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Do longer implants improve clinical outcome in immediate loading?

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M. Degidi, A. Piattelli, G. Iezzi, F. Carinci: Do longer implants improve clinical outcome in immediate loading?. Int. J. Oral Maxillofac. Surg. 2007; 36: 1172–1176.

Abstract. It is generally believed that longer implants (length >13 mm) have higher success rates than standard implants (length = 13mm). Few reports focus on long implants and none specifically address the clinical outcome of immediate loading (IL) of longer implants. This retrospective study was performed to compare the clinical outcomes of long and standard length implants. A total of 244 standard and 536 long implants were inserted and immediately loaded. The mean follow-up was 3 years. Only 4 of 780 implants (99.5%) were lost, and these 4 were all 13 mm long. No or reduced marginal bone loss was taken as an additional indicator of success to evaluate the effect of several factors on clinical outcome. Only 4 of the 244 13-mm-long implants were lost (98%), but this was statistically different from the survival rate of longer implants. Poor quality bone was related to increased marginal bone loss and thus a worse outcome in both groups. IL standard length implants have a high survival rate, but it is statistically worse than that of IL longer implants. Standard or longer implants are reliable devices for insertion in poor quality bone, although slightly higher bone resorption is to be expected.

Key words: general linear model; immediate loading; implant failures; long implants; dental fixtures.

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Osseointegrated dental implants have proved to be predictably successful when appropriate guidelines are followed. Traditionally, implant treatment of edentulous patients was based on a two-stage surgical protocol with a healing period of 3–6 months during which the implants were submerged to achieve osseointegration[1]. This approach was considered to be an essential step for successful implant treatment, because it was believed that micromovement of implants, due to functional forces at the bone–implant interface during wound healing, could induce the formation of fibrous tissue rather than bone, leading to failure[1]. In addition, a submerged implant was thought necessary to prevent infection and epithelial downgrowth[1].

In the 1980s, the concept of a one-stage surgical approach was proposed: Babbush et al.[5] reported a cumulative success rate of 88% in 1739 immediately loaded (IL) titanium plasma-sprayed screw implants[5]. The problem with this study was that the denture was often not connected with the clips for a month, and was tissue borne and not implant borne. Subsequently, several clinical and histological studies focused on possible guidelines to achieve from the one-stage surgical/prosthetic procedure the same results as from the traditional submerged technique[7,21]. In these studies, implants inserted according to a one-stage surgical procedure showed the same success rate as obtained with the original two-stage protocol. Further studies confirmed that a one-stage surgical procedure followed by immediate loading (IL) of the

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implants (in totally edentulous patients to avoid removable prostheses in the healing phase) can achieve high clinical and radiographic success rates[8,19]. Excellent results have also been reported for partial or totally edentulous jaws[12–15], indicating that IL is a successful and time-saving procedure when appropriate protocols are followed. IL means placing the final or provisional prosthetic restoration immediately or within 48 h of the surgical procedure, whereas early loading is prosthetic rehabilitation delivered from the second day up to a week after surgery[12–15].

Generally, it is believed that longer implants (i.e. length >13 mm) have higher success rates than standard (i.e. 13-mm-long) implants, because the former have higher bone–implant contact and a better crown-height/implant-length ratio. To the authors' knowledge, there has been no report that specifically addressed the clinical outcome of IL of longer implants, and thus it was decided to perform a retrospective study to evaluate success rates and marginal bone loss over a 3-year follow-up period. The aim of the present study was an evaluation of the possible differences regarding clinical outcome of long versus standard-length implants.

Materials and methods

Data were collected as in previous published studies[12–15].

Patients

In the period January 1995–October 2004 (median follow-up 36 months, range 1–107 months), 780 IL implants were inserted (336 in males, 444 in females; median age 55 years, range 15–83). All operated patients were evaluated. Informed written consent approved by the Ethics Committee of the University of Chieti-Pescara was obtained from patients to use their data for research purposes.

Patients were screened according to the following inclusion criteria: controlled oral hygiene (overall plaque score <20%[4]), the absence of any lesions in the oral cavity, sufficient residual bone volume; in addition, the patients had to agree to participate in a postoperative control program.

Exclusion criteria were as follows: insufficient bone volume, a high degree of bruxism (i.e. occlusal emanel and dentin abrasions of four, two antagonists per jaw, or more teeth), smoking more than 20 cigarettes/day and excessive consumption of alcohol (about 1 L/day of wine), localized radiation therapy of the oral cavity, antineoplastic chemotherapy, blood, liver and kidney diseases, immunosupressed patients, patients taking corticosteroids, pregnant women, inflammatory and autoimmune diseases of the oral cavity, poor oral hygiene (overall plaque score >20%[4]).

