Immediate Rehabilitation of the Edentulous Mandible with a Definitive Prosthesis Supported by an Intraorally Welded Titanium Bar

Marco Degidi, MD, DDS[1]/Diego Nardi, DDS[1]/Adriano Piattelli, MD, DDS[2]

Purpose: *The aim of this prospective study was to evaluate the suitability of intraoral welding of implant frameworks to allow placement of the definitive restoration on the same day of surgery.* ***Materials and Methods:*** *Forty patients with an edentulous mandible were planned to be treated with a fixed restoration supported by an intraoral welded titanium bar. Definitive abutments were to be connected to the implants and then welded to a titanium bar using an intraoral welding unit. This framework was to be used as support for the definitive restoration, which was to be placed on the same day as the implants. Mean marginal bone loss and radiographically detectable alterations of the welded framework were to be assessed using periapical radiographs immediately after surgery, and at 6-, 12-, and 24-month follow-up examinations.* ***Results:*** *Twenty men and 20 women, with a mean age of 47.8 years (± 13.9), were consecutively treated with 160 immediately loaded implants. All implants osseointegrated. No fractures or radiographically detectable alterations of the welded frameworks were present. All implants were clinically stable at the 24-month follow-up. Mean marginal bone loss (n = 160 at all time points), assessed using 640 periapical radiographs, was 0.59 ± 0.12 mm at 6 months, 0.21 ± 0.051 mm at 12 months, and 0.11 ± 0.036 mm at 24 months. The accumulated mean marginal bone loss was 0.91 ± 0.21 mm.* ***Conclusions:*** *It is possible to successfully rehabilitate the edentulous mandible on the same day as implant placement surgery with a fixed definitive prosthesis supported by an intraorally welded titanium framework.* INT J ORAL MAXILLOFAC IMPLANTS 2009;24:342–347

Key words: *dental implants, immediate restoration, implant-supported prosthesis, titanium framework*

Several studies have reported that rehabilitation with a fixed, two-stage, implant-retained prosthesis is a predictable long-term therapy for the edentulous mandible. In recent years, researchers have been focusing on a technique that allows the placement of a definitive restoration on the same day as surgery or a few days afterward.

In 1999, Brånemark et al[1] proposed a clinical protocol with prefabricated components and surgical guides, elimination of the prosthetic impression procedure, and attachment of a definitive fixed prosthesis on the day of implant placement. The authors reported a 98% success rate for both implants and prostheses in the rehabilitation of mandibular edentulism, showing that a definitive reconstruction can be placed on the day of surgery.

[1]Private Practice, Bologna, Italy.
[2]Professor, Dental School, University of Chieti-Pescara, Chieti, Italy.

Correspondence to: Prof Adriano Piattelli, Via F. Sciucchi 63, 66100 Chieti, Italy. Fax: +390-871-3554076.
Email: apiattelli@ unich.it

Using Brånemark's clinical protocol, van Steenberghe et al[2] observed cumulative failure rates for implants and prostheses of 7.3% and 5%, respectively, after 1 year. The authors stated that marginal bone levels can be maintained around immediately loaded implants in the mandible in an average patient population for at least 1 year.

Klee de Vasconcellos et al[3] proposed the rehabilitation of the mandible with a definitive fixed prosthesis anchored by prefabricated titanium bars attached to the implants on the day of implant placement. The overall implant and prosthetic survival rates were 100%. The authors concluded that an immediately placed occlusally loaded complete fixed dental prosthesis supported by four implants did not appear to jeopardize osseointegration and represented a viable treatment. In 2006 Degidi et al[4] published a protocol for the immediate loading of multiple implants by welding a prefabricated titanium bar to implant abutments directly in the oral cavity, so as to create a customized metal-reinforced provisional restoration. The success of this protocol suggested to the authors that the same concept could be applied for a definitive restoration.

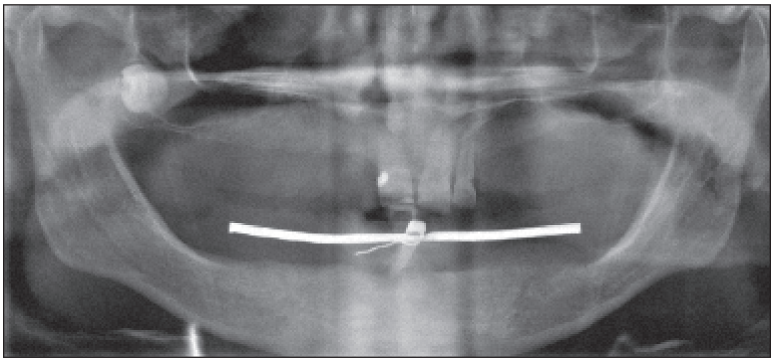

Fig 1 Presurgical panoramic radiograph.

