Early Loading of Maxillary Fixed Cross-Arch Dental Prostheses Supported by Six or Eight Oxidized Titanium Implants: Results after 1 Year of Loading, Case Series

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ABSTRACT

Background: Recent reports have demonstrated that immediate/early loading of dental implants is a clinically feasible concept with results similar to those for two-stage procedures, at least in good bone qualities. However, documentation of the outcome of immediate/early loading in the totally edentulous maxilla is scarce.

Purpose: The present investigation was undertaken to evaluate the outcome over 1 year of oxidized titanium implants when loaded with a fixed full-arch bridge in the maxilla 1 to 9 days after implant placement.

Materials and Methods: Ten patients with totally edentulous maxillas were treated with 61 oxidized titanium implants, and a provisional fixed bridge was delivered after 1 to 9 days (mean 2.5 d). Nine patients had six implants and one patient had eight implants supporting the bridge. The provisional bridge was replaced with a permanent bridge after 2 to 7 months (mean 4.1 mo) of loading. Resonance frequency analysis (RFA) for implant stability measurements was made at implant placement in eight patients and in conjunction with permanent bridge connection in five patients. The patients were followed up for 1 year with clinical and radiographic examinations.

Results: Four implants (6.6%) were lost in one patient after 10 weeks of loading owing to an infection. All other implants were clinically stable with a mean marginal bone loss of 1.3 ± 0.6 mm after 1 year of loading. RFA showed a mean primary stability of 60.1 ± 3.6 ISQ (implant stability quotient), which increased to 62.8 ± 1.6 ISQ after, on average, 4 months.

Conclusions: The results from this limited study on 10 cases indicate that early loading protocols can be applied for cross-arch dental bridges supported by six to eight implants in the maxilla. However, more clinical trials are needed to establish the long-term predictability of the treatment.

KEY WORDS: anodic oxidation, clinical study, dental implants, immediate loading, maxilla

Osseointegrated dental implants are widely used and are, for many dentists, the first choice of treatment modality for prosthetic rehabilitation of the edentate patient. The long-term experiences with machine-surfaced screw-shaped implants show that predictable results can be obtained in most patients and on most indications,[1] although situations with high failure rates also have been identified.[1–3] Submerged implant placement and healing before loading was anticipated as a precondition to obtain predictable results according to the first protocols for osseointegrated implants.[4] However, the two surgical procedures and long treatment time have been major drawbacks with implant therapy. There is an increasing bulk of clinical evidence suggesting that one-stage surgery and immediate/early loading of dental implants may be a viable concept.[5–26] Schnitman and colleagues treated 10 patients with implant-supported prostheses in the mandible and used 28 implants for a provisional bridge during the healing of 35 submerged implants.[5] They found that most immediately loaded implants maintained stability over a 10-year period, although some implants were lost ($n = 4$) during the early loading period.[6] Since then several studies using various implant systems for fixed bridges or overden-

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tures have shown similar results to those for two-stage implant protocols in the mandible.[5–20] One explanation for the good results has been the possibility of achieving high primary stability owing to the good bone density in the mandible.[27] Another factor contributing to the results is the favorable biomechanical situation obtained by placing five to six implants in an arch form, which counteracts and minimizes bending forces.[28] Recent clinical studies have evaluated the use of immediate/early loading for single-tooth replacements and partial bridges in the mandible and the maxilla.[21–26] Maló and colleagues[24] reported high survival rates for machined implants placed in the anterior parts of the mandible and maxilla when using an adapted surgical technique to achieve high primary stability and reduced occlusal contacts. Moreover, Glauser and colleagues[26] tested an immediate-loading protocol in all regions where the provisional crown and bridges were in centric occlusion. They experienced a high failure rate (17.3%), and analysis of the implant losses showed that most failures occurred in the posterior maxilla, a region with soft bone, and in patients with bruxism. The results from the studies by Maló and colleagues[24] and Glauser and colleagues[26] point to the fact that bone density and primary stability are determinants for the outcome of immediate loading, at least with machined implants.

In analogy with the favorable biomechanical situation of the arch formed mandible, it may be anticipated that immediate loading may be successfully applied also in the maxilla. One concern is the softer character of maxillary bone and the difficulty of obtaining a high primary stability as in mandibular bone.[29] However, it may be speculated that the use of long implants, a surgical technique aiming at high primary stability and cross-arch stabilization of a bridge, may compensate for the softer bone. Moreover, the use of surface-modified implants may facilitate implant integration as it has been shown in experimental studies.[30–35] Immediate loading of the totally edentulous maxilla has been presented in the literature[9,14,23,26] with promising outcomes; however, the number of documented cases is few (16 patients and 122 implants).

