Immediate Functional Loading in the Maxilla Using Implants with Platform Switching: Five-year Results

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Purpose: *Immediate loading in the maxilla is not a routinely recommended treatment concept; however, some clinical series have shown a high survival rate for nonfunctionally loaded implants. The purpose of this study was to demonstrate the prognosis for immediately loaded implants with a progressive thread design and platform switching placed in the maxilla with or without simultaneous augmentations using autogenous bone.* ***Materials and Methods:*** *Ninety implants were placed (six in each maxillary arch) in 15 patients. Immediately after surgery, the implants were loaded with a provisional acrylic resin prosthesis (immediate occlusal loading). Splinting of the implants with the provisional remained for 6 to 8 weeks of healing. In patients with augmented sites, a 3-month period of provisionalization was necessary to ensure implant stability; a soft/liquid diet was recommended for this intermediate transitional period. Definitive fixed restorations were then fabricated and delivered. Clinical and radiologic examinations of the implants were performed at various times.* ***Results:*** *After a mean loading period of 42.4 (± 19.15) months, only three failures were reported. This represented a survival rate of 96.66%. No complications, including inflammation or bone loss, were reported during the study period.* ***Conclusions:*** *Based on these results, the immediate loading protocol in the maxilla can be used successfully when implant primary stability, cross-arch stabilization, and a soft diet for the initial stages of healing are considered.* Int J Oral Maxillofac Implants 2009;24:1106–1112

Key words: *dental implants, immediate loading, maxilla*

The osseointegration of oral implants has been defined as the stable connection between titanium surface and bone bearing a load.[1] It is expected to be observed within 3 to 6 months after surgery if loading of the implants is avoided. Osseointegration has been confirmed by light microscopy, which shows new bone in contact with the implant surface and without the formation of fibrous tissue around the implant. Histomorphometrically, osseointegration has been characterized as bone-to-implant contact of at least 60%. Sometimes, additional histomorphometric characteristics such as bone volume are used to define the quality (density) of the bone at the interface under loading conditions when compared to other areas.[2]

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Nkenke et al[3] examined immediate loading (IL) of implants in minipigs. The immediately loaded implants in the maxilla had higher bone-to-implant contact than unloaded implants. A higher quantity of secondary osteons and marrow spaces was also present, confirming better remodeling around immediately loaded implants.[4] Clinically, implant stability, verifying osseointegration, has been evaluated using mobility tests (Periotest, resonance frequency analysis, etc) after the healing period or radiographically, ie, the absence of radiolucent areas around implants after healing.

The primary mechanical stability of an implant at the time of placement is dependent on bone quality; better bone quality is associated with increased primary bone-to-implant contact, decreased micromotion, and increased long-term success. Attempts to decrease micromotion have been used in different clinical protocols. Cross-arch stabilization[5–7] and splinting using a bar[8,9] are well documented and promote healing and osseointegration when the implants are loaded immediately. The concept of IL seems to be successful in the anterior mandible. However, there have been few reports to date demonstrating IL in the maxilla. Moreover, no routine procedure with an immediate functional loading protocol in the maxilla has been recommended.[10] Testori et al[11] showed high

success rates for implants that were loaded early (97.96%) or restored immediately (without occlusal contacts; 96.15%) in the maxilla in partially edentulous patients. Also, limited histologic data from human retrieved biopsies of immediately loaded threaded implants (3i, Ankylos, Frialit-2, and Nobel Biocare) in the maxilla showed bone-to-implant contact percentages above 50% after a loading period between 2 and 10 months.[12] Histologic evaluation of immediately loaded implants in the maxilla of a human autopsy specimen showed a relatively high bone-to-implant contact percentage (over 50%) after 7 months of loading, although the patient had been a heavy smoker and had been undergoing chemotherapy.[13]