Data collection

Before surgery, radiographic examinations were performed using periapical radiography, orthopantomography and computerized tomography. In the follow-up period periapical radiographs were used.

In each patient, peri-implant marginal bone level was evaluated by calibrated examination of periapical X-rays. Measurements were recorded after surgery and at the end of follow-up. These were carried out mesially and distally to each implant, calculating the distance between the edge of the implant and the most coronal point of contact between the bone and implant. The bone level recorded just after surgical insertion of the implant was the reference point for the following measurements. The measurement was rounded off to the nearest 0.1 mm. A peak Scale Loupe with a magnifying factor of seven times and a scale graduated in 0.1 mm was used. All the measurements were made by three independent examiners. Peri-implant probing was not performed because controversy still existed regarding the correlation between probing depth and implant success rates[28].

Implant success rate was evaluated according to the following criteria: (1) absence of persisting pain or dysesthesia; (2) absence of peri-implant infection with suppuration; (3) absence of mobility; and (4) absence of persisting peri-implant bone resorption greater than 1.5 mm during the first year of loading and 0.2 mm/year during the following years[3].

Implants

A total of 780 implants were inserted. There were 9 Ankylos (DENTSPLY-Friadent, Mannheim, Germany), 51 Branemark (Nobel Biocare, Gothenburg, Sweden), 268 Frialit-2 (DENTSPLY-Friadent), 40 Frialoc (DENTSPLY-Friadent), 34 IMZ (DENTSPLY-Friadent), 51 Maestro (BioHorizons, Birmingham, AL, USA), 67 Restore (Lifecore Biomedical, Chaska, MN, USA), 60 TiUnite (Nobel Biocare, Gothenburg, Sweden), 133 XiVE (DENTSPLY-Friadent) and 67 XiVE TG (DENTSPLY-Friadent). Implant diameter ranged from 3.0 to 6.5 mm and implant length ranged from 13 to 18 mm. There were 329 post-extraction implants. Implants replaced 301 incisors, 145 cuspids, 238 premolars and 96 molars. Three hundred and ninety-three fixtures were inserted in the maxilla and 387 in the mandible. Implants were used to support single-tooth restorations (18 standard and 79 long implants), mandibular overdentures (42 standard and 145 long implants), and mandibular long-span (68 standard and 115 long implants) and maxilla full-arch (116 standard and 197 long implants) restorations. Bone quality was $D \leq 2$ in 532 cases and all 780 implants were IL. Bone quality was defined as indicated by Misch[23] (D1 = thick cortical and dense cancellous bone; D2 = thick cortical and fenestrated cancellous bone; D3 = thin cortical and dense cancellous bone; D4 = thin cortical and fenestrated cancellous bone).

Surgical and prosthetic technique

All patients underwent the same surgical procedure. Antimicrobial prophylaxis was obtained with 500 mg amoxycillin twice daily for 5 days starting 1 h before surgery. Local anaesthesia was induced by infiltration with articaine/epinephrine and post-surgical analgesic treatment was performed with 100 mg Nimesulid twice daily for 3 days. Patients had a soft diet for 4 weeks and oral hygiene instructions were provided.

After a crestal incision a mucoperiosteal flap was elevated. Implants were inserted according to the procedures recommended by different systems. A temporary restoration was relined with acrylic, trimmed, polished, and cemented or screw retained 1–2 h later. Occlusal contact, when possible, was avoided in centric and lateral excursions. After provisional crown placement, a periapical radiograph was impressed by means of a customized Rinn holder device. This device was necessary to maintain the X-ray cone perpendicular to a film placed parallel to the long axis of the implant. Sutures were removed 14 days after surgery. After 24 weeks from implant insertion, the provisional crown was removed and a final impression of the abutment was recorded by using a polyvinylsiloxane impression material. The final restoration was always cemented and was delivered approximately 32 weeks after implant insertion. All patients were included in a strict hygiene recall.

Statistical analysis

Statistically significant differences were evaluated using the Fisher exact test (*P*-value <0.05)[2]. In addition, no or reduced marginal bone loss (MBL) was considered as an indicator of success rate (SCR) to evaluate the effect of several host-, surgery-, implant-, and occlusion-related factors.

The difference between the implant abutment junction and the marginal bone level was defined as the insertion abutment junction (IAJ) and calculated at the time of surgery and during follow-up. Delta IAJ was defined as the difference between IAJ at the last control and IAJ recorded just after surgery, and was an indicator of MBL. Delta IAJ medians were stratified according to the variables of interest. A linear general model was then performed to detect those variables associated with a delta IAJ[16].

