Luc Gillot, Bernard Cannas, Jacopo Buti, Renaud Noharet

A retrospective cohort study of 113 patients rehabilitated with immediately loaded maxillary cross-arch fixed dental prostheses in combination with immediate implant placement

Key words: cross-arch fixed dental prosthesis, immediate implant placement, immediate loading, maxillary edentulous patients

Purpose: To retrospectively evaluate the outcome of immediately loaded cross-arch fixed dental prostheses 6 months after loading. A second aim was to compare survival rates of implants placed in healed versus fresh extraction sites.

Materials and methods: In total, 113 consecutive patients about to have their maxillae rendered fully edentulous (mean extractions per patient: 6.7 teeth) received four to eight implants each (total number = 675) which were immediately placed in healed sites (323 implants, 47.9%) or fresh sockets (352 implants, 52.1%). Immediate loading of provisional prostheses was performed and all patients were followed up for 6 months. The success criteria included prosthesis success, assessment of individual implant stability and complications.

Results: No patients dropped out and all 113 patients received definitive fixed prostheses after 6 months of loading. The overall implant survival rate after 6 months was 99.1%. Six implants were lost in 6 patients (5.3%). Five of them were inserted in fresh extraction sockets (1.4%) and one in a healed site (0.3%). No significant difference ($P = 0.1621$) was found for implants placed in healed sites versus fresh extraction sites. Ten patients had fractures of the provisional prostheses as complications.

Conclusions: Immediate implant placement and loading resulted in high implant as well as prosthetic survival rates. Placement in healed or fresh extraction bone sites may not influence implant survival.

Conflict-of-interest statement: All materials used in this study were purchased by the authors and there are no conflicts of interest.

Introduction

The treatment of the fully edentulous maxilla with implant-supported prostheses has been well documented, including immediate function of cross-arch fixed dental prostheses. Immediately loaded implant-supported fixed dental prostheses have a success rate which seems to be equivalent to that of conventional treatments in which implants are submerged to osseointegrate for 4 to 8 months, but with fewer steps as well as shorter treatment periods. Immediate implant placement after tooth extraction shows satisfying success rates, though inferior to implant placement in healed sites. There are sev-
eral studies that have evaluated the combination of immediate placement and immediate function\textsuperscript{9-13}. The results are contradictory: some more favourable\textsuperscript{8,10,14,15} and some less favourable\textsuperscript{9,15-20}.

The goal of this study is to retrospectively evaluate the prosthetic and implant survival rates in the maxillae at 6 months after immediate loading in patients rendered fully edentulous in the maxillae. The second goal was to compare the survival rates of implants placed in fresh extraction sites versus those placed in healed sites.

This study is reported following the STROBE Statement (http://www.strobe-statement.org/).

## Materials and methods

Only patients who were rendered edentulous in the maxilla and had implants placed and loaded the same day were considered in the present study.

Exclusion criteria were: alcohol addiction, drug addiction, history of radiotherapy in the head and neck area, psychological disorders, and heavy smokers (>15 cigarettes per day). From the total of 120 patients considered for this treatment, 2 patients were excluded due to psychological disorders and 5 for heavy smoking.

Retrospective chart audits were conducted on the 113 remaining patients who were treated with maxillary implant-supported cross-arch fixed dental prostheses from January 2006 to December 2010.

Patients were treated by two different teams at two private clinics: 48 patients were treated with 284 implants at clinic A and 65 patients with 391 implants at clinic B for a total of 675 maxillary implants.

Fifty-six males and 57 females were included in the present study, with ages ranging from 37 to 93 years.

Before implant placement, every patient went through periapical and panoramic radiographic examinations of the remaining teeth to evaluate the possibility of tooth extraction (Figs 1 and 2) and to discuss the prosthetic treatment plan. The main reason for tooth extraction was periodontal disease. Other reasons were decay recurrence and occlusal disturbance.

Conventional computed tomography scans were evaluated with the help of planning software (Simplant\textsuperscript{®}, Materialise Dental, Leuven, Belgium or Nobelguide\textsuperscript{®}, Nobel Biocare, Göteborg, Sweden) to assess the possibility of placing sufficient numbers of implants at the same stage as teeth extraction (Figs 3 and 4). It was then decided which implants could be placed into or outside fresh extraction sites, to obtain initial stability.

