Retrospective Multicenter Study of 230 6-mm SLA-Surfaced Implants with 1- to 6-Year Follow-Up

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Purpose: *Using short implants poses a challenge in implant surgery. Implant surfaces have evolved, making it possible to improve the success of short implants substantially. However, there is still little information about the long-term predictability achieved with short, rough-surfaced implants. The objective of this study was to evaluate the long-term survival rate of 6-mm rough implants.* ***Materials and Methods:*** *A retrospective multicenter analysis of the survival of short 6-mm SLA-surfaced implants was conducted. A total of 230 implants placed in 159 patients were included. The follow-up time ranged between 1 and 6 years.* ***Results:*** *Seven of the 230 implants failed, which gives a cumulative survival rate of 96.4%. Two hundred and fourteen implants were placed in the mandible (93.1%), as opposed to 16 placed in the maxilla (6.9%). Five implants failed during the osseointegration period, and two failed after receiving the prosthetic load. No statistically significant differences were found (*P *< .44). Of the loaded implants, 209 were splinted to other implants, as opposed to 14 that were not. One implant failed in each group, resulting in a 99.5% for the splinted implants and 92.9% for the unsplinted implants. No statistically significant differences were found between the splinted and unsplinted groups (*P *< .12).* ***Conclusions:*** *The short implants used in this study displayed high long-term predictability when placed in the mandible and splinted. There is insufficient information to extrapolate these results to the maxilla and non-splinted implants.* Int J Oral Maxillofac Implants 2013;28:1331–1337.
doi: 10.11607/jomi.3129

Key words: *bone regeneration, implant failure, implant length, osseointegration, prognosis, short implant*

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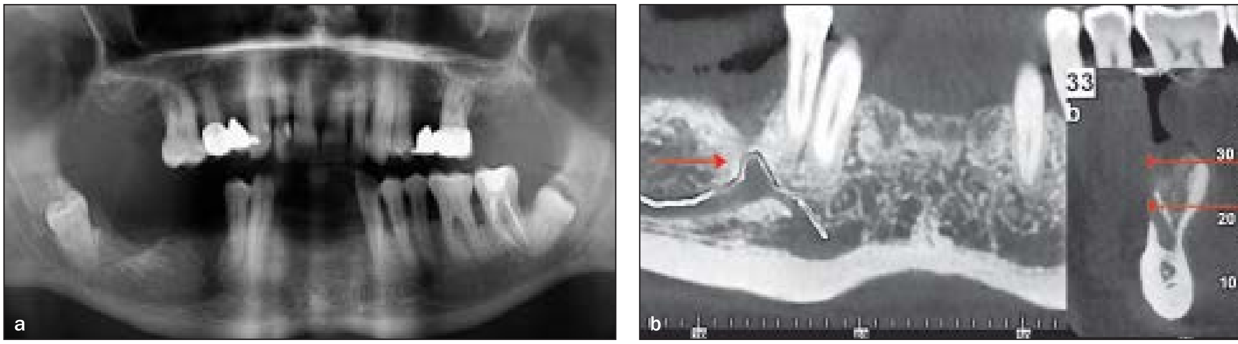
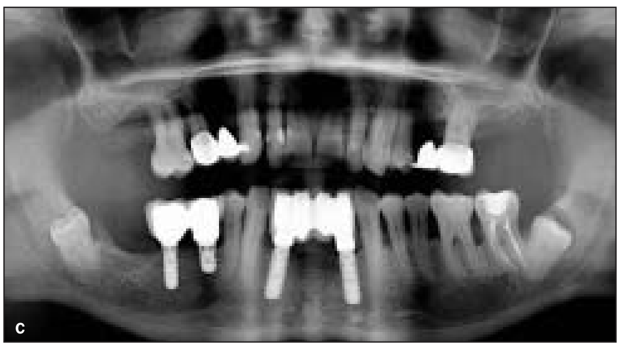
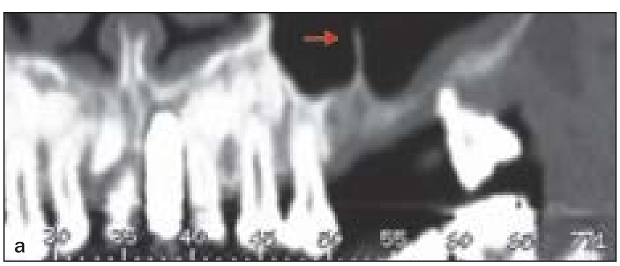
The dentist's main objective is to prevent and treat dental and periodontal complaints in order to keep teeth healthy. However, on numerous occasions, the dentist must deal with the replacement of missing teeth. The increasingly widespread use of dental implants has been accompanied by the development of research that has led to more predictable, simpler treatments. In fact, the survival and success rates of implants and implant-supported rehabilitations boast higher figures than traditional tooth-supported prostheses, thus improving the quality of life for patients.[1–3]

