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Immediate vs. early loading of SLA implants in the posterior mandible: 5-year results of randomized controlled clinical trial

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Abstract

Objectives: The aim of this study was to compare clinical results of immediate and early loading (EL) self-tapping implants placed in posterior mandibles.

Material and methods: Twelve patients with bilateral edentulous posterior mandibular were randomly assigned to treatment either with immediate (test) or early loaded implants (control). Seventy-two self-tapping implants with SLA surface (\varnothing 4, 1/4, 8 mm; length 8 and 10 mm) were analyzed in this study. Test implants (36) were loaded on the day of surgery and control implants 6 weeks later. The measuring of implant stability quotient (ISQ) was performed on 0, 6th, 12th, and 52nd week after implant insertion. The bone resorption, modified plaque, and bleeding index were notified at 1 and 5 years later.

Results: After 5 years, survival in the both groups was 100%. The mean value of primary implant stability was 76.92 ± 0.79 ISQ. In the first 6 weeks, ISQ values significantly increased in the test group (77.92 ± 1.16 vs. 79.61 ± 0.90) as well as in the control group (7.92 ± 1.05 vs. 77.55 ± 0.99). A significant longitudinal increase in ISQ value was recorded in test and control group. The differences between immediate and early loaded implants were statistically insignificant ($P > 0.05$). At the 5 years, no statistically significant differences were found between immediate and early loaded implants with respect to mean crestal bone loss measurements (0.4 ± 0.24 vs. 0.8 ± 0.15 mm), mean bleeding index (0.22 ± 0.11 vs. 0.25 ± 0.11), and mean plaque index (0.17 ± 0.15 vs. 0.19 ± 0.20).

Conclusion: Based on these results, the self-tapping implants inserted in posterior mandible can provide adequate primary stability value as the main factor for immediate and EL protocol.

Since beginning of early eighties in the 20th century, treatments with dental implants are routine method of rehabilitation edentures and partially edentured jaws. The absence of force on dental implant on the beginning of healing stimulates the bone formation around. Brunski et al. (1979a,b) presented fibrous tissue healing around immediate-loaded dental implants in their clinical and histological studies. These studies were part of traditional implant loading protocol. The two-stage loading protocol presented by Brånemark (1977) involves healing period of 3–6 months. A healing period without stress was recommended in the order to present better survival rate. This loading protocol was developed in the time when micro- and macrodesign of implant surface was machine produced. Design evaluation of the implant

surfaces influenced on significantly shorter initial healing period. The period until definitive prosthetic reconstruction became shorter using immediate loading (IL) concept.

Archeological findings of one piece implants show that IL protocol has long traditional history (Crubezy et al. 1998). Capacity on bone tissue formation on titanium surface has been presented in early fifties of the 20th century. Brånemark was the first to define this biological reaction as osseointegration. Osseointegration represents fusion between live bone tissue and titanium oxide surface (Brånemark et al. 1969).

The factors of influence on osseointegration are as follows: biocompatibility of material, precise preparation of implant site, minimal traumatic surgical technique, and type of loading procedure.

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The conventional two-stage loading protocol has been recommended for dental implants with polish, machined, and first version of rough surfaces (Chiapasco 2004). Shorter healing period was presented in many experimental and clinical studies using SLA surfaces (Cochran et al. 1998, 2002).

Modern aspects of dental implant procedures are coordinated by ITI Consensus Conference from 1997. According to that conference, conventional loading protocol has been suggested after minimum of 3-month healing period.

New loading definition has been presented on Conference in Spain 2002 (Aparicio et al. 2002). Concerning the insertion period, loading can be immediate or late. Immediate prosthetic reconstruction is in the first 48 h after implant placement and can be immediate functional loading or nonfunctional IL (termed immediate restoration). Late prosthetic reconstruction has been termed as early loading (EL), conventional, and delete loading.

The decision of immediate implant loading on restoration has been different by clinical parameters during the implant insertion. Most authors think that primary stability, type of surface as well as implant design are the most important clinical IL factors (Tarnow et al. 1997; Romanos et al. 2001; Aparicio et al. 2002; Nkenke et al. 2003).

