Fifteen-Year Follow-up of Short Dental Implants in the Completely Edentulous Jaw: Submerged Versus Nonsubmerged Healing

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Purpose: *Short implants are a minimally invasive alternative in the management of alveolar bone atrophy. This study aimed to assess the influence of the surgical approach (1-stage vs 2-stage) on the 15-year survival and marginal bone loss of short implants in a fixed complete denture.*

Materials and Methods: *A retrospective clinical study was conducted in a single private dental clinic that included short implants placed between January 2001 and December 2002.*

Results: *Forty-one short implants supported 18 screw-retained complete dentures. The mean follow-up time was 15 ± 3 years. The surgical approach (1-stage vs 2-stage) did not significantly affect implant survival and marginal bone loss. The implant survival rate was 90.2%.*

Conclusions: *Short dental implants could be predictably indicated to support fixed complete dentures. The implants could be placed through a 1- or 2-stage surgery. (Implant Dent 2019;28:551–555)*

Key Words: short implant, implant survival, marginal bone loss, submerged healing, long-term

Minimally invasive implantology has gained popularity in recent years.[1] This popularity could be related to improvements in the surface and design of the implants and to the development of minimally invasive surgical techniques that preserve, at most, the residual alveolar bone.[2,3]

The use of short implants could be an alternative to bone augmentation surgery. Short (length ≤8 mm) implants have been shown to have high survival rates and have resulted in 3 times fewer intraoperative complications compared with long implants.[4] Different meta-analysis studies have found similar implant and prosthesis survival rates for short dental implants and standard implants placed in vertically augmented bone.[5,6] Short dental implants may be the preferred treatment in atrophic alveolar bone, as they have been associated with lower biological complications and decreased morbidity, costs, and surgical times.[4,7]

There are 2 types of implant surgery: a 1-stage surgery in which the implant and a transmucosal abutment are placed in the same surgery (nonsubmerged healing) and a 2-stage surgery in which the implant and the abutment are placed in 2 different surgical interventions (submerged healing).[8–11] Submerged healing enables implant osseointegration, and it protects the implant from excessive micromovements.[8,9] Nonsubmerged healing is less invasive and shortens the time of implant loading and prosthesis delivery.[10,11] However, it is important to avoid implant micromovements that exceed 150 μm due to the detrimental effect on implant osseointegration and the increase in the risk of early implant failure.[12–15]

The high life expectancy at birth and the longevity of our patients indicate that dental implants work for an increased time. However, there is a paucity of clinical studies that have assessed the long-term prognosis of short dental implants. There have been few studies with a follow-up time longer than 10 years.[16–18]

The purpose of the study was to assess the long-term outcomes of short dental implants supporting fixed complete prostheses and the effect of the

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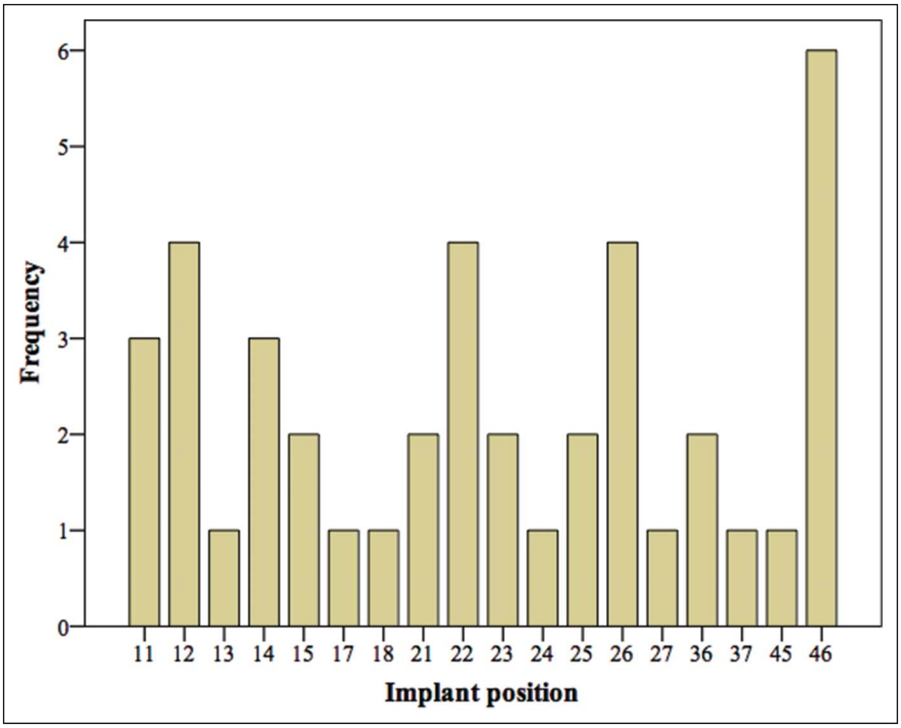

Fig. 1. Anatomical position of the placed dental implants: Most of the dental implants were in the maxilla.

surgical approach (1-stage vs 2-stage). The hypothesis of the study was that the surgical approach is not a risk factor for the survival of short dental implants supporting fixed complete dentures. The implant survival rate, marginal bone loss, antagonist type, and crown-to-implant ratio (CIR) were assessed.

