Comparative Analysis of Immediate Functional Loading and Immediate Nonfunctional Loading to Traditional Healing Periods: A 5-Year Follow-Up of 550 Dental Implants

Marco Degidi, MD, DDS;* Giovanna Iezzi, DDS, PhD;† Vittoria Perrotti, DDS, PhD;‡
Adriano Piattelli, MD, DDS§

ABSTRACT

Background: Clinical, radiographical, and histological findings have shown that immediately loaded implants show the presence of mineralized tissues at the interface.

Purpose: The aim of this study was to compare an immediate loading protocol with a two-staged one using an implant with a square thread design.

Materials and Methods: One hundred fifty-five consecutive patients (71 men, 84 women), aged between 18 and 78 years (mean: 54 years) participated in this study. A total of 550 implants (Maestro; BioHorizons, Birmingham, AL, USA) were inserted. In group A, 264 implants were inserted in 82 patients with immediate functional loading with occlusal contact if the patients were completely edentulous, or with immediate nonfunctional loading without occlusal contact if the patients were partially edentulous. In group B, 286 implants were inserted in 73 patients with a one-stage or two-stage surgical procedure. All patients were followed for at least 5 years.

Results: In the immediately loaded implants group, three implants failed, all in posterior mandibular sites, with an overall 98.8% 5-year survival rate. In the control group, no implant failed, with a 100% 5-year survival rate. No statistically significant differences were found in the survival rates of the implants in the two groups.

Discussion: A very high implant survival rate was also present in our series for the immediately loaded implants. All the three failed implants were retrieved from the same patient, who had poor oral hygiene, after a loading period of 5 years. These data can suggest that, from a clinical point of view, an abbreviated healing period is compatible with the development and maintenance over a longer time period (5 years) of mineralized tissues at the interface with dental implants.

Conclusion: We can then conclude that shorter healing periods can be highly satisfactory from a clinical point of view.

KEY WORDS: immediate loading, implant survival, long-term studies, peri-implant bone resorption, square thread

INTRODUCTION

It was believed that a too early implant loading could cause the presence of fibrous tissue at the interface.[1–5] Recent clinical, radiographical, and histological findings have shown that immediately loaded implants can heal with the presence of mineralized tissues at the interface and maintain stability over time, at least in dense bone qualities.[6–27] In general, the case reports and studies indicate that once immediately loaded implants integrate, they appear to have a longitudinal bone loss and a soft tissue stability comparable with those of conventionally loaded implants.[28] It can be speculated that loading within physiological limits stimulates bone formation as a result of the bone adaptation to loading.[20] Rocci

*Private practice, Bologna, Italy and visiting professor, Dental School, University of Chieti-Pescara, Chieti, Italy; †research fellow, Dental School, University of Chieti-Pescara, Chieti, Italy; ‡student, Dental School, University of Chieti-Pescara, Chieti, Italy; §professor of oral medicine and pathology, and dean and director of studies and research, Dental School, University of Chieti-Pescara, Chieti, Italy

Reprint requests: Professor Adriano Piattelli, Via F. Sciucchi 63, 66100 Chieti, Italy; e-mail: apiattelli@unich.it

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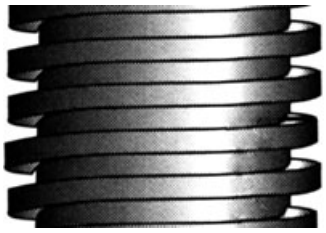

Figure 1 The design of the square thread (modified from Misch CE. Contemporary implant dentistry. 2nd ed. St. Louis, MO: Mosby, 1999:336).

and colleagues[20] found higher values of bone-implant contact (BIC) percentages and resonance frequency analysis values in immediately loaded implants with a compaction of bone toward the implant surface, and a lamina dura-like structure was observed for implants placed in trabecular bone. This compaction of bone probably has an influence on implant stability because of an increased stiffness of the bone-implant system: this may explain why implants placed in soft bone show increased stability with time.[20] Also, in other studies, higher BIC was found at the interface of immediately loaded implants.[26,27] On the contrary, Becker and colleagues[29] found higher BIC values for unloaded implants. Becker and colleagues[29] observed that the implant threads facing the osseous tissue were filled primarily with mature lamellar bone and that newly formed secondary osteons were frequently observed; these osteons indicated ongoing remodeling. Implant design has a greater impact on the functional surface area of the implants than implant size.[30] Threaded implants have many advantages over press-fit implants when used in immediate loading protocols.[30] It has been reported that the thread geometry may be related to the osseointegration processes and to the amount of bone at the implant interface.[30] Square threads have been reported to have a higher BIC percentage and higher reverse torque values compared with a V-shaped thread or a reverse buttress thread.[30] The square thread may then be particularly useful in immediately loaded implants.[30] Square-shaped threads have a parallel major diameter and reverse taper minor diameter (Figure 1).

