Immediate Loading of Implants Placed Simultaneously with Sinus Membrane Elevation in the Posterior Atrophic Maxilla: A Two-Year Follow-Up Study on 10 Patients

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ABSTRACT

Background: Clinical studies on immediate loading of implants in the posterior atrophic maxilla are rare.

Purpose: The study aims to evaluate immediate loading of implants placed with sinus membrane elevation without additional grafting material for bone augmentation of the maxillary sinus floor.

Materials and Methods: The study group comprised of 10 patients in whom a total of 10 maxillary sinus floor augmentations were performed. A total of 21 dental implants (1 to 4) were inserted through the residual bone to protrude into the maxillary sinus under the elevated sinus membrane. The implant site was underprepared to improve primary stability. All the implants were inserted with a torque insertion no less than 20 Ncm. Implants were loaded immediately after surgery with a screw-retained temporary acrylic restoration. Intraoral X-rays were taken at implant insertion, after 6 months loading, and after 1st and 2nd year of loading. Resonance frequency analysis (RFA) was performed at the time of initial placement and after 6 months of functional loading.

Results: RFA after implant insertion gave an implant stability quotient (ISQ) level with a range from 62 to 72. All implants remained clinically stable during the follow-up period of 2 years. Radiography demonstrated on average 5.7 ± 3.4 mm of intrasinus new bone formation after 6 months of implant loading. RFA measurements showed ISQ mean values of 67 (range: 62–72) and 68 (range: 62–71) at placement and after 6 months of loading, respectively.

Conclusion: Within the limits of this case series report, it is concluded that maxillary sinus membrane elevation with simultaneous placement and immediate loading of implants without the use of any additional grafting material shows predictable results after 2 years of functional loading. Moreover, evidence of intrasinus bone formation around the implants was found in all patients. Further studies are needed to study the influence of immediate loading on the mineralization of bone forming at dental implant sites.

KEY WORDS: bone augmentation, dental implants, GBR, maxillary sinus

INTRODUCTION

Immediate loading of implants could have obvious advantages over delayed loading technique in reduction of treatment time and single surgical procedure. Good results have been reported on different indications, that is, total, partial, or single edentulism.[1,2] Surgical protocol for enhanced primary stability in favorable bone conditions together with the use of insertion torque and implant stability quotient (ISQ) measurements are reported.[3–5] Few studies have been published on immediate loading in the posterior maxilla, an area with

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low bone density, small bone volumes and risk for low primary stability. Nevertheless, the available studies have shown good results also in these situations.[6–9]

An additional bone augmentation procedure may be needed to ensure stability and integration of implants in many cases due to an insufficient amount of bone. The posterior maxilla is the most common site for bone augmentation because of the presence of large maxillary sinuses.[10,11]

Different grafting techniques with the use of different grafting materials have been suggested to increase the amount of bone in order to enable placement of endosseous implants in the posterior maxilla.[12–23] Other studies[24–38] have suggested that the mere elevation of the sinus membrane can result in new bone formation in accordance with the principles of guided tissue regeneration.[39,40] In a recent clinical follow-up study, it was demonstrated that simultaneous implant placement and membrane elevation resulted in predictable bone formation around the implants in the maxillary sinus.[35] It was further shown that primary stability could be achieved in the 1 to 6 mm of bone that was available under the sinus cavity. Moreover, loading of the implants after a healing period of 6 months resulted in high implant survival rates and stable marginal bone levels after up to 6 years of follow-up. As primary stability can be obtained in small bone volumes, it is possible that implants placed with a sinus augmentation procedure may be immediately loaded, which has been demonstrated in previous publications.[41,42]

The aim of the present study was to evaluate immediate loading of implants placed with sinus membrane elevation without additional grafting material for bone augmentation of the maxillary sinus floor.