Materials and Methods

Study Design

The article was prepared according to the Strengthening the Reporting of Observational studies in Epidemiology (STROBE) guidelines.[19] This study was performed after the Helsinki declaration regarding investigations with human subjects. An exemption from institutional review board approval of the study protocol was granted by the author's institution, as it was a retrospective study, and the evaluated medical device had already been approved for clinical use.

In this retrospective study, the inclusion criteria were patients older than 18 years at the time of surgery, presence of a fixed complete denture supported by at least 1 dental implant with a length ≤8.5 mm, and implant insertion between June 2001 and December 2002. There were no specific exclusion criteria.

Variables

The predictor variable was the surgical approach (1-stage vs 2-stage). The primary outcome was the implant survival rate that was assessed by time-to-event analyses. The secondary outcomes were (1) patients' sex and age, (2) marginal bone loss after loading,[20] (3) CIR,[13] and (4) number of failed dental prostheses.

Table 1. Implant Dimensions Grouped by the Type of Surgical Approach

	Length (No. of Implants)		Diameter (No. of Implants)		
Surgical Approach	7.0 mm	8.5 mm	3.3 mm	3.75 mm	4.0 mm
One-stage (25 implants)	1	24	11	10	4
Two-stage (16 implants)	0	16	3	11	2
P	0.418*			0.176*	

No differences between the groups in relation to the variables of sex and smoking. Groups were significantly different in the age of the patients.
*Chi-squared test.

Data Collection Methods

Clinical and radiographic data were reviewed by the treating dentists to assess implant survival (the patient had the implant in their mouth at the last visit). The measurement of the marginal bone loss was performed on a digital radiograph.[20] The marginal bone loss was measured on the mesial and distal aspects of each implant. Marginal bone loss was later determined by calculating the mean of the mesial and distal bone loss.

Surgical technique. After the reflection of a full-thickness flap, implant sites were marked by the initial drill (1.5-mm drill) working at 850 to 100 rpm under irrigation. Implant site preparation was continued with appropriate diameter drills.[12,21] The implant surface was bio-functionalized with plasma rich in growth factors (BTI Biotechnology Institute; Vitoria, Spain) before placement in the bone.[22,23] The implants evaluated in this study had a moderately rough and acid-etched surface.[24]

None of the implants was immediately loaded. The prosthesis was screwed to surgical abutments (not directly to the implant). The rehabilitation was performed at a centric occlusion.

Data Analysis

Qualitative variables were described by calculating the absolute and relative frequency, and quantitative variables were described by the mean and SD. The normal distribution of the data was verified with a Shapiro-Wilk test. Qualitative variables were analyzed with a χ^2 test. A Mann-Whitney test was used to analyze the age and follow-up time according to the surgical approach. A *t* test was used to compare the variables of the CIR and marginal bone loss according to the surgical approach. A *t* test was also used to assess the influence of sex, age, smoking, antagonist type, and number of neighboring implants on marginal bone loss. Linear regression was selected to test the effect of age, CIR, and implant

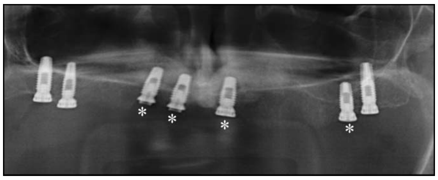

Fig. 2. Radiographic image showing the dental implants after implant surgery. *Noted the short implants followed in this study.

diameter on marginal bone loss. The statistical significance was set at $P < 0.05$. SPSS v15.0 for Windows statistical software package (SPSS Inc. Released 2006. SPSS for Windows, Version 15.0. Chicago, SPSS Inc.) was used for statistical analyses.

RESULTS

In this study, 41 short dental implants supporting 18 fixed complete prostheses (screw retained) were assessed. The implants were placed in 9 patients, and the patients' mean age at the time of surgery was 62 ± 9 years (range: 47–72 years). Figure 1 shows the position of the short dental implants.