Stable bone-implant contact without micromovements is the most important for future osseointegration (Horinchi et al. 2000). Early after insertion, primary implant stability is only mechanical. During the healing period, it converts to combination form of mechanical and biological stability (Davies 1996; Berglundh et al. 2003).

Micromovements lower than 100 µm stimulate osteoblastic activity and micromovements higher than 150 µm can result in unsuccessful osseointegration as fibrous tissue healing around implants (Horinchi et al. 2000).

Lower frequency micromovements are experimentally presented as stimulative factor on the bone healing (Esposito et al. 1998). A rigid connection between implant suprastructures reduces micromovements significantly.

To provide adequate force distribution, the rigid connection between implants is recommended in IL procedure. No functional IL is advised on single implants (Schnitman 1995; Aparicio et al. 2002).

Acceptable implant insertion makes primary stability proportional to implant

design (Salvi et al. 2004). The screw implant design provides wider contact surface with bone comparing to cilindric implant with parallel surfaces (Schulte & Heimke 1976; Gomez-Roman et al. 1997). To expand initial implant stability and to reduce stress during the loading, new design has been developed. (Pierrisnard et al. 2002) in his study presented positive influence of new implant design during the IL procedure.

Increase in implant diameter, surface roughness, and number of threads on implant's body is crucial factor of its active surface (Salvi et al. 2004). The design of Straumann TE implants is conical in shape with tapered part in upper root area and more numbers of threads on its body. Self-tapper implants are basically indicated for the implant insertion in fresh extraction socket. This kind of implant design provides adequate initial stability (Ak-kocaoglu et al. 2005).

The propose of this clinical study was therefore: (1) to evaluate value of primary implant stability for Straumann® TE implants inserted in posterior part of lower jaw; (2) to evaluate longitudinally stability changes of implants in the immediate and loaded gropes, (3) to compare marginal bone resorption, peri-implant soft tissue health, and successful rate between groups of immediate and early loaded Straumann® TE placed in posterior mandible.

Material and methods

Subject

The present investigation comprised 12 patients consecutively treated with dental implants in bilateral posterior partial edentulism in the mandible. The study was performed at the Clinic of Oral Surgery, School of Dentistry, University of Belgrade, Serbia. Ethical approval was obtained from Belgrade University Ethics Committee (No 162/2, 2004) and participants received oral and written information about study and provided informed consent.

Inclusion criteria

1. Patients of ASA I and ASA II group;
2. Patients with bilaterally terminal edentulous space distal from first premolar in the mandible (Kennedy 1st class);
3. Presence of natural teeth or prosthetic rehabilitation in the posterior maxilla to provide occlusal contact with prosthetic units on the implants in the mandible;
4. The same type of antagonistic dentition on both sides of the maxilla;

5. Patients with same type of antagonists on both side in maxilla;
6. Adequate oral hygiene;
7. Surgical sites with bone density type I, II, III (Lekholm & Zarb 1985);
8. Patients with dimension of alveolar jaw in bucco-oral position ≥ 6 mm to provide bone wall thickness of at least 1 mm on the facial and the lingual side;

Exclusion criteria

1. Systemic disease likely to compromise implant surgery;
2. Patients with oral parafunctions (bruxism);
3. Heavy smokers (≥ 10 cigarettes a day);
4. Self-declared pregnancy or intention to become pregnant;
5. The use of regenerative procedure in conjunction with implant placement;

The randomization was carried out using a lot just after the surgery for implant placement. The loading protocol for the implants was randomized using sealed envelopes. A randomization table was kept by an independent body, where the investigators received the assignment of the respective sites to either test or control groups. The envelopes were opened after the temporaries had been fabricated for both groups. One side of the mandible was thus randomly determined to be the immediate loading group (test group) and the other one to be the early loading group (control group). In the IL group, the temporary was then inserted and fixed, whereas in the EL group, the temporary was set aside and inserted 6 weeks later.

Clinical procedures

Preoperative procedures

The preoperative planning was based on clinical and radiographic (cone beam computer tomograms) examination. Preoperative radiograph with radiograph guide was used for surgical evaluation of selected sites for each patient. Surgical and prosthetic guides were made before surgery. Prosthetic guides were prepared and used for the producing of the temporary restoration. In addition, individual impression trays were fabricated before surgery.