Tarnow et al[5] presented four patients with edentulous maxillae; a minimum of 10 implants (Biomet 3i, Astra, Brånemark) were placed and loaded immediately in each patient. In some patients, a fixed provisional prosthesis was used. Screw-retained restorations were suggested for this protocol by the authors. In a follow-up examination 1 to 4 years later, all 40 immediately loaded implants were found to have survived (100% survival rate). Horiuchi et al[6] documented five patients with edentulous maxillae, who received 52 Brånemark implants. Eight implants were submerged. The minimum length was 10 mm and the diameters were 3.5, 4.0, or 5.0 mm. Forty-four implants were loaded immediately and the provisional prostheses were in place for a healing period of 4 to 6 months. The cumulative survival rate was 96.5%; 2 of the 44 immediately loaded implants were lost. Minimum insertion torque was 40 Ncm for IL of the implants, and screw-retained restorations were used. Grunder[14] used the IL concept in five patients with edentulous maxillae, who received 48 implants (Biomet 3i). Thirty-five of these implants were placed in fresh extraction sockets (immediate implants). Only 2 of the immediate implants and 3 of the implants placed in healed alveolar bone were lost; therefore, the overall cumulative survival rate was 87.5%. Jaffin et al[15] studied the concept of IL in the mandible as well as in the maxilla using 149 implants with different rough surfaces. The survival rate in the maxillae of four patients (27 implants) was high (100%). The authors recommended the use of rough surfaces and threaded implants in the maxilla because of the poor bone quality at the insertion sites. Misch and Degidi[16] presented 12 patients from two different centers, who received IL in the maxillae after placement of 8 to 10 implants each. The implants were loaded with provisional acrylic resin prostheses at the day of placement. The definitive restorations were placed 7 months later. No implants were lost (100% survival rate). Degidi and Piattelli[17] studied 14 patients who received a total of 133 immediately loaded implants in the maxilla. In the follow-up period, which ranged between 2 and 60 months, two implants were lost, representing an overall survival rate of 98.5%.

According to a recent critical review of the literature by Chiapasco,[9] there are no randomized controlled clinical trials of IL in the maxilla. In some of these studies only the survival rate of implants—not the success rate—was documented, and case series were presented prospectively or retrospectively. The number of placed implants was relatively high, and the selection criteria were not well defined. No clinical measurements to evaluate implant stability were reported. Furthermore, an insertion torque of at least 35 Ncm has been suggested as an important factor for decision making in the IL protocol, depending on the implant system used (implant design). Other authors recommend at least 40 Ncm torque prior to use of the IL protocol.[18] Some authors recommended a soft diet during the initial stages of the healing of immediately loaded implants.[7,15] Moreover, the fabrication of a screw-retained provisional restoration was suggested as a significant factor to reduce the excessive forces that might cause implant failure.[5] A comparison of immediately loaded and delayed loaded implants with oxidized surfaces (TiUnite, Nobel Biocare) placed in the maxilla showed cumulative survival rates of 99.2% and 100% for immediate and delayed loading protocols, respectively, after 12 months of loading. The marginal bone resorption was higher for the delayed loaded group compared to the immediate loaded group, without significant differences between the two groups at any time during the observation period.[19]

In general, at present only sparse data are available on IL in the maxilla.[20] This is based on immediate temporization or early loading but not immediate functional occlusal loading. Furthermore, there is little long-term data on IL in the maxilla. For these reasons, immediate or early loading in the maxilla is not sufficiently supported scientifically and thus cannot be used routinely in daily practice.[9] There are reported data of immediately loaded implants placed in the maxilla with poor bone quality with or without combined augmentative procedures (eg, lateral augmentations and guided bone regeneration, sinus lift procedures, bone splitting, spreading). However, implants with platforms wider than the abutment collar have been developed in the hopes of better stabilizing the crestal bone level. No data are yet available regarding the effects of so-called "platform switching" (or "shifting") on IL. The purpose of the present study was to demonstrate the clinical and radiologic evaluation of immediately loaded platform-switched implants placed in maxillae with poor bone quality with or without augmentations using autogenous bone.

MATERIALS AND METHODS

Fifteen patients were included in this study (10 men and 5 women; mean age, 54.8 ± 5.7 years). Ninety commercially pure titanium (grade 2) implants with a progressive thread design and a sandblasted surface (Ankylos, Friadent) and a platform switch were placed and loaded on the same day with a provisional prosthesis. All implants had a 2.0-mm machined collar and were placed after clinical and radiologic presurgical examination by the same surgeon (GR) using a surgical guide splint. These implants had diameters of 3.5 and 4.5 mm and lengths of 8.0, 9.5, 11.0, and 14.0 mm.

Patients were included in the study according to the following criteria: *(1)* they were completely edentulous in the maxilla; *(2)* rehabilitation with endosseous dental implants had been chosen; *(3)* they had provided written informed consent; and *(4)* they were physically and mentally able to tolerate conventional surgical and restorative procedures. The exclusion criteria at the time of implant insertion were: *(1)* active infection in the sites selected for implant placement; *(2)* systemic diseases, such as uncontrolled diabetes; *(3)* pregnancy; and *(4)* severe bruxism. All patients were informed and had to sign a special form approved by the Ethical Committee of the University of Frankfurt (including the Declaration of Helsinki) (no. 91/99, substudies B and C).