Bone deficit has traditionally been regarded from a quantitative and/or qualitative standpoint as an indicator of risk for implant survival.[4–6] A compromised residual bony ridge implies a higher risk of damage to important anatomical structures and forces the practitioner to perform bone grafting or reconstructive procedures, especially in posterior locations in the maxilla and mandible. In these regions, the maxillary sinus and the inferior alveolar nerve, respectively, are the most significant anatomical constraints. The use of short

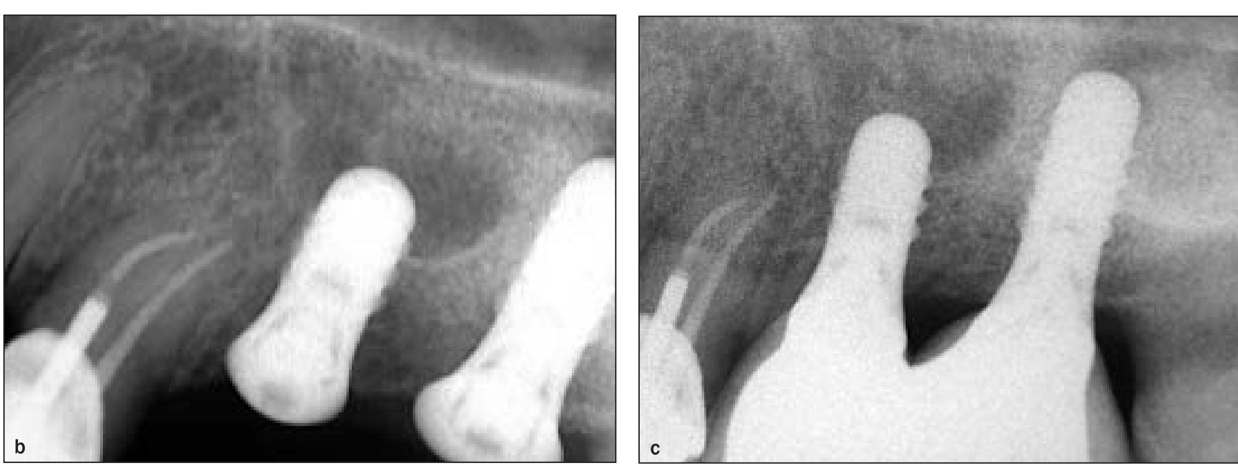




Figs 1a to 1c Six-mm implant splinted to another implant in the right mandibular second premolar showing reduced bone availability (7 mm): *(a and b)* presurgical situation, *(c)* 3-year follow-up.



Figs 2a to 2c Reduced bone availability in the posterior maxilla: (*a*) presurgical situation, (*b*) postsurgical situation, (*c*) 3-year follow-up.



implants at least partially reduces the difficulty inherent in compromised situations (Figs 1 and 2). It also reduces the biologic and economic cost for the patient, because it avoids complementary reconstructive procedures. The question at issue is whether the use of this type of implant increases the risk of failure from a biologic or prosthetic standpoint (success/survival rate). The authors found many publications that reflect poorer results with short implants,[7,8] especially in locations where the lack of bone volume is compounded by a poor quality of bone.[9,10] Most of these papers concern smooth implants. However, to date there is little long-term data for a large sample size evaluating the long-term predictability of rough implants.

The purpose of this paper is to elucidate some of the paradigms concerning the use of short implants. With this objective in mind, retrospective multicenter analysis of 230 SLA-surfaced implants with a 1- to 6-year follow-up was conducted in what is, to the best of the authors' knowledge, the largest published sample with 6-mm implants.

