Long-Term Evaluation of Immediately Loaded Implants in the Edentulous Mandible Using Fixed Bridges and Platform Shifting

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ABSTRACT

Background: The immediate loading concept has been extensively documented in the anterior part of the mandible when six primary stable implants are placed, splinted with a fixed prosthesis.

Purpose: The aim of this study was to evaluate the long-term success of immediately occlusal loaded implants with a progressive thread design and platform shifting in the edentulous mandible.

Materials and Methods: Seventy-eight implants placed in 13 patients and were connected with their abutments immediately after surgery. The implants were splinted using a fixed temporary restoration having occlusal contacts in the centric and group function in the lateral movements of the mandible (immediate occlusal loading). The patients were advised to use soft/liquid diet for the first 6 to 8 weeks of healing in order to reduce excessive loading in the bone-to-implant interface. Abutment level impressions were taken without removing the abutments in order to fabricate the final prostheses. The final restorations were delivered 4 to 8 weeks after surgery and cemented temporarily in order to evaluate the peri-implant soft tissue condition at the different time intervals after removal of the restoration. Clinical stability and radiological indices were evaluated at the start of loading, at 3-month interval after loading, and then annually.

Results: After a mean loading period of 75.29 (± 38.18) months, no implant was lost (100% success rate). All clinical indices had values in normal levels. The Periotest values demonstrated a continuous reduction, representing high stability. The crestal bone level was relatively stable and only minimal crestal bone loss was observed in some implants.

Conclusions: Long-term success and stability of the peri-implant tissues around immediately loaded mandibular implants are expected when implants with platform shifting are restored with bridges without abutment removal.

KEY WORDS: immediate loading, implant, long-term success, mandible

INTRODUCTION

A load-free period of time around endosseous oral implants has been reported as a prerequisite in order to achieve osseointegration. In edentulous mandibles, it is possible to load implants immediately after surgery if some requirements are considered. Primary stability and rigid immobilization using a bar are important factors when loading with four intraforaminal implants using an overdenture takes place.[1,2] Recent studies suggested the use of a different type of restoration in the lower jaw using prefabricated abutments or only the healing abutments.[3–5]

The general rule of this treatment concept is to load implants, without any excessive micromotions at the interface. Increasing the implant length, choosing an appropriate thread design, improving the surface roughness, reducing the loading forces, and recommending soft/liquid diet at the initial stages of healing are important factors in achieving bone-implant integration.[6–9]

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Moreover, some authors increased the number of implants in order to compensate for loading forces,[7] rigidly immobilized the implants with fixed restorations.[7,8,10–15] Transitional (secondary) implants were preferred to load immediately for the temporary restoration and were splinted later with implants, which were already healed submerged (i.e., primary implants).[8,16,17]

Looking critically at the present literature, there is no consensus between different authors for an exact definition of the term "immediate loading." Some authors classified the type of loading according to the time of the prosthesis installation and the existence or not of occlusal contacts.[13,18,19]

If loading starts in the first 3 days after implant placement, using a prosthetic restoration with occlusal contacts, the loading may be defined as an "immediate functional (occlusal) loading." If the loading is performed after 3 days of healing, but within the first 3 weeks, it is an "early" but not "immediate" loading. If the loading of implants takes place in a later time, this loading is termed as a "delayed loading." There is a lack of clarity in the literature with regard to terms. Many references to "immediately loaded implants" can be found for implants, which are in fact "early-loaded" implants and *vice versa*.

The present study was performed in order to evaluate, after 5 years, the clinical and radiological condition of six immediately loaded implants with platform shifting placed in the mandible using arch-shaped fixed prostheses.

MATERIALS AND METHODS

Thirteen patients (seven male and six female) with an age of 60.82 (± 8.99) years were included in this study. Seventy-eight implants (six implants in each mandible) with a progressive thread design and sandblasted, acid-etched surface (Ankylos®, Dentsply Implants, Waltham, MA, USA) made from commercially pure titanium (grade IV), and platform shifting were placed in the edentulous mandible using a surgical guide after clinical and radiological presurgical diagnostics by the same surgeon (G.E.R.). These implants had a 2.0-mm collar with acid-etched surface and diameters of 3.5, 4.5, and 5.5 mm. The lengths varied between 9.5 and 14 mm.

Patients were included in the study according to the following criteria: (1) completely edentulous in the mandible; (2) rehabilitation with endosseous dental implants considered the ideal treatment of choice; (3) informed consent signed; and (4) physically and mentally able to tolerate conventional surgical and restorative procedures. The exclusion criteria were the following: (1) active infection in the sites selected for implant placement; (2) systemic diseases, such as diabetes without control; (3) pregnancy; and (4) severe bruxism (Table 1).