The planning phase was aimed at avoiding fresh extraction sites as much as possible since good primary implant stability is more difficult to achieve in those sites. After the patient’s consent, impressions were taken and the teeth to be extracted were removed on the plaster model. A waxup of the final prosthesis was prepared and discussed with the patient. A customised impression tray was made and tested before the surgery (Fig 5).

Prophylactic antibiotics were used for all patients: amoxicillin, 2 g per day, for 6 days, starting the day before surgery.

Precautions were made during extraction/implant insertion to preserve the alveolar bone in the best possible way (Fig 6) and to meticulously clean the alveolar sockets from granulation tissue. Therefore, thin periotomes, which enabled gentle tooth luxation, were used during the extraction phase.
An overall mean of 6.7 teeth per patient were extracted (Table 1).

Implants were inserted starting with a 20 Ncm torque. The torque was raised gradually to engage the implant until its final location. The final insertion torque used was a maximum of 50 Ncm (Fig 7). Of the 675 inserted implants, 24 were cylindrical with parallel walls (MkIII®, Nobel Biocare), 640 were cylindrical with tapered walls (Speedy® or MkIV®, Nobel Biocare) and 11 were self-tapping (NobelActive®, Nobel Biocare); this decision was made dependent

**Table 1** Number of residual teeth per patient.

<table>
<thead>
<tr>
<th>Number of residual teeth</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of patients</td>
<td>2</td>
<td>6</td>
<td>9</td>
<td>7</td>
<td>8</td>
<td>29</td>
<td>12</td>
<td>9</td>
<td>14</td>
<td>7</td>
<td>3</td>
<td>5</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Percentage</td>
<td>1.8</td>
<td>5.3</td>
<td>8.0</td>
<td>6.2</td>
<td>7.1</td>
<td>25.7</td>
<td>10.6</td>
<td>8.0</td>
<td>12.4</td>
<td>6.2</td>
<td>2.7</td>
<td>4.4</td>
<td>0.9</td>
<td>0.9</td>
</tr>
<tr>
<td>Number of teeth</td>
<td>2</td>
<td>12</td>
<td>27</td>
<td>28</td>
<td>40</td>
<td>174</td>
<td>84</td>
<td>72</td>
<td>126</td>
<td>70</td>
<td>33</td>
<td>60</td>
<td>13</td>
<td>14</td>
</tr>
<tr>
<td>Total</td>
<td>113</td>
<td>755</td>
<td>755</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The two distal implants were tilted to pass both inferior and mesial to the sinus\textsuperscript{21}. In the case of a gap between the bone and the implant, the bone that had been harvested during drilling was used to fill the space. Abutments were then placed, followed by impression coping placement. After suturing the flap around the copings, an impression was taken using a customised pre-made impression tray\textsuperscript{22} (Fig 8) with polyvinylsiloxane rigid impression material (CliniBite Fast Clinix\textsuperscript{®}, CFPM, Tremblay, France) (Fig 9).

This ‘post-surgical’ impression tray possessed saddles that were carefully fitted on the residual edentulous alveolar crest, mainly its posterior part uninvolved in implant placement, and on palatal mucosa in order to obtain a very stable device. Some posterior teeth were temporarily retained in order to stabilise this device (Fig 9) and to obtain a better quality transfer to the laboratory. Since they maintain natural proprioception, the teeth could also protect the occlusion from overload during the healing period. These teeth were extracted at the time of final prosthesis delivery.

The anterior part of the customised tray was opened to provide access for the impression on the abutments (Fig 8). A rubber dam was placed through impression copings to protect the operation site and avoid the impression material spreading under the flap. A polyvinylsiloxane rigid impression material (CliniBite Fast Clinix) was injected with a self-mixing syringe in the impression tray window (Fig 9). Then, guide pins were unscrewed and the impression tray was removed. The abutment replicas were connected to the impression copings and the impression tray was repositioned on the model before placing a new plaster layer (Figs 10 and 11).