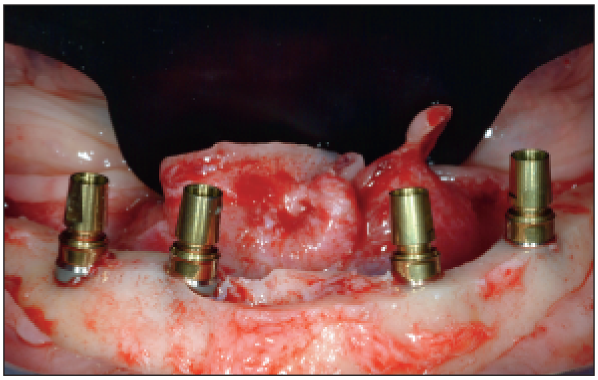

Fig 2 Four implants are placed in the interforaminal region.

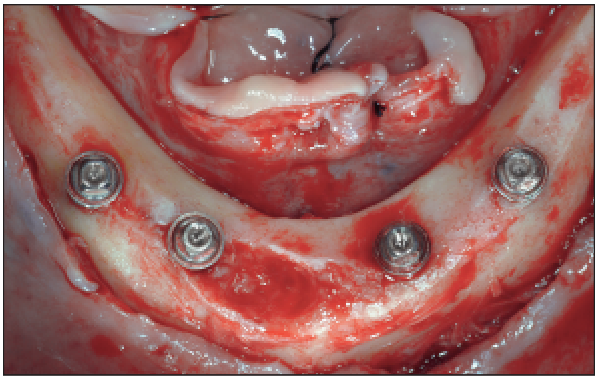

Fig 3 MP abutments are connected to the implants.

The aim of this study was to assess the suitability of intraoral welding to assist fabrication of a metal framework for a definitive restoration on the same day of implant placement.

MATERIALS AND METHODS

Forty patients, 20 men and 20 women, were consecutively included in this prospective study. All patients were at least 18 years old. Patients were not accepted into the study if they met any of the following exclusion criteria: (*1*) active infection in the sites intended for implant placement, (*2*) systemic disease that could compromise osseointegration, (*3*) treatment with radiation therapy in the craniofacial region within the past 12 months, (*4*) smoking more than 20 cigarettes per day, (*5*) pregnancy or lactation, (*6*) severe bruxism, (*7*) presence of a pacemaker, (*8*) unsuitable quantity of bone in the interforaminal region or need for bone augmentation procedures prior to implant placement, or (*9*) partial mandibular edentulism.

All implants were placed by the same experienced surgeon (MD) and were recruited in a private dental office in Bologna, Italy. Patients were eliminated from the study if at least one of the four implants to be placed met any of the following exclusion criteria: (*1*) did not achieve good primary stability, (*2*) was positioned with insertion torque < 25 Ncm, or (*3*) an implant stability quotient (ISQ) < 60 was recorded.

The patients were evaluated preoperatively with respect to mandibular size, bone quantity, interarch relationship, and maxillomandibular distance. Preoperative analysis of anatomic features was performed with panoramic radiography, lateral cephalograms, and computerized tomography. Impressions were made of the maxilla and mandible, and laboratory casts were made. The color, shade, and structure of the prosthetic teeth were decided, and appropriate highly wear-resistant commercial denture teeth (VITA PHYSIODENS, VITA Zahnfabrik/H. Rauter, Bad Säckingen, Germany) were chosen. According to the arch shape, which determined the cantilever length, 10 to 12 teeth were mounted on a mandibular cast on a semiadjustable articulator and joined with acrylic resin. This definitive acrylic resin cross-arch restoration was then hollowed to create a space for housing the future titanium framework.

All patients started antibiotic therapy the day before surgery (2 g amoxicillin per day). Local anesthesia (2% articaine/adrenaline 1:100,000) was also administered prior to surgery. Patients maintained a soft diet for 4 weeks after surgery. Oral hygiene instructions were provided.

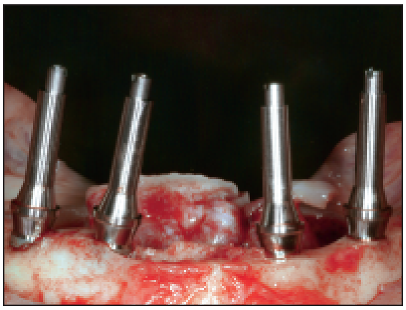

Fig 4 Welding abutments in position.