In the opposing upper arch dentitions, the patients had five different types of restorative arrangements

TABLE 1 Immediate Loading in the Edentulous Mandible

Sex	Age (years)	Smoker	Disease	Augmentations (site number)	Loading Period (months)
Female	45.65	Yes	No	1	64.40
Female	58.06	No	High blood pressure	4	83.03
Female	61.35	Yes	No	4	125.60
Female	63.12	No	No	5	99.63
Female	71.41	No	No	0	133.93
Female	51.02	Yes	Deceased because of cancer	0	6.3
Male	69.74	No	Asthma, high blood pressure	0	75.9
Male	72.74	No	Angina pectoris, high blood pressure	0	83.9
Male	67.74	No	High blood pressure	1	96.8
Male	62.85	Yes	Diabetes type II, high blood pressure	4	95.67
Male	45.13	Yes	Deceased because of cancer	0	8.73
Male	61.01	No	No	0	72.27
Male	60.77	No	No	0	32.63

TABLE 2 Characteristics of the Immediately Loaded Implants in the Mandible

	Diameter (mm)			
Length (mm)	3.5	4.5	5.5	Total
8.0	0	0	0	0
9.5	3	3	0	6
11.0	34	2	2	38
14.0	29	5	0	34
Total	66	10	2	78

existed. The patients had in the maxilla implant-supported restorations (seven patients), tooth-implant-supported fixed bridge (one patient) or removable restoration (one patient), healthy teeth (two patients), or were edentulous wearing a full denture (two patients). Five patients were heavy smokers (smoking more than 10 cigarettes/day for a period of more than 10 years). All patients had to sign a special form according to the Ethics Committee of the University of Frankfurt (including the Declaration of Helsinki) with the number 91/99 (substudies B and C). The implants placed had the following diameters: 66 implants with a diameter of 3.5 mm, 10 implants with 4.5 mm, and only two implants with a diameter of 5.5 mm (Table 2). The 5.5 mm–diameter implants were placed only in areas with poor bone quality. The implants had lengths as follows: 14 mm (34 implants), 11 mm (38 implants), and 9.5 mm (six implants).

The implants were placed according to the prosthetic guidelines established from a diagnostic setup (Figure 1). This setup was then duplicated and a surgical guide was made using the Vac-u-form™ (Buffalo Dental Manufacturing Co., Inc., Syosset, NY, USA). In areas with inadequate autogenous bone quantity (19 implants at the mesial, buccal, and distal sites in each one of them), exposed threads were augmented simultaneously using autogenous bone graft harvested from the adjacent areas of the mandible. The augmented areas were covered by a Biogide®-collagen membrane (Geistlich Co., Wolhusen, Switzerland), which was fixated in place with Frios®-titanium pins (Friadent Co., Mannheim, Germany). The implants were connected to abutments (straight or angulated standard abutments) immediately after their insertion (Figure 2) using the final torque (15–25 Ncm). Temporary caps were placed and the flap was sutured using silk-suture material (No. 4-0, Resorba Co., Nürnberg, Germany) and interrupted sutures.

All implants were splinted using a fixed temporary restoration immediately after surgery. The temporary bridges were made chairside with Protemp®-resin material (Espe Co., Seefeld, Germany) using a Vac-u-form™ over the temporary caps placed on the abutments (Figure 3). The provisional bridges were cemented temporarily at the same day of the surgery using Temp Bond®-cement material (Kerr Co., Karlsruhe, Germany). The temporary restorations had occlusal contacts in the maximal intercuspidation (ICP) and group functional contacts in the lateral movements of the mandible keeping the vertical dimension in the correct height (immediate occlusal functional loading).

The patients were advised to use soft/liquid diet for the first 6 to 8 weeks of healing in order to reduce excessive loading at the bone-to-implant interface. A postoperative antibiotic administration was given to all patients during the total treatment period.

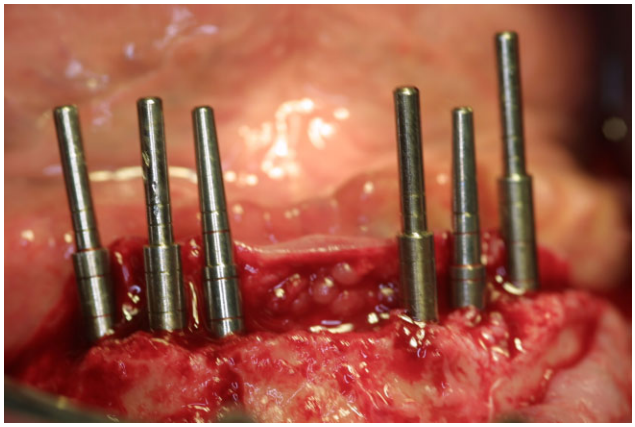

Figure 1 Insertion guides in the mandible indicating the parallel direction of the osteotomies.

