

Immediately Loaded Mandibular Fixed Implant Prosthesis Using the All-On-Four Protocol: A Report of 183 Consecutively Treated Patients with 1 Year of Function in Definitive Prosthesis

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Purpose: The purpose of this study was to evaluate a specific protocol using four implants to support immediately loaded fixed prostheses to restore edentulous and partially edentulous mandibles and report on the outcome after 1 year of function with the definitive prostheses. **Materials and Methods:** A retrospective study was conducted of all patients who were treated between June 2008 and December 2010 with fixed prostheses that were loaded immediately after placement of implants. The provisional prostheses were later replaced with computer-aided design/computer-assisted manufacture titanium frames supporting acrylic resin and denture teeth in the definitive prosthesis. All patients were followed for a minimum of 12 months and were assessed for implant survival and prosthetic performance, with descriptive statistics utilized to demonstrate results. **Results:** One hundred eighty-three consecutive patients received immediately loaded axial and tilted implants according to the defined protocol. One implant failed, resulting in a 99.86% implant success rate. There were two catastrophic prosthetic failures (fracture of the titanium framework), for a 98.9% prosthetic success rate. Three patients (1.6%) presented with fracture of a prosthetic mandibular incisor tooth. No prosthetic screw loosening or fractures were seen. Radiographic evaluation revealed no major bone loss around dental implants. **Conclusions:** Based on this retrospective study, the following conclusions can be drawn: (1) this technique appears to provide a highly predictable implant performance; (2) it is necessary to critically evaluate framework design, especially around the connectors for cantilever extensions around the most distal implants; and (3) minor complications related to acrylic resin tooth fracture may be anticipated during the early phases of prosthetic treatment. *INT J ORAL MAXILLOFAC IMPLANTS* 2012;27:628–633.

Key words: dental implants, immediate loading, implant-supported fixed prosthesis, tilted implants

The comprehensive reconstruction of the mandible presents a multidisciplinary challenge. The typical resorption pattern of the mandible makes its rehabilitation both complex and difficult because of the mechanics of complete dentures.^{1–3} The rehabilitation of teeth and hard and soft tissues features inherent difficulties, which can be overcome by dental implants and various surgical and prosthetic treatments, such as intraforaminal implant supporting prostheses with long distal cantilevers⁴ or short dental implants.⁵

The use of as few as four implants for the reconstruction of edentulous maxillae and mandibles was reported by Brånemark et al in a 10-year retrospective study.⁶

The survival rates for both implants and prostheses were the same after 10 years in patients restored with four implants and in those restored with six implants, validating the four-implant treatment modality.

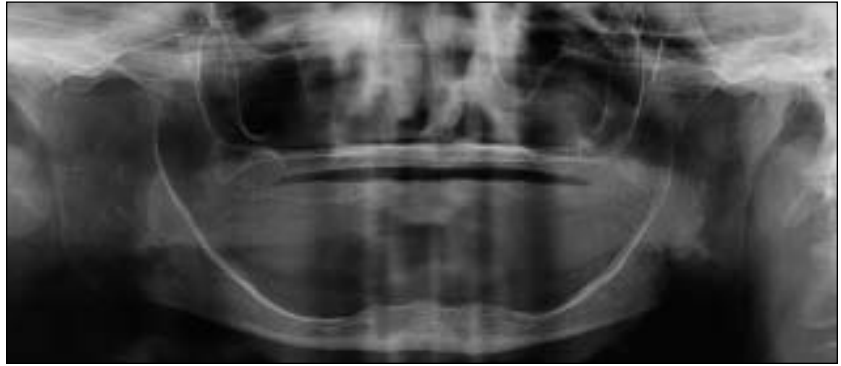
The use of tilted distal implants for the support of a fixed hybrid prosthesis has been reported by varied authors as a viable alternative to grafting, nerve lateralization, and extensive cantilevers, as it offers an increased prosthetic base of support.^{7–11} Clinical studies related to the placement of tilted implants have demonstrated that this is a feasible treatment option, enabling implant placement without the need for additional grafting procedures and greatly reducing cantilever length without sacrificing the anteroposterior stability of the prosthesis.¹² The tilting of the distal implants was also found to reduce the tensile stresses placed on the prosthesis. Two-dimensional finite element analysis demonstrated that the use of cantilevers results in higher stress in the marginal bone around implants. The elimination of the cantilever arm by the use of an apically tilted implant mitigated the observed stress pattern in

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Fig 1 Preoperative panoramic radiograph of a patient with severe mandibular posterior alveolar atrophy.