Results

Only 4 of the 780 implants were lost (i.e. survival rate, SRR = 99.5%). These four implants were all 13 mm long, and were inserted in four different patients. A statistically significant difference was found between 13-mm-long implants (244 cases and 4 failures) and longer implants (536 cases and no failures) ($P = 0.02$). The four failed implants had a diameter ≥3.8 mm. There was no statistically significant difference between the group with diameter ≤3.75 (208 cases and no failures) and the group with diameter ≥3.8 mm (572 cases and 4 failures) using the Fisher exact test ($P = 0.58$).

Tables 1–5 show the median delta IAJ according to the studied variables. Table 6 shows that good quality bone was related to a lower delta IAJ (or reduced MBL) and thus a better outcome in both groups. No differences were detected between longer and standard length implants as regards bone quality using the Mann–Whitney *U*-test ($P > 0.05$). Implant type, diameter, tooth site, and post-extraction implants also showed no differences. In Table 7 the four failed implants are described.

Table 1. Distribution of series with regard to implant type and delta IAJ or MBL

	N		
	Valid	Missing	Median
G-1			
BRANEMARK	14	–	−1.05
FRIALIT2	79	4	.01
FRIALOC	5	–	−.5
IMZ	14	–	−1.2
MAESTRO	47	–	−.7
RESTORE	27	–	.01
TiUnite	17	–	.01
XiVE	29	–	−.3
XiVE TG	8	–	−.5
G-2			
BRANEMARK	37	–	−1.1
FRIALIT2	185	–	.01
FRIALOC	35	–	−.5
IMZ	20	–	−1.1
MAESTRO	4	–	−1.5
RESTORE	40	–	−.5
TiUnite	43	–	.01
XiVE	104	–	−.3
XiVE TG	59	–	−.5
ANKYLOS	9	–	.01

Delta IAJ/MBL correspond to median (mm). Missing cases are failures; valid cases are those still in place at the end of follow-up and considered for MBL (or SCR). G-1 = 13 mm long; G-2 > 13 mm long.

Table 2. Distribution of series with regard to site and delta IAJ or MBL

	N		
	Valid	Missing	Median
G-1			
Incisors	65	–	−.7
Cuspids	34	1	−.6
Premolars	76	1	−.45
Molars	65	2	−.1
G-2			
Incisors	236	–	−.4
Cuspids	110	–	−.25
Premolars	161	–	−.5
Molars	29	–	−.5

Delta IAJ/MBL correspond to median (mm). Missing cases are failures; valid cases are those still in place at the end of follow-up and considered for MBL (or SCR). G-1 = 13 mm long; G-2 > 13 mm long.

Table 3. Distribution of series with regard to implant diameter and delta IAJ or MBL

	N		
	Valid	Missing	Median
G-1			
$D < 3.75$ mm	42	–	−.65
$D = 3.75$ mm	20	–	−1.05
$D > 3.75$ mm	178	4	−.3
G-2			
$D < 3.75$ mm	72	–	−.25
$D = 3.75$ mm	72	–	−1.0
$D > 3.75$ mm	391	–	−.4
	1	–	.01

Delta IAJ/MBL correspond to median (mm). Missing cases are failures; valid cases are those still in place at the end of follow-up and considered for MBL (or SCR). G-1 = 13 mm long; G-2 > 13 mm long; *D* = diameter.

Table 4. Distribution of series with regard to post-extractive (Yes) site and delta IAJ or MBL

	N		
	Valid	Missing	Median
G-1			
No	125	2	−.5000
Yes	115	2	−.2000
G-2			
No	324	–	−.4000
Yes	212	–	−.4000

Delta IAJ/MBL correspond to median (mm). Missing cases are failures; valid cases are those still in place at the end of follow-up and considered for MBL (or SCR). G-1 = 13 mm long; G-2 > 13 mm long.

Table 5. Distribution of series with regard to bone quality and delta IAJ or MBL

	N		
	Valid	Missing	Median
G-1			
D1	8	–	−.35
D2	129	2	−.5
D3	79	2	−.4
D4	24	–	.01
G-2			
D1	47	–	−.4
D2	346	–	−.5
D3	127	–	.01
D4	16	–	.01

Bone quality (D1–D4) defined according to Misch[23]. Delta IAJ/MBL correspond to median (mm). Missing cases are failures; valid cases are those still in place at the end of follow-up and considered for MBL (or SCR). G-1 = 13 mm long; G-2 > 13 mm long.

Discussion

The high success rate of dental implants has changed the quality of life for many patients. IL finds its application in some clinical cases and certainly supplies another modality of treatment for the implant patient. Starting with a couple of implants placed in the mandible and IL after surgical placement with an overdenture[8,19], this concept evolved to immediately loading multiple implants in both the maxilla and the mandible[12,13,14,15].

