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Abstract

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Reference

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Immediate Rehabilitation of Completely Edentulous Jaws With Fixed Prostheses Supported by Implants Placed Into Fresh Extraction Sockets and in Healed Sites: A 4-Year Clinical Evaluation

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Titanium dental implants have made fixed prostheses suitable for completely edentulous patients, and most studies have reported predictable results when the proper guidelines are correctly followed.1,3 According to the Brånemark 2-stage protocol, after implant placement, a period of 3 to 6 months in the absence of occlusal loading was required to achieve successful osseointegration.4-6 This strict protocol required the wearing of a temporary prosthesis between surgery and prosthetic rehabilitation to maintain function and aesthetics.

Over the past 2 decades, however, some of the original concepts have been reassessed to satisfy the patients’ expectations for shorter rehabilitation time, improved aesthetic outcomes, and increased comfort during healing. Because the recommended healing time that is necessary before implants can be loaded has been proposed as a result of clinical observations rather than biological documentation, clinicians have questioned whether this period was actually necessary to achieve the highest success rate or if it could in fact be shortened. The concept of immediate loading was therefore introduced.7

It has been seen that immediate loading reduces functional discomfort and also improves the outcome of the implants, thus avoiding the risk of implant failure due to the unexpected overload imposed on the top of the fixtures in the early healing phase.8 Survival rates of 96% to 100% are reported for immediately loaded full-arch fixed prosthesis in the mandible.9-11 Few studies have evaluated the success of immediately loaded implants in the edentulous maxilla, but the preliminary results seem encouraging.12,13 Nevertheless, these protocols still include the use of a provisional removable device during the healing period between tooth extraction and implant placement, for instance, in those partially edentulous patients in whom extraction of all the remaining teeth was indicated and planned to undergo an implant-supported rehabilitation.14 For patients who have their own teeth but will lose them all and intend to receive an implant-supported rehabilitation, it

Purpose: To evaluate the outcome of treatment in the rehabilitation of edentulous jaws with early loaded full-arch screw-retained prostheses after up to 4 years of function.

Methods: Patients with completely edentulous maxillae and/or mandibles, or presenting natural teeth with a poor or hopeless prognosis, received 6 implants each in the mandible and/or 8 in the upper jaw. All patients received a full-arch prosthetic reconstruction.

Results: A total of 19 patients were treated with a total of 164 implants. One hundred nineteen implants were placed immediately after tooth extraction, and 45 implants were placed in healed sites. Overall, 8 implants failed, leading to a 4-year cumulative survival rate of 95.1%.

Conclusions: The rehabilitation of the edentulous maxilla and mandible with an early loaded prosthesis represents a viable alternative treatment to classic loading protocols. (Implant Dent 2012;21:272–279)

Key Words: immediate loading, immediate implants, cumulative survival rate
would be interesting to get a full-arch fixed prosthesis on implants immediately after tooth extraction, in 1 single surgical procedure.

The results reported by several clinical studies suggested that placing implants at the time of tooth removal may have many advantages compared to the traditional approach, enabling the placement of wider and longer implants.15,16

Few reports are available in the literature regarding the possibility of immediate/early functional loading of implants placed into fresh extraction sockets. Some studies reported that immediately loaded implants placed in fresh extraction sockets are associated with a higher risk of failure compared to immediately inserted implants inserted into healed sites.17,18 Nonetheless, other studies described similar success rates for premature loaded implants inserted in mature bone and immediately after tooth removal.19–23

Considering these premises, the aim of the present study was to evaluate the survival rate of implants placed in healed sites and fresh extraction sockets and immediately loaded with a full-arch screw-retained prosthesis after up to 4 years of function.

**Materials and Methods**

**Patient Population**

Between February 2003 and January 2006, a total of 19 patients (13 women and 6 men) ranging in age from 39 to 72 years, with a mean age of 60.26 years, were treated with a total of 164 implants.

