A Six-Year Follow-up of Full-Arch Immediate Restorations Fabricated With an Intraoral Welding Technique

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Monzani and Mondani were the first to introduce a time-effective technique for intraorally welding titanium implants and components to create a fixed prosthesis without the need for lengthy laboratory procedures. Hruska further developed this concept and, in 2002, he published a clinical report regarding the immediate loading of 1301 implants, of which 436 were used to support partial or full-arch temporary prostheses that were relined over an intraorally welded framework. The failure of 3 (0.7%) of these implants was reported in this article: 1 failed after 1 year of loading because its neck fractured, and 2 failed between the second and the third year after surgery because of periimplantitis. The authors noted that in cases involving extended reconstructions, intraoral welding had the advantage of simplifying the application of the fixed temporary prosthesis by overcoming the problem of abutment disparallelism. Furthermore, the welded framework acted as a mesestructure and reduced the risk of fracture or partial luting failure of the temporary prosthesis.

Purpose: The aim of this study was to evaluate the 6-year effectiveness of maxillary and mandibular full-arch immediately loaded prostheses fabricated using an intraoral welding technique.

Methods: All patients received the same day of surgery a fixed full-arch prosthesis supported by an intraorally welded titanium framework created directly in the patient’s mouth using a titanium bar. Life table analysis of implant survival, complications, and any other adverse events were recorded at yearly follow-up for a period of 6 years.

Results: One hundred twenty-four (86.11%) of 144 implants placed in maxillary cases and 87 (77.68%) of 112 implants placed in mandible cases completed the planned 6-year follow-up. At the 72-month follow-up, the accumulated mean marginal bone loss was, respectively, 1.39 mm (SD = 0.67) for the implants placed in the maxilla (n = 124) and 1.29 mm (SD = 0.71) for the implants placed in the mandible (n = 87). Fracturing of the composite resin superstructure was the most common adverse event.

Conclusions: After a 6-year follow-up period, the intraoral welding technique proved to be a predictable technique for successfully rehabilitating the fully edentulous patient with a fixed and immediate prosthesis. (Implant Dent 2013;22:224–231)

Key Words: intraoral welding, immediate loading

More than 20 years after the article by Monzani and Mondani, Degidi et al published a protocol for the immediate loading of multiple implants using a premanufactured titanium bar welded to implant abutments directly in the oral cavity to create a customized metal-reinforced provisional prosthesis. All the 192 rigidly temporized immediately loaded implants osseointegrated and an implant success rate of 100% was achieved over a postplacement period of 6 months. No fracture or luting cement failure of the provisional restoration occurred during the observation period. A finite element analysis of the provisional prostheses resulted in a significant reduction in deformation and strain within the metal-reinforced restoration in comparison with the ordinary nonreinforced acrylic restoration. The intraoral welding technique subsequently proved to be a highly successful option in the rehabilitation of the edentulous mandible with a fixed final restoration delivered on the same day as implant placement, using both butt-joint and tapered connection implants. The same positive outcomes were reported for the rehabilitation of the edentulous maxilla and in cases involving posterior mandibular edentulism, using
both immediately loaded and immediately restored implants.\textsuperscript{8} Recently, Avvanzo et al\textsuperscript{7} reported the immediate provisionalization of 48 dental implants placed in augmented sites and stabilized with an intraorally welded framework in a retrospective case series. Hruska et al\textsuperscript{3,9} provided the longest follow-up available for the intraoral welding technique using blade-form titanium implants (Linkow, Ortronics, Hruska, and SteriOss), and root-form titanium implants (Garbaccio, Hruska, Pasqualini, SteriOss without hex-lock, and SteriOss with hexlock). To the best of the authors’ knowledge, the longest available follow-up on implants in literature is 3 years for both partial\textsuperscript{10} and full prostheses.\textsuperscript{10}

The aim of this study was to evaluate the 6-year effectiveness of maxillary and mandibular full-arch immediate restorations fabricated using the intraoral welding technique.

**Materials and Methods**

This prospective study involved patients with complete mandibular or maxillary edentulism with an age of 18 years or older. This study was designed and conducted in full accordance with the World Medical Association Declaration of Helsinki, as revised in 2002. All patients signed a specific written informed consent form. Patients were not accepted into the study if any of the following exclusion criteria were met: (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 previous 12 months; (4) pregnancy or lactation; (5) bruxism; (6) unsuitable bone quantity in the surgery site or need of bone augmentation procedures before implant placement. All implants were placed in healed sites by a single experienced surgeon in a private dental office in Bologna, Italy. All patients were treated using 3.4- or 3.8-mm parallel screw, grit-blasted and acid-etched implants with an internal hexagonal connection (XIVE Plus; DENTSPLY-Friadent, Mannheim, Germany).