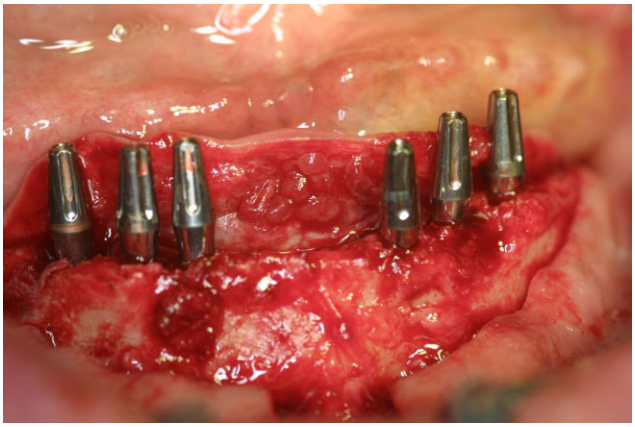

Figure 2 Abutment connection for immediate loading immediately after implant placement.

Figure 3 Provisional restoration for immediate functional loading.

Immediately after surgery, implant stability was evaluated using the Periotest device (Gulden, Bensheim, Germany) and 2 weeks after surgery all clinical peri-implant indices (i.e., plaque index, sulcus bleeding index, and probing pocket depth at the mesial and buccal sites, and width of the keratinized mucosa) were evaluated (baseline). The bone loss was classified from the implant top to the marginal crest of bone at the baseline (Figure 4). One week to 10 days after surgery, the sutures were removed. The clinical indices were evaluated at the time of the delivery of the final prosthesis, as well as at 3-month follow-up visits. Radiological evaluations with panoramic radiographs recorded the peri-implant bone levels at the same time intervals according to Gomez-Roman and colleagues[20] using the Sidexis® software (Next Generation® Viewer 1.51, Sirona, Bensheim, Germany). More specifically, in every patient, traditional panoramic radiographs have been performed using the same panoramic unit and identical film developing methods, calibrating in that way the images attempting to get the same magnification due to the distortion.

Three to four weeks after surgery, the temporary restorations were removed in order to take impressions for the final bridges. The abutments were in place and only impression caps were used for the final impressions. The surgeon was also the restorative dentist (G.E.R.) in all of these patients. Occlusal registrations and determination of the vertical dimension were also performed. A custom-made framework was fabricated for a metaloceramic fixed prosthesis. In one case with extreme atrophy of the mandible, a customized milled bar restoration was fabricated in order to replace the lost soft and hard tissues with a removable (hybrid-type) bridge. The final restorations were delivered 4 to 8 weeks after surgery and cemented temporarily in order to evaluate the peri-implant soft tissues at the different time intervals after removal of the restoration. The patients were checked for sufficient occlusal contacts. Excessive contacts in the lateral movements of the mandible were eliminated (Figure 5).

The criteria for success were the following: (1) no clinically detectable mobility; (2) no peri-implant radiolucency; (3) no complaint of pain at the implant site; (4) no recurrent or persistent peri-implant infection; (5) no neuropathy or paresthesia; and (6) no marginal bone loss more than 2 mm after 1 year of functional loading and less than 0.2 mm/year in the follow-up visits according to the criteria of success presented previously.[21]

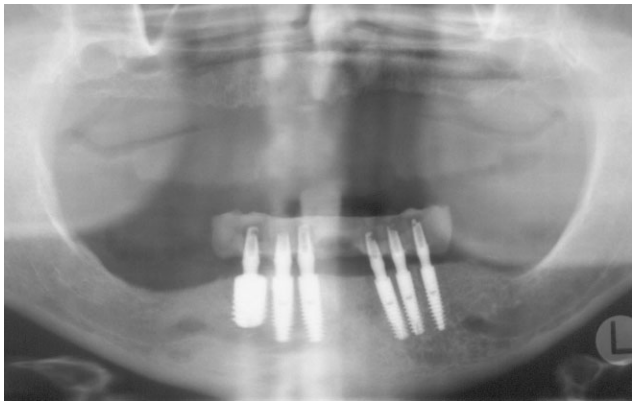

Figure 4 Radiological evaluation at the implant placement immediately after surgery presenting the crestal bone levels.