the bone.¹³ Furthermore, Krekmanov et al and Agliardi et al demonstrated that tilted implants did not exhibit advanced or extreme bone loss, nor did they demonstrate significant bone stress in comparison to cantilevers on traditionally placed vertical implants.^{7,8}

Immediate loading of implants placed in healed ridges or following dental extractions allows for a shortened treatment time by reducing the healing phase, reduces the number of surgical procedures, and allows for the delivery of a functional prosthesis in a short time frame while still providing favorable treatment results.^{14–16} In addition, immediate loading avoids the need for provisional complete removable prostheses, which have poor patient acceptance, especially in the mandible.¹⁷

Initial work on immediately loaded mandibular implants came from Schnitman et al in their reported 10-year experience using Brånemark implants.¹⁸ Since then, the concept of immediately loaded full-arch splinted restorations in the edentulous mandible, supported by four or six implants, has been well documented by several authors.^{19–22} The use of fewer implants in immediate loading situations in the edentulous mandible was further elaborated by Maló and Rangert under a method now known as the All-on-Four concept.²³ The technique employed four Nobel Biocare Speedy TiUnite implants, with the anterior implants placed vertically and the posterior implants placed at a 30-degree angle. All implants underwent immediate loading with a splinted one-piece all-acrylic resin full-arch restoration. A 1-year follow-up study demonstrated a prosthesis success rate of 100% and implant success rates of 96.7% and 98.2%, respectively, for their development and routine groups.

The principles of tooth extraction, immediate placement, and immediate loading have also been elaborated extensively in the literature, and this modality has become an accepted treatment option.^{24–26} Villa and Rangert reported on the placement of dental implants into compromised extraction sites (periodontal disease and endodontic lesions) and loading with a provisional all-acrylic resin prosthesis within 3 days postoperatively.²⁷ The implant success rate after up to

44 months was reported at 100%, with marginal bone loss of 0.5 to 0.7 mm during the first year. Similar results were reported by Cooper et al²⁸ and Grunder²⁰ following a similar protocol of extraction, immediate placement, and loading; the authors reported survival rates of 100% and 97.3%, respectively. Using standard surgical and maintenance protocols, Maló and coworkers reported a cumulative implant survival rate with immediate extraction, placement, and loading of 100% at 1 year, with average bone loss of 1.1 mm.²⁹

The present study is a retrospective analysis of 183 consecutive patients treated between June 2008 and December 2010, each of whom was restored with four dental implants and fixed acrylic resin prostheses that were loaded immediately following surgical placement of implants. Ultimately, the provisional prostheses were replaced with computer-aided design/computer-assisted manufacture (CAD/CAM) titanium frames that supported acrylic resin and denture teeth in the definitive prosthesis. All patients were followed for a minimum of 12 months after seating of the definitive prostheses and were assessed for implant survival and prosthetic performance. Descriptive statistics were utilized to assess the results.

MATERIALS AND METHODS

Patients of any race and gender were treated if they were at least 18 years of age and in good general health (both physical and psychologic) and able to undergo conventional dental implant surgery and immediate restorative procedures. The selection protocol included a comprehensive prosthetic exam, presurgical discussion with necessary medical consultations, and an anesthesia evaluation. Only patients with an American Society of Anesthesiologists status of 1 or 2 were treated.

The presurgical prosthetic treatment included comprehensive clinical and radiographic evaluation including cone beam computed tomography (CBCT) scanning and periapical and panoramic radiography (Fig 1). Bone height and width, cortical anatomy, and



Fig 2 Occlusal view of mandibular provisional with adjusted occlusal scheme.



Fig 3 Occlusal view of the healed tissues and four multi-unit abutments, 4 months after surgery.

position and trajectory of the inferior alveolar nerve were evaluated using the CBCT software. The anticipated bone reduction was evaluated clinically and radiographically and noted on the surgical prescription. The overall goal was to ensure at least 15 mm of clearance in the anterior mandible and 12 mm in the posterior mandible for structural integrity of the provisional and definitive prostheses.

All patients were treated by the same surgical-prosthetic team. Extractions and/or bone reduction was performed when indicated, followed by simultaneous implant placement and immediate (within 2 to 3 hours postsurgery) occlusal loading with a fixed acrylic resin full-arch prosthesis. All surgical treatment was completed under intravenous sedation, including intraoperative glucose monitoring when required. When teeth were present, these were removed in the most atraumatic fashion using periostomes and forceps. The mental nerve was identified bilaterally in relation to the distalmost extraction sites. The alveolar ridge was reduced according to the clinical requirements of each individual patient. The midline was identified and a 2-mm twist drill was used to develop the osteotomy for the surgical guide. Posterior implant sites were developed just distal to the second premolar at a 30-degree angle and anterior sites were in the canine or lateral incisor areas.