In a histological study of immediately loaded implants with a square thread, retrieved from man after a 6-month loading period, we have observed a very high percentage of BIC.[31]

The aim of this study was to compare an immediate loading protocol with a two-staged one using an implant with a square thread design.

MATERIALS AND METHODS

One hundred fifty-five consecutive patients (71 men, 84 women), aged between 18 and 78 years (mean: 54 years) participated in this study. A total of 550 implants (Maestro; BioHorizons, Birmingham, AL, USA) were placed by the same surgeon (M.D.). The protocol was approved by the Ethics Committee of the University of Chieti-Pescara, and a written informed consent was obtained from each patient.

The inclusion criteria were controlled oral hygiene, absence of any lesions in the oral cavity, sufficient residual bone volume to receive implants of at least 3.4 mm in diameter and 9.5 mm in length, and an implant insertion torque (IIT) >25 Ncm. In addition, the patients had to agree to participate in a postoperative control program.

Exclusion criteria were insufficient bone volume, bone quality type D4, a high degree of bruxism, smoking more than 20 cigarettes/day and excessive consumption of alcohol, localized radiation therapy of the oral cavity, antitumor chemotherapy, liver diseases, blood diseases, kidney diseases, immunosuppressed patients, corticosteroid therapy, pregnancy, inflammatory and autoimmune diseases of the oral cavity, poor oral hygiene, and an IT <25 Ncm.

Implant survival 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.[21]

Data Collection

At the initial visit, all patients received clinical and occlusal examination, periapical and panoramic radiographs, and computerized dental scan.

The patients were divided into two groups; the allocation to one of the two groups was made by randomization. In group A, 264 implants were inserted in 82 patients with immediate functional loading with occlusal contact if the patients were completely edentulous, or with immediate nonfunctional loading without occlusal contact if the patients were partially edentulous (Figure 2). In group B, 286 implants were inserted in 73 patients with a one-stage or two-stage surgical procedure. All anatomical configurations were treated in both groups of patients (single tooth, edentulous mandible,

Figure 2 Immediate loading. The lower incisors have been extracted and two implants have been simultaneously placed in the second lower incisor region (*right* and *left*).

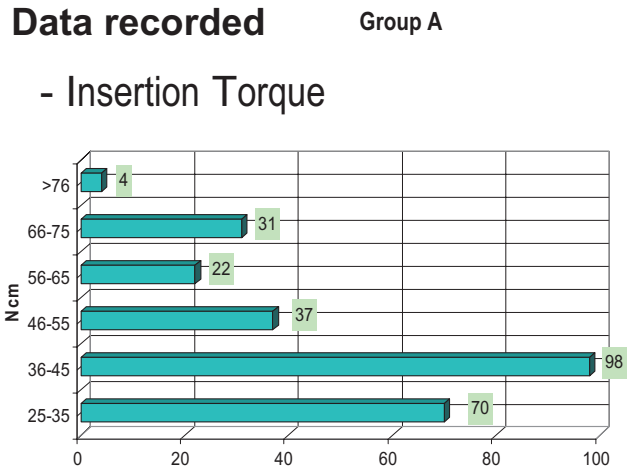

Figure 3 Immediately loaded implants. Insertion torque values.

edentulous maxilla, anterior mandible, posterior mandible, anterior maxilla, and posterior maxilla) (Tables 1 and 2). Healing time was 6 months for both arches. The insertion torque values, implant diameters, and implant lengths for the immediately loaded implants are reported in Figures 3–5. The insertion torque values, implant diameters, and implant lengths for the control implants are reported in Figures 6–8.

