10-Year Follow-Up of Immediately Loaded Implants with TiUnite Porous Anodized Surface

Marco Degidi, MD, DDS;* Diego Nardi, DDS;† Adriano Piattelli, MD, DDS‡

ABSTRACT

Background: The immediate loading of implants with a porous anodized surface is a well-described technique. Few data are however available on the long-term outcomes.

Purpose: The aim of this prospective study was to assess the 10-year performance of TiUnite implants supporting fixed prostheses placed with an immediate loading approach in both postextractive and healed sites.

Materials and Methods: All patients received a fixed provisional restoration supported by immediately loaded parallel design, self-tapping implants with a porous anodized TiUnite surface, and an external-hexagonal connection. Both healed and postextractive cases were included. Success and survival rate for restorations and implants, changes in marginal peri-implant bone level, probing depth measurements, biological or technical complications, and any other adverse event were recorded at yearly follow-up up to 10 years after surgery.

Results: A total of 210 implants fulfilled the inclusion criteria and were consecutively placed in 59 patients. Forty-seven (22.38%) implants were lost because of the recalled patient refused to attend the planned 10-year follow-up. Five over 210 (2.38%) implants were lost. At the final follow-up, the accumulated mean marginal bone loss and probing depth were, respectively, 1.93 mm (SD 0.40) and 2.54 mm (SD 0.44) for the implants placed in healed sites ($n = 84$); 1.98 mm (SD 0.37) and 2.63 mm (SD 0.39) for the implants placed in postextractive sites ($n = 74$). The restorations examined achieved a cumulative 65.26% success rate and 97.96% survival rate. The implants placed in healed and postextractive sites, respectively, achieved a 98.05% and a 96.52% cumulative survival rate.

Conclusions: Positive results in terms of bone maintenance in the long-term perspective are to be expected using immediately loaded implants with a TiUnite porous anodized surface in both postextractive and healed sites when adequate levels of oral hygiene are kept.

KEY WORDS: immediate loading, implant surface, long term, TiUnite

INTRODUCTION

The anodization is a chemical process that, trough an electrolytic passivation, increases the thickness of the natural oxide layer on the surface of a titanium part.

In their analysis on dental implant surfaces, Albrektsson and Wennerberg[1] described in the TiUnite surface (Brånemark System, Nobel Biocare, Göteborg, Sweden) an increased TiO_2 layer, roughness, and an enlarged surface area. This moderately rough microstructure was reported to enhance the adhesion of human osteoblast-like MG-63 cells to titanium without significantly affecting the pattern of gene expression.[2] The study groups of Ivanoff and colleagues[3] and Zechner and colleagues[4] assessed the osseoconductive properties of the TiUnite design resulting in a faster integration of the implant in the surrounding bone. A high bone-to-implant contact percentage (60%) was found in an immediately loaded TiUnite implant retrieved from a posterior maxillary site 6 months after surgery.[5] Positive short- and medium-term clinical performances of immediately loaded implants fitted with the TiUnite porous anodized surface supporting fixed prostheses were reported by many authors.

Balshi and colleagues[6] evaluated 82 consecutive patients treated with complete-arch maxillary restorations using a bilateral pterygomaxillary approach and supported by TiUnite implants and concluded that the

*Private practice, Bologna, Italy; †private practice, Bologna, Italy; ‡full professor, Dental School, University of Chieti-Pescara, Chieti, Italy

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

DOI 10.1111/j.1708-8208.2012.00446.x

titanium oxide surface appeared to assist the healing response of the bone-implant interface.

Glauser and colleagues[7] followed 102 immediately loaded TiUnite implants for a period of up to 5 years. A mean marginal bone remodeling of 1.54 mm (SD 0.99) was assessed at the end of the study, along with the absence of marginal plaque and bleeding on probing, respectively, for 75% and 74% of the sites.

Ostman and colleagues[8] prospectively evaluated TiUnite implants supporting fixed partial prostheses over a 4-year follow-up period. One over 180 implants (0.6%) failed and the average marginal bone resorption assessed was 0.7 mm (SD 0.8). The authors concluded that immediate loading of implants with firm primary stability in partially edentulous areas of the mandible appears to be a viable procedure with predictable outcome.

Johansson and colleagues[9] followed a total of 312 implants in 52 patients that received prefabricated, immediately loaded fixed prosthetic constructions in the maxillae. Two implants were lost during the 1-year study period, resulting in a cumulative survival rate of 99.4%. The assessed mean marginal bone resorption was 1.3 mm (SD 1.28) and the most frequently reported complications were gingival hyperplasia, prosthesis screw loosening, and occlusal fractures.

Fischer and colleagues[10] clinically and radiographically evaluated a total of 16 Replace Select TiUnite implants placed in single-tooth replacements and loaded the same day as surgery with a temporary crown. One implant failed and a marginal bone loss of 1.5 mm (SD 1.0) was observed.

Calandriello and Tomatis[11] reported on the clinical and radiological performance of 40 immediately loaded TiUnite Wide Platform implants supporting single molars in the lower jaw and followed for up to 5 years. The authors reported the loss of two implants, leading to a cumulative success rate of 95.0% and a mean marginal bone loss of 1.17 mm (SD 0.90) after 5 years from surgery.

Mura[12] retrospectively studied 66 Replace Select Tapered TiUnite implants placed according to an immediate loading protocol in postextraction sites and reported a cumulative implant survival rate of 100% after 5 years of load.

The aim of this prospective study was to assess the 10-year performance of TiUnite implants supporting fixed prostheses placed with an immediate loading approach in both postextractive and healed sites.