All the patients requiring dental implants for a full-arch implant-supported rehabilitation who were 18 years or older and able to sign an informed consent form were considered eligible for inclusion in this study. Eligible patients had to have sufficient bone volume allowing placement of implants, which should be used for a full-arch implant-supported rehabilitation. Patients with completely edentulous jaws and/or presenting natural teeth with a hopeless prognosis were included in the study. All the included patients were scheduled for a screw-retained full-arch rehabilitation selected on the basis of the following inclusion criteria: age ≥18 years; rehabilitation with oral implants considered elective; physical ability to tolerate conventional surgical and restorative procedures; all implants could be seated with a torque ≥45 N.cm and had initial primary stability; and finally had signed an informed consent form.

Patients were not included in the study on the basis of the following exclusion criteria:

- presence of acute infection or inflammation in the area scheduled for implant placement;
- systemic diseases that would contraindicate implant surgery;
- severe skeletal jaw discrepancies (Class V to VI according to the classification of Cawood and Howell24);
- treatment with therapeutic radiation in the head or neck regions within the past 12 months;
- severe bruxism or clenching;
- poor oral hygiene;
- pregnancy.

A smoking habit was not considered an exclusion criterion, but patients who smoked more than 10 cigarettes per day were excluded and those who smoked less than 10 cigarettes per day were advised to attend counseling sessions.

**Preoperative Assessment**

A complete examination of hard and soft oral tissues was conducted for each patient to assess the bone volume of the scheduled implant sites. Each case was accurately evaluated examining diagnostic casts for the intraarch relationship, periapical and panoramic radiographs, and computed tomography if necessary.

Before surgery, the diagnostic casts were mounted in an articulator, and a diagnostic wax-up was prepared in which occlusion, aesthetic parameters, and relation between the teeth and alveolar ridge were evaluated. On the base of this setup, a cross-arch provisional template and a surgical custom guide in transparent heat-processed acrylic resin were provided by the dental technician.

**Surgical Procedures**

Antimicrobial prophylaxis was prescribed with 2 g of amoxicillin 1 hour before the surgery, and thereafter 1 g twice per day for 5 days. All patients were operated without sedation under local anesthesia induced by infiltration with articaine/epinephrine (1:100000), and each patient received 6 implants in the mandible and/or 8 in the upper jaw.

A crestal incision, or an intrasulcular incision in the cases of immediate postextraction implants, was made from the first molar to the first contralateral molar, with one releasing incision at the midline to allow for an easier flap reflection. After this, a full mucoperiosteal flap was raised to expose the sites for implant placement. In the cases of immediate postextraction implants, the compromised teeth were carefully removed, and the residual extraction sockets were thoroughly debrided. A periodontal probe was used to assess the integrity of the bony walls of the extraction sockets. If a lack of 1 or more bony walls was detected, the postextraction site was excluded. Subsequently, implants with a bioceramic, grit-blasted, and acid-etched surface (Ossean; Intra-Lock International, Inc, Boca Raton, FL) were placed using a sterile surgical technique, as recommended by the manufacturer, with the aid of surgical templates and inserted directly in some of the fresh extraction sockets as well as into healed edentulous sites adjacent to the sockets. Implants were inserted with a minimal torque of 45 Ncm. The resistance to implant insertion was evaluated with a hand torque controller device (Torque-Lock; Intra-Lock International, Inc,). Depending on the size and anatomy of the extraction socket, if there was a bone defect larger than 2 mm between the bone walls and the implant body, it was grafted with autogenous bone chips collected during implant site drilling. According to the panoramic radiograph, in some of the patients, the residual bone height under the maxillary sinus was ≤8 mm. The osteotome sinus floor elevation technique was applied by light malleting as previously described25; no grafting biomaterials were used during the osteotome sinus floor elevation.
Prosthetic Procedures