The temporary implant-supported prosthesis was then made around titanium temporary cylinders (Figs 12 and 13). Screw retention was preferred to avoid the risk of cement debris getting trapped in the fresh surgical sites. Outcome measures analysed at 6 months after loading and prior to the definitive restoration procedure (Fig 14) were:

- Success of the prosthesis.
- Success of the implants evaluated by checking implant stability at 6 months postoperatively when re-tightening the abutment screw with a 35 Ncm torque for straight abutments or 15 Ncm for angled abutments.
- Any complication.

Then, definitive restoration procedures were performed by different prosthodontists, referring to both clinics, and provided a screw-retained permanent titanium framework with resin teeth (Procera\textsuperscript{®} Implant Bridge, Nobel Biocare).

A logistic multilevel model\textsuperscript{23} was created at two levels for the binomial outcome variable ‘Success/Failure’. Level 1 was the implant level, while level 2 was the patient level. The explicative variable ‘Fresh Socket’ was used at the implant level. This variable was 1 for implants placed in fresh sockets and 0 for implants placed in healed sockets.

The explicative variable ‘Clinic A’ was used at the patient level. This variable was 1 for implants placed in clinic A and 0 for implants placed in clinic B.

### Results

The study included 56 males and 57 females. The overall mean age of patients was 60.4 years (males: 61.4; females: 59.3) at implant placement.

<table>
<thead>
<tr>
<th>Length</th>
<th>Number</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>4</td>
<td>0.6</td>
</tr>
<tr>
<td>8.5</td>
<td>6</td>
<td>0.9</td>
</tr>
<tr>
<td>10</td>
<td>77</td>
<td>11.4</td>
</tr>
<tr>
<td>11.5</td>
<td>107</td>
<td>15.9</td>
</tr>
<tr>
<td>13</td>
<td>410</td>
<td>60.7</td>
</tr>
<tr>
<td>15</td>
<td>70</td>
<td>10.4</td>
</tr>
<tr>
<td>18</td>
<td>1</td>
<td>0.1</td>
</tr>
<tr>
<td>Total</td>
<td>675</td>
<td>100</td>
</tr>
</tbody>
</table>
The total number of extracted teeth was 755, which corresponded to a mean of 6.7 teeth per patient. These were mainly anterior teeth.

Ninety-eight patients (86.7%) received 6 implants, 6 patients (5.3%) received 4 implants, 6 patients (5.3%) received 7 implants, 2 patients received 8 implants (1.8%) and 1 patient (0.9%) received 5 implants (Table 3).

A total of 352 implants were inserted into sockets of severely diseased end-stage teeth. Thus, a total of
52.1% of the implants were placed into extraction sockets (Table 4).

Complications consisted of 14 prosthesis fractures of the resin material: 13 occurred in clinic A, and 1 in clinic B. Ten patients had fractures: 8 patients with 1 fracture in 6 months, 1 patient with 2 fractures and 1 patient with 4 fractures. At the 6-month follow-up, no peri-implant infection was found during the clinical or radiological evaluations. Sinusitis was not checked for as no patients complained of it. A few patients complained about the space that appeared beneath the provisional restoration during the healing period. This is a normal and predictable mucosa shrinkage following the extraction of compromised teeth. This gap was filled when the final prosthesis was made.

Six of the 681 implants placed were lost in 6 patients. The implant survival rate after 6 months of loading, based upon the implant survival criteria defined above was 99.1% (Table 5). The success at patient level was 94.7%. Six failures were diagnosed after removal of the provisional prostheses at follow-up after 6 months. All failed implants were asymptomatic. The prosthesis was re-fitted on remaining implants and the fixed dental prosthesis shortened if needed due to loss of a posterior implant. As soon as possible, a new implant was placed and connected. It was re-evaluated after 6 months of further healing. Four failures occurred among the 284 implants placed in 48 patients at clinic A (8.3%), and 2 failures among the 391 implants placed in 65 patients at clinic B (3.1%). Of the 6 failures (2 concerned distal implants), 1 was in a healed site and 5 in fresh sockets. Four failures occurred for intermediate implants, all placed in fresh sockets.

