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Modified protocol of the intraoral welding technique for immediate implant-supported rehabilitation of the edentulous maxilla

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ABSTRACT: (172 words)

Purpose: The aim of this study is to report the outcomes of a treatment option of immediate loading with intra-oral welding on only 4 implants for the restoration of patients with maxillary edentulism .

Materials and methods: Seventeen consecutive patients were rehabilitated with 2 parallel and 2 tilted implants in the maxilla. Immediately after implant placement, angulated abutments were screwed on the implants to create better parallelism among the implants, thereafter; a titanium bar was intraorally welded to welding pins in order to create a superstructure that rigidly splinted the implants. A fixed full-arch durable prosthesis was delivered on the same day of the surgery. The patients were followed for 26.5 months on average.

Results: During the follow up time, 2 implants were lost giving an implant survival rate of 97%. Nonetheless, all the prostheses remained in function and the prosthetic success was 100%.

Conclusions: The rehabilitation of the edentulous maxilla with an immediately loaded full-arch prosthesis, obtained through intra-oral welding on only 4 implants, is a functionally and aesthetically successful treatment.

KEYWORDS: Immediate loading, intra-oral welding, definitive restoration, tilted implants, angulated abutments.

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In cases of mandibular edentulism, immediate function of oral implants has been widely documented, even on a reduced number of fixtures^{1-3, 1-3}. On the other hand, complete maxillary edentulism is perceived as a challenging condition, especially if loading is planned shortly after placement and due to the lower bone quality and limited amount of bone often found due to high levels of atrophy.

The minimum amount of implants to support maxillary fixed restorations has not yet been established. However, in case of delayed loading, comparable outcomes of full-arch prostheses supported by 4 or 6 implants have been reported⁴, and regardless of the implant number, the posterior implant bears the most load⁵. What is thought to be more important than the number of implants is the well-spread position of the implants, in order to shorten the cantilevers. In general, the use of few (6 or 4) and tilted implants has actually been shown to be a reliable alternative to bone grafting⁶⁻⁹, leading to shorter treatment period with less discomfort for the patients.

In recent years, a variety of clinical studies proposed new protocols to restore the edentulous maxilla with early/immediate function, reporting good clinical outcomes^{9-14, 9-14}. One of the crucial factors for success of the proposed protocol is the rigid fixation of fixtures to prevent excessive micromovements in the surrounding bone^{15, 16}. Provisional prostheses have been reinforced with metals or fibers and various designs of metal frameworks have been fabricated for the cross-arch stabilization of implants.

A time-effective and successful protocol to rigidly splinting multiple implants in a precise manner is the intra-oral welding technique^{17, 17}. This consists of welding a titanium bar to the implant abutments directly intraorally, which avoids extra laboratory procedures.

Introduced by Huska¹⁸ and Mondani and Mondani¹⁹, it has been widely documented by Degidi et al.^{3, 10, 20}, who pointed out how the prosthetic procedure of assembling the framework directly in the

patient mouth allowed the creation of a precise and passive prosthetic structure. This technique has shown to be cost-effective, providing the patients with a complete fixed full-arch restoration on the same day of implant placement.

Degidi et al^{3, 10, 12, 21-23} have provided evidence of this protocol on different immediate rehabilitations, both in the maxilla and in the mandible, and in combination with the axial, tilted zygomatic implants. They have documented the predictability of this technique over 6 years²⁴.

In this article, an innovative protocol for the immediate and durable rehabilitation of maxillary total edentulism, based on that described by Degidi and coworkers, is proposed and tested on 17 consecutive patients with positive outcome. We introduce novel steps and the standardization of some surgical, prosthetic and esthetical aspects of the intra-oral welding technique, which could simplify and standardize the full arch immediate restoration in the maxilla.

MATERIAL AND METHODS

Seventeen patients (13 female and 4 male, average age 62.5 years) were consecutively enrolled in this study.

All patients required a full arch rehabilitation of the maxilla and were considered eligible for a fixed rehabilitation supported by dental implants. All patients signed a written agreement to be treated and be part of the study.