Surgical and Prosthetic Techniques

All patients underwent the same surgical protocol. Antimicrobial prophylaxis was obtained with mouthrinses of

TABLE 1 Immediately Loaded Implants

	Number of Cases	Number of Implants	Number of Failures	Implant Survival Rate (%)	Number of Prosthetic Failures	Prosthetic Success Rate (%)
Single tooth	22	22	0	100	0	100
Edentulous mandible	15	102	0	100	0	100
Edentulous maxilla	4	28	0	100	0	100
Anterior mandible	8	22	0	100	0	100
Posterior mandible	16	43	3	93	0	100
Anterior maxilla	9	24	0	100	0	100
Posterior maxilla	8	21	0	100	0	100
Total	*82*	*262*	*3*	*98.8*	*0*	*100*

TABLE 2 Control Implants

	Number of Cases	Number of Implants	Number of Failures	Implant Survival Rate (%)	Number of Prosthetic Failures	Prosthetic Success Rate (%)
Single tooth	23	23	0	100	0	100
Edentulous mandible	13	108	0	100	0	100
Edentulous maxilla	6	46	0	100	0	100
Anterior mandible	7	21	0	100	0	100
Posterior mandible	8	33	0	100	0	100
Anterior maxilla	5	13	0	100	0	100
Posterior maxilla	11	42	0	100	0	100
Total	*73*	*286*	*0*	*100*	*0*	*100*

Minimum follow-up is 5 years.

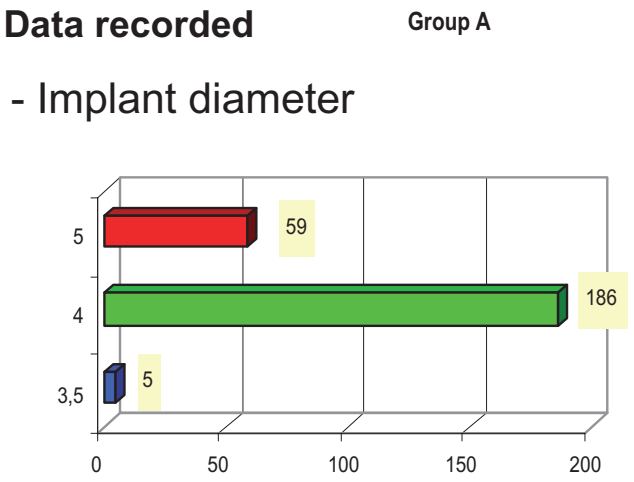

Figure 4 Immediately loaded implants. Implant diameters.

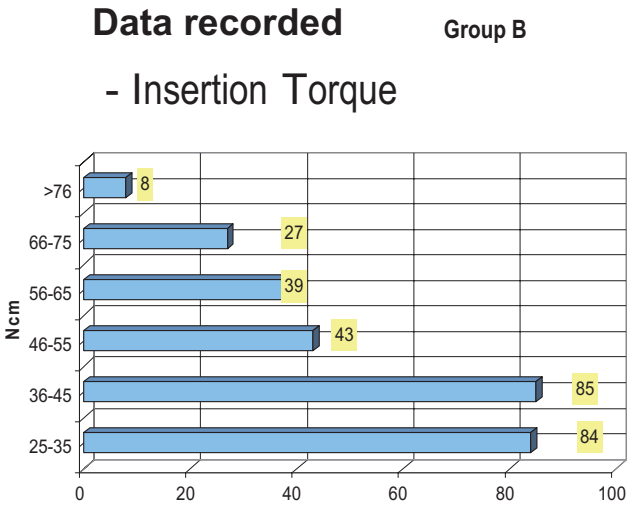

Figure 6 Control implants. Insertion torque values.

0.12% chlorhexidine gluconate solution (three times a day for 7 days starting 3 days before surgery) and antibiotics (2 g/day of clavulanic acid and amoxicillin for 3 days starting 1 hour before surgery). Local anesthesia was induced by infiltration with articaine/epinephrine.