The identification of guidelines for long-term SRR (i.e. all implants still in place at end of follow-up) and SCR (i.e. good clinical, radiological and aesthetic outcomes) are the main goals of the recent literature. Several variables can influence the final result, but in general they are grouped as (1) surgery-, (2) host-, (3) implant- and (4) occlusion-related factors[18]. The surgery-related factors include

Table 6. Output of the general linear model reporting variables statistically associated to delta IAJ

Length	Parameter	*B*	Standard error	*t*	Sig.	95% CI		Observed power
						Lower bound	Upper bound	
G-1	Intercept	−1.197	.338	−3.540	.000	−1.863	−.531	.941
	Diameter	.139	.058	2.411	.017	2.544E−02	.253	.671
	Length	0	–	–	–	–	–	–
	Bone quality	.224	.064	3.516	.001	9.836E−02	.349	.938
	Tooth site	2.197E−02	.025	.877	.381	−2.738E−02	7.133E−02	.141
	Age	−3.579E−03	.005	−.785	.433	−1.256E−02	5.397E−03	.123
G-2	Intercept	.309	.529	.585	.559	−.730	1.348	.090
	Diameter	5.798E−02	.037	1.552	.121	−1.543E−02	.131	.341
	Length	−6.227E−02	.032	−1.936	.053	−.125	9.035E−04	.489
	Bone quality	.187	.043	4.370	.001	.103	.272	.992
	Tooth site	−3.795E−02	.018	−2.152	.032	−7.260E−02	−3.305E−03	.575
	Age	−4.464E−03	.003	−1.773	.077	−9.409E−03	4.813E−04	.425

Sig. = significance, i.e. *P*-value.

Table 7. Description of failed implants within 6 months of operation

Type	Site	Diameter	Length	Post-extractive	Bone quality
Frialit-2	Molar	5.5	13	Yes	D3
Frialit-2	Premolar	3.8	13	Yes	D2
Frialit-2	Cuspid	5.5	13	No	D2
Frialit-2	Molar	3.8	13	No	D3

an excess of surgical trauma such as thermal injury[17], bone preparation, and drill sharpness and design[30]. Bone quality and quantity are the most important host-related factors[25,27], while design[26,29,31], surface coating[26,29,31,33], diameter[22] and length[11] are the main implant-related factors. Finally, quality and quantity of force[10] and prosthetic design[20] are the variables of interest among the occlusion-related factors. All these variables are a matter of scientific investigation because they may affect the clinical outcome.

In the last decade, several investigators have reported that IL is a successful and time-saving procedure. In this study, a series of 780 IL implants with the loss of only 4 implants was evaluated during a mean post-loading follow-up of 3 years (global SRR = 99.5%). All four failed implants were 13 mm long, so the SRR of the standard length group was 98% and this was statistically different from that of longer implants. Consequently, there is a slight but significant increased risk of failure when 13-mm-long implants are IL compared to longer implants. These results are in agreement with those reported by Tarnow et al.[32].

In addition to SRR, no or reduced MBL was considered as an indicator of SCR to evaluate the effect on final outcome of various factors. In addition to length (Table 4), surface (Table 1) and diameter (Table 3) are considered to be relevant implant-related factors. In the present series, implant diameter and type were not critical for SRR or for SCR. Of the failed implants there were two 3.8 and two 5.5 mm wide (mean value = 4.65 mm; Table 7). Although several different implant systems have been used, no differences were detected when comparing 244 IL standard implants and 536 IL longer implants (Table 1).

Bone quality, a host-related factor, is believed to be the strongest predictor of outcome in IL. Misch[24] has reported that most of the IL implants are placed in anatomical sites with bone quality D1 or D2. It is well known that the mandible (especially the interforaminal region) has better bone quality than the maxilla, and this is probably the reason why several reports are available regarding IL implants inserted in the mandible with a high SRR[6,9,29]. In the present study, differences in SRR related to bone quality (Table 5) and site (Table 2) were found. As regards SCR, bone quality was the only variable that was found to affect MBL (i.e. better outcome for higher quality bone). Poor quality bone was related to a higher delta IAJ (or increased MBL) and thus a worse outcome in both groups (i.e. long and standard implants, see Table 6). With regard to MBL related to bone quality, no statistical difference was demonstrated between long and standard length implants using the Mann–Whitney *U*-test.

In conclusion, IL of 13-mm-long implants seems to be a reliable technique with high SRR and SCR. A slightly, but statistically significant, worse SRR was noted when compared to longer implants. No differences were detected among implant types, diameter, tooth and post-extraction site. Bone quality was not a major limiting factor, although a slightly higher resorption is to be expected in cases of poor bone quality.

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