Inclusion criteria were as follows: 1) age older than 18; 2) complete edentulism of the maxilla or requirement of extraction of all maxillary teeth; 3) rehabilitation with endosseous dental implants planned; 4) physical and mental ability to tolerate conventional surgical and restorative procedure.

Exclusion criteria were 1) systemic diseases such as uncontrolled diabetes; 2) pregnancy; 3) therapy with bisphosphonates if injected, 4) radio- or chemotherapy for treatment of cancer.

In 16 patients the implants were placed immediately after extraction of teeth. In 13 patients teeth were extracted due to periodontal disease, in the other 3 for endodontic problems. Eight patients were smokers and 3 patients were diagnosed as bruxers. Ten patients had natural teeth in the mandible, while 7 had implant-supported prostheses.

Preoperative analyses of anatomical features and choice of implant length and position were made using panoramic radiographs and computed tomography.

Preliminary to the day of the surgery an acrylic resin cross-arch restoration, with highly wear-resistant commercially available denture teeth (Physiostar®, Candulor, USA) had been prepared. Casts of the maxilla and mandible were fabricated in the laboratory after impressions were taken. The teeth, with color, shade and form in accordance with the esthetic requirements, were pre-mounted on a cast and occlusion aspects were checked on an adjustable articulator. The mounting of the teeth followed an aesthetical and functional analysis performed by the clinician and based upon a pre-intervention set of digital photographs and a pre-intervention cast of the upper and lower jaws of the patient. An occlusal scheme without the second premolars was chosen for the prosthesis. The mounting then followed ideally the line of the upper lips forming an arch, which resulted in accordance with the previous analysis. The restoration included a part of pink resin, where soft tissue replacement was needed.

On the day of surgery, the patients received antimicrobial prophylaxis (1 gr amoxicillin twice a day for 5 days, starting the night before the intervention) and consciously sedation by an anesthesiologist, who monitored them during the whole intervention.

Surgery began with a crestal incision and the careful elevation of a full-thickness flap to expose the crest. When teeth were present, extraction of all maxillary teeth and mechanical debridement of the alveoli was performed.

The placement of the implants consisted for each patient of two parallel implants in the lateral incisor sites and two distally tilted implants, tilted to an angle between 30° and 45° (measured clinically) and with the neck in the premolar area (Fig. 1). A total of 68 implants were placed, with length and diameter as follows: 67 implants were 3,75 mm diameter and 1 implant was 5 mm diameter; 39 implants were 15 mm long, 24 were 13-mm long, 3 were 18-mm long and 2 were 11-mm long. Insertion torque was registered with the surgical unit (Elcomed, W&H, Bürmoos, Austria). All implants had an insertion torque greater than 15 Ncm.

The implants were connected with angulated abutments immediately after placement. Abutments with a 17° angle were screwed on the parallel implants, while abutments with an angle of 30° were screwed on the tilted implants (Fig. 2). The abutments were never unscrewed throughout the procedure.

The welding protocol was carried out as described by Degidi et al¹². First, a so-called “welding abutment”, a titanium cylinder, was connected to each abutment with a long pin screw. A 2.0-mm-diameter bar (Bio-Micron, s.a.s, Limbiate, Italy) made of grade 2 commercially pure titanium was welded to the most distal abutment on the left using an intra-oral welding unit (Intra Oral Welding, International Implant Company s.r.l, Verona) (Fig. 3). The bar was then shaped with orthodontic utility pliers to passively contact all the abutments. The bar was buccal to the implant abutments. Thereafter, the bar was intra-orally welded to all the abutments, in the most apical position possible. After the welding, the prosthetic framework was removed and its passivity was checked with the Sheffield one-screw test.

The framework was then removed from the oral cavity. The welding abutments of the framework were screwed to analogues of the angulated definitive abutments, which reproduced the exact direction of the angulated abutments, and the abutment analogues were inserted in a cast-model (Fig. 4). The framework was refined to fit into the prepared prosthesis, hollowed in the middle. Then the framework was sandblasted (Rocatec Junior, 3M Espe, St Paul, MN, USA)) and opaques (OVS 2, Opaker, Dentsply Trubyte, York, PA, USA), to prevent the appearance of metal shades through the acrylic resin teeth of the final restoration. Thereafter, it was placed back and screwed in the patient's mouth ¹².