MATERIALS AND METHODS

The present prospective study included patients with single, partial, or complete edentulism with an age of 18 years or more. Opposing dentition was not considered to be a discriminating factor. This study was designed and conducted in full accordance with the year 2000 fifth revision of World Medical Association Declaration of Helsinki. All patients signed a specific written informed consent form. Patients were not accepted into the study if they met any of the following exclusion criteria: (1) active infection in the sites intended for implant placement; (2) systemic disease that could compromise osseointegration; (3) treatment with radiation therapy in the craniofacial region within the previous 12 months; (4) pregnancy or lactation; (5) bruxism; and (6) unsuitable bone quantity in the surgery site or need of bone augmentation procedures prior to implant placement. Tooth extraction was considered in cases of endodontic failure, destructive decay, or traumatic fractures that jeopardized the integrity of the root. All implants were placed in by a single experienced surgeon (M.D.) in a private dental office in Bologna, Italy. The patients were treated using 3.3, 3.75, or 4.0 mm–diameter parallel design, self-tapping implants with a porous anodized surface, and an external-hexagonal connection (Brånemark System Mk III, Nobel Biocare).

During the implant placement procedure, the insertion torque and the implant stability quotient (ISQ) were recorded using a surgical unit (FRIOS Unit E, W&H Dentalwerk GmbH, Buermoos, Austria) and a digital measurement probe (Osstell AB, Gamlestadsvägen 3B, Göteborg, Sweden). Patients were dropped from the study if any of the implants met one of the following exclusion criteria: (1) insertion torque <25 Ncm; (2) an ISQ of <60.

Preoperative analysis of anatomical features was performed using periapical and digital panoramic radiography. All patients underwent the same surgical protocol. Antimicrobial prophylaxis was obtained with amoxicillin 500 mg (Amoxicillin, Pfizer Manufacturing, Puurs, Belgium) twice daily for 5 days starting 1 hour before surgery. Local anesthesia was induced by infiltration with articaine, 4% (40 mg/mL). After a crestal incision, a mucoperiosteal flap was elevated. Depending from the site of surgery, sensible anatomical features

such as the mental foramina were located and secured. In cases involving a knife-edge ridge, a mild osteoplasty of the ridge was performed under profuse irrigation with sterile saline solution. In cases were a postextractive procedure was planned, care was paid during tooth extraction in order to preserve the socket walls. All implants were inserted according to the procedures recommended by the manufacturer. The implant platform was positioned slightly above the alveolar crest. Implants with lengths from 10.0 to 15.0 mm were used. No bone grafting material was employed and extensions on tooth abutments were always avoided. The provisional crowns and bridges were always prefabricated and adapted to the abutments; the same procedure was used for both partial and complete edentulous cases as well as single-tooth replacement. The temporary abutments were placed and the provisional restoration was relined with acrylic, trimmed, polished, and cemented or screw retained 1 to 2 hours later. The correct vertical length was checked and established using facial reference marks recorded prior to surgery. In partially edentulous patients, occlusal contact was avoided in centric and lateral excursions. Sutures were removed 14 days after surgery. After 18 weeks from implant insertion, the provisional crown was removed, implant stability was checked, and a final impression of the abutment was recorded by using a polyvinylsiloxane impression material. The final gold alloy/ceramic restoration was always cemented and was placed approximately 28 weeks after implant insertion. Postsurgical analgesic treatment was performed with Nimesulid (Merck, Cinisello Balsamo, Milano, Italy) 100 mg twice daily for 3 days. Oral hygiene instructions were provided and patients were instructed to have a soft diet for at least 4 weeks. The patients were recalled for a professional cleaning treatment by a dental hygienist every 6 months. Scaling or scaling and root planning were performed as needed (Figures 1–6).

Periapical radiographs were taken with a positioning jig and a customized Rinn® holder (Rinn, Elgin, IL, USA). A set of probing measurements were performed at each planned follow-up.

The following observations were made:

- Final restoration success, defined as prosthesis that underwent no repair procedure with a complete absence of fractures or porcelain chippings, absence of phonetic, and occlusion defects;

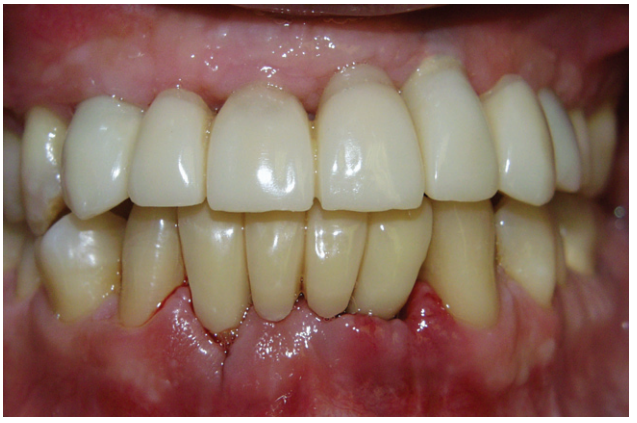

Figure 1 Placement of the immediate temporary restoration.