The present investigation was undertaken in 10 consecutive patients to evaluate the outcome up to 1 year of Brånemark System® TiUnite™ (Nobel Biocare AB, Gothenburg, Sweden) implants when loaded with a fixed full-arch bridge in the maxilla 1 to 9 days after implant placement.

MATERIALS AND METHODS

Patients

Ten patients (six females, four males) with edentulous maxillas, with a mean age of 59 years (range 50–86 yr), were included in the study. The patients were consecutively recruited from referrals to the clinic for implant treatment; they were included if they met with the inclusion criteria, accepted inclusion, and consented to the protocol.

The presurgical evaluation included clinical and radiographic examinations with periapical radiography, orthopantomographs, and tomography. The inclusion criteria were (1) the need for a cross-arch fixed implant-supported bridge in the maxilla, (2) the possibility of placing at least six implants, preferably with lengths of 10 mm or longer, (3) sufficient primary stability as judged clinically, (4) no general or local health-related contraindications for implant surgery, and (5) patient consent to the protocol.

Five patients had natural teeth, three patients had natural teeth and a removable partial denture, and two patients had an implant-supported bridge in the mandible. Nine patients were healthy; one had diabetes.

Surgery and Implants

The patients were given 3 g amoxicillin (Amimox®, Tika Läkemedel AB, Lund, Sweden) and diazepam (0.3 mg/kg body weight, Stesolid®, Alpharma, Stockholm, Sweden) orally 1 hour prior to surgery. Local anesthesia was induced by infiltration with articaine/epinephrine (Septocain®, Septodont, Saint-Maur-Des-Fosses, France). The alveolar process was exposed via a continuous incision on the top of the crest and vertical releasing incisions in molar regions. Mucoperiosteal flaps were raised to identify the anterior borders of the maxillary sinuses, the aperture of the nose, and the incisive canal. Five to eight implant sites were prepared in the widest possible anterior-posterior distribution (Figure 1A). One patient had a previously placed implant in the maxilla and received another five implants. One patient received eight implants, and eight patients had six implants placed. Final drill diameters of 2.85, 3.0, or 3.15 mm were used depending on bone density. No or minimal countersinking was performed. A total of 61 self-tapping oxidized implants (TiUnite) were placed with an insertion torque of 20 to 40 Ncm followed by manual tightening. Both straight (RP Mk III, $n = 50$) and tapered (RP