MATERIALS AND METHODS

Patients

Clinical examinations, intraoral and panoramic radiographs, and computed tomographies were used for presurgical evaluation. The inclusion criteria were: (1) need for implant treatment in the maxillary premolar or molar area and a residual bone height of 7 mm or less; (2) healthy maxillary sinuses as judged from the radiographic and clinical examinations; and (3) possibility to achieve primary stability in the residual bone with an implant torque insertion of a minimum of 35 Ncm in case of single tooth loss and 20 Ncm in case of partial multiple edentulism. Bruxers were excluded. A total of 10 healthy consecutive patients (eight women and two men, mean age 48 years) met with the inclusion criteria (Table 1). Opposing dentition is described in Table 2. There were one smoker and nine nonsmokers. Four patients were treated for single edentulism while six were treated for partial edentulism, giving a total of 10 sinus augmentations. All patients were informed about the treatment and follow-up; they could withdraw from the study at any time and gave written consent to participate in the study. The principles of the declaration of Helsinki were followed.

Surgical Technique

Maxillary Sinus Membrane Elevation and Implant Placement. The surgical procedure was performed under local anesthesia. The technique used to approach the maxillary sinus was previously described by Lundgren and colleagues[27] and modified by Cricchio and colleagues[35] In brief, the access to the maxillary sinus was performed creating a replaceable bone door using a reciprocating micro-saw (Aesculap, B Braun Melsungen Ag, Melsungen, Germany). After a careful dissection of the sinus membrane, dental implants were inserted with an underpreparation site approach in order to increase their primary stability (Figure 1). After implant insertion, the lateral bone doors were put back in their original position creating a closed space, containing the protruded implants, delimitated by the residual bone crest coronally and palatally, the repositioned bone door laterally and the sinus membrane superiorly. In case the bone door was not stable after its repositioning, a cyanacrylate tissue glue (Indermil, Henkel Corporation, Düsseldorf, Germany) has been used to stabilize it. The stabilization was performed with a single drop of glue on two to three sites of the bone osteotomy. The length of the implants was chosen independent from the height of the residual bone. A total of 21 Brånemark System, TiUnite implants (Nobel Biocare AB, Gothenburg, Sweden) were used. Of these implants, seven were MKIII 3.75 mm in diameter and three were MKIII 5 mm in diameter. Additionally, 11 were Brånemark System TiUnite Groovy implants 3.75 mm in diameter.

Of the 21 implants, 3 were inserted entirely in residual bone, anterior to the maxillary sinus cavity, and the remaining 18 protruding into the maxillary sinus. A standard length of 13 mm was chosen in most of the situation. In one patient, a shorter implant (11.5×5 mm) has been chosen in order to apply a

TABLE 1 Demographic Table

Patient (10)	Sex	Age at Surgery Time	Number of Implants (21)	Implant Position	Implant in Sinus (18)	Implant Type	Residual Bone (mm)	Implant Length (mm)	Implant Length in Sinus (mm)	Insertion Torque
1	F	33	1	15	15	Ti-unite rp	6	13	7	35
2	F	56	1	16	16	Ti-unite rp	6	13	7	35
3	F	56	3	14	14	Groovy rp	10	13	3	30
				15	15	Groovy rp	4	13	9	20
				16	16	Groovy rp	4	13	9	20
4	M	51	3	15	–	Ti-unite rp	–	13	–	20
				16	16	Ti-unite rp	4	13	9	20
				17	17	Ti-unite rp	2	13	11	20
5	F	52	1	26	26	Ti-unite wp	4	13	9	35
6	F	44	2	15	15	Groovy rp	4	13	9	30
				16	16	Groovy rp	5	13	8	25
7	F	50	3	15	15	Groovy rp	6	13	7	30
				16	16	Groovy rp	5	13	8	30
				17	17	Ti-unite wp	5	13	8	25
8	M	40	1	16	16	Ti-unite wp	7	11,5	4,5	45
9	F	43	4	14	–	Groovy rp	–	13	–	35
				15	–	Groovy rp	–	13	–	35
				16	16	Groovy rp	5	13	8	30
				17	17	Groovy rp	3	13	10	25
10	F	62	2	15	15	Ti-unite rp	9	13	4	40
				16	16	Ti-unite rp	3	13	10	25

minor tension on the elevated sinus membrane. All of the 18 protruding implants protruded a minimum of 3 mm in the created sinus compartment. The average length of implants part protruding into the sinus was 7.8 mm with a range of 3–11 mm.