During the implant placement procedure, the insertion torque and the implant stability quotient (ISQ) were recorded using a surgical unit (FRIOS Unit E; W&H Dentalwerk GmbH, Bueromoos, Austria) and a digital measurement probe (Ossstell AB, Garnelealvägen 3B, Göteborg, Sweden). Patients were dropped from the study if any of the implants met one of the following exclusion criteria: (1) insertion torque <25 N·cm; (2) an ISQ of <60.

Preoperative analysis of anatomical features was performed using digital panoramic radiography. Impressions were made of the maxilla and mandible, and laboratory casts were made. The shades and prosthetic teeth molds were selected. The appropriate number of commercial highly wear-resistant composite denture teeth was chosen (Visio Lign; Bredent GmbH, Senden, Germany), and they were arranged on a cast mounted on a semiadjustable articulator and then joined with heat-polymerized resin. Antimicrobial prophylaxis was obtained with the use of 500 mg of beta-lactam antibiotics (Amoxicillin; Pfizer Manufacturing, Puurs, Belgium), twice daily for 5 days, starting 1 hour before surgery. All patients received detailed oral hygiene instructions. Local anesthesia (2% articaine/adrenaline
1:100,000) was administered at the time of surgery. Surgery began with a mid-
crestal incision, a full-thickness flap was elevated, and in cases involving a knife-
edge ridge, a mild osteoplasty of the ridge was performed under profuse irrigation
with sterile saline solution. Depending on the site of surgery, sensitive anatomical
features, such as the mental foramina, were located and secured. All implants
were placed without the use of any surgical template, with the 0.4-mm pol-
ished collar above the healed alveolar crest. Implants with lengths from 11.0 to
15.0 mm were used. Bone density was recorded after the insertion of each
implant using the Lekholm and Zarb classification.3 No bone grafting materi-
1al was used. The internal hexagonal connection of the implant was replaced
by an abutment with an external circular and conic connection (MP; DENTSPLY-
Friadent) to compensate for any possible lack of parallelism between the implants.
These abutments were connected to the implants by fastening screws with 24
N·cm torque. A welding abutment (Passive Fit; DENTSPLY-Friadent) was then
connected to each abutment with a long pin screw. Two-part abutments were used
(abutment and retaining screw), so as to guarantee that the welded framework
could be recovered after welding. A
2.0-mm-diameter bar (Bio-Micron s.a.s.,
Limbiate, Milano, Italy) made of com-
mercially pure titanium (grade 2) was
welded to the first abutment using the
intraoral welding protocol.3 The welding
process is subdivided into 3 stages: prep-
1aration, welding, and cooling.

Preparation Stage

The 2 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 any surface
oxidation. The copper electrodes at the extremity of the pincers are gently put in
contact with the parts to be welded and firm pressure is then applied. It is

![Fig. 5. Pressure applied with the clamp during the spot welding.](image)

![Fig. 6. The bar is welded to each abutment.](image)

![Fig. 7. The framework is removed.](image)

![Fig. 8. Extraorally, the framework is reinforced and retentions are added.](image)

![Fig. 9. The framework is placed on the abutments.](image)

![Fig. 10. The framework is cemented on the abutments.](image)

![Fig. 11. The framework is adjusted on the abutments.](image)

![Fig. 12. The framework is finished and polished.](image)

![Fig. 13. The framework is checked for fit.](image)

![Fig. 14. The framework is sanded and polished.](image)

![Fig. 15. The framework is checked for fit.](image)

![Fig. 16. The framework is finished and polished.](image)

![Fig. 17. The framework is checked for fit.](image)

![Fig. 18. The framework is finished and polished.](image)

Researchers concluded that the use of the new welding technique significantly
improved the strength and longevity of the restorations, making it a viable
alternative to conventional soldering methods.
composite resin. All the immediate prostheses were subsequently under full occlusal load (Figs. 1–16).

The patients were recalled for a professional cleaning treatment by a dental hygienist every 6 months. Periapical radiographs taken with a customized positioning jig and a complete set of probing measurements were performed at each scheduled follow-up.

The following assessments were made:

- Life table analysis of implant survival, with implant survival defined as absence of implant mobility and swelling, including cases subject to more than 2.0 mm of peri-implant bone loss or positive outcome of treated mucositis or peri-implantitis.
- Changes in marginal peri-implant bone level, defined as modification of the distance between the implant-abutment junction and the highest coronal point of the supporting bone, were assessed using periapical radiographs taken with a customized positioning jig. Each periapical x-ray was digitized with a scanner (Epson Expression 1680 Pro; Epson Italia, Cimisello Balsamo, Milano, Italy) and analyzed with measurement software (Measure 2.0 build 158; C Thing Software, Sunnyvale, CA) using platform height and implant length as double cross-references. The precision of the digital measurement was set at 0.1 mm.
- Biological or technical complications and any other adverse event, including incidence of mucositis and peri-implantitis, the need for any repair procedure, fracturing of the acrylic superstructure or the welded joints, speech problems and occlusion defects.