Figure 5 Final restoration in place 6 weeks after implant placement. No abutment removal was performed.

TABLE 3 Peri-Implant Clinical Values around Immediately Loaded Implants in the Mandible

	T0	T1	T2
PV	−1.85 ± 1.99	−2.41 ± 1.76	−4.37 ± 2.74
PlI	0.95 ± 0.93*	0.78 ± 0.88	0.47 ± 0.85
SBI	0.77 ± 0.86*	0.70 ± 0.87	0.08 ± 0.31
PPD(m)	1.75 ± 0.67 mm*	1.65 ± 0.57 mm	2.17 ± 0.62 mm
PPD(b)	1.77 ± 0.70 mm*	1.78 ± 0.76 mm	2.26 ± 0.63 mm
KM	3.27 ± 1.51 mm*	3.31 ± 1.62 mm	2.36 ± 1.14 mm

*Measured at 2 weeks after surgery.
b = buccal; KM = keratinized mucosa width; m = mesial; PlI = plaque index; PPD = probing pocket depth; PV = Periotest value; SBI = sulcus bleeding index; T0 = baseline; T1 = placement of the final fixed reconstruction; T2 = follow-up.

The patients were examined annually clinically and radiographically and the crestal bone loss was determined using the Sidexis software.

RESULTS

After a mean loading period of 75.29 (± 38.18) months (range 6.3–133.93 months), no implant failure was observed (100% survival rate). The peri-implant clinical values were evaluated by an independent examiner (K.G.) and presented in Table 3 during the total loading period. The Periotest values presented a continuous reduction, which had a significant difference (*t*-test; $p < .05$) between the baseline (T0) and follow-up (T2) visit. All other clinical indices had values in normal levels, which explain the healthy peri-implant soft tissue condition. The bone loss represented by the radiographies showed vertical bone loss more than 2 mm (in only five sites) and horizontal bone loss more than 2 mm (in only one site). Specifically, a minimum of 2.11-mm and a maximum of 2.64-mm bone loss were observed. In 72 sites, a crestal bone loss (horizontal or vertical) less than 2 mm was found (Figure 6). No implant had a crestal bone loss more than 0.2 mm/year of loading.

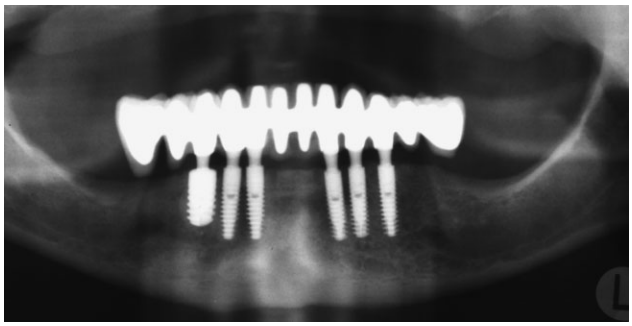

Figure 6 Seven years postoperative radiograph demonstrating crestal bone stability around implants with platform switching.

Therefore, the success rate of this study was also 100%. Success of the immediately loaded implants was not related to bone quality, diameter, length, position of the implant, or simultaneous augmentation.

DISCUSSION

The present paper showed that only six implants with a high primary stability and a progressive thread design are adequate in order to restore edentulous mandibles using fixed implant-supported restorations with the immediate occlusal loading protocol. The implants had a platform shifting and were loaded immediately after surgery using fixed (cement-retained) restorations with adequate occlusal contacts in the day of surgery (i.e., immediate functional/occlusal loading). An excellent splinting of the immediately loaded implants is necessary in order to avoid excessive movements at the bone-to-implant interface. The abutments were placed and torqued down at the day of surgery and had never been removed for the entire observation period.

Histological examination of the bone around immediately versus delayed loaded implants with the same implant thread design placed in the posterior part of the mandible in monkeys with poor bone quality showed that the bone-to-implant contact percentages had no significant differences between the two loading protocols[22,23] and an excellent implant integration was found. Moreover, it has been shown that the mineralized bone (bone density) was significantly higher within the threads around immediately in comparison with delayed loaded implants in nonhuman primates.[19,22] This density was higher around loaded (immediately or delayed) implants than around unloaded implants.[19,23]