MATERIALS AND METHODS

The data in this study were obtained retrospectively from the consecutive analysis of the clinical records of 10 centers with private periodontal and implant practices. The data were gathered on 159 patients who were fitted with a total of 230 6-mm-long SLA-surfaced implants (Straumann).

Before surgery, bone availability was evaluated through orthopantomograms, periapical radiographs, and/or computed tomography (CT) scans. All cases presented bone height deficiencies, mostly in posterior regions of the maxilla and mandible. The 6-mm implants were rehabilitated with different types of superstructures, including individual crowns, fixed partial prostheses, fixed complete prostheses, and removable complete prostheses.

The objective of the analysis was at all times the implant survival rate instead of the implant success rate from the biologic or prosthetic viewpoint. Removal of the implant for any of the following reasons was considered failure: non-osseointegration, persistent pain, mobility, or untreatable infection. Although the primary variable was implant survival, data concerning the type of dental arch, width, and splinting of the implant were also analyzed.

Fisher's exact test was performed to analyze the association between failure and the different variables. The threshold value for statistical significance was $P < .05$. The odds ratio was also estimated, with a 95% confidence interval (CI). Moreover, a survival table was drawn up to calculate the number of failures in a defined interval in connection with the number of implants at risk during that interval. This ratio was cumulative for the entire study period. The number of implants at risk decreased with time. Therefore the confidence interval for the average survival was established as a function of time.

RESULTS

The follow-up time for the implants ranged between 1 and 6 years. The distribution of patients, implants, and failures by centers is shown in Table 1. Of the 230 implants placed, 7 failed, which represents a cumulative survival rate of 96.4% (Table 2). Most of the implants (90.4%) had a diameter of 4.1 mm, and the rest (9.5%) had a 4.8 mm diameter. Two hundred and fourteen implants (93%) were placed in the mandible, as opposed to 16 in the maxilla (6.9%). Only 2 implants were situated in the anterior region, both in the maxilla, as opposed to 228 implants placed in posterior sectors (Table 3).

Table 1 Implants Placed and Lost by Center

Center	Patients	Implants	Implants lost
1	14	22	0
2	47	65	2
3	29	49	3
4	11	11	0
5	12	13	0
6	19	32	1
7	3	6	0
8	3	5	1
9	17	19	0
10	4	8	0
Total	159	230	7

The distribution of the failed implants by centers is shown in Table 4. The development of the implants and their survival is shown in Table 5. All the implants that failed were placed in the mandible. Five implants failed during the osseointegration period, and in addition, two implants were not loaded and left submerged; therefore, only 223 implants received a superstructure. Of these 223, 2 failed. A single implant in a free-end situation failed 3 weeks after loading. The other implant was splinted to a longer implant and failed after 32 months in function as a consequence of peri-implantitis in a patient who smoked and failed to keep maintenance appointments. No statistically significant differences were found between failure before or after receiving a load ($P = .44$). The odds ratio (OR) was 2.48, showing a tendency toward an increased possibility of failure before loading rather than after, although there was no statistical significance. Of the loaded implants, 209 (93.7%) were splinted to other implants of the same or greater length, as opposed to 14 implants (6.2%) that received individual crowns. One implant in each group failed, resulting in a survival rate of 99.5% for the splinted loaded implants and 92.9% for the unsplinted loaded implants, and a survival rate of 99.1% for all implants that received a prosthetic load (regardless of splinting). No statistically significant differences were found regarding splinting ($P = .12$) (Tables 4 and 5).