Implants

A total of 72 implants were placed (SLA Straumann® TE; Straumann AG, Basel, Switzerland) exhibiting diameters of 4.1 mm and lengths 8 and 10 mm.

Surgical procedure

Antimicrobial prophylaxis (Amoxicillin® 1 g; Galenika a.d., Belgrade, Serbia) were given

orally 1 h before each surgery. The patients rinsed with a chlorhexidine digluconate solution (0.2%) for 1, 10 min before the operation. The operations were carried out under local anesthesia (Xilestesin®; Espe Dental AG, Seefeld, Germany) containing 2% epinephrine. Thereafter, a middle crest incision and buccal extensions were performed in both edentulous sides of mandible. Every side received three implants in the position of 2nd premolar, 1st and 2nd molar. After flap elevation, implant sites were prepared using the surgical guides and accordance with the manufacturer's recommendations (Fig. 1). Flaps were closed with horizontal and single sutures. Impressions were taken with individual impression trays and sterile impression material. The abutments for the temporary reconstructions were used as transfers of implant position (Fig. 2). Suitable healing caps were placed until insertion of the temporaries.



Fig. 1. Implants in the position of 35, 36, and 37.



Fig. 2. Impression for temporary restoration has been taken with abutments as transfers and individual impression trial.

Postoperative treatment

Antibiotics and nonsteroidal analgesics (Nimulid® tablet 100 mg; Panacea Biotec, New Delhi, India) were continued for 3 days. Postoperative edema was controlled with corticosteroids (Dexason® 4 mg i.m. 1 h before and 8 h after surgery; Galenica a.d., Belgrade, Serbia). Patients were asked to consume a soft diet for 1 month after surgery as well as to use 0.12% chlorhexidine digluconate mouth rinses during the same period. Sutures were removed 10 days after surgery.

Temporary reconstruction

Temporary acrylic reconstructions were made in the laboratory and placed onto the implants in both groups within the first 24 h after surgery. Thereafter, periapical radiographs were made. The temporary reconstructions in the control group (EL) were removed after taking the periapical radiographs, and healing caps were put onto the implants. Six weeks later, the healing caps were removed and the temporary reconstructions were seated. At 1 year of implant loading, the temporary reconstruction was replaced with a permanent reconstruction.

Measurement parameters

Crestal peri-implant bone levels

Periapical radiographs were taken within a day after surgery as well as 12 months and 5 years after the beginning of prosthetic loading. To make standardize the exposure geometry of the periapical radiographs, individual film holders were fabricated for both sides of the mandible in every patient. On these radiographs, crestal bone levels were measured from the shoulder of the implant to the first bone to implant contact (Fig. 3).

Peri-implant soft tissue health was assessed applying previously described parameters (mBI, mPII) at 1 and 5 years of prosthetic loading (Mombelli & Lang 1994).

Resonance frequency analysis

Resonance frequency analysis (RFA) (Osstell® Mentor; Integration Diagnostics AB, Sävedalen, Sweden) was performed at both test and control implants to determine the implant stability. These measurements were performed immediately after implant insertion 6, 12 weeks, and 1 year thereafter. The measuring device (Smartpeg™; Integration Diagnostics AB) was attached to the implant, and measurements were performed with the RFA probe (Osstell™ mentor Probe II; Integration Diagnostics AB) detecting from the buccal direction. At each measurement time, the temporary reconstruction was removed to give access to each single implant. Measurements were transformed into implant stability quotient (ISQ) units, which are given on scale of 1–100, with 100 being the highest degree of stability.

Statistic analysis

All data were first analyzed by descriptive methods (QQ plots, box plots) (SPSS 18.0; SPSS, Austin, TX, USA). Analyses of variance were applied to detect difference between the two treatment modalities. Measurements obtained from the three different implants on one side of the mandible in each patient were averaged. The patient was chosen as the unit for statistical analysis. The sample size was statistically determined. In addition, the implants of different lengths were compared with each other and for that implant has been chosen as the unite for statistical analysis. The Wilcoxon signed rank test was used. Pearson's coefficient of correlation was used to assess the linear relationship of implant stability between two treatment modalities in different time points. The level of significance chosen in all statistical test was at $P < 0.05$.