After the surgical procedure, impressions with impression copings were taken using a polyether elastomeric material (Impregum Penta; 3M ESPE, Milan, Italy) and the provisional template; the analogs were then attached to the transfer copings in the impression and sent to the dental laboratory. After impression, the centric relation was registered with wax (Dental Wax; Moyco Technologies) and, subsequently, flat abutment cover screws were seated. The working model produced in the laboratory incorporated implant analogs. The casting cylinders were placed onto the analogs and connected with a small amount of self-curing resin and the structure “waxed up.” On the following day, the vertical dimension, occlusion, aesthetics, phonetics, and fit of the wax-up were checked intraorally. After the wax up was verified, a rigid 1-piece Cr-Co framework was fabricated. Finally, the full-arch screw-retained prosthesis was finalized and inserted within 48 hours after surgery. The abutment screws were tightened, and the occlusion was carefully checked. At the time of prosthesis delivery, periapical radiographs were taken to check the presence of any misfits between the prosthetic framework and the implants. All prostheses were screw retained and fabricated with a metal framework combined with resin teeth.

Postoperative Care

Postoperative analgesic treatment was prescribed with 100 mg of nimesulide twice daily for the following 3 days. Patients were instructed to eat a soft diet for the first 8 weeks after implant placement. Oral hygiene was re instructed with the soft manual toothbrush and additionally with appropriate-sized interdental brushes.

Follow-up Evaluations

Patients were scheduled for follow-up evaluations at 6 and 12 months after implant insertion and then every 6 months up to a period of 4 years. At each visit, periapical radiographs were taken to evaluate the perimplant radiolucency. Oral hygiene reinstructions were given when considered necessary. All mobile implants were recorded as failures. All implants without signs of mobility, without pain or discomfort on pressure, and exhibiting radiographic evidence of osseointegration were considered survivals. Cumulative implant survival over time was assessed using the Kaplan-Meyer analysis. The survival function is used to represent the probability that implant survive from their placement to sometime beyond. During the observation period, implant may fail, survive, or “be censored.” Censored observations arise whenever the dependent variable of interest represents the time to a terminal event, and the duration of the study is limited in time. For some implants, the event of interest (failure) has occurred, and therefore, we know the exact survival time (their survival time is uncensored), whereas for others, it has not occurred, so the survival time exceeds the observation time. An implant is censored when follow-up ends before the occurrence of the event (failure) or completion of the full period of observation (the observation of this implant is incomplete). About the result for this observation, it is known only that it occurs later than its indicated censoring time (Censoring is a form of missing data problem that is common in survival analysis, the branch of statistics that deals with failure in biological and mechanical systems26). A log-rank test was used to explore the differences between the survival curves stratified for the variable of interest. The investigation considered the following parameters: time of implant placement; jaw position; implant diameter and length; and finally, any additional augmentation procedures (osteotome sinus floor elevation). The null hypothesis, being no differences between groups, was rejected as \( P < 0.05 \). All evaluations were performed using SPSS software version 6.1.2 for Windows.

RESULTS

No patients dropped out of the study, and the evaluation data of all patients was used for the statistical evaluation. In total, 132 of 164 implants inserted were of narrow diameter (3.3 mm) and the remaining 32 implants were of wide diameter (5 and 5.5 mm). One hundred thirty-three fixtures were 13 and 15 mm long, whereas the remaining 31 were 8 mm long. Three patients received implant-supported reconstruction both in their maxilla and mandible, so that these 164 implants were distributed over 16 upper jaws and 6 lower arches. No patient dropouts were recorded during the observation period. Patients healed with minor discomfort or swelling and no surgical complication was recorded. Four of the 16 upper jaws were healed edentulous maxilla, whereas 12 had some hopeless teeth that needed to be removed. Forty-nine implants required augmentation procedures and were inserted after a simultaneous sinus floor elevation using the osteotome technique. All the 6 lower arches treated with full-arch implant rehabilitation presented residual teeth, which were judged to be unrecoverable.