Regarding implant characteristics, all but one of the implants were 8.5 mm in length and had a diameter of 3.75 mm or less (Table 1). There were no statistically significant differences in implant characteristics according to the surgical approach. The short implants (9 implants) were the most distal implants in 7 prostheses. Twelve implants were at in-between positions in 5 prostheses. Another 20 implants (6 prostheses) had the short implants at the most distal and in-between positions. The differences in the number of neighboring implants with respect to the surgical approach were not statistically significant (Figs. 2 and 3).

After insertion, the dental implants were followed for 179 ± 36 months.

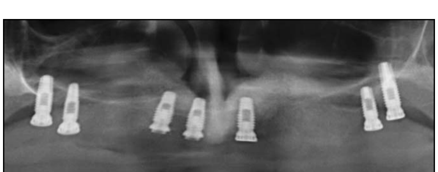

Fig. 3. Radiographic image showing the dental implants at the time of implant loading. The implants were placed with 2-stage surgery.

Four implant failures were registered, and there was no significant effect of the surgical approach (Table 2). Two implants in the 2-stage group failed after 7 and 97 months. In the 1-stage group, 2 implants also failed after 118 months. The cumulative survival rates were 92% and 87.5% for 1- and 2-stage surgery ($P = 0.590$).

Table 2 shows that the mesial marginal bone loss but not the distal bone loss was significantly higher in 1-stage implant surgery. There was no significant effects relating to sex, age, smoking, number of neighboring implants, CIR, antagonist type, and implant diameter on the marginal bone loss (Table 3). The proximal marginal bone loss (the mean of the mesial and distal marginal bone loss) was not significantly affected by the surgical approach ($P = 0.092$). The proximal bone loss was 0.95 ± 0.64 mm and 0.57 ± 0.70 mm for the 1-stage and 2-stage groups, respectively (Figs. 4 and 5).

The mean follow-up time of the prosthesis was 166 ± 34 months. There were no statistically significant differences in the type of the antagonist and the CIR (Table 4). Two implant failures required the renewal of 2 prostheses. Another 7 prostheses were modified due to the loss of a nonshort implant (1 prosthesis), changes in their design (5 prostheses), or both (1 prosthesis).

DISCUSSION

This study aimed to analyze the long-term outcomes of short dental implants placed in 1-stage versus 2-stage surgery. The study hypothesis was that the type of surgical approach (1-stage vs 2-stage) is not a risk factor for the survival of short dental implants supporting fixed complete prosthesis. The implant survival rate, the marginal bone loss, the prosthesis survival, and influencing factors were assessed. The 15-year survival rate (90.2%) and the marginal bone loss (less than 1 mm) strengthened the indication for short dental implants in the completely edentulous jaw.

In this study, all the implants were ≤8.5 mm in length. The definition of short dental implants has gone through several changes over time. Short length was previously considered as <10, ≤8.5, ≤8, <8, and 6 mm.[4,7,25–27] This tendency to shorten the implant length could be considered as indirect evidence of the predictability of short implants. A short dental implant is a minimally invasive option to treat edentulism in an atrophied alveolar process.[4] Minimally invasive implantology has gained popularity in recent years.[1] Moreover, patients surviving chronic diseases would benefit from minimal surgical intervention.

The implants in this study have been supporting fixed complete prostheses. All the dentures were screw-retained. The implant survival rate was 90.2% after a mean follow-up time of 15 years. Only 3 studies have documented the outcomes of short implants at a mean follow-up time greater than 10 years.[16–18] The study by Lops et al[17] had the highest mean follow-up time (13.2 years). In that study, 26 short implants (8 mm in length) were supporting 4 fixed complete dentures, and 3 implant failures were documented.

Placing the dental implants in a 1-stage versus 2-stage approach did not significantly affect the long-term

Table 2. Implant-Centered Outcomes Grouped by the Type of Surgical Approach

Surgical Approach	Follow-up (mo) Implant	Follow-up (mo) Prosthesis	Mesial MBL (mm)	Distal MBL (mm)	Implant Failures
One-stage (25 implants)	188 ± 6	166 ± 29	0.94 ± 0.76	0.98 ± 0.69	2
Two-stage (16 implants)	190 ± 14	170 ± 28	0.38 ± 0.76	0.75 ± 0.86	2
P	0.552*	0.171*	0.038†	0.399†	0.636‡

There were no statistically significant differences in relation to implants length and diameter.
*Mann-Whitney test.
†*t* test.
‡Chi-squared test.