Following implant placement, straight or angulated multi-unit abutments (Nobel Biocare) were torqued according to the manufacturer's instructions, followed by soft tissue management and closure. Impression copings were attached to the prosthetic abutments and an impression was made on a clear disposable tray using cartridge-dispensed Aquasil Ultra Rigid Regular Set (Dentsply Caulk) and Imprint 3 Penta Heavy Body (3M/ESPE). The impression was allowed to set and was then removed and inspected for completeness. The

impression was then poured using Gingifast Rigid soft tissue material (Zhermack Technical) and type IV dental stone. Provisional cylinders were then connected to prosthetic abutments and luted to the mandibular complete denture using Unifast Trad acrylic resin (GC America) to verify the occlusal plane orientation. The provisional prosthesis was then finished on the surgical casts and inserted 2 to 3 hours later. Prosthetic screws were torqued to 15 Ncm and the access holes were sealed with Teflon tape (DuPont) and Fermit (Ivoclar Vivadent AG). The prosthesis was designed with centric occlusion with no occlusal contacts in the second premolar/first molar area and with excursive group function (Fig 2).

Patients were advised to adhere to a soft diet for the first 2 months postsurgery and to return to a regular diet but avoid harder food items for another 2 months. The patients were seen for follow-up appointments after 10 days, 2 months, and 4 months. During the healing phase, all necessary treatment for the maxilla was completed, with the exception of those patients receiving similar dental implant treatment. In that scenario, both arches were restored simultaneously.

After 4 to 6 months in function with the provisional and in the absence of pain and inflammation, definitive restorative procedures were initiated, including maxillomandibular records and final impressions. The provisional was removed and implant stability checked using a manual torque wrench (Fig 3). Implants with angulated multi-unit abutments were torqued to 15 Ncm, while straight abutments were torqued to 35 Ncm. A previously fabricated and sectioned Pattern Resin LS jig (GC America) on temporary copings (Nobel Biocare) was fixed over its corresponding abutments and joined with composite resin. After setting, the final impressions were made using Imprint 3 Monophase (Medium-Body) and Imprint 3 Penta



Fig 4 Anterior view of the definitive mandibular hybrid CAD/CAM prosthesis.



Fig 5 Definitive prosthesis fixed over implants and torqued to 15 Ncm; the access holes were sealed with composite resin.

Fig 6 Panoramic radiograph of definitive prosthesis and implants.



Heavy-Body impression materials on rigid disposable trays (Directed Flow Impression Trays, 3M/ESPE). Final impressions were poured with Gingifast Rigid and type IV dental stone. Irreversible hydrocolloid impressions (Jeltrate Plus, Dentsply) were made of the maxillary and mandibular provisionals and poured in type III dental stone. At that time, maxillomandibular records were obtained, facebow transfer was performed, and a traditional wax trial denture was fabricated.

The definitive prosthesis was made following the Nobel Biocare CAD/CAM Procera prosthetic procedures with a milled titanium framework (Fig 4). Centric occlusion was used, with group function for laterotrusive and protrusive excursions. The prosthetic screws were torqued to 15 Ncm and the access holes were sealed with PTFE tape and composite resin (Figs 5 and 6). Patients were re-evaluated at 10 days, 6 months, and 1 year after the delivery of the definitive prostheses.

The implants and prosthesis were evaluated at each control appointment, and the prosthesis was removed only if complications arose. Intraoral radiographs were obtained at abutment connection, 2 months, 4 months, framework try-in, seating of the definitive prosthesis, and annually thereafter. Follow-up CBCT scans were obtained at the 4-month postop appointment to evaluate the height and volume of the bone around the implants. Areas with inadequate bone height around an implant were planned for grafting. At all postoperative exams, the stability of the implants and the soft tissue around the abutments was checked and recorded, as were the integrity of the prosthesis and occlusion.

For the purposes of this study, implant survival was defined as dental implants that did not present with pain, infection, or mobility. Any complication related to material fracture, screw loosening, screw fracture, excessive material wear, or prosthetic loss was recorded. Descriptive statistics were used to report these outcomes.