Table 2 Survival Table of Implants

Time interval (mo)	Implants placed	Implants lost	Failed implants	Failure probability %	Survival probability %	Cumulative survival %
0	230	0	6	2.6	97.39	97.39
12	224	87	0	0	100	97.39
24	137	59	1	0.93	99.07	96.48
36	77	49	0	0	100	96.48
48	28	15	0	0	100	96.48
60	13	8	0	0	100	96.48
72	5	0	0	0	100	96.48

Table 3 Position and Characteristics of Implants by Center

Center	Upper	Lower	Posterior	Anterior	Splinted	Unsplinted	Diameter 4.1	Diameter 4.8
1	0	22	22	0	20	2	18	4
2	0	65	65	0	63	1	63	2
3	2	47	48	1	43	1	43	6
4	6	5	11	0	11	0	9	2
5	4	9	13	0	10	3	7	6
6	1	31	32	0	29	3	32	0
7	2	4	5	1	6	0	5	1
8	0	5	5	0	3	1	4	1
9	1	18	19	0	17	2	19	0
10	0	8	8	0	7	1	8	0
Total	16	214	228	2	209	14	208	22
	6.90%	93%	99.10%	0.9%	93.70%	6.2%	90.4%	9.5%

DISCUSSION

The present retrospective clinical study on 230 implants demonstrated a survival rate of 96.4% after 6 years of follow-up. A total of seven implants in seven patients failed in the present investigation. Numerous publications have questioned the predictability of short implants[5,11] for the replacement of missing teeth. Nevertheless, recent studies demonstrated favorable results with survival and success rates consistent with those achieved with longer implants.[12–19] In the study of Kotsovilis et al,[18] a meta-analysis on the survival of short implants compared to conventional implants was conducted, and the authors concluded that the placement of short rough-surface implants is not a less efficacious treatment modality than the placement of conventional rough-surface implants in either totally or partially edentulous patients. The same results were corroborated for Annibali et al,[16] who presented a cumulative survival rate (CSR) of 99.1% (95% CI: 98.8% to 99.4%). The biological success rate was 98.8% (95% CI: 97.8% to 99.8%), and the biomechanical success rate was 99.9% (95% CI: 99.4% to 100.0%). Results from the present investigation are in agreement with these latter data. From a surgical standpoint, the posterior region of the maxillae is frequently associated with a deficient bone quality and quantity. Considering these limitations, two therapeutic options are available for the clinician: bone augmentation or short implant placement. The second option may offer some advantages, due to the reduced need for open sinus elevation and graft techniques, which, albeit predictable,[20] do imply a higher biological risk[21] and increase economic cost and rehabilitation time. Recent publications on short and rough implants[14,21] have established higher survival rate ranges than those found in papers on augmentation procedures in the posterior maxillary zone.[22,23]

In the lower posterior region of the mandible, the most important risk is that the inferior alveolar nerve may be affected and the mandibular lingual cortex may be perforated, thus compromising the sublingual artery. Vertical augmentation procedures in the mandible

Table 4 Distribution and Characteristics of Failed Implants

Center	Failed	Before loading	After loading	Upper	Lower	Splinted	Un-splinted
2	2	1	1	0	2	0	1
3	3	3	0	0	3	0	0
6	1	0	1	0	1	1	0
8	1	1	0	0	1	0	0
Total	7	5	2	0	7	1	1

Table 5 Development and Survival of Implants

	No. of implants	No. of implant failures	Implant survival	
			No.	%
Placed	230	7 (2 left sleeping)	223	96.9
Maxilla	16	0	16	100
Mandible	214	7	207	96.7
Loaded	223	2	221	99.1*
Splinted	209	1	208	99.5
Unsplinted	14	1	13	92.9**

*$P < .44$, odds ratio (OR) = 2.47, 95% confidence interval (CI) = 0.47 –12.91.
**$P < .12$, OR = 0.06, 95% CI = 0.003 – 1.058

do not have a very high predictability.[24] The transposition of the inferior alveolar nerve entails numerous secondary effects and a high morbidity.[25] Bone distraction processes, though predictable, increase the treatment time, pain, and risk of complications[26] and are saved for exceptionally severe situations. The survival rate of short implants in the mandible as shown in this study (96.7%) demonstrated that the use of short implants is a reasonable therapeutic alternative.[5,15–19,24,26–28] The risk of implant failure may depend on different factors such as bone quantity and quality,[21,29] microscopic and macroscopic design of the implants,[8,6–30] occlusal load,[31–33] and infection,[11,34,35] as well as surgical factors related to the osteotomy preparation.[30,36] Some of these variables are mainly related to an early failure of the implant, whereas other factors represent risk of a late failure, ie, after loading. Nevertheless, although some of these are considered to be more important than others, it is most likely the combination of two or more factors that precipitates failure. In the present investigation, seven implants failed; five before prosthetic loading, and two afterwards. These results showed a high predictability of 6-mm long SLA implants loaded and in function (99.1%). Most of the publications agree with these results and report a higher number of failures during the osseointegration period[37–39] or during the first year of loading.[8,40]