Table 3. Factors Influencing the Marginal Bone Loss

Variables	Categories	Mesial MBL (mm)	*P*	Distal MBL (mm)	*P*
Sex	Male	0.94 ± 0.45	0.808*	1.28 ± 1.14	0.397*
	Female	0.81 ± 0.70		0.82 ± 0.67	
Smoking	Yes	0.97 ± 0.80	0.688*	1.15 ± 0.67	0.460*
	No	0.79 ± 0.67		0.82 ± 0.72	
Antagonist	Periodontal ligament	0.99 ± 0.95	0.370*	1.16 ± 0.84	0.343*
	Osseointegration	0.69 ± 0.77		0.87 ± 0.73	
No. of neighboring implants	One implant	0.66 ± 0.94	0.688*	0.81 ± 0.81	0.066*
	Two implants	0.77 ± 0.72		1.1 ± 0.68	
Age		0.617†		0.084†	
Anatomical CIR		0.407†		0.856†	
Implant diameter		0.924†		0.264†	

The marginal bone loss was not significantly affected by any of the following factors.
*t test.
†Linear regression.

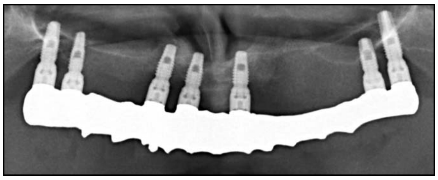

Fig. 4. Radiographic image showing the dental implants after 11 years of implant insertion. Marginal bone loss was 0.1, 0.3, 0.5, and 0.7 mm for the implants at the position of #14, #26, #11, and #21, respectively.

implant survival and proximal marginal bone loss. Mezzomo et al[28] showed no statistically significant effect of the surgical approach on the mean failure proportion of short implants (<10 mm). A recent systematic review has also shown no significant effect of the surgical approach on late implant failure (after at least 6 months after insertion).[11] Regarding marginal bone loss, a small effect size (0.13 mm), although statistically significant, has been shown in favor of the nonsubmerged healing (1 year after loading).[11] However, in another systematic review, submerged healing has resulted in lesser marginal bone loss. An important difference between both reviews is that in the study by Mezzomo et al,[28] only short implants were assessed.

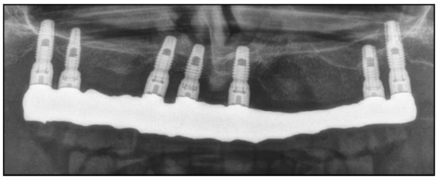

Fig. 5. Radiographic image showing the dental implants after 15 years of implant insertion. New prosthesis was inserted.

Submerged healing allows for implant osseointegration and protects the implant from excessive micromovements.[8,9] Implant micromovements exceeding 150 μm may have detrimental effects on implant osseointegration and may increase the risk of early failure.[12–15] A second surgery is needed to uncover the implant and connect the implant abutment. Nonsubmerged healing is less invasive and shortens the time of implant loading and prosthesis delivery.[10,11] Davies[14] suggested that excessive implant micromotion may interfere with the formation of the fibrin clot on the implant surface during early wound healing. Primary implant stability allows for bone formation that increases the bone-to-implant contact.[12] Engelke et al[15] have concluded that an insertion torque greater than 30 Ncm is advisable to achieve adequate primary stability and a torque value ≤11 Ncm is considered a risk factor that increases the likelihood of implant failure.

This study suffers from the limitation of a retrospective design where there is dependence on the availability and accuracy of medical/dental records, and it is difficult to control bias and confounders. There is no randomization or blinding.

CONCLUSIONS

Short dental implants could be predictably indicated to support fixed complete dentures. Long-term follow-up (15 years) showed the absence of significant effects of the surgical approach (1-stage vs 2-stage) on implant survival and marginal bone loss. Future controlled and prospective clinical research is needed to confirm the outcomes of this retrospective study.

DISCLOSURE

E. Anitua is the Scientific Director of BTI Biotechnology Institute (Vitoria, Spain). He is the head of the Foundation Eduardo Anitua, Vitoria, Spain. He also has the patent of PRGF technology. M. H. Alkhraisat is a researcher at BTI Biotechnology Institute (Vitoria, Spain).

Table 4. Prosthesis-Centered Outcomes Grouped by the Type of Surgical Approach

Surgical Approach	Antagonist: Periodontal Ligament	Antagonist: Osseointegration	CIR: Anatomical	No. of Neighboring Implants: 1 implant	No. of Neighboring Implants: 2 Implants
One-stage (25 implants)	8	0	1.5 ± 0.3	9	16
Two-stage (16 implants)	13	13	1.5 ± 0.5	7	9
P	0.835*	0.859†	0.620*		

There were no statistically significant differences in relation to the antagonist type, CIR, and the number of neighboring implants.
*Chi-squared test.
†t test.

Approval

An exemption from institutional review board approval of the study protocol was granted by the author's institution, as it was a retrospective study, and the evaluated medical device had already been approved for clinical use.

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