Preoperatively, a setup of teeth in wax was done and a surgical template was prepared for each case. A cross-arch acrylic temporary empty shell was also prepared. Surgery began with a bone crest incision (sulcular incision in case of immediate extraction and implantation). Usually, separation beyond the mucogingival junction was avoided and osteoplasty was carried out if necessary. After identification of the implant sites, these were prepared using surgical templates according to the protocol. Implants were placed according to the manufacturer protocol. In group A patients, provisional abutments were then positioned, the previously prepared provisional shell was relined with acrylic, allowed to cure, trimmed, and finally cemented or screwed in place a few hours later (Figures 9 and 10). A postoperative radiography was done (Figure 11). A soft diet was recommended for a 3-week period. After a healing time of 4 to 6 months, the provisional crowns were removed, implant mobility was checked, and a final impression was taken. A porcelain-fused-to-metal cement-retained restoration was delivered in all cases (Figure 12). All patients were included in a strict recall of 4 and 6 months and were reevaluated after 1 (Figure 13), 2, 3 (Figure 14), 4, and 5 years (Figure 15). In the follow-up period, periapical radiographs were used.

In group B patients, one-stage (Figure 16) surgery was performed when the implants showed high primary

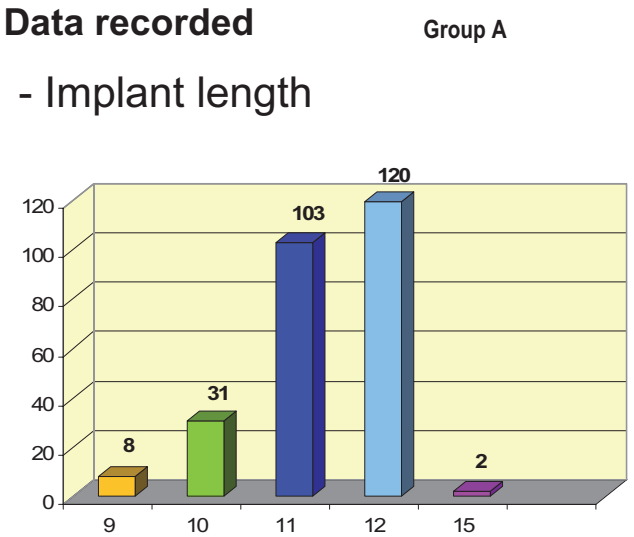

Figure 5 Immediately loaded implants. Implant lengths.

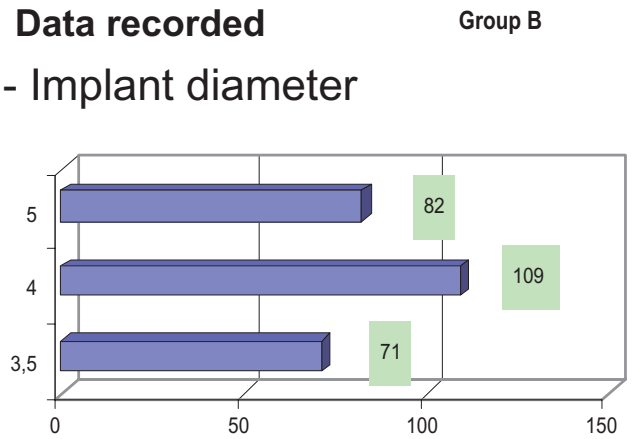

Figure 7 Control implants. Implant diameters.

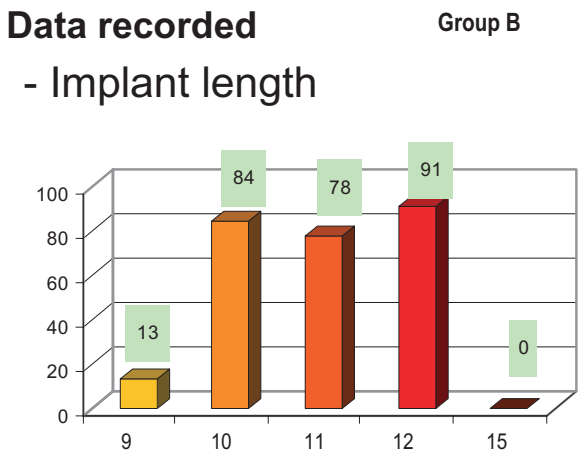

Figure 8 Control implants. Implant lengths.

stability, while on the contrary, a two-stage surgical approach was chosen when primary stability was low.