The implants used had diameters as follows: 62 implants had a diameter of 3.5 mm and 28 implants had a diameter of 4.5 mm. The implants with a diameter of 3.5 mm had lengths as follows: 14 mm (16 implants), 11 mm (44 implants), 9.5 mm (1 implant), and 8.0 mm (1 implant); the 4.5-mm-diameter implants had lengths of 14 mm (4 implants) and 11 mm (24 implants). The patients had implant-supported restorations (seven patients) or healthy teeth (eight patients) in the mandible. Seven patients were heavy smokers (smoking more than 1 pack/day for at least 10 years).

The implants were placed 1 mm subcrestally using a surgical guide according to the prosthetic considerations (after a diagnostic setup was fabricated). All implants had primary stability. Primary stability was scored as "good" when a range of 10 to 12 Ncm was attained (integrated cover screw was removed without implant mobility) and "tight" when a range of 15 to 20 Ncm was reached (without implant mobility) when the abutments were connected. In areas with an inadequate quantity of autogenous bone (at the mesial, buccal, and distal sites of 18 implants), the exposed threads were augmented simultaneously using autogenous bone grafts harvested with a rongeur or Safescraper (Astra Tech) from the tuberosity or adjacent residual sites. Eighteen implants were placed in combination with simultaneous augmentations using autogenous bone grafts from the tuberosity or the ramus. Two of them were placed simultaneously with a sinus lift procedure (window preparation, according to Tatum[21]), one was placed in combination with an internal sinus lift (osteotome) procedure,[22] and three implants were placed in extraction sockets immediately after tooth extraction (immediate implants) and loaded immediately.

The augmented areas were covered with a BioGide collagen membrane (Geistlich) and fixed in place with Frios titanium pins (Friadent). With final torques of 15 Ncm for angulated abutments and 25 Ncm for straight abutments, the implants were connected to their abutments (straight or angulated standard abutments) immediately after insertion. In this way, the implants remained in the same position during abutment placement because of the relatively low torque exerted during abutment connection. Healing caps were placed and the flaps were sutured using interrupted 4–0 silk sutures (Resorba). Immediately after surgery, all implants were splinted using a fixed provisional restoration. The provisional prostheses were made chairside with Protemp acrylic resin (ESPE) using a template over the healing caps placed on the abutments. The provisional prostheses were cemented temporarily on the day of surgery with Temp Bond (Kerr). The provisional restorations had centric occlusal contacts in maximal intercuspation and only group functional contacts during the lateral movements of the mandible, with the vertical dimension kept at the correct height (immediate occlusal functional loading) (Figs 1 to 3).

The patients were advised to use a soft or liquid diet during the first 6 to 8 weeks of healing to reduce excessive loading forces at the bone-to-implant interface. A postoperative antibiotic was given only to patients who underwent simultaneous augmentations. Patients with simultaneous augmentations used a strict soft and liquid diet protocol for a total of 3 months.

Immediately after surgery and abutment connection, implant stability was measured using the Periotest device (Gulden). Two weeks after surgery (considered baseline), all clinical peri-implant indices (Plaque Index, Sulcus Bleeding Index, probing pocket depth at the mesial and buccal sites, and width of the keratinized mucosa) were evaluated. Any bone loss was classified from the implant top to the marginal crestal bone level at baseline and classified as horizontal or vertical bone loss depending on the long axis of the implant and the bone crest.[23] One week after surgery, the silk sutures were removed. Clinical indices were recorded at the time of the placement of the definitive restoration and at 6-month follow-up

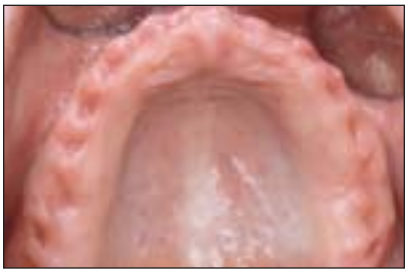


Fig 1 Preoperative view of the maxilla.

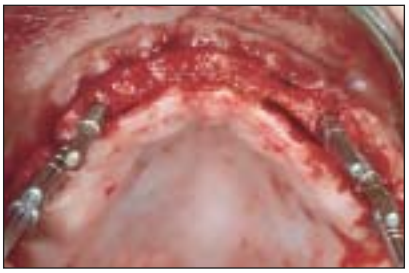


Fig 2 Implant placement and abutment connection for immediate loading.