Table 1 Distribution of Patients According to Gender and Dental Condition

Condition	Men	Women	Total
1 to 3 teeth remaining	3	2	5
4 to 6 teeth remaining	11	19	30
7 or more teeth remaining	60	65	125
Edentulous	8	15	23
Total	82	101	183

Table 3 Distribution of Implants According to Type

Implant type	No. of implants
Brånemark System Nobel Speedy Groovy	672
NobelActive	60
Total	732

Table 2 Distribution of Systemic Health Conditions Among Patients

Condition	Men	Women	Total
Smoking	28	27	55
Diabetes	10	4	14
Bruxism	22	21	43

Table 4 Distribution of Placed and Failed Implants According to Type and Angulation

Implant type/angulation	No. placed	No. failed
Nobel Speedy Groovy axial	337	1
Nobel Speedy Groovy angulated	335	0
NobelActive axial	29	0
NobelActive angulated	31	0
Total	732	1

RESULTS

This study reports on the treatment of 183 consecutive patients (82 men and 101 women; mean age at surgery, 60.3 years; range, 24 to 89 years) who received 732 dental implants (672 Brånemark System Nobel Speedy Groovy, 60 NobelActive, all with a TiUnite surface; Nobel Biocare) and immediate functional loading. Treatment was performed in 23 edentulous (12.6%) and 160 partially edentulous mandibles (87.4%) (Table 1). The patient population was very diverse and included smokers (30.1%), diabetics (7.7%), and self-diagnosed bruxers (23.5%) (Table 2).

All prostheses were supported by four dental implants. The total number of implants placed was 672 Speedy Groovy implants, which were inserted with torque values of at least 35 Ncm, and 60 NobelActive implants, which were inserted with torque of at least 70 Ncm. All implants had a TiUnite surface (Table 3).

Any implant that demonstrated pain, infection, or mobility was considered to have failed. During the course of treatment, one axial implant was lost in the anterior mandible as a result of postoperative infection 5 months after placement, for an individual implant survival rate of 99.86% (Table 4). In spite of this, the prosthesis remained stable; the failed implant was replaced and treatment continued. The survival rate for the provisionals was 100%.

After at least 1 year in function with the definitive prostheses, three patients (1.6%) presented with fracture of a denture tooth. The definitive prosthesis was removed, the fractured teeth were replaced, and the

prosthesis was resealed over the implants. Two patients (1.1%) presented with fracture of the titanium framework in the definitive prosthesis. These two prostheses were remade on new frameworks. No prosthetic screws loosened or fractured during the course of the study. No signs of excessive occlusal wear were noted at the 1-year evaluation in any of the patients.

All periapical radiographs were evaluated by the same clinician. There was no visual evidence of bone loss greater than 1 mm on any of the implants.

DISCUSSION

The purpose of this study was to evaluate the outcomes of a procedure designed to provide immediate rehabilitation of partially or completely edentulous mandibles using dental implants. The 1-year results indicate that this procedure has an excellent prognosis. These results are comparable to results presented by other authors^{23,30,31} using similar techniques, although this is the first report to present a significant partially edentulous cohort of patients who were restored immediately.

Several factors are involved in the success of these procedures. From the surgical perspective, the most notable are careful implant site preparation (including tapping), use of relatively low torque-producing implants, the preparation of an osseous shelf to level the alveolar ridge and establish optimum implant sites, and the provision of adequate interocclusal space. From a prosthetic perspective, the high success rate obtained with this protocol, including minimal bone

loss even with multiple extractions and bone reduction followed by immediate function, may be the result of stable splinting of all four implants with the provisional immediately after surgery, careful occlusal adjustment to provide bilateral occlusion in the canine and first premolar areas and avoid occlusal contact toward the distal of the prosthesis, and maximizing the anteroposterior spread. An anteroposterior spread that minimizes the distal cantilevers and establishes well-distributed four-point stability was probably contributory to both implant and prosthetic success.

CONCLUSION

The findings from this report confirm that a combination of axially placed and angulated dental implants, following the All-on-Four procedure, for the rehabilitation of partially edentulous and edentulous mandibles leads to excellent treatment results. The immediate function protocol described minimized surgical morbidity as a result of the reduced number of procedures and implants placed, reducing overall treatment time and cost to the patient and offering very high patient satisfaction.

In this study, the majority of patients had hopeless dentitions as a result of severe periodontal disease, caries, or a combination of both and did not want to have a removable provisional denture. The present findings confirm that immediate implant loading and function in the dental extraction setting can be performed with a high degree of confidence.

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