In each patient, the peri-implant crestal bone levels were evaluated by calibrated examination of periapical X-rays. Measurements were recorded after surgery and after each 12-month time period (Figures 17–19). The measurements 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 the implant. The bone level recorded just after the 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 (GWJ, Hacienda Heights, CA, USA) with a magnifying factor of seven times and a scale graduated in 0.1 mm was used. All measurements were made by the same examiner (M.D.).

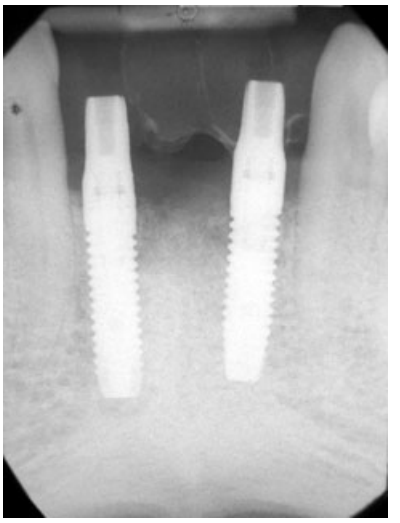

Figure 11 Postoperative X-ray.

Figure 9 An immediate temporary has been inserted (screw retained).

Statistical Evaluation

The statistical evaluation of the differences between the survival rates of the implants of both groups was done using the *z*-test for proportions.

Figure 10 The immediate temporary is in place.

Figure 12 Final restoration.

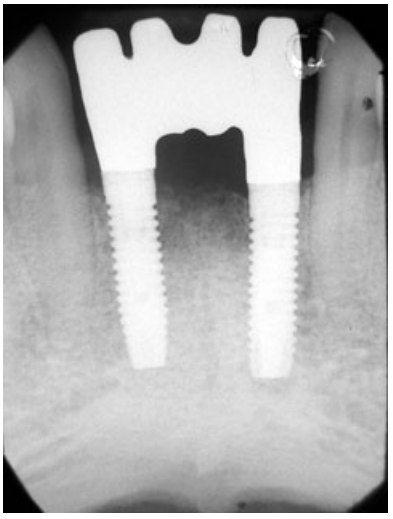

Figure 13 One-year follow-up X-ray.

Figure 15 Five-year follow-up X-ray.

RESULTS

All the patients were followed for 5 years. No dropouts or withdrawals were registered. All implants have been evaluated radiographically to analyze the crestal bone loss at baseline and at the other recall periods. In the immediately loaded implants group, three implants failed, all in posterior mandibular sites, with an overall 98.8% 5-year survival rate (Table 3). In the control group, no implant failed, with a 100% 5-year survival rate. No statistically significant differences were found in the survival rates of the implants in the two groups ($p = .196$). No differences were found in the implant survival rates and in the bone resorption rates in implants with occlusal load and in implants without occlusal load. The failures in the immediately loaded group occurred in the same patient, who had poor oral hygiene, after a loading period of 5 years. All these implants were hydroxyapatite coated. The marginal bone loss was, in the immediately loaded implants, 0.3 mm in the first year and 0.6 mm from the first year to the fifth year, while in the control group, the values were 0.3 and 0.5 mm, respectively.

DISCUSSION

The biomechanics of implants in patients that are edentulous in single-tooth gap or partial-arch space are significantly different from those in completely edentulous patients, particularly in immediate loading conditions.[28]

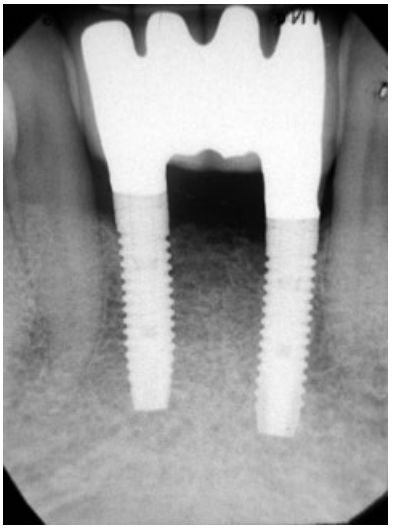

Figure 14 Three-year follow-up X-ray.