- Final restoration survival, defined as a prosthesis that is still functional after the need of any repair or fixing procedure, including cement failure or screw loosening;
- Changes in marginal peri-implant bone level, defined as modification of the distance between the implant/abutment junction and the highest coronal point of the supporting bone. The measurement was rounded off to the nearest 0.1 mm. A Peak Scale Loupe® (Peak Optics, GWJ Co., Hacienda Heights, CA, USA) with a magnifying factor of ×7 and a scale graduated in 0.1 mm was used. Measurements were taken mesially and distally and then averaged for each implant;
- Level of marginal gingiva assessed with mesial, distal, and buccal probing depth measurements taken using a metal probe (PCP-UNC-15, Hu-Friedy, Chicago, IL, USA), frequency of bleeding on probing;
- Biological or technical complications and any other adverse event;

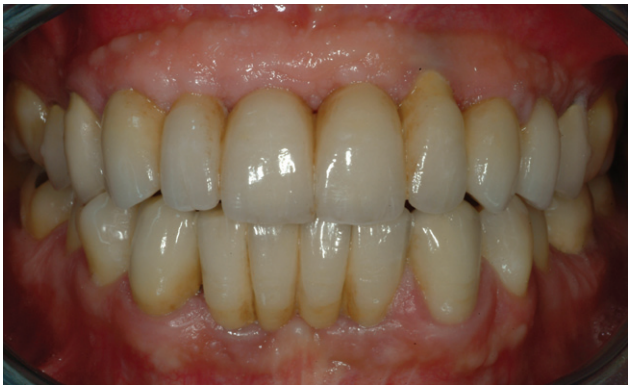

Figure 2 Final metal ceramic restoration 10 years after surgery.

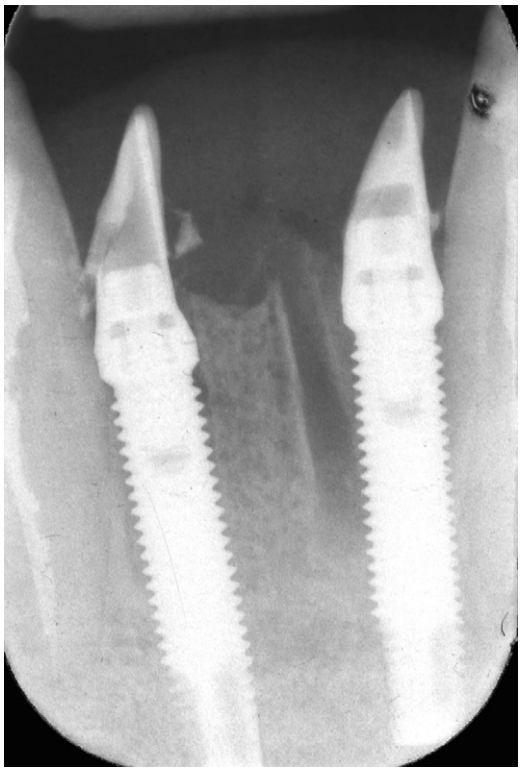

Figure 3 Periapical radiograph immediately after surgery.

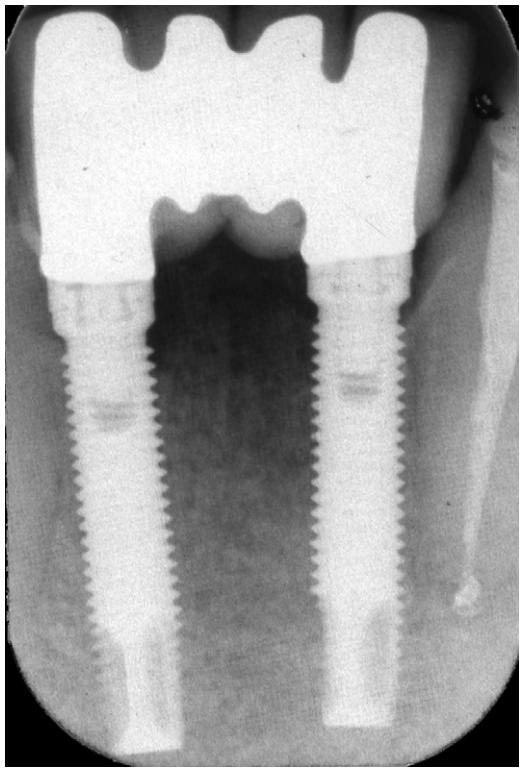

Figure 5 Placement of the final metal ceramic restoration.

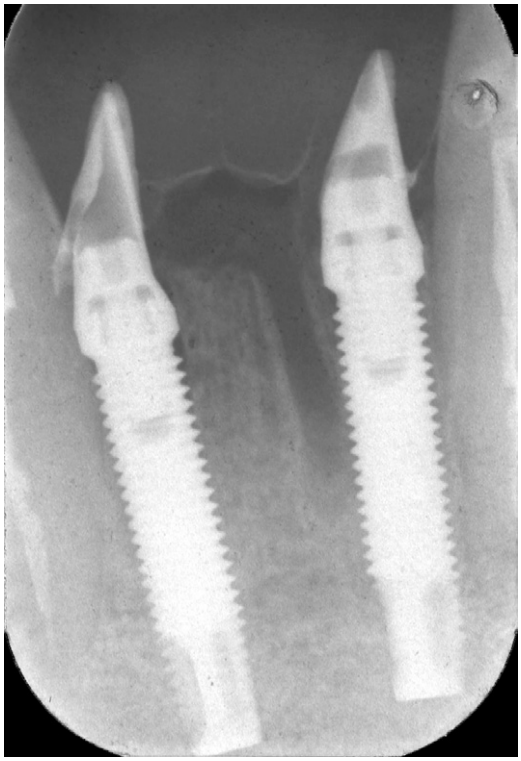

Figure 4 Periapical radiograph 6 months after surgery.