One hundred nineteen implants were placed immediately after tooth extractions (immediate implants), and 45 implants were placed in healed sites (delayed implants). One hundred twenty-eight implants were placed in the maxilla (85 immediate and 43 delayed) and 36 in the mandible (34 immediate and 2 delayed). For all 164 implants followed, the follow-up period ranged from 36 to 68 months (mean, 45.33 months). Eight implants failed and were consequently removed due to mobility after 12 months of loading, leading to a 4-year cumulative survival rate (CSR) of 95.1% (Table 1). All the failures occurred in the same patient and consisted in the loss of all the adjacent implants splinted together to complete a full-arch rehabilitation in the upper jaw. The patient was a 61-year-old female, and the opposite denture was a full-arch tooth-supported fixed bridge. All the failed implants were placed in mature bone. As a consequence, for immediate implants, a survival rate of 100% was
achieved, whereas for delayed implants, the survival rate was 82.2% \( (P = 0.000) \). The survival rate for the 128 maxillary implants was 93.8% and 100% for the 36 mandibular implants \( (P = 0.125) \). The 4-year survival rates of groups divided according to implant length (di- chotomized in <10 mm and >10 mm) were 74.2% and 100%, respectively \( (P = 0.000) \). The 4-year survival rate of groups stratified according to implant diameter were 93.9% and 100% for diameter <3.5 mm and for diameter >3.5 mm, respectively \( (P = 0.155) \). For implants placed in augmented sites, a survival rate of 91.8% was achieved, whereas for implants placed in pristine bone, it was 96.5% \( (P = 0.204) \). Figures 1 to 4 show different implant survival curves according to the Kaplan-Meier algorithm.

### Discussion

The majority of immediate implant loading studies reported similar success rates when compared to the traditional 2-stage approach.\(^{10-13,27-30}\) However, several factors may affect the outcome of immediate loading protocols. These could be divided into the following 4 categories: surgical, host, implant, and occlusion-related factors.\(^{31}\)

Immediate loading of implants placed in postextraction sockets is a matter of current discussion because few reports have addressed this surgery-related factor. In some studies, immediate implants are placed immediately after the extraction of teeth presenting irreversible endodontic and periodontal lesions, although the number of implants and the success rates obtained are not reported.\(^{20,31,32}\) In a study by Pieri et al.,\(^{33}\) implants placed immediately after tooth extraction were immediately loaded with a full-arch fixed prosthesis, and the outcomes were clinically and radiographically evaluated after 1 year of loading. The high overall implant survival rate after 1 year (98.6%) and the limited marginal bone changes encouraged the hypothesis that immediately loaded dental implants may be a predictable treatment modality when placed immediately after tooth removal. In a study of Degidi et al.,\(^{34}\) 388 implants were immediately loaded, of which 213 were inserted in healed bone and 175 in postextraction sockets. At a 5-year follow-up, the overall survival was 98%. No statistically significant differences were observed. In the present study, 164 implants were loaded within 48 hours after implant placement, of which 45 were inserted in healed bone and 119 in postextraction sockets. Overall, only 8 implants failed and were consequently removed due to mobility after 12 months of loading, leading to a 4-year CSR of 95.1%. Surprisingly, all the failed implants were located in mature bone. As a consequence, for immediate implants, a survival rate of 100% was achieved, whereas for delayed implants, it was 82.2%. The difference between the groups was statistically significant. Consequently, the immediate loading of implants inserted in postextraction sites could be considered a predictable clinical procedure.

It should be noted that host bone density plays a fundamental role in determining the success of immediate implant loading. It is well known that the mandible has better bone quality compared to the maxilla, and this is probably why the available documentation on immediate loading of implants mostly focused on completely edentulous mandibles. Interestingly, few investigations have shown similar predictability regardless of anatomical location.\(^{35,36}\) In our study, we did not find statistically significant differences between mandible and maxilla, and we can conclude that the maxilla is also an appropriate site for immediate loading. The survival rate for the 128 maxillary implants was 93.8% and 100% for the 36 mandibular implants. Within the limited available information, it seems that primary stability, more than the arch (anatomical) location, may be the fundamental requirement for immediate implant loading techniques.