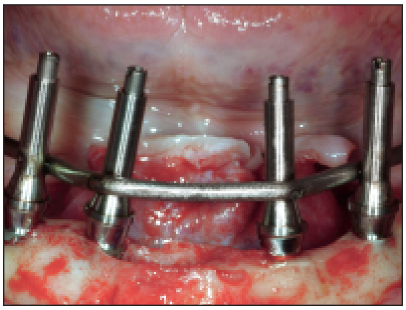

Fig 5 Intraorally welded framework.

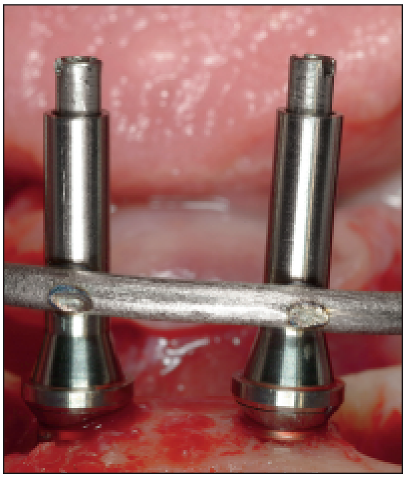

Fig 6 Abutment and intraorally welded bar: note the welding spot.

Surgery began with a crestal incision that ran from the right first molar position to the left first molar position. The mandible was exposed, and the mental foramina were located. In the case of immediate implantation or in the presence of a knife-edged ridge, a mild osteoplasty of the ridge was performed under profuse irrigation with sterile saline solution. Four implant sites were chosen in the interforaminal area: the distal sites were placed 2 mm mesial to the mental nerve, and the mesial sites equally divided the remaining anterior space (Figs 1 and 2). During the implant placement procedure, the insertion torque was registered by a surgical unit (Frios Unit E, W&H Dentalwerk). Definitive abutments (MP, DENTSPLY Friadent, Mannheim, Germany) were then attached to the implants by screws with a torque wrench (20 Ncm applied torque) (Fig 3). The next step was to attach a welding abutment (in effect a titanium cylinder) to each abutment using a long pin screw (Fig 4). Two-part abutments were used (abutment and retaining screw) to ensure that the welded framework could be recovered after welding. A 2-mm-diameter bar (Bio-Micron, Limbiate, Milano, Italy) made of commercially pure grade 2 titanium was welded to the first distal abutment on the left using an intraoral welding unit (Aptiva NS1100, EnneServizi, Lusiana, Vicenza, Italy). The bar was then bent with a pair of How straight utility pliers (Unitek, 3M, St. Paul, MN) so that its curve reached passive contact with the abutment next to the one that had just been welded. This process was repeated for the other abutments in turn (Fig 5).

Intraoral Welding

The modern intraoral welding protocol is a refinement of the technique reported by Mondani and Mondani[5] and Hruska.[6] The welding process is subdivided into three stages: preparation, welding, and cooling.

Preparation Stage. The two electrodes of the welding pincers are placed on either side of the bar and the abutment, both of which must be clean and free of surface oxidation. The copper electrodes at the extremities of the pincers are gently put into contact with the parts to be welded and firm pressure is then applied. It is crucial to maintain complete contact between the curved bar and the welding abutment during the entire process. Firm and constant pressure must be constantly applied to ensure a perfect joint between the parts to be welded. The presence of water or saliva does not compromise the quality of the welded joint. The surgical team and the patient must wear protective goggles during the entire process.

Welding Stage. An electrical charge from a previously unloaded capacitor is transferred to the copper electrodes of the welding pincers. Electrical current supplied to the electrodes instantly raises the temperature of the two titanium components to fusion point (Fig 6). The process takes only 2 to 5 ms to carry out and brings the core of the titanium parts to a temperature of nearly 1,660°C. A barely perceptible clicking sound can be heard during this phase. Welding is performed without the use of filler metal.

Cooling Stage. Thanks to the different thermal conductivity of the titanium parts (19) and copper electrodes (386), the process is carried out without producing any discomfort to the patient or damage to the surrounding tissue, as no heat is transmitted to the peri-implant area. The copper electrodes dissipate all the heat that is generated. During this stage, the titanium crystallizes; therefore, the bar and the abutment must be kept under firm pressure.

Fig 7 The welded framework is removed.