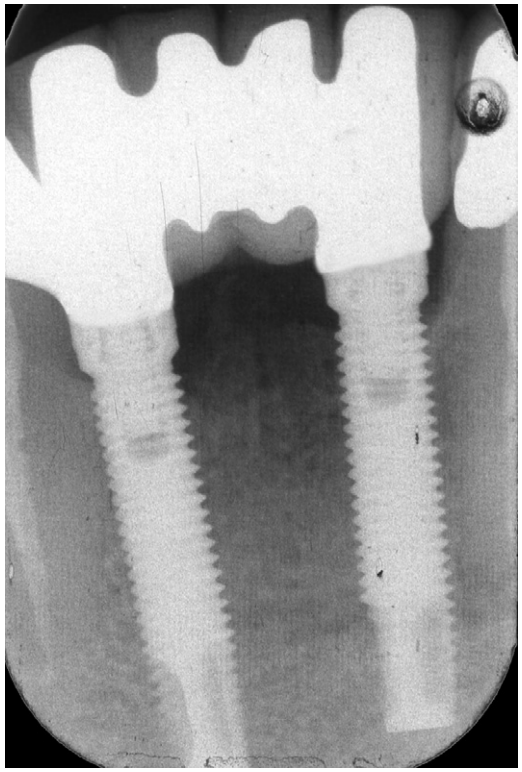

Figure 6 Periapical radiograph of the final restoration 10 years after surgery.

- Implant success, survival, and failure evaluated following the International Congress of Oral Implantologists (ICOI) Pisa Consensus Conference criteria.[13]

Follow-up frequency was the following:

- T0: after surgery and fitting of the immediate provisional restoration;
- T1: 6 months after surgery, first final restoration control;
- T2: 1 year after surgery;
- T3 to T11: yearly follow-up up to 10 years after surgery.

Statistic

Life table analysis of implant survival data was performed for the pool of all implants placed, for the implants placed in healed sites, and for the implant placed in postextractive sites using the following criteria:

- Time interval: the duration of this study is divided into 11 intervals;
- Number of implants at the beginning of the time interval;
- Number of implants failed during the time interval. Implants were considered failed when removed from the patient for any reason;
- Number of dropouts during the time interval;
- Effective sample size used as the correction factor for unaccountable dropouts;
- Survival rate during the time interval;
- Cumulative survival rate.

The log rank test was used to compare the survival distributions of the samples of the implants placed in healed and in postextractive sites.

RESULTS

During the inclusion period between November 2000 and May 2001, five implants placed in healed sites and 16 implants placed in postextractive sites were excluded due to lack of good primary stability. A total of 210 implants fulfilled the inclusion criteria and were consecutively placed in 59 patients. The early results of part of the implants included in this study were published in a paper by Degidi and colleagues.[14] Forty-seven (22.38%) implants were lost because of the recalled patient refused to attend to the planned 10-year follow-up. Five over 210 (2.38%) implants were lost.

TABLE 1 Average Insertion Torque, ISQ, and Bone Quality Values[24]

Torque (Ncm) ($n = 210$; min: 25, max: 54)	39.79 (SD 8.6)
ISQ ($n = 210$; min: 61, max: 79)	69.86 (SD 5.2)
Type 1 bone	13–6.19%
Type 2 bone	111–52.86%
Type 3 bone	78–37.14%
Type 4 bone	8–3.81%

ISQ = implant stability quotient.

Forty-eight (81.36%) patients, for a total of 158 (75.24%) implants, were available for the final 10-year data analysis. The mean age of the 48 patients at the time of surgery was 49.9 years (SD 18.6). Eighty-six (54.43%) and 72 (45.57%) implants were, respectively, placed in 27 (56.25%) female and 21 (43.75%) male patients. Average insertion torque and ISQ values of the 210 implants placed are listed in Table 1. Implant success, survival, and failure rates at each follow-up following the ICOI Pisa Consensus Conference criteria[13] are listed in Table 2. At the final follow-up, the accumulated mean marginal bone loss and probing depth were, respectively, 1.93 mm (SD 0.40) and 2.54 mm (SD 0.44) for the implants placed in healed sites ($n = 84$); 1.98 mm (SD 0.37) and 2.63 mm (SD 0.39) for the implants placed in postextractive ($n = 74$). The details of the bone

TABLE 2 Implant Success and Survival Rate following the International Congress of Oral Implantologists Pisa Consensus Conference Criteria[13]

Months	Health Scale				Available Implants
	I	II	III	IV	
6	210	0	0	0	210
12	210	0	0	0	210
24	202	6	0	0	208
36	187	17	1	0	205
48	169	30	1	0	200
60	133	57	3	1	194
72	119	67	5	2	193
84	92	83	8	3	186
96	81	84	11	4	180
108	64	91	13	4	172
120	57	88	13	5	163

I = success; II = satisfactory survival; III = compromised survival; IV = clinical or absolute failure.