In this study, all implants attained primary stabilization at placement, regardless of the amount of alveolar bone. Additional supporting bone for the implants was attained by augmentation with an osteotome technique, engaging the thin cortical bone of the antral floor in the maxilla to obtain bicortical primary stabilization. Forty-nine implants required such augmentative procedures and were inserted after simultaneous sinus floor elevation with the osteotome technique. For implants placed in augmented sites, a survival rate of 91.8% was achieved, whereas for implants placed in pristine bone, it was 96.5%. No statistically significant difference was found.

<table>
<thead>
<tr>
<th>Interval (mo)</th>
<th>Number of Implants</th>
<th>Number of Failed Implants</th>
<th>Survival Rate (%)</th>
<th>CSR (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0–6</td>
<td>164</td>
<td>0</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>6–12</td>
<td>164</td>
<td>0</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>12–18</td>
<td>164</td>
<td>8</td>
<td>95.1</td>
<td>95.1</td>
</tr>
<tr>
<td>18–24</td>
<td>156</td>
<td>0</td>
<td>100</td>
<td>95.1</td>
</tr>
<tr>
<td>24–30</td>
<td>156</td>
<td>0</td>
<td>100</td>
<td>95.1</td>
</tr>
<tr>
<td>30–36</td>
<td>156</td>
<td>0</td>
<td>100</td>
<td>95.1</td>
</tr>
<tr>
<td>36–42</td>
<td>156</td>
<td>0</td>
<td>100</td>
<td>95.1</td>
</tr>
<tr>
<td>42–48</td>
<td>128</td>
<td>0</td>
<td>100</td>
<td>95.1</td>
</tr>
<tr>
<td>48–54</td>
<td>68</td>
<td>0</td>
<td>100</td>
<td>95.1</td>
</tr>
<tr>
<td>54–60</td>
<td>16</td>
<td>0</td>
<td>100</td>
<td>95.1</td>
</tr>
<tr>
<td>60–66</td>
<td>8</td>
<td>0</td>
<td>100</td>
<td>95.1</td>
</tr>
<tr>
<td>&gt;66</td>
<td>8</td>
<td>0</td>
<td>100</td>
<td>95.1</td>
</tr>
</tbody>
</table>

The life table examines the extent to which a specific event occurs across intervals of time. In the analysis presented here, time intervals correspond to follow-up periods. During each observation period, it is calculated the possibility that an event will occur for those implants that have yet to experience the event.

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Table 1. Life Table Analysis for the Whole Number of Implants
which allow faster osseointegration, greater bone-to-implant contact, and shorter healing times compared to machined surfaces.38–43

Implant length is another important factor that may also influence the outcome of immediate implant loading. The majority of studies have suggested that implants should be ≥10 mm long to ensure high success rates.18,27,44,45

Given that the data from these studies are based mainly on a clinical experience with a limited patient cohort, the critical length and diameter of immediately loaded implants remains to be fully determined. However, in the case of immediate implants, using implants with the longest possible length for immediate insertion after tooth extraction was of great importance in achieving implant engagement in basal bone apical to the socket. In the present investigation, fixtures were between 8 and 15 mm long and between 3.3 and 5.5 mm wide. The 4-year survival rates of groups divided according to implant length, dichotomized in <10 mm and ≥10 mm, were 74.2% and 100%, respectively, and the difference between the groups was statistically significant. Degidi and Piattelli18 found a different survival rate according to specific cutoff points for implant diameters: large diameter implants had a worse trend compared to those of a smaller diameter. The authors concluded that this may be due to both the excessive depletion of trabecular bone from the implant site and the stress patterns related to increased implant surface area. Otherwise, the reason that wider diameter implants showed a poorer prognosis is probably related to an inverse correlation between the quality of bone and the implant diameter. The 4-year survival rates of groups stratified according to implant diameter in our sample were 93.9% and 100% for diameters of <3.5 mm and ≥3.5 mm, respectively. No statistically significant difference was found between these groups.