Follow-up frequency was:

- T0: after surgery and fitting of the immediate final prosthesis.
- T1: 6 months after surgery.
- T2: 1 year after surgery.
- T3: 2 years after surgery.
- T4: 3 years after surgery.
- T5: 4 years after surgery.
- T6: 5 years after surgery.
- T7: 6 years after surgery.

RESULTS

A total of 256 implants were consecutively placed in 52 patients in the period between February 2004 and March 2006. The mean age of the patients at the time of surgery was 62 years (SD = 10.2 years; minimum, 45 years; maximum, 79 years). One hundred twenty-six (49.22%) and 130 (50.78%) implants were, respectively, placed in female and male patients. One hundred forty-four (56.25%) implants were placed in 24 maxillary cases and 112 (43.75%) implants were placed in 28 mandible cases. All implants were placed in healed sites without the use of any bone grafting material. The details of the age and gender distribution and the smoking habits of the patients are displayed in Table 1.Average insertion torque, ISQ values, and bone quality assessments are listed in Table 2. At the 72-month follow-up, the accumulated mean marginal bone loss was, respectively, 1.39 mm (SD = 0.67 mm) for the implants placed in the maxilla (n = 124) and 1.29 mm (SD = 0.71 mm) for the implants placed in the mandible (n = 87) (Table 3).

A life table cumulative survival rate (CSR) of 90.31% was achieved by the implants in this study. More specifically, the implants placed in the maxillary sites achieved a CSR of 92.12% and the implants placed in the mandible sites achieved a CSR of 87.89%. Forty-two (16.4%) implants were lost because 9 (17.3%) patients
were not traceable or refused to attend the scheduled follow-up (Table 4).

One implant placed in the maxillary lateral right incisor position and 1 implant placed in the right first bicuspid mandible area failed to osseointegrate. Two patients, a 69-year-old nonsmoking woman and a 72-year-old moderate smoking man, reported minor discomfort, pain, and moderate gingival bleeding. The prostheses were subsequently removed and the implants were found to be mobile. The implants were removed, and the prostheses were carefully reined and modified. Pain was immediately controlled with 1000 mg of paracetamol, and the patient underwent an antimicrobial cycle, consisting of 500 mg of beta-lactam antibiotics twice daily for 5 days. The modified prosthesis was put back in place 2 hours after implant removal.

One hundred twenty-four (86.11%) of 144 implants placed in maxillary cases and 87 (77.68%) of 112 implants placed in mandible cases were without problems at the 6-year follow-up. Signs of soft tissues' adverse events were present in a total of 32 (15.16%) of 211 implants at the end of the follow-up. There was inflammation of the mucosal cuff around the neck of the implant associated with edema, rubor, and bleeding on probing in the area around 25 (11.85%) implants. The implants were classified as positive for mucositis and were treated with weekly professional submucosal debridement sessions and home mouth rinses with 0.2% chlorhexidine until complete remission of the symptoms. Seven (3.31%) implants presented more important signs of infection, with purulence and peri-implant radiological translucency. The implants were then classified as positive for peri-implantitis.

<table>
<thead>
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<th>Table 1. Age, Gender Distribution, and Smoking Habits</th>
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The prostheses were removed and a full-thickness flap was elevated. The bone defect and implant surface were deeply cleaned and debrided using carbon curettes. Local irrigation with 1 g of tetracycline was performed, and the soft tissues were sutured into place. Home mouth rinses with 0.2% chlorhexidine and local application of 1% chlorhexidine gel were prescribed until the complete absence of the symptoms.

One patient reported a persisting sensory disturbance immediately after the local anesthesia wore off 2 hours after surgery. The control periapical radiograph revealed a distance of more than 2 mm distal to the mental foramen. The patient was then recalled weekly for a mental nerve sensornial control until complete recovery, which was achieved 4 weeks after surgery.

Respectively, 1 and 2 weeks after surgery, 1 female and 1 male patient with maxillary prostheses reported discomfort associated with moderate chewing difficulties. The prostheses were carefully modified to reduce occlusal contact in both centric and lateral excursions.

Three patients fitted with maxillary prostheses and 2 patients with mandible prostheses (a total of 5 patients) reported small fractures of the acrylic resin superstructure. All prostheses were repaired with light-cured composite resin, polished, and screw-retained within 1 hour.