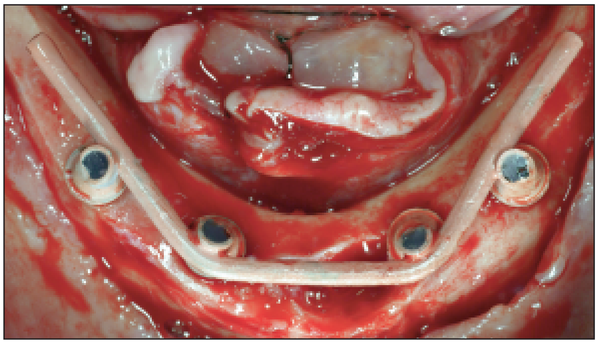

Fig 8 Opaqued framework repositioned in the oral cavity.

Fig 9 Trimmed and polished definitive restoration.

Fig 10 Screw-retained definitive restoration.

If all of the aforementioned instructions are followed carefully, a solid joint is created. The operator must always be very accurate during the preparation stage. The only way the process can fail is if there is inaccurate positioning of the titanium components or if insufficient pressure is applied during the welding and cooling stages. If either of these occur, the joint obtained is very unstable and fragile. In this event, the joint must be broken with the utility pliers, the surfaces of the bar and the abutment must be carefully polished, and the process must be repeated. In short, without perfect contact between the titanium components and the copper electrodes, the welding process must not take place.

Finally, the prosthetic framework created by welding the titanium bar to the implant abutments is removed (Fig 7). The passive fit of the whole structure is checked with the Sheffield 1-screw test. The framework was then sandblasted (Modulars 3, Silfradent, S. Sofia, Forli-Cesena, Italy) and opaqued (OVS 2 Opaker, Dentsply Trubyte, York, PA) to avoid reflection of the metal through the acrylic resin. The soft tissue was positioned around the abutments and sutured into place. The opaqued framework was repositioned in the oral cavity and the hollowed acrylic restoration was relined over the titanium framework (Figs 8 and 9). During the relining procedure, the correct vertical length was confirmed and established using facial reference marks recorded prior to surgery. The restoration was trimmed, polished, and screwed into place the same day (Fig 10). The prosthesis was connected to the abutments by fastening four titanium retaining screws with a torque wrench using 20 Ncm torque. Screw holes were closed with light-cured composite resin. Antibiotics were prescribed for 5 days postoperatively (2 g amoxicillin per day).

Patient Assessment

Mean marginal bone loss was assessed in each patient. Periapical radiographs were obtained after surgery and during follow-up examinations using a customized jig. Digital measurements were made employing the Jaffin et al[7] protocol, using platform height as a reference point. Each periapical radiograph was digitalized with an Epson Expression 1680 Pro scanner (Epson Italia spa, Cinisello Balsamo, Milano, Italy) and analyzed with CDR DICOM 3.0.1 (SP1, build 1046; Schick Technologies, Long Island City, NY) guide software and Meazure 2.0 (build 158; C Thing Software, Sunnyvale, CA) measurement software. Peri-implant probing was not performed because there is still controversy regarding the correlation between probing depth and implant success rates.[8]

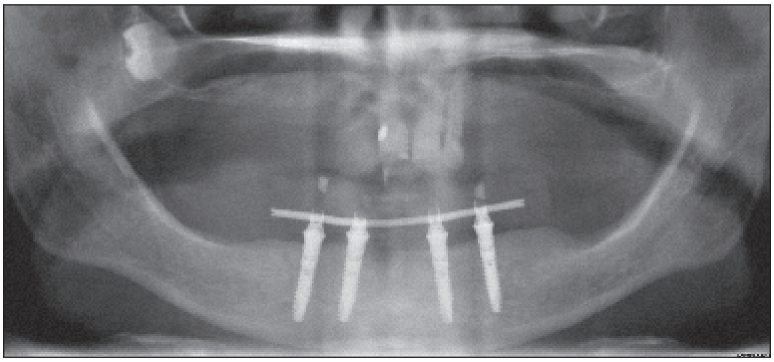

Fig 11 Final panoramic radiograph.

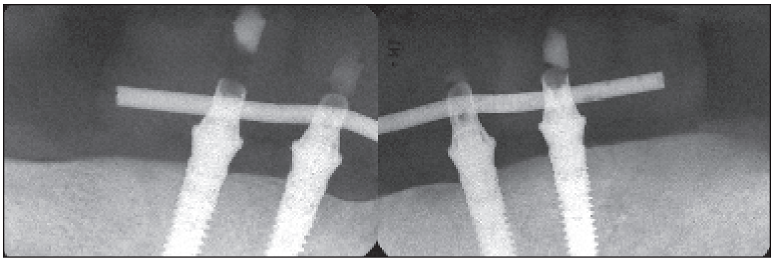

Fig 12 Two-year follow-up radiograph.