It was previously pointed out that immediate loading results for full-arch implant-supported restoration are dependent on factors such as occlusion, type of prosthesis, and the number of implants.46 Controlling functional forces is one of the conditions for obtaining success of immediate implant loading. Oblique or horizontal forces applied during function are more detrimental to implant stability compared to vertical forces. As a consequence, it is often suggested that patients with parafunctional habits should be excluded or at least well-informed about the
potential risks associated when immediate loading protocols are performed.\textsuperscript{31} In our study, bruxism was considered a contraindication for immediate implant loading. As regards the prosthetic design, when cross-arch implant splinting is performed, primary stability can be enhanced. Taking into account these preliminary considerations, the positive results described in this present study can be attributed to the interaction of several favorable contributing factors: the use of implants with the longest possible lengths, an immediate cross-arch splinting of the implants with a passively fitting bar minimizing micromobility, and an even occlusal load distribution on a sufficient number of implants. In our study, each patient received 6 to 8 implants: in the upper jaw, the implants were distributed at sites 3, 5, 6, 8, 9, 11, 12, and 14, whereas in the mandible, they were distributed at sites 19, 21, 23, 26, 28, and 30. Whenever possible, depending on the opposing dentition, the cross-arch implant-supported restoration was given a fully balanced occlusion and articulation with an equal spread of the load to all implants. Moreover, a brand new abutment shape was employed in the present experimentation. Such abutments, having a specially designed screw joint and a flat bottom fitting with the head of the fixture, were preferred in the current application. This is due to the fact that they apply uniform pressure around the entire radius of their planar surface extension under occlusal loading and because they are designed to be compressed flat and maintain their tension when abutment retaining screws are torqued.

Finally, it should be considered that the total number of failures occurred in a single patient and consisted in the loss of all the adjacent implants. We were unable to evaluate the causes of this distribution of the implant failures. The opposing denture in the patient concerned was a full-arch tooth-supported fixed prosthesis. It is reasonable to hypothesize that increased functional loads in the posterior quadrants may have represented an important factor, which resulted in implant failure.\textsuperscript{33} Nevertheless, a similar cluster trend has been widely observed in implant failures. Previous studies have examined the finding that implant failures are not randomly distributed in the treated population.\textsuperscript{47–49} Because failures tend to cluster within subjects, suggesting heterogeneous risk among patient population, some authors developed and applied newer survival methodologies.
to adjust survival estimates for both within-subject clustering of observations and heterogeneous risk among subjects. They found that risk for implant failure among subjects varied to a statistically significantly degree.\(^{26-32}\) Actually, these findings indicate the presence of patient-related factors, which affect the survival of all implants within a given patient population and may cause multiple implant failures. Occlusal factors, such as inadequate adjustment of the prosthodontic appliance and overload, could play a role in this pattern behavior. Rather, in this individual, implant failure triggered a “domino” effect resulting in further implant failures, as previously reported.\(^{33}\) Such a phenomenon and its triggering causes should be the subject of further investigation.

**CONCLUSION**

In conclusion, the present report has shown that immediate occlusal loading of implants with full-arch fixed restorations is a reliable surgical procedure, and it can be done successfully either in immediate extraction sites or in sound edentulous ridges. The overall success rate was high and appeared stable over time, regardless of anatomical location. The use of implants with the longest possible length and favorable occlusal loads seemed to play a fundamental role for the success of this protocol. Finally, the beneficial contribution of an osseococonductive implant surface should also be further investigated.

**DISCLOSURE**

The authors claim to have no financial interest, either directly or indirectly, in the products or information listed in the article.

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