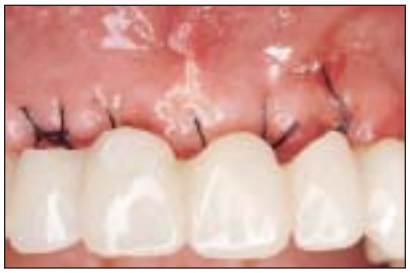
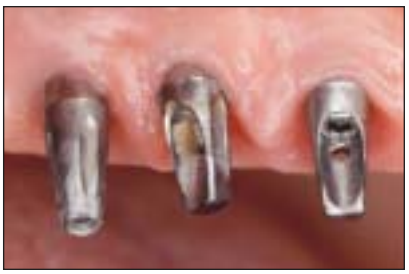


Fig 3 Provisional prosthesis is delivered and cemented for functional loading immediately after implant surgery.

Fig 4 Healthy peri-implant soft tissues around immediately loaded implants after 2 years of loading.

Fig 5 Healthy soft tissues around immediately loaded implants 5 years after loading.



visits by an independent blinded examiner, who was not informed about the exact implant protocol. Panoramic radiographs were used, after 10× magnification, to measure the peri-implant bone levels at the same time intervals. All radiographs were obtained using the same magnification scale of 1.25× and with the patient's head placed in the same position with regard to the radiographic film.

Three to 4 weeks after surgery, the provisional restorations were removed so that impressions could be made for the definitive prostheses (for patients with augmentations or implants placed immediately after extraction, 3 months after surgery). The attending surgeon made the impressions for all of these patients. The prosthetic reconstructions were fabricated in a dental laboratory by a selected team of dental technicians. Occlusal registrations and determination of the vertical dimension were also performed. Custom-made frameworks were fabricated for fixed porcelain-fused-to-metal implant-supported restorations. The definitive prostheses were delivered 3 to 5 weeks later and cemented temporarily (Temp Bond, Kerr) so that the peri-implant soft tissues could be evaluated every 6 months (after removal of the restorations). The patients were checked for sufficient occlusal contacts and excessive contacts during lateral movements of the mandible were reduced. Each patient was evaluated every 6 months for the first 2 years and once a year thereafter (Figs 4 to 6).

The criteria for success were: *(1)* no clinically detectable mobility; *(2)* no peri-implant radiolucency detectable radiographically; *(3)* no complaints of pain at the implant site; *(4)* no recurrent or persistent peri-implant infection; *(5)* no neuropathy or paresthesia; and *(6)* marginal bone loss of no more than 1.5 mm after 1 year of functional loading and less than 0.2 mm/year in subsequent years. These criteria were based on the criteria for implant success presented previously by Albrektsson et al.[24]

RESULTS

After a mean loading period of 42.4 ± 19.15 months, only three failures were documented. This represented a survival rate of 96.66%. Two of these failures were reported in a female patient during the first month of healing after implant insertion; she had a history of bruxism. This overloading in terms of bruxism had developed during provisionalization because of different psychologic reasons and stress. In these areas, no suppuration, radiolucency, or findings of peri-implantitis were demonstrated. The third failed implant was an implant placed in close association with the sinus floor and in which the floor was perforated during surgery. The patient complained during the entire loading period of some pain, but no clinical or radiologic findings were observed. This implant failed at the

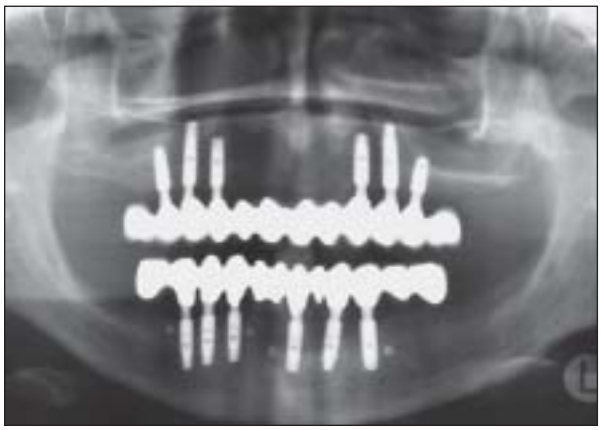


Fig 6 Radiographic appearance 5 years after immediate functional loading. No crestal bone resorption was seen around any implant.