The hollowed prosthesis, with multiple notches on its edge, was filled with impression material and was positioned in the mouth of the patient, who was asked to clench gently. In addition, the correct vertical height of the patient's jaws was checked and established using reference marks recorded on the patient's face before surgery.

Once the impression material hardened, the hollowed prosthesis was removed from the oral cavity, while the hardened impression material remained around the titanium framework. In the area subject to the passage of the abutment screws, the impression material was removed. The structure was then unscrewed and delivered to the laboratory.

Thereafter, the hollowed prosthesis and the impression, which incorporated the titanium framework, were re-assembled, due to the interlocking in the notches, the exact position of the framework inside the prosthetic structure could be found even out of the oral cavity (Fig. 5). This position was fixed in three points with acrylic resin and the impression material was completely removed.

A rubber dam was positioned on the cast, with holes in correspondence of the abutment analogue. The framework assembled with the prosthesis was screwed onto the cast (Fig 6). Then, the

hollowed part of the denture was relined with acrylic resin, with the help of the rubber dam, which prevented overflow. Finally, the prosthesis was refined, trimmed and gently polished.

On the same day of the surgery, the restoration was screwed on the implants by fastening the retaining screws to the abutments. Soft tissues were replaced and sutured (Vicryl 4.0, Ethicon Inc, Sommerville, NJ, USA) around the implant abutment (Fig. 7).

During the laboratory procedures, on that same day the patients underwent an open-flap debridement of the mandibular teeth²⁵.

Ten days after surgery, the sutures were removed and the status of the peri-implant soft tissue was assessed clinically. The patients were recalled for clinical examination and hygienic maintenance at 1, 3 and 6 months. At the six-month visit, the prostheses were unscrewed and eventually relined. The titanium frameworks were unscrewed, however the angulated abutments were not removed. In fact, the framework was removed unscrewing only the “welding abutment”. Panoramic radiographs of the prostheses were taken after 6 months (Fig. 8) and at yearly recalls.

RESULTS

The implants were followed for 27.5 months (range from 18 to 36 months). No patient was lost to follow up during the whole duration of the study. Pictures of a patient’s dentition before and immediately after the treatment are shown in Figure 9. Pictures of the patient’s esthetical aspect before and after the treatment are shown in Figure 10.

Of the 68 implants, 2 failed to achieve osseointegration, giving a survival rate of the implants of 97%. Nonetheless, all the prostheses remained in place for the entire duration of the study, giving a

100% prosthetic survival rate, and any prosthetic complications, such as fracture of the acrylic resin, was encountered during the follow-up period.

The two implants that failed to osseointegrate were both distal and were removed. In those cases, the prostheses were unscrewed and the implants removed, then the last distal tooth of the prosthesis was cut before the restoration was screwed again in its position, supported by 3 implants. Another implant, with a diameter of 5 mm, was inserted in the same surgery and let to heal submerged for 2 months. After the healing time the new implants were uncovered, new abutments were screwed, impressions were taken with the prostheses on and after that the prostheses were connected to the new implants. The patients did not have to stay without the prosthesis during the osseointegration time, since the remaining 3 implants supported the prostheses.