The high success rate reported in this paper can be explained with the high stability of the implant system used. Previous studies showed that the total surface of this implant design (3.5 mm diameter/14 mm long) is similar to multirooted teeth.[24] For these reasons, only one implant with a relatively narrow diameter (3.5 mm) was needed to replace single molars successfully.[25] It is routinely not necessary to insert two implants or an implant with a wider diameter in order to replace successfully one molar as has been recommended elsewhere.[26] Furthermore, other authors suggested avoiding the use of wide-diameter implants routinely in order to prevent buccal recessions after resorption of the buccal bone.[27]

Because of the good primary stability of this implant system, six implants were necessary to restore edentulous mandibles with fixed implant-supported prostheses in comparison with other studies, showing that 10 to 12 implants are necessary using implants with different designs.[7,13] There is no doubt that also other concepts, such as the "all-in-one-day" concept with the Brånemark TiUnite®-surfaced fixtures (Nobel Biocare, Gothenburg, Sweden), allow high survival rates in the long term, but this concept is recommended to be used specifically only by well-trained surgeons and prosthodontists.[28]

However, there is no wide spectrum of experience from general practitioners using this concept in daily practice, but recent clinical findings seem to be very promising.[29]

Van Steenberghe and colleagues[30] reported a cumulative survival rate of 92.7% after 1 year in 50 mandibles using the Brånemark Novum® (Nobel Biocare, Gothenburg, Sweden) concept (lower than the conventional loading protocol), where only three immediately loaded implants (with a wide diameter of 5.5 mm) were placed and connected together rigidly by a bar.

Becker and colleagues[4] placed four Brånemark (Nobel Biocare, Gothenburg, Sweden) implants in the anterior part of the mandible and inserted a full denture, loading the implants 5 days after implant insertion. The implant restorations were replaced 6 months later and a bar-reinforced fixed detachable denture was placed. The implants demonstrated a success rate of 96.3% after 2 years. The crestal bone level at 5 days was 2.1 mm maybe due to insufficient oral hygiene around the implants in the first stages of the healing (the denture flange did not allow optimal plaque control).

Malo and colleagues[31] reported an immediate-function concept with four Brånemark implants to restore edentulous mandibles with fixed prostheses. According to their data, a cumulative survival rate of 96.7% in the first 6 months of loading and a small amount of bone resorption have been reported. In contrast to that, immediately loaded Brånemark® implants with a simultaneous augmentation of the exposed threads covered by a membrane had a good prognosis in the long term when they were placed in areas with poor bone quality.[32]

Misch and Degidi[33] presented data from 19 edentulous mandibles with a total number of 100 implants (5–10 implants per patient), which were loaded the day of surgery with a provisional bridge. The final restorations were fabricated and placed 7 months after surgery. In the follow-up observation of 1 to 5 years after loading, the survival rate was 100%.

In a multicentric study from four different centers, Testori and colleagues[14] presented data from three hundred twenty-five 3i-Osseotite® (Biomet 3i, Palm Beach Gardens, FL, USA) implants placed in the edentulous mandibles of 62 patients and immediately loaded. No smokers or pregnant patients, no patients with systemic diseases such as diabetes, and no active infections in the sites of implant placement or areas with augmentations were included in this study. The provisional prosthesis was delivered in the first 48 hours after surgery and the final restoration placed 6 months after surgery. The cumulative success rate using this immediate loading protocol was 99.4% in a mean loading period of 29 months (range 12–60 months).

Previous studies performed with immediate loading in the mandible without addressing the topic of loading forces (opposing dentition and soft/liquid diet)[14,34] compared with other authors, who suggest soft/liquid diet protocol.[7,10]

Patients with known parafunctional habits (i.e., bruxism) were excluded from such treatment protocols and should be treated using conventional loading protocols.[7]

The rigid splinting (immobilization) of the immediately loaded implants using cross-arch splinting with fixed or bar restorations (screw-retained restorations) is mandatory immediately after surgery. Studies with cylindrical and symmetrical implant geometries (Brånemark® system) placed in poor bone qualities are associated with lower survival rates.[7,8,35]

Using this implant system, we were not able to find any failures (100% success) in a prospective, randomized split-mouth study after a 2-year period of loading

in the posterior mandible in 12 patients,[19] even in such anatomic regions the bending moments are relatively high.[36] Moreover, we were able to show histologically an excellent bone-to-implant integration in nonhuman primates.[19,22,37]

In the present prospective clinical study, we demonstrated 100% success rate of immediately loaded implants in the mandible without evidence of peri-implant marginal bone loss (crestal bone loss less than 0.5 mm), possibly due to the platform shifting and the issue that the abutments were placed at the day of the surgery and were never removed. This concept was initially documented in immediately loading concepts in the maxilla and mandible presenting successful long-term results.[38]

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