Table 1 Patient Characteristics

Patient	Sex	Age (y)	Loading time (mo)	No. of augmented sites	Failures
DL	F	56	35	2	
KM	M	55	43	0	
CS	M	45	42	6	
CK	M	56	33	0	
AK	M	44	10	0	
AN	F	50	6	0	
CZ	M	51	67	0	
DT	M	54	58	2	
MH	M	66	66	0	
BM	M	58	53	2	
IG	F	54	55	0	2 (bruxer)
SR	F	55	69	0	
CM	M	58	46	0	1 (in sinus)
RS	F	60	61	6	
CK	M	60	35	0	
Total		54.8 ± 5.7	42.4 ± 19.15	18	3

Table 2 Clinical Parameters (Means ± SDs) of the Immediately Loaded Implants

Parameter	Baseline (n = 90)	Follow-up (n = 87)
Periotest	2.23 ± 3.11	−2.94 ± 2.32
Width of keratinized mucosa	4.26 ± 1.72 mm	3.44 ± 1.78 mm
Probing pocket depth		
Buccal	1.83 ± 0.60 mm	2.58 ± 1.17 mm
Mesial	2.14 ± 0.84 mm	2.73 ± 0.86 mm
Sulcus Bleeding Index	0.35 ± 0.60	0.70 ± 1.02
Plaque Index	0.51 ± 0.95	0.50 ± 0.60

Table 3 Bone Loss (x) between Baseline and Final Examination (n = 87)

Dimension	Bone loss (no. of sites)	
	0 mm	0 < x < 2 mm
Horizontal	79	8
Vertical	77	10

final recall visit, when the fixed restoration had to be retrieved for reevaluation of the implants (33 months after loading). At this examination visit, the implant was mobile and was therefore removed. No other signs of inflammation were present, and no inflammation was seen in the sinus (Table 1). Regarding the implants placed in combination with sinus augmentation, clinical (Periotest values) as well as radiographic evaluations were performed to evaluate sinus graft remodeling. Clinical parameters evaluated during the entire loading period and peri-implant vertical and horizontal bone loss are shown in Tables 2 and 3.

DISCUSSION

High clinical primary stability should be achieved before implants are immediately loaded in sites with poor bone quality or quantity. An implant system with a slightly tapered thread design and a rough surface may be used. Good condensation of the bone graft within the threads of the implant and stable fixation of the membrane to immobilize the grafting material on the implant surface are of great importance for long-term success. Tapping should be avoided when implants are placed in areas of poor bone quality. The rough surface of the implants may be important in secondary healing.

In general, implants that did not reach an insertion torque of 30 Ncm[9,11] or 40 Ncm[18] were excluded from IL. In this study, which used a tapered implant-abutment connection, a lower insertion torque of 15 to 20 Ncm was considered necessary to ensure excellent sealing between the abutment and the implant and to avoid micromovement, which can lead to implant failure. Therefore, implants with this geometry placed with an insertion torque of 20 to 30 Ncm may be loaded immediately without any failures.

A soft and/or liquid diet in the initial stages of healing was recommended in the present study, especially in patients who underwent simultaneous augmentation. In addition to cross-arch stabilization, a soft/liquid diet is mandatory when implants are placed simultaneously with sinus lift procedures or vertical or lateral augmentations in conjunction with immediate functional loading over the entire healing period. Other clinical reports have suggested the soft diet when an IL protocol was used.[7,15,23] Excessive and uncontrolled forces during loading (overloading) and the frequent retrieval of the provisional prostheses must be avoided. Very careful removal of provisional prostheses must occur. Distal cantilevers must be avoided during the provisional stage. Adequate splinting is necessary and bilateral group function is recommended to minimize micromotion. In this way, bending moments are controlled and the success rate of immediately (functionally) loaded implants of the maxilla may be high when cross-arch immobilization is used. The use of splinting resulted in a higher success rate for immediately loaded maxillary partial restorations than for single-tooth reconstructions (94.2% versus 81.4%).[25]

However, other studies with different implant systems showed that immediately nonfunctionally loaded[26] or early loaded[27] single implants seem to be associated with relatively high success rates. The survival rate dropped significantly when these implants were placed in fresh extraction sockets (75%) compared to immediately loaded, single-tooth, nonimmediate implants (100%) placed in healed sites in the maxilla.[28] Similar findings were presented by Malo et al[29] when these implants were placed and loaded immediately in the esthetic zone.

Characteristically, implants with platform switching showed, in the present study in most clinical cases, minimal or no crestal bone loss under IL conditions. This may provide additional evidence for bone stability around platform-switched implants.

CONCLUSIONS

It can be concluded from the present study that an immediate occlusal (functional) loading protocol may be used successfully in the maxilla, even in patients undergoing simultaneous augmentations and sinus lift procedures, if micromovements at the bone-to-implant interface are controlled. Primary stability of the implants may be increased by the selection of an appropriate implant design and surface roughness. Immobilization via cross-arch fixation may also be important for long-term success. A progressive thread design results in higher initial stability and can be considered mandatory in patients with implants placed with immediate loading in areas of poor bone quality. In addition, the special abutment geometry of the tapered implant-abutment connection and the platform switching seem to be important for bone stability around immediately functionally loaded implants.

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