DISCUSSION

Intra-oral welding is a beneficial procedure to create a very precise rigid framework quickly and directly inside the oral cavity when immediate functionalization is planned²⁶. With this technique, time-costly laboratory steps can be avoided, such as the creation of a customized impression tray, while a passive fit of the framework is easily obtained¹². This procedure has been reported by Degidi *et al.* in several studies ^{3, 10, 12, 21, 23} and has shown to be reliable for the immediate restoration of edentulous patients, both in terms of implant survival and marginal bone preservation. The 6-year cumulative survival rate that they report for implants placed in the maxilla and intra-orally welded was 92.12%²⁴

In the current study, a consecutive series of 17 patients with edentulous maxillae was restored following a protocol which introduced some modifications to the original procedure described by Degidi *et al.* ^{12, 17, 21}, in an attempt to make the procedure simpler and with a predictable cosmetic and functional outcome. In each patient, following also the All On Four TM concept, only 4 implants

were placed in the maxilla to support the intra-orally splinted bar and the prosthesis, since the rigid splinting obtained with the intra-oral welding could reduce mechanical stress exerted on the single implants and assure an optimal distribution of the occlusal load decreasing the lateral forces on the healing implant²⁶. This was partly confirmed by a survival rate of the implants of 97% during the follow-up time.

The 4 implants were strategically distributed in the upper jaws (Fig. 1); two parallel implants in the area of lateral incisors and two distally tilted implants, with the emergence in the area of the premolars, in order to use the load-bearing capacity of maxillary bone in a more favorable way, as has been shown by other studies ^{9, 13}.

The tilting of the implants and the emergence of the distal implants in the area of the premolars influenced the choice of a shortened occlusal arch for the prosthesis, with the first molar substituting the second premolar, because the teeth supporting the higher functional load was preferred in correspondence of the fixture emergence, reducing the cantilever.

The use of only 4 tilted implants was indicated for those patients with a reduced opening (chronic lock) and for those with severe bone resorption in the posterior region, as an alternative to bone incrementing techniques ^{6-9, 27}.

We decided to include in the present study all the implants that reached an insertion torque of at least 15 Ncm, which is relatively low compared to other studies²⁸. This was because of our hypothesis that the micromovements often seen for this low level torque can be minimized with the intra-orally splinted bar²². Moreover, Norton²⁹ has pointed out that a high degree of rotational friction, which is expressed by a high insertion torque, could not be the most pertaining parameter to ensure an implant to osseointegrate. It was further clinically reported that implants inserted in

posterior maxillary sites after sinus lift procedures presented an average insertion torque values of 23 Ncm and the outcomes were comparable to the studies reporting higher insertion torque values³⁰.

Another modification that was introduced was the standardized use of angulated abutments (17° for anterior implants and 30° for posterior implants) (Fig. 2). They were screwed onto the implant platform to adjust for the implant dis-parallelism, to obtain a prosthetically favorable and predictable emergence of the implants, to assure the palatal direction of the retentive screw holes and to be able to apply the titanium bar in the buccal side of the welding abutments. Those abutments were definitive, since they were never removed and this approach has reported to reduce the peri-implant bone loss due to frequent abutment reassembly³¹.

In the current procedure, a 2-mm diameter titanium bar was welded to the implant components and was applied to the buccal aspect of the welding abutment, which was made possible by the selection of angulated abutments. The reduced number of implants and the buccal position of the bar further facilitated the welding procedure, allowing optimal forming of the titanium bar. No welding was applied extraorally with the aim to reduce the risk of introducing tensions in the framework.

Welding the titanium bar buccally to the implants allowed a more vestibular placement of the prosthesis, providing more lip support and avoiding interference with function. The vestibular placement was necessary, due to the occlusal discrepancy often found in patients with the edentulous maxillae³².

At the level of the prosthetic manufacturing, some novel steps were introduced. One was the use of the hollowed prosthesis as impression tray (Fig. 5) and its total relining outside of the oral cavity thanks to a cast-model, which incorporated the abutment analogues (Fig. 6). The use of the 3

notches on the hollowed prosthesis assured repeatable interlocking between the impression and the prosthesis outside of the oral cavity.

The passage through an impression had several advantages. First, it avoided the intra-oral relining of the prosthesis on the framework, which might include biological fluids in the acrylic material. Secondly, the impression allowed controlling the prosthetic position, before the definitive incorporation of the framework in the hollowed prosthesis due to the relining. The esthetic and functional goals, planned in advance and that guided the prosthetic construction, were checked again intraoperatively and, in case the ideal position of the prosthesis was not found at the first attempt, it was only necessary to repeat the impression. Moreover, the cast model created for each patient (Fig. 4) was and used to manufacture the prosthesis outside the oral cavity, was useful to avoid fortuitous torsions of the framework during the hardening of the resin and could be kept as a fiducial marker of the position of the implants and to be used again if the prosthesis needed further relining at follow-up visits.