Results

The total of twelve adult patients (nine women and three men; average age at the time of surgery: 49 years; range: 20–62) received total 72 Ø4.1/4.8 mm Straumann® TE implants with 8 mm ($n = 37$) and 10 mm ($n = 35$) in length. Equal numbers of implants ($n = 36$) were in IL (test) and EL (control) groups (Table 1). During the study, the results of all the patients were analyzed. Survival rate for implants in both groups at 5 years of loading was 100%.

Resonance frequency analysis

At implant placement, all implants had to be clinically stable before the ISQ was



Fig. 3. Individual holder for radiograph film.

Table 1. Distribution of implant length in both (IL, EL) groups

Group	Length		Total
	8 mm	10 mm	
IL	18	18	36
EL	19	17	36
Total	37	35	72

EL, early loading; IL, immediate loading group.

measured. At baseline, the average ISQ value in the IL group was 77.92 (SD 6.99; range 60–85), and in EL group, it was 75.92 (SD 6.28; range 60–83) with no significant difference.

In the IL group, the average ISQ values increased from 77.92 (SD 6.99) at implant placement to 82.97 (SD 3.34) after 1 year (Table 2; Fig. 4). This increase was statistically significant. In the EL group, these values amounted to 75.92 (SD 6.28) at implant placement and 81.14 (SD 3.35) after 1 year (Table 3; Fig. 5). Again, this increase was statistically significant. At each observation point, differences in both groups (IL, EL) were statistically significant.

When comparing the mean ISQ measurements between the control and the test group at all time points of registration (implant placement, 6 and 12 weeks and 1 year), no statistically significant differences were noted (Tables 2 and 3).

Table 2. Mean implant stability quotient (ISQ) values (standard deviation) for all observation points in immediate loading (IL) group. Statistically significant differences were presented as P-value

Week	Mean ISQ (SD)	Range	P-value
0	77.92 (6.99)	60–85	
6	79.61 (5.41)	63–88	0.008
12	82.03 (3.09)	72–88	0.000
52	82.97 (3.34)	73–91	0.000

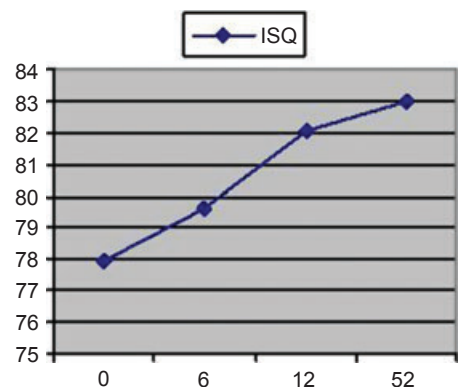


Fig. 4. Significant increase in mean implant stability quotient value for immediate loading group group during observing period of 52 weeks.

Table 3. Mean implant stability quotient (ISQ) values (standard deviation) for all observation points in early loading group. Statistically significant differences were presented as P-value

Week	Mean ISQ (SD)	Range	P-value
0	75.92 (6.28)	60–83	
6	77.55 (5.99)	63–85	0.047
12	80.42 (3.92)	73–85	0.000
52	81.14 (3.35)	73–86	0.000

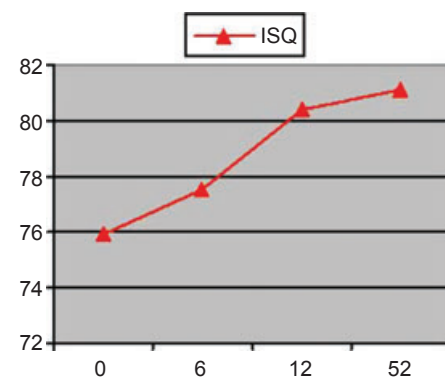


Fig. 5. Significant increase in mean implant stability quotient value for early loading group during observing period of 52 weeks.

Very high coefficients of correlation were found, when correlating the mean ISQ values at 12 weeks and 1 year (IL 0.961; EL 0.920). This finding indicated that high values recorded at 12 weeks predict the high values to be found at 1 year and vice versa (Figs 6 and 7).