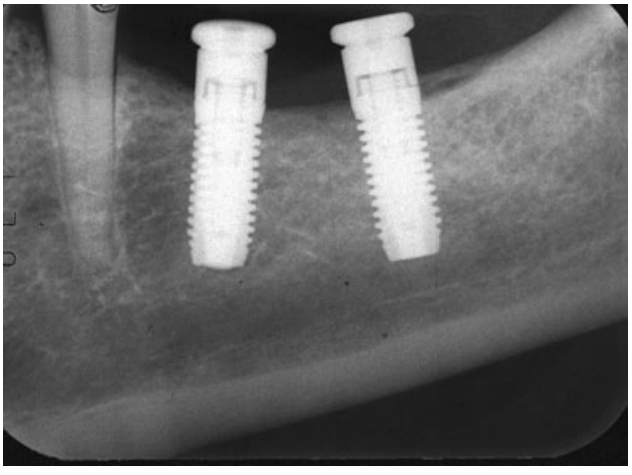

Figure 16 Submerged healing group. Postoperative X-ray (one-stage surgery).

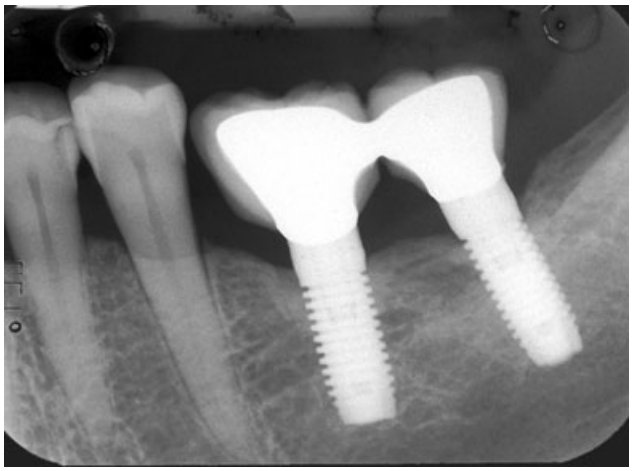

Figure 17 One-year follow-up X-ray.

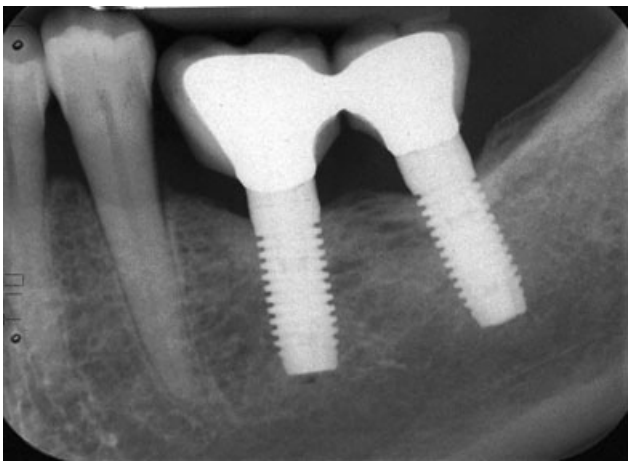

Figure 19 Five-year follow-up X-ray.

Some prerequisites are necessary for an immediate loading of dental implants:

1. primary clinical stability;
2. adequate splinting;
3. provisional restorations that promote splinting and reduce or control the mechanical load applied to the implants; and
4. prevention of provisional restoration removal during the recommended period of healing.[32]

Risk factors are:

1. presence of high masticatory or parafunctional forces;
2. poor bone quality or volume; and
3. presence of infection.[32]

An adequate number of implants should be positioned to facilitate splinting and protection from the possible effects of micromotion.[32] Clinical stability should be achieved. This is made possible by selecting patients who exhibit adequate bone quality and quantity, selecting an implant with a rough surface and adequate dimension, and using a good clinical technique to maintain contact between implant and bone.[32]

Threads are used to increase the initial contact area between implant and bone, improve the initial stability, enlarge the implant surface area, and favor the dissipation of interfacial stresses.[33]

