the presence of greater chewing forces in the posterior maxillary areas,[14,26] and an excessively elevated crown in relation to the length of the implant.[1,14] However, Rokni and colleagues[23] in a retrospective analysis of the influence of the crown-to-root ratio in short implants, concluded that neither this ratio nor the estimated implant surface area exerts an influence upon crest bone loss, because the latter remained stable during the loading period of implants measuring 5 or 7 mm in length. In contrast, long implants (9 or 12 mm in length) showed increased bone loss (0.2 mm more). Tawil and colleagues[21] agreed with these authors, but indicated that occlusion must be favorable to ensure that neither the crown/implant ratio nor the mesiodistal length or occlusal width becomes a principal risk factor.

On the other hand, Misch[14] proposes a series of measures to reduce excessive mechanical loading on the bone, and to distribute the forces over the prosthetic area, in order to optimize the function of short implants. These may be achieved by reducing the lateral forces of the posterior implant-supported prosthesis by means of an anterior guide, with elimination of the cantilevers of the restorations, or by placing a larger number of implants, increasing their diameter, employing designs with a greater surface area, and splinting the implants. We agree with these measures, although Deporter and colleagues.[26] reported a survival rate of 100% with microporous implants (Endopore®) measuring 7 and 9 mm in length, in the context of unit restorations (83%). Hagi and colleagues[24] in their literature review of implants measuring 7 mm or less in length, concluded that both the type of surface and geometry play a very important role in determining implant success. On the other hand, Petrie and Williams,[27] using three-dimensional finite-element models, assessed interactive effects of implant diameter, length, and taper on calculated crestal bone strains. The authors concluded that if the objective is to minimize peri-implant strain in the crestal alveolar bone, a wide and relatively long, untapered implant appears to be the most favorable choice. Narrow, short implants with taper in the crestal region should be avoided, especially in low-density bone.

The type of surface should be also considered. Renouard and Nisand,[22] in a 2-year retrospective clinical study, reported a cumulative survival rate of 94.6% with implants measuring 6 to 8.5 mm in length. Out of a total of 96 implants, five failures were registered (5.4%), four (4.2%) of which corresponded to machined surface implants and one to an oxidized surface implant. In our study, the failure rate was also higher for machined surface type. Goené and colleagues[6] reported a 95.8% success rate with Osseotite® implants (3I, Implant Innovations, Inc., Palm Beach Gardens, FL, USA) measuring 7 and 8.5 mm in length over a 3-year follow-up period, and claimed that the combination of a greater surface with contact osteogenesis because of the rough implant surfaces can cause short implants with an acid-etched surface to offer survival rates equivalent to those of implants measuring 10 mm or more in length with the same macroscopic design. Peleg and colleagues[16] indicated that the frictional resistance created by rough implant surfaces combined with surgical protocols that produce slight bone compression, can improve primary stability of the implant, ensuring greater strength between the bone and implant than implants with machined surfaces. Piattelli and colleagues[28] observed an increased percentage bone-implant contact with sandblasted surface implants compared with machined surface implants, and suggested that this may be because of the greater bone conductivity of the former as a result of the greater surface roughness of the sandblasted implants.

However, it should be acknowledged that immediate loading may be one of the limitations of short implants. A requirement for the long-term success of implants subjected to immediate or early loading is that in the case of mandibular implants, the remaining bone must allow the balanced distribution of 5 to 6 implants with a minimum length of 10 mm. Different authors[29–35] consider that the length of implants subjected to immediate loading should be at least 10 mm. However, Horiuchi and colleagues[35] used fixations of 10 mm or more for the maxilla and intermental zone, while in the distal mandibular region they used lengths of at least 7 mm, and out of 105 mandibular fixations, only 2 were lost in the intermental zone. In our study, none of the cases were subjected to immediate loading. In fact, the required passive osteointegration was respected to ensure the success of osteointegration as far as possible.

In summary, implants of 10 mm in length or less may be a useful option in patients with severe alveolar bone resorption. The survival of short implants may be influenced by a number of factors, including location and bone quality, as well as design, type, and diameter of the implant. These factors, however, should be assessed in further studies.

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