At the time of surgery, the ISQ values of the 10-mm-long implants were statistically significantly higher than the values of the 8-mm-long implants (Table 4). At later time points, no significant difference was found between 8- and 10-mm-long implants.

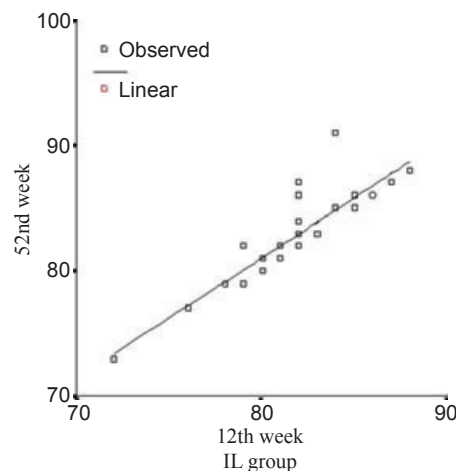


Fig. 6. Correlation between implant stability quotient values measure in 12th and 52nd week in test group.

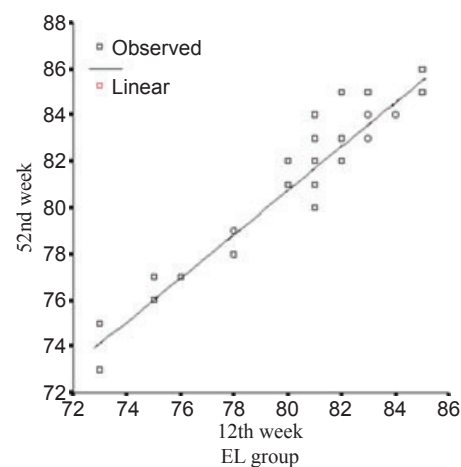


Fig. 7. Correlation between implant stability quotient values measure in 12th and 52nd week in control group.

Clinical and radiographic evaluations

In both the control and the test group, only very small amounts of crestal bone resorption were noted at 5 years (test 0.4 mm, SD 0.24; control 0.8 mm, SD 0.19). At 1 and 5 years of loading, the measurements of the crestal peri-implant bone levels did not show significant difference between the IL group and the EL group (Table 5).

In terms of representation of peri-implant bone resorption in relation to the position of implants in the control group showed the presence of resorption in all analyzed regions ($P > 0.05$), while in the test group, it was mostly observed around one implant embedded in the position of 1st molar ($P = 0.04$). The type of the antagonistic dentition had no statistically significant effect on bone resorption around the implants in both groups (Table 6).

The results of peri-implant soft tissue parameters (modified bleeding index mBI, modified plaque index mPII) did not show any statistically significant differences between immediate and early loaded implants (Table 7).

Discussion

The results of the present study have not shown any difference in RFA values and in crestal bone level changes between the immediately and the early loaded groups. Over the observation time, the implant stability increased significantly in both groups. Whereas at placement the longer implants exhibited higher RFA values than the shorter implants, this difference was no longer present at later time points.

Table 4. Mean implant stability quotient (ISQ) values at the baseline according to implant length. Statistically significant higher value of primary stability has been noted for 10-mm-long implants

	8 mm		10 mm		Significance
	Mean	SD	Mean	SD	
Primary Stability	74.15	7.26	79.57	5.17	0.004
Range	60–83		60–85		

Table 5. Mean peri-implant bone resorption in millimeters (mean, SD) of test and control implants at 1st and 5th year of loading

Group	Mean (SD)–1st year	Mean (SD)–5th year
Test (IL)	0.01 (0.18)	0.4 (0.24)
Control (EL)	0.08 (0.31)	0.8 (0.19)
P-value	0.059	0.118

EL, early loading; IL, immediate loading.

Table 6. Distribution of antagonistic type

Antagonistic occlusion	Number of patients
Natural teeth	2
Removable prosthesis	4
Fixed dental restoration	6

Using of RFA to assess implant stability has been presented in many papers (Bischof et al. 2004; Glauser et al. 2004; Nedir et al. 2004; Sim & Lang 2010). The results of a previous study referring to the primary stability of the same implant type showed primary stability sufficient for adopting an IL protocol (Akkocaoglu et al. 2005). Recent data indicate that primary implant stability between 60 and 65 ISQ-a is prerequisite for the load immediately after installation (Glauser et al. 2004; Nedir et al. 2004). In the present study, this putative critical level of primary implant stability was surpassed in both groups. The lowest measured value of primary implant stability in group of 72 analyzed implants was 60 ISQ. Consequently, biological implant stability was successfully obtained in all situations and no implants were lost.