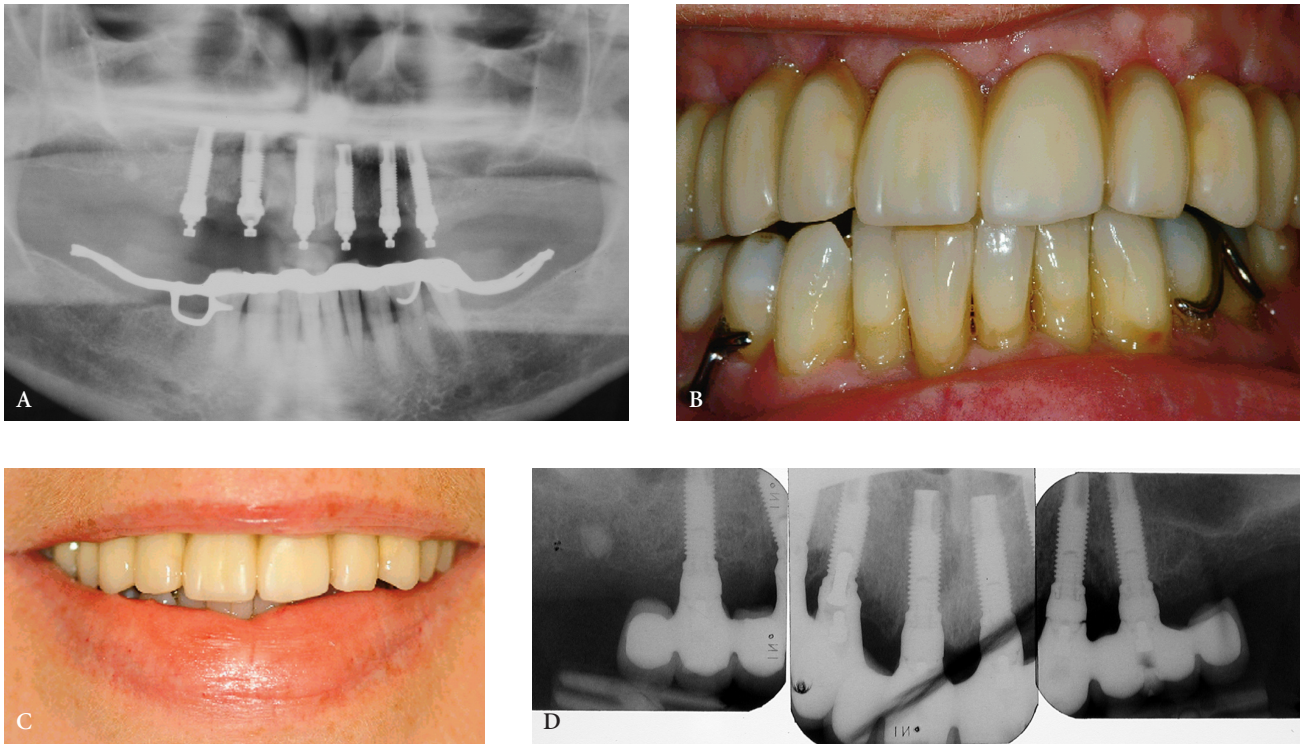

Figure 1. *A,* Radiograph taken after implant placement; *B,* view of provisional bridge; *C,* view of permanent bridge; *D,* periapical radiographs showing minimal bone resorption after 1 year of loading.

Mk IV, $n = 11$) implants of different lengths (8.5–18 mm) were used (Table 1). Abutments (Multi-Unit Abutment®, Nobel Biocare AB) were connected, and the fixation screws were tightened with a torque controller set at 20 Ncm. Flaps were adjusted to the abutments, repositioned, and sutured with resorbable suture (Vicryl®, Ethicon, Inc., Somerville, NJ, USA).

Prosthetics and Follow-up

An acrylic screw-retained provisional bridge was fabricated and delivered to the patient 1 to 9 days (mean 2.5 d) postoperatively (see Figure 1B). Goals included group function and a flat occlusal plane with occlusal contacts above the implants. Checkups were made after 2 weeks, when sutures were removed, and after 1 and 2 months, when occlusion was checked and adjusted if needed. A permanent screw-retained bridge (Procera® Implant Bridge, Nobel Biocare AB) was fabricated and delivered 2 to 7 months (mean 4.1 mo) after surgery, after which time patients were checked every 3 months (see Figure 1C).

TABLE 1. Implant Characteristics*

Implant Length (mm)	No. of Implants		Total
	Mk III	Mk IV	
8.5	1	—	1
10	1	—	1
13	8	7	15
15	38 (4)	4	42
18	2	—	2
Total	50	11	61

*Failed implants are shown in parentheses.

Orthopantomographs were taken immediately after surgery. Periapical radiographs and orthopantomographs were taken after 1 year of loading (see Figures 1D and 2A and B). Marginal bone levels in relation to the abutment-implant junction were measured using a computerized system for image analysis. In brief, the radiograph was captured from a light desk by a video camera into an image analysis program (Image Access®, Micro Macro AB, Gothenburg, Sweden). Measurements were made in tenths of millimeters on the screen at optimal settings of brightness and contrast. A mean value was calculated for each implant based on mesial and distal implants.

Resonance frequency analysis (RFA) (Osstell®, Integration Diagnostics AB, Sävedalen, Sweden) was per-

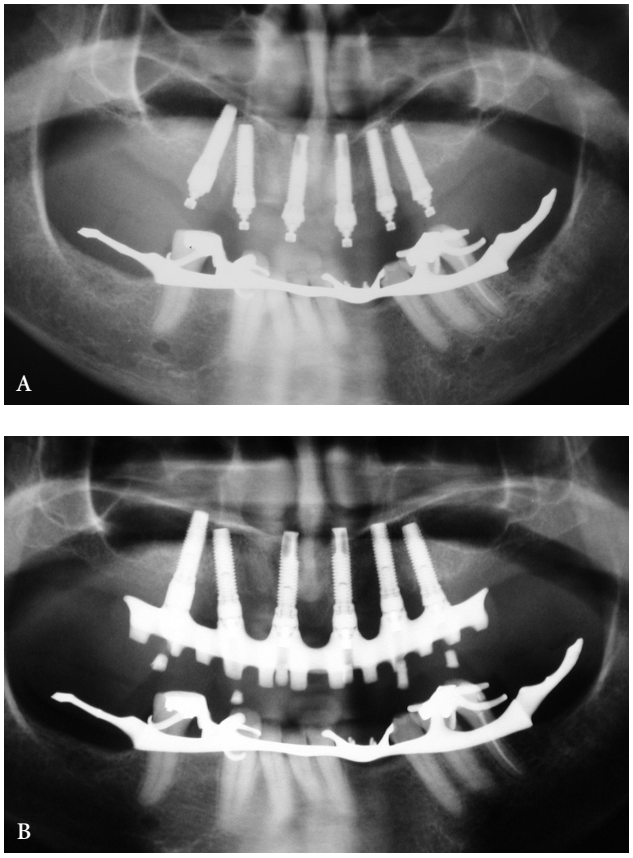

Figure 2. *A,* Radiograph taken after implant placement; *B,* radiograph showing extent of permanent bridge.