It is important to decrease strain to the immediately loaded implant-bone interface, because the higher the microstrain in bone, the greater the bone turnover rate.[30] A higher remodeling rate around the top of the implant threads has been reported.[34] This results in the formation of more woven bone. The design of a dental implant should be such that high stress peaks are avoided in the peri-implant bone.[34] One method to decrease the strain in bone is to decrease the stress to the implant and to the prosthesis.[30] As a result, conditions that increase the area of support in the bone or methods that decrease the force to the prosthesis are appropriate.[30] Area may be increased by implant number, because a number of implants splinted together may decrease the risk of overload to each implant as a result of a greater surface area and improved biomechanical distribution.[30] Area of load may also be increased by implant size, implant design, and implant surface conditions. In addition, stress may be reduced by decreasing the force applied to the prosthesis.[30] The smaller the peak stresses in the bone, the bigger the load that can be carried before the onset of bone resorption.[34] In this study, the minimum follow-up for all implants has been 5 years.

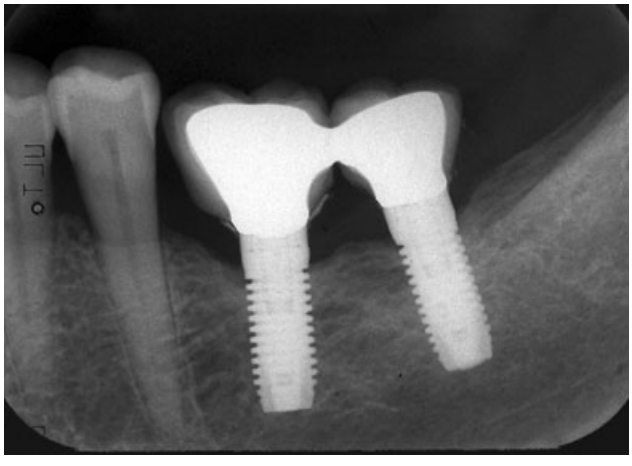

Figure 18 Three-year follow-up X-ray.

TABLE 3 Implant Failures

	Load	Bone Quality	Bone Quantity	Ø Implant	Implant Length	Location	Primary Stability	Abutment	Smoker	Type of Restoration	Age (years)	Sex	Parafunctional Habits	Extraction Site	Years Since Loading	Torque (Ncm)
Pt 1	INFL	D4	A	4	10	46	Yes	Titanium	Yes	FTB cemented	50	M	No	No	5	10
Pt 1	INFL	D4	A	4	10	47	Yes	Titanium	Yes	FTB cemented	50	M	No	No	5	63
Pt 1	INFL	D4	A	4	10	48	Yes	Titanium	Yes	FTB cemented	50	M	No	No	5	30

Minimum follow-up is 5 years.

All the failures in immediately loaded implants in the present study occurred in the posterior region of the mandible. Bone quality has been recognized as a key parameter in the prognosis of dental implants,[27] and implant stability is related to the quantity and quality of the interface.[35] Implant sites with poor bone quality have been associated with lower implant success rates.[36] This clinical observation most probably is related to the lower bone content and to the lower BIC percentage resulting from the highly cancellous structure of these sites; in fact, the percentage of bone in the posterior maxilla has been reported to be around 20%.[36] Moreover, all these three failed implants were hydroxyapatite coated and were retrieved in the same patient, who presented very poor oral hygiene, and the implants had failed after a loading period of 5 years. In all probability, the loading conditions (immediate loading) of these implants did not play a relevant role in the implant failure; the failures can most probably be related to a persistent inflammation of the soft peri-implant tissues caused by the local conditions in the patient's mouth. Moreover, no statistically significant differences were found in the survival rates of the implants in groups A and B. Furthermore, no differences were observed in the peri-implant crestal bone resorption in the two groups. No differences were found in the survival rates and in the crestal bone remodeling in the implants with occlusal and non-occlusal loading.

A very high implant survival rate was also found in the present study for the immediately loaded implants, and these data can suggest that, from a clinical point of view, an abbreviated healing period is compatible with the development and maintenance over a longer time period (5 years) of mineralized tissues at the interface with dental implants. Comparable results have also been reported by other researchers, but with shorter follow-up periods.[11]

We can then conclude that shorter healing periods can be highly satisfactory from a clinical point of view even in the long term (more than 5 years). No differences were found in the survival rates and crestal bone resorption rates between immediately loaded and control implants. No differences were found between implants with occlusal load and in implants without occlusal load.

A very low (less than 1 mm) bone resorption was found in the two groups of implants at the 5-year follow-up.

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