The multilevel model did not show any statistically significant difference for failures of implants placed in ‘Fresh Socket’ at implant level ($P = 0.1498$).

The odds ratio was 4.87 with a confidence interval of 2.15;41.97. Where:

- Odds ratio values $>1$ are associated with an increased risk for implant failure with regard to placement in fresh extraction sockets.
- Odds ratio values $<1$ are associated with an increased risk for implant failure with regard to placement in healed sockets.

The multilevel model did not show any statistically significant differences for ‘Clinic A’ at implant level ($P = 0.2141$).

### Table 3 Number of implants per maxilla.

<table>
<thead>
<tr>
<th>Number of implants</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of patients</td>
<td>6</td>
<td>1</td>
<td>98</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>%</td>
<td>5.3%</td>
<td>0.9%</td>
<td>86.7%</td>
<td>5.3%</td>
<td>1.8%</td>
</tr>
</tbody>
</table>

### Table 4 Implants and site.

<table>
<thead>
<tr>
<th></th>
<th>Implants in sockets</th>
<th>Implants in healed sites</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of implants</td>
<td>352</td>
<td>323</td>
<td>675</td>
</tr>
<tr>
<td>%</td>
<td>52.15%</td>
<td>47.85%</td>
<td>100%</td>
</tr>
</tbody>
</table>

### Table 5 Success rate of implants.

<table>
<thead>
<tr>
<th>Clinic A</th>
<th>Clinic B</th>
<th>General</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Success</td>
<td>Failure</td>
</tr>
<tr>
<td>Number</td>
<td>280</td>
<td>4</td>
</tr>
<tr>
<td>%</td>
<td>98.6</td>
<td>1.4</td>
</tr>
<tr>
<td>Healed sites</td>
<td>142</td>
<td>1</td>
</tr>
<tr>
<td>%</td>
<td>99.3</td>
<td>0.7</td>
</tr>
<tr>
<td>Socket sites</td>
<td>138</td>
<td>3</td>
</tr>
<tr>
<td>%</td>
<td>97.9</td>
<td>2.1</td>
</tr>
</tbody>
</table>
The odds ratio was 2.95 with a confidence interval of 2.09;16.27. Where:
- Odds ratio values >1 are associated with an increased risk for implant failure with regard to placement in clinic A.
- Odds ratio values <1 are associated with an increased risk for implant failure with regard to placement in clinic B.

## Discussion

The results of the present study indicate that up to 6 months after loading, implants immediately placed in fresh extraction sockets and immediately loaded with cross-arch fixed dental prostheses have favourable clinical outcomes.

Within the limits of the absence of a sample size calculation and the low power of the analysis, the statistical comparison performed in the present study between survival rates for implants placed in healed versus fresh extraction sites revealed no significant difference ($P = 0.1621$).

The overall implant success rate for the present investigation (99.1%) is in agreement with rates published in similar studies. Pieri et al\textsuperscript{12} reported a success rate of 98.48% following a protocol in maxillae with immediate placement of final prostheses (66 implants placed in 9 patients). A total of 24 implants were placed in sockets, which were associated with one failure.

The literature gives different success rates for healed versus fresh socket implants that are immediately loaded. Cannizzaro et al\textsuperscript{6,24} showed excellent results regarding immediate loading of maxillary implants placed with flapless surgery to support a full-arch prosthesis, also combined with extractions\textsuperscript{6,24}.

Different success rates are reported for implants immediately placed in fresh extraction sockets. Most of the published studies involve single-tooth replacement and describe high failure rates\textsuperscript{14}.

Many other publications are available that report on immediate implant placement, but indications (single or partial) and protocols are different or concerned the mandibular arch\textsuperscript{13}.

From a biomechanical point of view, single implants may be at higher risk of overloading. The present authors speculate that the connection of 4 to 8 implants provides a safer transfer of loading on each implant. Moreover, the present authors suggest that the higher survival rates observed both in healed and in fresh extraction sockets could be influenced by the very strict protocol used for the impression at the end of surgery\textsuperscript{22}. This technique allows for a reduction of errors during laboratory steps and provides a provisional reinforced fixed prosthesis in a few hours.