formed in eight patients to measure implant stability after implant placement and in five patients in conjunction with connection of the permanent bridge (mean 4 mo). A resonance frequency transducer was attached to the implant abutments perpendicular to the alveolar crest. Measurements were made in ISQ (implant stability quotient) units, which are given on a scale of 1 to 100, with 100 being the highest degree of stability. The ISQ unit is based on the underlying resonance frequency of the transducer, which in turn is determined by the stiffness of the bone-implant interface.

RESULTS

All patients attended the 1-year follow-up. Four (6.6%) of the 61 implants were lost. All four losses occurred in one patient after 10 weeks of loading, and consequently the bridge was also lost (Figure 3). This patient had an infection in the area, which was diagnosed as actinomycosis.

Few other complications were recorded. Fracture of the provisional bridge occurred in two patients.

The marginal bone level was 1.3 ± 0.6 mm from the reference point after 1 year of loading. RFA showed a mean primary stability of 60.1 ± 3.6 ISQ, which increased to 62.8 ± 1.6 ISQ after, on average, 4 months. It was apparent that the stability of implants with low values increased and that of implants with high values decreased from placement to permanent bridge connection (Figure 4).

DISCUSSION

The present study demonstrated the possibility of applying early loading to six to eight implants used to support a full-arch fixed bridge in the totally edentulous maxilla. Four of 61 implants were lost in one patient because of an infection in the area. The successful outcome in the remaining nine patients indicates that the use of six to eight implants, with the majority of implants being 13 to 15 mm in length, may serve as sufficient anchorage for a bridge and enable load distribution to the maxillary bone without causing implant loss. The RFA measurements indicated that the implant stability increased with time; this may be interpreted as an effect of undisturbed bone formation, remodeling, and an increased stiffness at the bone-implant interface. Such an increase has previously been described for the maxilla when using a two-stage procedure.[36]

In a previous study by Tarnow and colleagues,[9] 4 patients were treated with 10 or 11 implants, of which 6 to 10 were loaded the same day with a provisional bridge. No implant losses were experienced over 1 to 3 years of follow-up. The authors concluded that factors such as the use of multiple long implants (at least 10 mm), cross-arch stabilization, and no distal cantilevers contributed to the successful outcome. Horiuchi and colleagues[14] reported on immediate loading in the edentulous maxilla. They placed 8 to 10 implants with

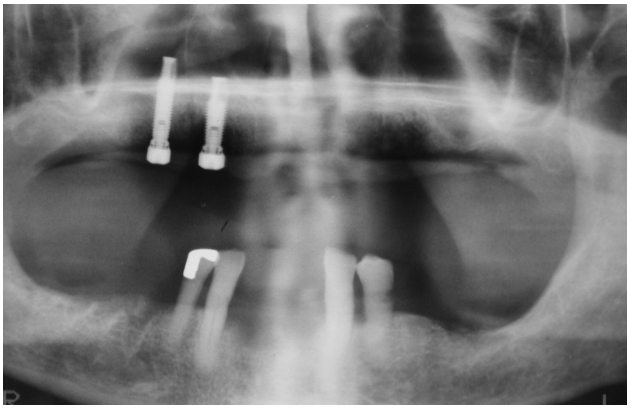

Figure 3. Radiograph of failure case after removal of four implants.