TABLE 3 Bone Loss Pattern in Healed ($n = 84$) and Postextractive ($n = 74$) Implants from T0 (Surgery)

	Healed Sites				Postextractive Sites			
Months	Mean	SD	Min	Max	Mean	SD	Min	Max
6	0.56	0.21	0.1	1.1	0.63	0.20	0.2	1.3
12	0.93	0.24	0.6	1.5	0.98	0.25	0.6	1.7
24	1.26	0.37	0.7	1.9	1.38	0.35	0.6	2.0
36	1.36	0.34	1.0	2.1	1.46	0.38	0.7	2.3
48	1.45	0.36	1.0	2.1	1.58	0.34	1.0	2.2
60	1.58	0.43	1.0	2.3	1.68	0.34	1.0	2.4
72	1.72	0.32	1.3	2.3	1.78	0.37	1.1	2.5
84	1.82	0.28	1.4	2.4	1.91	0.29	1.4	2.5
96	1.87	0.31	1.5	2.6	1.95	0.32	1.5	2.6
108	1.89	0.37	1.5	2.7	1.99	0.36	1.6	2.6
120	1.93	0.40	1.5	2.7	1.98	0.37	1.6	2.6

loss patterns are presented in Table 3 and Figures 7 and 8. The restorations examined achieved a cumulative 65.26% success rate and 97.96% survival rate. The implants placed in healed and postextractive sites, respectively, achieved a 98.05% and a 96.52% cumulative survival rate. No statistically significant difference was detected between the survival distributions of the two groups using the log rank test ($p = .517$) (Tables 4–6).

None of the treated patients reported sensorial disturbances after the surgery and no implant fractures were recorded. At the time of the removal of the temporary restoration, 18 weeks after surgery, all available implants were stable.

Eleven patients (22.92%) reported minor problems during the early phases of the treatment. Eight patients (16.67%) reported small fractures, chippings, or acrylic tooth detachment from the temporary restoration. All prostheses were repaired with light-cured composite resin, polished, and delivered to the patients in 1 hour. A minor relining procedure was required in order to avoid food entrapment in two cases (4.16%), wearing a full

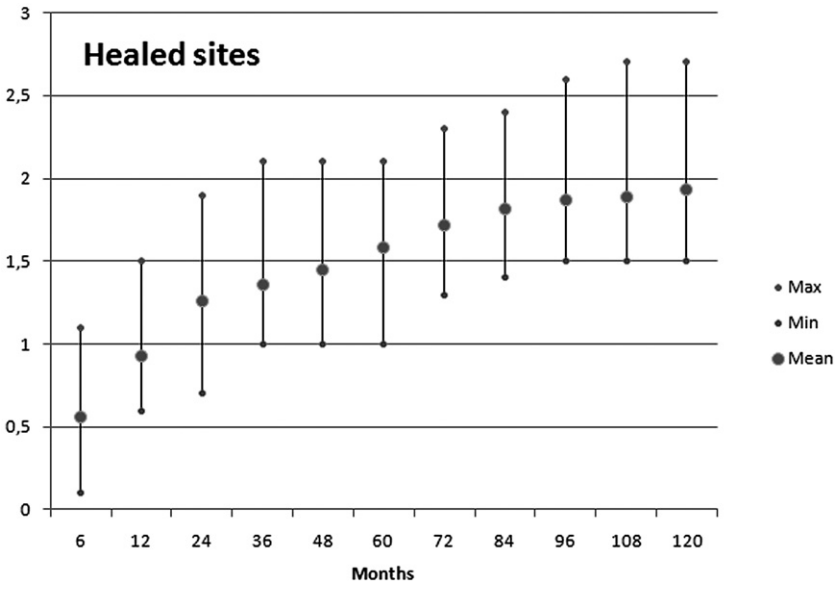

Figure 7 Mean marginal bone loss pattern of implants placed in healed sites.

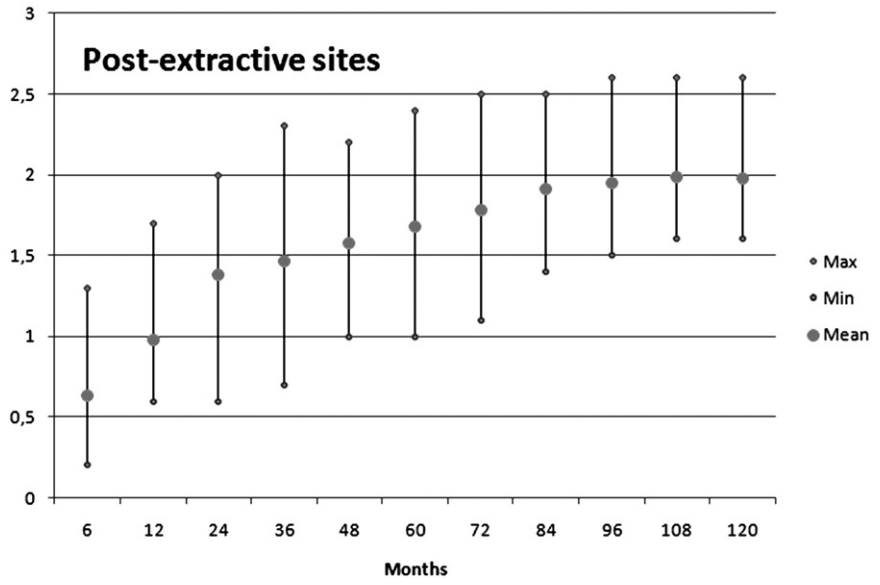

Figure 8 Mean marginal bone loss pattern of implants placed in postextractive sites.

mandible temporary restoration. One patient (2.08%), a 19-year-old nonsmoker female, was unsatisfied of the color shade and the mold of the provisional restoration. The patient wore a single maxillary, screw-retained incisor placed in a postextractive site. The temporary restoration was carefully removed approximately 1 month after surgery and replaced following the patients esthetic requests.

One patient (2.08%) wearing a full maxillary restoration reported nuisance associated with severe chewing difficulties immediately 3 days after surgery. The patient, a 79-year-old nonsmoker female, wore a 12-unit resin provisional bridge supported by eight implants placed in postextractive sites. One week after surgery, the patient was recalled and an early contact defect was found in the occlusion scheme. The restoration was carefully adapted in order to balance the occlusal contacts in both centric and lateral excursions.