Most of the unfavorable results observed in the literature are related to studies that investigated smooth-surfaced implants.[20,29,41] The moderately rough surface available on the market nowadays demonstrated[42] higher bone-implant contact percentages[36,43] and faster rates of osseointegration[20,44,45] when compared to smooth-surfaced implants. The SLA surface used in the present investigation[20,46,47] yielded favorable results in clinical and experimental studies[20] when compared to other surfaces, and this may in part justify the results observed. In fact, in light of the growing favorable evidence on short implants and new implant surfaces, the authors consider it a possibility to reclassify the "non-standard" implant into "reduced-length implants" (8 to 9 mm) and "short implants" (< 8 mm).

Five of the seven failures that occurred during the observation period were identified before loading; therefore these failures can be somehow related with surgical aspects of implant placement. According to the literature, early healing failures may be related to bone overheating during implant bed preparation[48] or impaired implant stability due to macroscopic design,[40] bone quality, and implant length.[5]

Two more failures occurred after loading. One implant was part of a two implant–supported bridge that failed as a consequence of a process of peri-implantitis in a patient who smoked and failed to attend the appropriate supportive periodontal therapy care. The second implant was a free-end single unit that failed 3 weeks after loading. It has been proposed that loss of osseointegration depends not only on bacterial overload, but also on forces stemming from occlusal overload.[31,49,50] Both overload and infection may have precipitated implant failure. Although there is no agreement on the effective role of occlusal overload on the loss of osseointegration, it should be taken into consideration that shorter implants may be more susceptible to the possible effects of trauma stemming from occlusal overload.

The post-loading survival rate of the 6-mm implants observed in the present study (99.1%) was high. Few papers in the literature evaluated the influence of the implant-crown proportion on implant survival and success rates. Some research groups evaluated peri-implant health around short implants[13,22] and their findings are in agreement with observations from the present study. Nevertheless, biomechanical risks of screw loosening or fracturing, abutment loosening, or implant fracturing in these types of oral rehabilitations must be taken into account.

All the implants in this study except two were placed in posterior sectors and 209 implants (93.7%) were splinted to other implants of the same or greater length, whereas 14 implants (6.2%) were rehabilitated with a single unit crown. Both groups showed one implant failure after prosthetic loading, which rendered a survival rate of 99.5% for the splinted implants and 92.9% for the unsplinted implants. The suitability of splinting short implants is consistent with data observed in other studies.[8,9,51] However, in this study the authors have not categorized the lengths of the implants splinted to the 6-mm implants. Therefore it has not been able to analyze its possible impact on the results.

Bone quality is considered another risk factor for implant survival.[52] When there are both qualitative and quantitative deficiencies, the risk of failure grows, especially in the maxilla. In the present study, only 16 implants (6.9%) were placed in the maxilla. The lack of literature on the long-term behavior of short (5 to 7 mm) implants in the posterosuperior region[51,53] should alert the clinician to be cautious when placing short implants in such locations. The use of implants with improved surfaces, the placement of a larger number of fixtures, and splinting to other implants, as well as surgical techniques aiming to improve the implant stability, should be considered when dealing with such clinical situations.[42,51]

CONCLUSION

Within the limitations of this retrospective study, the 6-mm SLA implants presented in this study demonstrated an overall medium-term survival rate that may be comparable to that of standard-length implants. It may be suggested that implants included into multi-unit bridges are safer than single-crown units. Furthermore, the clinician should be aware of risk factors when placing short implants into the posterior region of the maxilla. More prospective studies and randomized controlled clinical trials are needed in order to confirm the present findings and allow a safe and predictable use of short implants within the therapeutic arsenal of the clinician.

ACKNOWLEDGMENTS

The authors kindly acknowledge Dr Fabio Vignoletti for his assistance during the review process.

The authors reported no conflicts of interest related to this study.

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