Esposito et al\textsuperscript{25} showed the importance of prophylactic antibiotics for the success of implant placement. Prophylaxis is likely to be even more important for treatment at infected periodontal or endodontic sites.

An accurate prosthetic treatment plan is fundamental for the success of the procedures described in this protocol. The various pre-surgical steps are the same as those for the preparation of a complete immediate removable prosthesis.

The present protocol envisages the delivery of a fixed prosthesis in one surgical step in the same session as the extractions and without bone grafting before implant placement. When a grafting procedure is not carried out before implant placement and in the presence of general loss of alveolar bone, the use of artificial gingivae represents a valid approach. The morphology and quantity of artificial gingivae needs to be planned in agreement with the patient’s desires. This protocol is valid only for those patients who accept a more or less important layer of artificial gingival tissue on the final prosthesis. The final plan was submitted to the patient for approval by using a waxup model simulating the final restoration.

During the healing period, a temporary fixed dental prosthesis is required until the final volume of soft tissue and bone have been established. Once the maturation of the tissue has finalised, the final prosthesis can be made in direct contact with the healed soft tissues, to increase the patient's comfort (e.g. phonetics, air leakage, diet). The thickness of the prosthetic artificial gingival tissue will compensate for the lost tissue.

As a general rule, the prosthetic screws emerge at the level of the lateral incisors, first premolars and first molars. In rare cases of maxillae with severe bone resorption or skeletal class II patients, where the anterior bone is very thin, it may be necessary to
reduce the number of implants to 4 (n = 6). The 2 anterior implants will then be placed with a vestibular/palatine angulation, which may imply the use of angulated abutments. The 2 distal implants will be tilted along the anterior walls of the sinus\textsuperscript{26}, and the 2 intermediate implants should be placed into the most favourable sites (premolar or canine).

When compared to the treatment outcomes of the mandible presented in a previous study\textsuperscript{13}, the proportion of tapered implants is higher (94.8\% in the maxilla versus 17\% in the mandible). The reason for this is the demand for high primary stability, which is crucial in eliminating micromovements and thereby promoting osseointegration. The technique of underpreparing implant sites\textsuperscript{7,24} increases primary stability.

The length of the implant is another important aspect to be considered in order to gain a maximum degree of primary stability. Whenever possible, the longest implants are recommended with the aim of increasing the bone-implant interface and to look for an anchorage beyond the alveolar socket. Almost all implants (98.5\%) were longer than 10 mm; 481 (71.25 \%) were 13 mm long or longer (Table 2). Implants with a diameter of 4 mm were used.

Fourteen fractures of the acrylic resin were reported, and most were fractures of the anterior teeth. Generally these can be explained by specific clinical situations, as was the case for 10 patients. The thickness of the resin seems to play a role. Under-estimation of the vertical dimension, limited prosthetic space and excessive vestibular placement of the fixation for the screw-retained prosthesis tend to reduce the volume of the resin and increase the fragility of the temporary prosthesis.

The benefits of the described technique with tooth extractions, immediate implant placement, and a one-stage implant procedure with immediate loading, can be seen in the high acceptance by patients. Even though a formal patient satisfaction assessment was not performed in this study, feedback was mostly positive for the following reasons: the number of interventions was reduced with fewer chairside steps, the surgical protocol was simplified, the total treatment duration was shorter, patients spent only a few hours without teeth, and, by means of provisional prostheses, soft tissues had healed and matured before finalising the prosthetic procedures.

Limitations of the present study are the retrospective nature of the protocol and the low statistical power. However, it can be concluded that immediate implant placement and loading of cross-arch maxillary fixed dental prostheses resulted in high implant and prosthetic survival rates.

Due to the restriction to fully edentulous patients, the results of the present study cannot be used to extrapolate the success to other situations, either with single or partial implants. Separate studies need to be conducted to evaluate these situations.

### References


### Conclusions

Within the limits of the retrospective nature of this study, the rehabilitation of maxillae after multiple tooth extractions with immediate implant placement and immediate loading can be highly successful. This technique reduces the overall duration of treatment time and allows patients to spend only a few hours without teeth. Placement in healed or fresh extraction bone sites may not have influenced implant survival to a great extent.