A total of 29 (18.34%) of the survived implants exhibited signs of soft tissue adverse events over the whole follow-up period. Ten over 84 (11.9%) implants supported full restorations, 16 over 58 (27.59%) implants supported partial restorations, and 3 over 16 (18.75%) implants supported single restorations. Sixteen (10.12%) implants presented signs of inflammation of the mucosal cuff around the neck of the implant

TABLE 4 Life Table Analysis – Survival of 210 Implants Placed

Months Since Implant Placement	Implants at Risk at Beginning of Interval	Implants Failed during Interval	Implants Lost to Follow-Up	Effective Sample Size	Survival Rate within Period	Cumulative Survival Rate
0–6	210	0	0	210.0	100.00%	100.00%
6–12	210	0	0	210.0	100.00%	100.00%
12–24	210	0	2	209.0	100.00%	100.00%
24–36	208	0	3	206.5	100.00%	100.00%
36–48	205	0	5	202.5	100.00%	100.00%
48–60	200	1	5	197.5	99.49%	99.49%
60–72	194	1	0	194.0	99.48%	98.98%
72–84	193	1	6	190.0	99.47%	98.46%
84–96	186	1	5	183.5	99.46%	97.92%
96–108	180	0	8	176.0	100.00%	97.92%
108–120	172	1	13	165.5	99.40%	97.33%

TABLE 5 Life Table Analysis – Survival of 114 Implants Placed in Healed Sites

Months Since Implant Placement	Implants at Risk at Beginning of Interval	Implants Failed during Interval	Implants Lost to Follow-Up	Effective Sample Size	Survival Rate within Period	Cumulative Survival Rate
0–6	114	0	0	114.0	100.00%	100.00%
6–12	114	0	0	114.0	100.00%	100.00%
12–24	114	0	2	113.0	100.00%	100.00%
24–36	112	0	0	112.0	100.00%	100.00%
36–48	112	0	2	111.0	100.00%	100.00%
48–60	110	0	5	107.5	100.00%	100.00%
60–72	105	1	0	105.0	99.05%	99.05%
72–84	104	0	2	103.0	100.00%	99.05%
84–96	102	1	5	99.5	98.99%	98.05%
96–108	96	0	5	93.5	100.00%	98.05%
108–120	91	0	7	87.5	100.00%	98.05%

associated with *oedema*, *rubor*, and bleeding on probing. The implants were classified as positive for mucositis and were treated with weekly professional submucosal debridement sessions and home mouthrinses with 0.2% chlorhexidine until the complete remission of the symptoms. Thirteen (8.23%) implants presented more important signs of infection, associated with purulence and peri-implant radiological translucency. The implants were then classified as positive for peri-implantitis. The restorations were removed and a full-thickness flap was elevated. The bone defect and implant surface were deeply cleaned and debrieded using carbon curettes. Local irrigation with 1 g of tetracycline was performed and the soft tissues were sutured in place. Home mouthrinses with 0.2% chlorhexidine and local application of 1% chlorhexidine gel were prescribed; the prostheses were cemented again at the complete remission of the symptoms. Seven (4.43%) of the implant subject to peri-implantitis presented recurrent signs of infection and underwent a further therapy cycle. The final restoration was removed and an implantoplasty at the supracrestally exposed implant parts was performed in order to completely remove the superficial layer and obtain a turned-like interface.

Five over 210 implants included in this study (2.38%) were treated for recurrent peri-implantitis and lost because of the treatment failed to completely eradicate the infection. Whenever possible (four cases), the implant was removed and the prosthesis was carefully relined and modified. Pain was immediately controlled

TABLE 6 Life Table Analysis – Survival of 96 Implants Placed in Postextractive Sites

Months Since Implant Placement	Implants at Risk at Beginning of Interval	Implants Failed during Interval	Implants Lost to Follow-Up	Effective Sample Size	Survival Rate within Period	Cumulative Survival Rate
0–6	96	0	0	96.0	100.00%	100.00%
6–12	96	0	0	96.0	100.00%	100.00%
12–24	96	0	0	96.0	100.00%	100.00%
24–36	96	0	3	94.5	100.00%	100.00%
36–48	93	0	0	93.0	100.00%	100.00%
48–60	93	1	3	91.5	98.91%	98.91%
60–72	89	0	0	89.0	100.00%	98.91%
72–84	89	1	4	87.0	98.85%	97.77%
84–96	84	0	0	84.0	100.00%	97.77%
96–108	84	0	3	82.5	100.00%	97.77%
108–120	81	1	6	78.0	98.72%	96.52%

with 1,000 mg of paracetamol and the patient underwent an antimicrobial cycle, consisting of 500-mg beta-lactam antibiotic twice daily for 5 days. The modified prosthesis was delivered to the patient 2 days after implant removal. In one case, however, the prosthesis was lost because of the strategic position of the implant. The patient, a 66-year-old moderate smoker male, wore a three element gold alloy/ceramic bridge supported by two implants placed in healed sites in the posterior maxilla.

Seventeen over 48 patients (35.42%) that completed the 10-year follow-up period reported problems involving the final metal ceramic restoration. Ten patients (20.83%) reported chippings of the porcelain veneer from the final restoration. Minor chippings were repaired with specific light-cured composite resin, polished, and delivered to the patients in less than 1 hour. In four partial posterior cases, a complete detachment of the ceramic was assessed. The prostheses were then sent to the dental laboratory for a complete refit of the esthetic veneer. Four (8.33%) patients reported the detachment of the prosthesis because of cement failure. Three (6.24%) patients wearing partial restorations reported an abutment screw loosening.