The four implants used in single tooth loss rehabilitations were inserted with a torque value no less than 35 N. The remaining 14 implants used for the treatment of partial edentulism were inserted with a torque no less than 20 Ncm (Table 1).

TABLE 2 Features of Opposite Dentition

	Opposing Dentition							
Patient (10)	47	46	45	44	34	35	36	37
1	NT	NT	NT	NT				
2	FDP	FDP	FDP	NT				
3	SC	SC	SC	SC				
4	I	I	NT	NT				
5					NT	NT	NT	SC
6	SC	SC	SC	NT				
7	–	–	NT	NT				
8	NT	NT	NT	NT				
9	NT	NT	NT	NT				
10	–	I	I	NT				

FDP = fixed dental prosthesis on natural teeth; I = implant-supported prosthesis; NT = natural tooth; S = single crown on natural tooth.

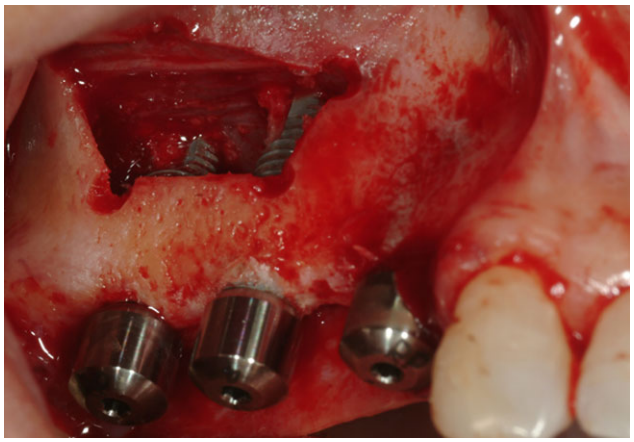

Figure 1 Implants in position after sinus membrane elevation.

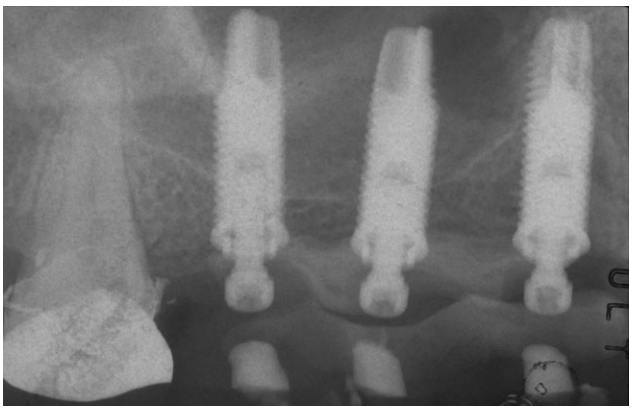

Figure 3 Intraoral X-ray performed immediately after surgery (baseline).

In all cases, the elevation of the membrane was uneventful.

The patients were kept on antibiotic regimen for at least 7 days postoperative and instructed to refrain from blowing the nose for 5 days postoperatively.

Abutment Connection and Prosthetic Restorations

The implants were immediately loaded with screw-retained temporary fixed partial restorations at the day of surgery. Based on the diagnostic wax-up, acrylic temporary crowns were fabricated in the dental laboratory. Using the (acrylic) manufacturer's cylinders specifically made for temporaries, temporary crowns were directly relined in the patient's mouth using a self-curing acrylic resin (Palavit, Paladur, Heraeus Kulzer, Hanau, Germany) (Figure 2). In case of multiple partial edentulism, all the implants were splinted. The reconstructions were designed to exhibit full centric occlusal contacts whereas excentric contacts were avoided.

After a minimum of 6 months after implant placement, a new impression was made to obtain a master cast on which the long-term fixed partial denture was fabricated.

A total of four single crowns and six fixed dental prosthesis were delivered.