Periapical radiographs were obtained at:

- T0: after surgery and placement of the immediate definitive restoration (Fig 11)
- T1: after 6 months of full occlusal loading (6 months)
- T2: after 1 year of full occlusal loading (12 months)
- T3: after 2 years of full occlusal loading (24 months) (Fig 12)

RESULTS

The planned number of 40 patients was achieved. Between January and September 2005, 41 patients in good health were consecutively enrolled in this study.

Two implants in one patient failed to achieve the desired ISQ. The patient dropped out of the study and a classic delayed-loading protocol was performed.

Twenty men and 20 women received a fixed restoration that was attached to dental implants in the edentulous mandible. One hundred and sixty XiVE Plus implants (DENTSPLY Friadent) were placed in interforaminal locations and immediately loaded. The mean age of the patients at the time of surgery was 47.8 years (SD = 13.9).

All 160 implants osseointegrated. No fractures or radiographically perceptible alterations of the welded substructures were present. Two patients reported temporary discomfort and pain that ceased 15 and 21 days after surgery, respectively. Two patients reported a fracture of the acrylic resin superstructure 9 and 22 months after surgery, respectively. Both prostheses were easily repaired by a dental technician on the same day. All implants were clinically stable at the 24-month follow-up. Three patients (12 implants) could not be contacted after the 24-month follow-up.

Mean marginal bone loss was 0.59 mm (SD = 0.12; n = 160) at 6 months, 0.21 mm (SD = 0.051; n = 160) at 12 months, and 0.11 mm (SD = 0.036; n = 160) at 24 months (Table 1). The accumulated mean marginal bone loss was 0.91 mm (SD = 0.21; n = 160).

DISCUSSION

The previously reported results[4] regarding immediate intraorally welded provisional restorations prompted the authors to verify whether it was possible to place a definitive restoration immediately, thus further reducing the time and costs for both the patient and surgeon. Instead of provisional abutments (TempBase, DENTSPLY Friadent), definitive abutments were used (MP, DENTSPLY Friadent), and rather than provisional acrylic resin teeth, definitive micro-filled reinforced polyacrylic commercial denture teeth were used (VITA PHYSIODENS, VITA Zahnfabrik).

This study achieved 100% implant and prosthetic survival rates at the 24-month follow-up. Minor, easily repaired fractures in two patients did not compromise the function of the prostheses.

Table 1 Progressive Mean Marginal Bone Loss (n = 160)

Time period	Bone loss (mm)
T0 to T1	0.59 ± 0.12
T1 to T2	0.21 ± 0.051
T2 to T3	0.11 ± 0.036
T0 to T3	0.91 ± 0.21

T0 = baseline; T= 6 months posttreatment; T2 = 12 months posttreatment; T3 = 24 months posttreatment.

The mean marginal bone loss observed in this study after 24 months of loading (0.91 mm) was similar to that reported by Klee de Vasconcellos et al,[3] Brånemark et al,[1] and Testori et al.[9]

Studies published to date and reporting on the placement of a definitive restoration supported only by interforaminal implants on the same day as implant placement are based on the use of prefabricated[2,3] or computer-assisted design/computer-aided manufactured (CAD/CAM) frameworks.[10] The intraoral welding concept allows the clinician to assemble and weld the framework directly in the patient's mouth. In this study, 160 welding joints between the abutment and the titanium bar were analyzed at each follow-up visit, and no fractures or radiographically detectable alterations of the welded framework were present after 24 months of functional loading. The welding joint structure was analyzed in a previous study,[4] which reported excellent microstructural quality, with only minor porosity detected at 50,000× magnification. However, a greater duration of follow-up is necessary to confirm the long-term stability of the welded joint.

The cost of a modern intraoral welding unit is comparable to that of any other important piece of surgical equipment. Compared to prefabricated[2,3] or CAD/ CAM[10] restorations, the prosthetic procedure described in this study is also extremely cost-effective, employing a simple titanium bar, commercially manufactured denture teeth, and standard titanium abutments.

Assembling and welding the framework directly in the patient's mouth allows the creation of a precise and passively fitting structure, without the need for any correction or further components, as is often necessary with CAD/CAM frameworks.[11] The technique described in this article grants more flexibility compared to what is possible with prefabricated framework procedures,[2,3] enabling the clinician to shape and weld the titanium bar according to the mandibular anatomy of each individual patient.

CONCLUSIONS

The goal of an immediate-loading protocol is to reduce the number of surgical procedures and to shorten the time frame between surgery and prosthetic placement without compromising the implant success rate. Within its limitations, this study has demonstrated that it is possible to successfully rehabilitate the edentulous mandible the same day as implant placement with a fixed definitive restoration supported by an intraorally welded titanium framework without jeopardizing osseointegration.

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