DISCUSSION

To the best of the authors' knowledge, this is the first 10-year report involving immediately loaded implants with a TiUnite surface. Before discussing the results, some factors must be taken into consideration. This study was designed few months after the commercial introduction of the TiUnite implant surface using standard surgical and prosthetic approaches of late year 2000. Implant success and survival rates were at first evaluated using the criteria proposed by Albrektsson and colleagues.[15] During the study, it was decided to implement those criteria by adopting the statements of the ICOI Pisa Consensus Conference published in 2008 by Misch and colleagues.[13] The implants inserted in postextractive cases were always placed in the center of the socket leaving the smallest possible gap between the implant platform and the bone wall. In some cases, the socket was completely obliterated. All final prostheses were manufactured with gold alloy and ceramic and were planned to be always cemented. The radiographic measurements were performed using a manual loupe and a graduated scale instead of using digital tools nowadays largely available, and probing was performed using a standard noncalibrated metal probe. This study also was subject to an important patient dropout rate. While a physiological loss is to be expected when planning a long-term study, more than 20% of the implants included in the recruitment phase were unavailable to the final follow-up. The main cause of the dropout was the unwillingness of the patient to attend the planned follow-up, although all patients involved in this protocol were clearly informed about the aims of the study and accepted to sign a specific written consent form. The percentage of recalled patients that refused to attend the examination increased as time elapsed.

The early implant loss is an adverse event described in papers involving both one stage procedures[16] and immediate loading of implants with TiUnite porous anodized surface.[8–10] The results of our study evidenced an excellent 100% survival rate in the first years of function. None of the implants included in our study failed to integrate and, at the time of the removal of the temporary restoration, 18 weeks after surgery, all implants available were found to be stable.

About 35.42% of the patients that completed the 10-year follow-up period reported minor prosthetic problems involving the final restoration. This result is comparable with the assessments of Simonis and colleagues[17] reported in their 10- to 16-year long-term report on success and survival of nonsubmerged dental implants. Porcelain veneer chipping from the final restoration, related to long-term effects of mechanical fatigue and occlusal load, was the most common prosthetic adverse event assessed in our study. This is in concordance with the findings of Zurdo and colleagues[18] that reported, after 5 years of follow-up, that one of the two most common prosthetic complications for implant-supported fixed partial dental prostheses was indeed the minor porcelain fracture.

The implants placed in postextractive sites exhibited a slightly increased bone loss when compared with the implants placed in healed sites. No difference between the two groups was assessed in the survival rate or in the incidence of mucositis and peri-implantitis. Nearly 55% of the supporting bone lost during the whole 10-year follow-up reabsorbed within the first year after surgery. These data grew at nearly 72% taking in consideration the second year. Only a minor remodeling in the hard tissue was assessed after the 5-year follow-up; a substantial stability in bone levels is to be expected in the long term using implants with a TiUnite surface if no

soft tissue adverse event happens. Major deviations from this pattern were, indeed, assessed only in implants affected by peri-implantitis. The adoption of a systematic hygienic protocol is mandatory in order to control plaque accumulation and reduce the incidence of mucositis and peri-implantitis. All patients enrolled in this study received precise oral hygiene instruction and were recalled for a professional cleaning treatment by a dental hygienist every 6 months. Scaling or scaling and root planning, for the dentate patients, were also performed when necessary. The results of our paper evidenced that more than 18% of the survived implants exhibited signs of soft tissue adverse events over the whole follow-up period. This assessment, comparable with the results of Simonis and colleagues[17] and comprehensively positive when confronted with the most recent long-term reports on mucositis and peri-implantitis incidence,[19] may have been influenced by the fact that the population of this study came from a high socioeconomic background and was highly motivated and trained with regard to oral hygiene.

The implants supporting partial restorations were subject to superior soft tissue adverse event incidence compared with implants supporting full restorations. As already evidenced by Kalykakis and colleagues[20] and Karoussis and colleagues,[21] this difference can be explained by increased cross-infection risks coming from the partially dentate situation. Fifty-three percent of the survived implants treated for peri-implantitis presented recurrent symptoms of infection. This result is slightly higher compared with a recent analysis of Serino and Turri,[22] which assessed signs of peri-implant disease in 42% of the cases 2 years after a pocket elimination procedure and a bone recontouring treatment. A percentage of 4.46% of implant lost to peri-implantitis was reported by Al-Nawas and colleagues[23] in their retrospective study evaluating the cumulative survival rate of a self-tapping, cylindrical implant system with a conical connection after 10 years of prosthetic loading. The recurrence of suppuration, bleeding, and subsequent bone resorption led to an implant failure in five over 210 (2.38%) implants included in our study. In one of those cases, the loss of the implant caused the loss of the whole prosthesis because of the strategic position of the implant. The evidence that the only failures recorded in our study are late implant losses caused by peri-implantitis is a very interesting assessment. Care must be paid, however, in keeping adequate levels of oral hygiene in the long term so as to avoid increasing risk of peri-implantitis.

CONCLUSIONS

Within its limitations, this study has assessed positive results in terms of bone maintenance in the 10-year long-term perspective using immediately loaded implants with a TiUnite porous anodized surface in both postextractive and healed sites when adequate levels of oral hygiene are kept.

ACKNOWLEDGMENTS

The authors have no commercial or financial relationship that may pose a conflict of interest or potential conflict of interest.