Radiographic Follow-Up Examinations and Measurements

Radiographic follow-up examinations were performed with intraoral radiographs, using a paralleling periapical technique, after surgery (baseline), after 6 months of loading, and thereafter annually (Figures 3–6).

Measurements of intrasinus newly formed bone (NB) and marginal bone levels (MBs) were performed in digitized radiographs using a specific software

Figure 2 Screw-retained temporary restoration directly relined at the day of surgery.

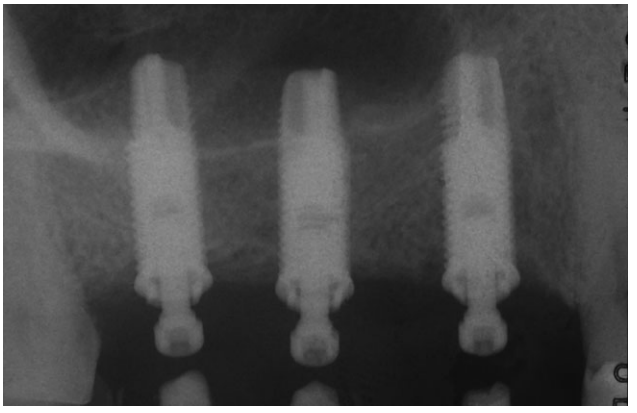

Figure 4 Intraoral X-ray performed after 6 months of loading.

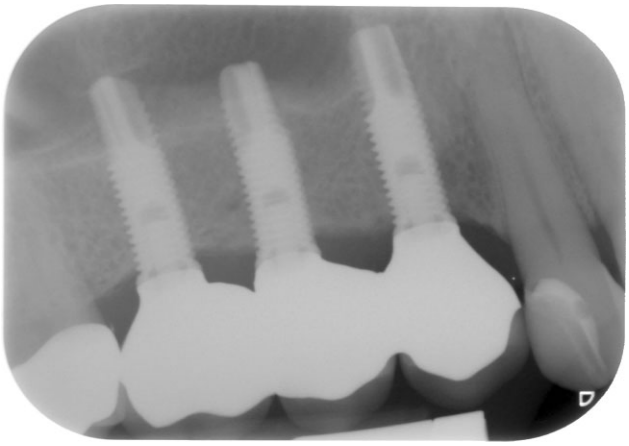

Figure 5 Intraoral X-ray performed after 1 year of loading.

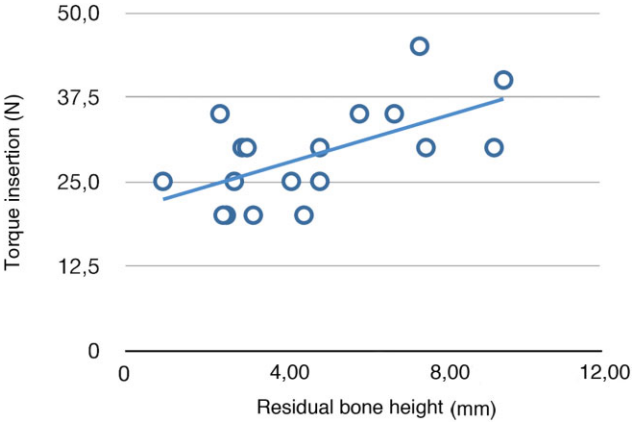

Figure 7 A plot showing the correlation between residual crestal bone height and implant torque insertion.

application (DBSWIN, Dürr Dental AG, Bietigheim-Bissingen, Germany). All radiographs were calibrated based on the known length of the specific implant that was found to be the most perpendicular implant in the radiograph. Apical (Abl) and marginal (Mbl) bone levels were measured at the mesial and distal aspects of each implant using the implant/abutment junction (A/F) as a reference point. From the radiograph, the bone level at both apical and marginal aspects of the implants was calculated twice by two different examiners for each radiograph.