The 17 consecutively treated patients reported in this case series were all treated with the same modified approach and followed for more than 2 years. Of the 68 implants, 2 failed to achieve osseointegration, presenting a survival rate of the implants of 97%, which is comparable with those obtained in other clinical studies on maxillary implants, both with immediate and delayed loading³³⁻³⁶. Nonetheless, all the prostheses remained in place for the entire duration of the study, with a 100% prosthetic survival rate, and no prosthetic complications, such as fracture of the acrylic resin, was encountered during the follow-up period.

In those cases when one of the implants failed, we opted for the replacement with new implants with a wider diameter. The survival rate of implants placed in site with previous implant failure has been documented to be lower than first attempts, but the replacement of the implants is considered a valid alternative anyway³⁷. In addition, thanks to this treatment option, the two patients with a

failing implants could wear the fixed restoration, supported by 3 rigidly splinted implants, even during the time the new implants were allowed to heal submerged.

Overall, this treatment approach seemed to be reliable and it expedited the creation of an immediately loaded definitive prosthesis on the same day of the implant placement. The prosthesis delivered to the patient was a durable one, diminishing treatment costs and times for both the clinician and the patient. Most importantly, all patients were satisfied with the esthetic outcomes and the treatment velocity. Further evaluation with an increased number of cases and a longer follow-up is warranted to confirm the long-term reliability of the proposed technique.

CONCLUSION

In this report, a treatment option based on the previously documented protocol of intra-oral welding presented successful rehabilitation of the edentulous maxilla with a definitive prosthesis delivered on the same day of the implant placement. The modifications from the conventional protocol that have been presented (the placement of 4 tilted implants in the maxilla, the use of angulated abutments and the use of the hollowed prosthesis as an impression tray) was suggested to have no clinically negative outcomes, with the implant survival rate to be 97% and a prosthetic success was 100% over a follow-up time of more than 2 years.

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DISCLOSURE

The authors have no conflict of interests. None of the authors received funding for the completion of the study.

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FIGURES AND LEGENDS

Fig. 1: Four implants are placed in the maxilla immediately after tooth extraction, two parallel in the area of the lateral incisors and two tilted, in the area of the second premolars.

Fig 2: Angulated abutments, two with an angulation of 17° (mesial implants) and two with an angulation of 30° (distal implants), are screwed to the implants to reduce the disparallelism.

Fig 3: Welding abutments are screwed on the implants and the welding of a 2-mm-diameter titanium bar is performed directly intra-orally (a). In figure (b) it is visible one abutment welded to the bar (left hand side) and the other one not welded, but in contact with the bar passively (right

hand side). The pictures of the welding refer to a different patient included in the current series and were selected for visualization purpose.

Fig. 4: The welded superstructure is transferred outside of the oral cavity and a cast-model is created, thanks to the incorporation of analogs of the angulated abutments (view from above and from one side).

Fig. 5: The hollowed prosthesis, prepared in advanced following functional and esthetical indications, is used as individual impression tray. The impression material hardened, housing the metal-superstructure, was then removed from the oral cavity. The presence of notches allowed finding the correct position of the metal framework within the hollowed prosthesis.

Fig. 6: The superstructure, connected with the prosthesis, is screwed on the abutment analogs, ready for relining with acrylic resin.

Fig. 7: The prosthesis in the oral cavity. The soft tissues are re-positioned and adapted around the implants and the prosthesis with resorbable sutures.

Fig. 8: Panoramic radiograph taken 6 months after the surgery.

Fig. 9: Frontal view of the patient's mouth on the day of the surgery before (a) and after (b) the restoration.

Fig. 10: The patient before the intervention (a) and at the removal of the sutures (b) 10 days after the surgery.