One patient, a 62-year-old nonsmoking man, reported a complete fracture of the resin portion of the distal cantilever up to the titanium joint 4 years after surgery. The patient had been fitted with a full-arc mandible prosthesis. The fractured portion included one first molar and nearly 13 mm of the resin body. The opposing dentition consisted of a full implant supported metal and ceramic bridge. The prosthesis was removed, repared, and relined at the dental laboratory within 2 hours.

One patient, a 61-year-old light smoking woman, reported the fracture of the fixation of her full-arch mandible prosthesis during a car accident. After 2 weeks, a 2-week recovery period, implant stability was checked, new abutments fixing screws were tested, and the prosthesis was repaired and refitted.

In 9 patients, a minor relining procedure was required to close open spaces (4 cases), avoid food entrapment (3 cases), and fix speaking problems (2 cases). These procedures were performed at the 6-month follow-up and required a 2-hour appointment.
DISCUSSION

The metal-reinforced acrylic restoration fabricated using the intraoral welding approach can be adapted chairside when the soft tissue support changes. This is the case of major surgical osteoplasty or aggressive surgery. A simple refining procedure can fix spaces that are too open or too closed, which may pose difficulties with cleaning access or with speech. Minor defects and early occlusal contacts can also be detected and removed with ease. None of the 211 titanium joints examined in this article evidenced radiological signs of fracture or impairment in the 6 year follow-up period after full occlusal load. This result had been assessed in the first intraoral welding studies and firmly supports the conclusion that the stability of the joint in the medium term cannot be questioned. Indeed, the fracture of the resin superstructure is the most common adverse prosthetic event to be expected in the early-medium term when using the intraoral welding technique. The same outcomes were reported by Fischer and Stenberg in their 10-year report on implant-supported full-arch maxillary prostheses. Most of the fractures assessed in our study were superficial chipping that were easily repaired with light-cured composite resin in less than 1 hour. Minor fractures seemed to chiefly occur in the vicinity of the holes provided for screws, where the reduced width of the resin creates a weak point. In one case, however, a complete fracture of the resin portion of the distal cantilever was reported 4 years after surgery and a major repair procedure was needed. Gillot recently monitored 211 implants placed in edentulous maxillary patients and immediately restored using the Nobelguide (Nobel Biocare AB, Göteborg, Sweden) technique. The authors reported 10 fractures of the acrylic resin superstructure in the group of 33 patients treated in the 12- to 52-month follow-up period. The use of porcelain as veneer material does not seem to have completely eliminated this adverse event. Zurodo et al. reported after 5 years of follow-up that one of the 2 most common prosthetic complications for fixed implant-supported partial prostheses was indeed minor porcelain fracturing. To maximize tensile strength, the design of the titanium framework evolved from the first concept to the one that uses composite instead of common acrylic resin and the application of secondary bars and additional titanium retentions. Composite resin has a more rigid 3-dimensional structure and in clinical use has proved itself less prone to fracture than common acrylic. Nevertheless, severe bruxism is currently the most common exclusion criteria for the use of the intraoral welding approach. In their 40-month analysis of 283 implants loaded with both single and partial prostheses, De Boever et al. concluded that bruxism seemed to play a significant role in the frequency of prosthetic adverse events and that longer elements seemed to be more prone to complications. Moreover, Zurodo et al. reported in their systematic review that the incorporation of cantilevers into implant supported prostheses may be associated with a higher incidence of minor technical complications. The only major prosthetic failure in this study was assessed in the cantilever area of a full mandible restoration.

The implant pool included in this study achieved a life table CSR of 90.31% after 7 years of full occlusal load. Although comparable with the recent 10-year assessments published by Fischer et al., this result is greatly affected by the patient drop-out caused by the unwillingness of patients to attend the scheduled follow-ups.

The results of this study evidenced that the 15% of the implants included in the research protocol were associated with signs of soft tissue adverse events over the whole observation period. In a recent article, Corbella et al. monitored a group of 61 patients fitted with immediately loaded full-arch fixed prostheses for more than a 4-year follow-up period. At the 12-month follow-up, the authors reported a 1.4% implant loss incidence due to severe peri-implantitis. The adoption of a systematic hygiene protocol and the delivery of carefully relined and polished prostheses are mandatory to prevent plaque accumulation and reduce the incidence of mucositis and peri-implantitis. The bar is soldered directly in the mouth of the patients. This avoids many of the factors that can lead to a nonpassive structure, such as the impression procedure, the fabrication of the master cast and the wax pattern, and the casting of a traditional metal alloy framework.

CONCLUSIONS

Within its limitations, this study has demonstrated that the intraoral welding technique is predictable to successfully rehabilitate the mandible and the maxilla of the fully edentulous patient with a fixed, final prosthesis for up to 6 years after surgery. Further studies should be undertaken to verify the long-term effectiveness of this approach.

DISCLOSURE

The authors claim not to have any financial interests in any of the products mentioned in this article.

REFERENCES

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