RFA Measurements

Implant stability measurements were made at placement, after 6 and 12 months of loading by measuring resonance frequency analysis (RFA) (Osstell®, Osstell AB, Gothenburg, Sweden). On these occasions a transducer was attached to each implant and measurements were taken in ISQ units.

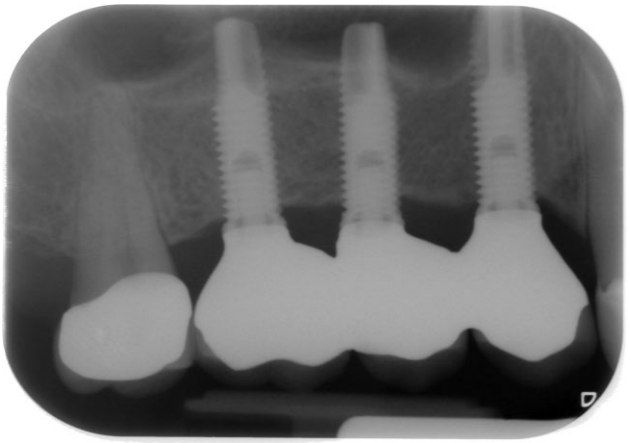

Figure 6 Intraoral X-ray performed after 2 years of loading.

RESULTS

Clinical Findings

Ten patients were followed for at least 2 years after loading of the implants.

No implants failed during the follow-up period and survival rate was thus 100%. Three implants were placed entirely in residual bone and the remaining 18 implants protruded a minimum of 3 mm into the sinus cavity.

A positive correlation between residual bone height and insertion torque value could be demonstrated (Figure 7). The strength of correlation was indicated by a correlation coefficient of 0.60.

No perforations occurred during the elevation of the sinus membrane.

Radiographic Findings

The average residual bone height in the lowest part of the maxillary sinus prior to implant/sinus membrane elevation surgery was 4.4 ± 1.5 mm ($n = 10$).

Bone height, calculated in all implant sites at different follow-up steps, is reported in Table 3. The calculated average height of the NB in the sinus was 5.7 ± 3.4 mm after 6 months of loading, 5.8 ± 3.5 mm after 1 year and 6.3 ± 3.3 mm after 2 years.

The average MB measured from the A/F, was 0.3 ± 0.5 mm after implant surgery, -0.9 ± 0.5 mm after 6 months of loading, -1.0 ± 0.6 mm after 1 year, and -1.0 ± 0.5 mm after 2 years (Table 4). Thus, the average bone loss from placement to 1 and 2 years was 1.3 mm.

TABLE 3 Average Crestal Bone Height of the Maxillary Sinus Floor as Measured in Intraoral Radiographs on 10 Patients at 18 Implant Sites

Apical Bone Level							
	Apical Bone Level (mm)	SD	Range	Apical Bone Gain (mm)	SD	Range	Number of Measurements
0	5.9	3.2	1.2–11.9	–	–	–	36
6-month load	11.6	2.1	6.9–14.8	5.7	3.4	0.7–11.1	36
1-year load	11.8	2.3	6.4–15,1	5.8	3.5	1.1–11.4	35
2-year load	12.2	1.8	7.3–15.1	6.3	3.3	1.1–11.4	34

Implant Stability Measurements

The average ISQ value for all implants was 67.1 ± 2.8 at placement ($n = 18$) and 68.1 ± 3.0 after 6 months of loading ($n = 18$).