REFERENCES

1. Albrektsson T, Wennerberg A. Oral implant surfaces: part 2 – review focusing on clinical knowledge of different surfaces. Int J Prosthodont 2004; 17:544–564.
2. Kim Y, Jang JH, Ku Y, et al. Microarray-based expression analysis of human osteoblast-like cell response to anodized titanium surface. Biotechnol Lett 2004; 26:399–402.
3. Ivanoff CJ, Widmark G, Johansson C, Wennerberg A. Histologic evaluation of bone response to oxidized and turned titanium micro-implants in human jawbone. Int J Oral Maxillofac Implants 2003; 18:341–348.
4. Zechner W, Tangl S, Fürst G, et al. Osseous healing characteristics of three different implant types. Clin Oral Implants Res 2003; 14:150–157.
5. Degidi M, Petrone G, Iezzi G, Piattelli A. Histologic evaluation of a human immediately loaded titanium implant with a porous anodized surface. Clin Implant Dent Relat Res 2002; 4:110–114.
6. Balshi SF, Wolfinger GJ, Balshi TJ. Analysis of 164 titanium oxide-surface implants in completely edentulous arches for fixed prosthesis anchorage using the pterygomaxillary region. Int J Oral Maxillofac Implants 2005; 20:946–952.
7. Glauser R, Zembic A, Ruhstaller P, Windisch S. Five-year results of implants with an oxidized surface placed predominantly in soft quality bone and subjected to immediate occlusal loading. J Prosthet Dent 2007; 97:59–68.
8. Ostman PO, Hellman M, Sennerby L. Immediate occlusal loading of implants in the partially edentate mandible: a prospective 1-year radiographic and 4-year clinical study. Int J Oral Maxillofac Implants 2008; 23:315–322.
9. Johansson B, Friberg B, Nilson H. Digitally planned, immediately loaded dental implants with prefabricated prostheses in the reconstruction of edentulous maxillae: a 1-year prospective, multicenter study. Clin Implant Dent Relat Res 2009; 11:194–200.

10. Fischer K, Bäckström M, Sennerby L. Immediate and early loading of oxidized tapered implants in the partially edentulous maxilla: a 1-year prospective clinical, radiographic, and resonance frequency analysis study. Clin Implant Dent Relat Res 2009; 11:69–80.
11. Calandriello R, Tomatis M. Immediate occlusal loading of single lower molars using Brånemark System® Wide Platform TiUnite implants: a 5-year follow-up report of a prospective clinical multicenter study. Clin Implant Dent Relat Res 2011; 13:311–318.
12. Mura P. Immediate loading of tapered implants placed in postextraction sockets: retrospective analysis of the 5-year clinical outcome. Clin Implant Dent Relat Res 2010. DOI: 10.1111/j.1708-8208.2010.00297.x.
13. Misch CE, Perel ML, Wang HL, et al. Implant success, survival, and failure: the International Congress of Oral Implantologists (ICOI) Pisa Consensus Conference. Implant Dent 2008; 17:5–15.
14. Degidi M, Perrotti V, Piattelli A. Immediately loaded titanium implants with a porous anodized surface with at least 36 months of follow-up. Clin Implant Dent Relat Res 2006; 8:169–177.
15. Albrektsson T, Zarb GA, Worthington P, Eriksson AR. The long-term efficacy of currently used dental implants: a review and proposed criteria of success. Int J Oral Maxillofac Implants 1986; 1:11–25.
16. Berglundh T, Persson L, Klinge B. A systematic review of the incidence of biological and technical complications in implant dentistry reported in prospective longitudinal studies of at least 5 years. J Clin Periodontol 2002; 29:197–212.
17. Simonis P, Dufour T, Tenenbaum H. Long-term implant survival and success: a 10-16-year follow-up of non-submerged dental implants. Clin Oral Implants Res 2010; 21:772–777.
18. Zurdo J, Romão C, Wennström JL. Survival and complication rates of implant-supported fixed partial dentures with cantilevers: a systematic review. Clin Oral Implants Res 2009; 20:59–66.
19. Rinke S, Ohl S, Ziebolz D, Lange K, Eickholz P. Prevalence of periimplant disease in partially edentulous patients: a practice-based cross-sectional study. Clin Oral Implants Res 2011; 22:826–833.
20. Kalykakis GK, Mojon P, Nisengard R, Spiekermann H, Zafiropoulis G-G. Clinical and microbial findings on osseointegrated implants – comparisons between partially dentate and edentulous subjects. Eur J Prosthodont Restor Dent 1998; 6:155–159.
21. Karoussis I, Müller S, Salvi G, Heitz-Mayfield L, Brägger U, Lang N. Association between periodontal and peri-implant conditions – a 10-year prospective study. Clin Oral Implants Res 2004; 15:1–7.
22. Serino G, Turri A. Outcome of surgical treatment of peri-implantitis: results from a 2-year prospective clinical study in humans. Clin Oral Implants Res 2011; 22:1214–1220.
23. Al-Nawas B, Kämmerer PW, Morbach T, Ladwein C, Wegener J, Wagner W. Ten-year retrospective follow-up study of the TiOblast dental implant. Clin Implant Dent Relat Res 2012; 14:127–134.
24. Lekholm U, Zarb GA. Patient selection and preparation. In: Branemark PI, Zarb GA, Albrektsson T, eds. Tissue integrated prostheses: osseointegration in clinical dentistry. Chicago, IL: Quintessence Publishing Company, 1985:199–209.