The purpose of this study was to longitudinally evaluate stability changes in implants subjected to two different loading protocols. During an initial period of 1 year, the values of implant stability significantly increased in the both groups analyzed. This kind of increase has been noted between all observation points (placement, 6, 12 weeks, 1 year). This is in agreement with recent studies, which also showed increases in RFA values over time

(Glauser et al. 2003; Bischof et al. 2004; Sim & Lang 2010). In a clinical study, decreasing values of implant stability were reported during the first 3 weeks of loading (Barewal et al. 2003). This decrease was most pronounced at implants placed in bone with low density (type IV) (Barewal et al.). Considering that in the present study no measurements were performed during the first 6 weeks, there is no information available from this period in the present study.

The implant length had a positive influence on primary implant stability in the present study. This influence was no longer observed at later time points of measurement. For both 8- and 10-mm-long implants, a significant increase in implant stability was observed during the time. Similar results were recently presented for 8-mm-long implants with a significant increase in stability (Sim & Lang 2010). In that study, however, no significant increase in implant stability was noted for the 10-mm-long implants over time. The results of these two studies indicate that short, 8-mm-long implant can successfully be subjected to IL provided the initial implant stability is in the range of the values reported in this clinical trial and a similar protocol is followed.

In the present study, no significant difference in peri-implant bone level changes was observed between the test and control group over the entire observation period of 5 years. These results are in agreement with a randomized clinical trial of immediate vs. early loaded implants inserted in the mandible (Zembic et al. 2010). In contrast to these

results, a recent study reported higher values of bone loss at immediately loaded implants compared with early loaded implants (Ganelles et al. 2008).

In the present study, significant differences between groups were found with regard to mean values and ranges of mBI and mPII at any time point of evaluation. These results are consistent with the published data of other trials investigating the soft tissue conditions at immediate and conventionally loaded implants (Glauser et al. 2006).

The survival rate for all implants from immediate and early loaded groups for period of 5 years was 100% in the present study. These results are very favorable, when compared with previously published data. In one study, a lower survival rate (96.7%) has been reported for single-tooth, immediately reconstructed implants in mandibular molar sites at the 12-month follow-up examination (Cornelini et al. 2004). In another recent study of immediate occlusal loading, 97.1% of survival was reported for a period of 4 years (Glauser et al. 2005). In a recent study comparing immediately and early loaded implants inserted in bilateral free mandibles, the cumulative survival rate for immediately loaded implants was 85%, and for early loaded implants, it was 100% (Zembic et al. 2010).

In the present study, no statistically significant differences were noted between the test and the control group regarding RFA values, clinical measurements and crestal bone level changes at any time point. This finding clearly demonstrated that, under the conditions of this clinical trial, IL was as successful procedure as EL.

The development of noninvasive diagnostic instruments for measuring of implant stability (RFA) has important role to detect early changes in this clinical parameter during the tissue integration.

Conclusion

This study demonstrated that design of Straumann® TE implants provides a high value of primary implant stability and that it is acceptable for IL protocol in the posterior region of the lower jaw.

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Table 7. Mean value (SD) of modified bleeding index (MBI) and modified plaque index (MPI) for test and control group at 1 and 5 years after implant loading

Group	MBI mean (SD)		MPI mean (SD)	
	1st year	5th year	1st year	5th year
Test (IL)	0.22 (0.11)	0.22 (0.11)	0.25 (0.20)	0.17 (0.15)
Control (EL)	0.22 (0.18)	0.25 (0.21)	0.17 (0.15)	0.19 (0.20)
P-value	>0.05		>0.05	

EL, early loading; IL, immediate loading.

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Supporting Information

Additional Supporting Information may be found in the online version of this article:

Table S1. CONSORT 2010 checklist of information to include when reporting a randomized trial.