DISCUSSION

Immediate loading in dental implant rehabilitation is a well documented procedure.[1,2] Early work in this field investigated mainly healed sites in totally edentulous patients[43,44] followed by partially edentated patients[4,6,7,45] and single tooth loss.[46–48] More recently, authors have suggested that immediate loading is applicable also for implants placed in previously augmented sites.[49] In particular, Lee and colleagues[41] analyzed immediate loading in implants placed 4 to 9 months after maxillary sinus floor augmentation with sinus floor elevation and bone grafting and reported good results. In a previous follow-up study on sinus floor augmentation using membrane elevation and simultaneous implant placement by and colleagues,[35] implant primary stability was obtained in 1 to 6 mm of bone below the maxillary sinus. In the vast majority of patients, the insertion torque value exceeded 30 Ncm and the ISQ value was frequently more than 65. Such levels of insertion torque and ISQ values have previously been accepted as being high enough to allow for early/immediate loading of the implant.[3–5] In the present study, 35 Ncm in case of single tooth replacement and 20 Ncm in case of partially edentulous cases were the minimal required levels. The mean values for single implants were 37.5 Ncm (range: 35–45) and for multiple implants 27.0 Ncm (range: 20–40). Anyhow, our findings show a positive correlation between residual bone height and implant torque value as shown in Figure 7. The RFA measurements confirmed that stability was achieved at implant placement with a mean ISQ value of 67, which is considered as sufficient for immediate loading.[3–5] The technique measures lateral stability and is sensitive to the density of the bone at the marginal portion of the implant. In the present studies, the residual crest consisted of dense cortical bone and reduced final drill diameters were used to enhance stability, a feature that may explain the high ISQ values. Follow-up measurements showed a minor increase of stability, which is expected when starting from such a high ISQ level as 67.[5]

Early loading means obvious advantages for the patient; it reduces the total time of treatment and number of surgical interventions. With abutments directly connected to the implants after surgery instead

TABLE 4 Average Marginal Bone Levels at Implants (10 Patients, 21 Implant Sites)

Marginal Bone Level							
	Bone Level (mm)	SD	Range	Bone Loss (mm)	SD	Range	Number of Measurements
0	0.3	0.5	–0.7/1.2	–	–	–	42
6-month load	–0.9	0.5	–2.2/–0.1	1.2	0.4	–2.0/–0.1	42
1-year load	–1.0	0.6	–2.6/0	1.3	0.6	–3.3/0.1	42
2-year load	–1.0	0.5	–2.3/0	1.3	0.5	–3.0/–0.4	42

of cover screws, implant stability can be monitored by ISQ measurements during the early healing period. If ISQ and/or torque insertion are low following surgery, loading can be postponed until sufficient ISQ has been reached. This concept has been tested by Bornstein and colleagues,[50] where implants were placed in healed sites and restored when the ISQ value reached 65 or higher, usually after 3 weeks of healing.

In a previous study on membrane elevation, a two-stage procedure with submerged implant healing was utilized.[35] Early cover screw exposure during the healing period after implant surgery was occasionally reported. As a consequence of the cover screw exposure, a higher marginal bone resorption could be detected. This phenomenon has been also described by other authors investigating on implants inserted in regular sites.[51,52] No sites with marked bone loss were seen in the present study as the one-stage surgery approach may be one way to eliminate this unwelcome cover screws exposure and the subsequent marginal bone resorption.

One of the most interesting aspect of our results that should be highlighted is that in the previous follow-up study from our group,[35] it was sometimes difficult to determine the amount of new bone formation inside the sinus during the first 6 months due to the slow mineralization process. In the present study, the new level of the maxillary sinus floor was easily detectable 6 months after implant surgery (Figure 4). It can be speculated that early functional loading positively influenced bone formation in accordance with Wolf's law.[53–56] Experimental studies on immediate loading have reported more bone in contact with implants than for unloaded implants, which support this notion.[57,58] These data seem to be confirmed in our study. In fact, it seems that early functional loading could positively influence the rapidity of bone mineralization also after maxillary sinus membrane elevation and directly during the early modeling phase of new bone formation.

The high implant survival rate (100%) after 2 years of loading, reported in this paper, confirms that immediate loading could be applied on dental implants inserted with the sinus membrane elevation technique, when a firm primary stability is obtained as shown by ISQ and torque insertion value.

Within the limits of this case series report, it is concluded that maxillary sinus membrane elevation with simultaneous placement and immediate loading of implants without the use of any additional grafting material shows predictable results after 2 years of functional loading. Moreover, all patients showed radiographic evidence of intrasinus bone formation around the implants. Further studies are needed to study the influence of immediate loading on the mineralization of bone forming at dental implants.

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