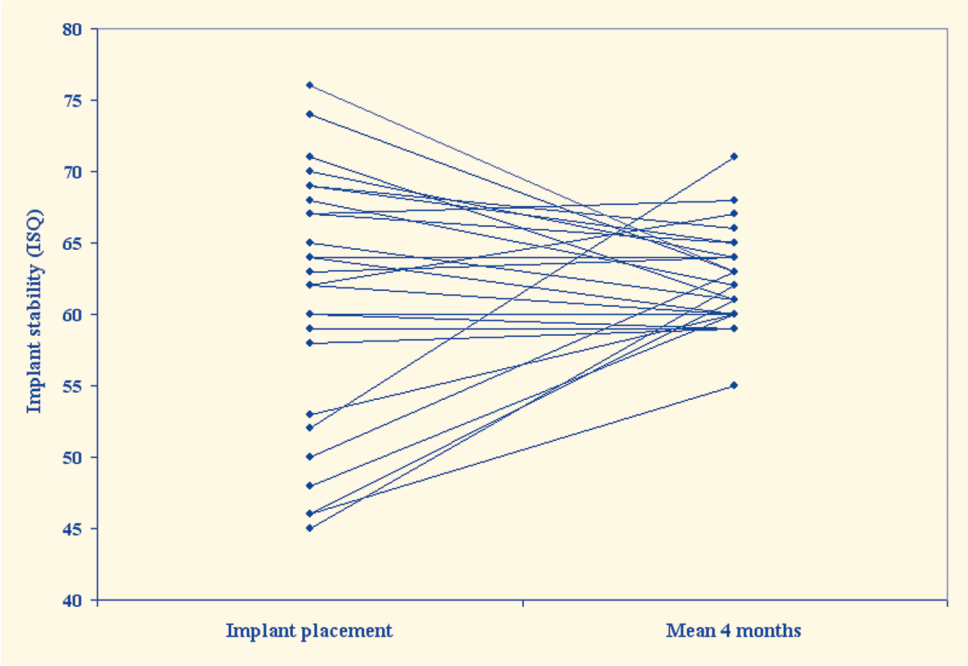

Figure 4. Development of Stability for 28 implants followed up from Placement to, on average, 4 months after surgery. The implants seemed to strive toward a Stability of 60 to 65 ISQ.

lengths of 10 to 18 mm in 5 patients and loaded the implants, which reached an insertion torque of at least 40 Ncm, with a provisional bridge. Thirty-six of 44 implants were loaded immediately following surgery. Two of the immediately loaded implants were lost during a follow-up of at least 12 months. These implants had served as the most distal abutments, and the authors speculated that overload resulting from an ill-fitting provisional bridge was the cause of the losses. Based on their experiences, Horiuchi and colleagues[14] proposed guidelines for immediate loading that included the use of multiple implants (at least eight), the use of long implants (at least 10 mm for regular-diameter implants), and an insertion torque of at least 40 Ncm.

Based on our own clinical experience, most edentulous maxillas have sufficient bone for 6 implants in the premolar to premolar region, but seldom can 8 or 10 be placed. Moreover, the use of many implants increases the cost for the treatment dramatically. The guidelines of Horiuchi and colleagues[14] and Tarnow and colleagues[9] exclude many patients from immediate loading in the maxilla. In the present study, 6 implants were used in 9 of the 10 patients. Our results from this case series suggest that immediate/early loading may be considered for patients treated with 6 implants.

The use of surface-modified implants may have played an important role in the favorable outcome of the present study. Experimental studies have shown a stronger and more rapid bone tissue response to surface-modified implants.[30–35] The implants used in the present study had been treated with anodic oxidation, which causes the native oxide layer to grow and results in a topography with large pits.[37] Studies in animals have demonstrated more bone in contact and a higher removal torque for oxidized implants than for machined ones.[38,39] Also clinical investigations have demonstrated differences. For instance, Glauser and colleagues[40] compared RFA values for immediately loaded oxidized and machined implants placed in the posterior maxilla of patients and followed up for 6 months. They observed a drop of stability during the first 3 months for both implant types, which, however, was significantly less for the oxidized ones. In a clinical prospective study on immediate loading of machined implants placed in all jaw regions, Glauser and colleagues[26] reported a failure rate of 17.3% after 1 year. In a recent study, the same group used oxidized implants with a similar protocol and experienced only 3% failures.[41] In can be hypothesized that bone grows into the irregularities of the oxidized surface and creates a faster and stronger fixation with bone compared with fixation to a machined surface. This may explain the differences seen. However, other authors have reported high survival rates with immediately/early loaded machined implants when

placed in challenging situations, such as in the maxilla[9,14] or for single-tooth replacements/partial bridges.[22–24,42] In contrast to Glauser and colleagues,[26] most authors have used reduced or no occlusion, which may partly explain the good outcomes. They have also been concerned to achieve high primary stability and have included few patients with quality 4 bone; in addition, some investigators have used various techniques to enable implant insertion with high torques.[24]

The results from this limited study indicate that early loading can be applied to cross-arch dental bridges supported by six to eight oxidized implants in the maxilla. However, more clinical trials are needed to establish the long-term predictability of the treatment.

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