Minimally Invasive Fixed Rehabilitation of a Totally Edentulous Severely Atrophic Mandible with 4-mm Ultrashort Immediately Loaded Implants: A Case Report

This case report describes the minimally invasive full fixed rehabilitation of a totally edentulous severely atrophic mandible. The patient refused to undergo any other treatment, from the reconstructive surgery to the removable prosthesis, and asked for a fixed minimally invasive solution in the shortest possible time. Considering that the posterior mandibular bone was inadequate in height and that the interforaminal bone was only 4.3 to 5 mm in height, the patient received four 4-mm-ultrashort implants in the interforaminal area that were immediately loaded. Within all the limitations of this case report this procedure in this specific case appears successful through 2 years of loading.


Over the last few decades, fixed-implant prosthetic rehabilitation has become a well-established treatment option for both partially and totally edentulous patients in terms of comfort, reliability, esthetics, and function.1

Implant placement requires the presence of adequate bone height and width. Periodontal disease, early loss of teeth, or prolonged use of removable prostheses can lead to bone atrophy, which makes placing standard-length implants in residual bone impossible.2 This clinical condition is quite common in both arches and can be associated with the posterior mandible, anterior areas, or both, especially when the patient is fully edentulous.

In the totally edentulous mandible, vertical bone defects (Cawood and Howell Classes V and VI)3 are quite common, in many cases with an adequate bone width. In these cases, it is common that the superficialization of the inferior alveolar nerve (IAN) prevents placing standard-length endosseous implants in the posterior mandible. However, in many cases, interforaminal bone volumes are sufficient for placing interforaminal bone implants in order to rehabilitate the patient with a fixed prosthesis solution in conjunction with immediate loading protocols, with extremely good results.1,4 Another option, given

Roberto Pistilli, MD1
Carlo Barausse, DDS, PhD2
Roberta Gasparro, DDS, PhD3
Cesare Berti, DDS2
Pietro Felice, MD, DDS, PhD2

1Oral and Maxillofacial Unit, San Camillo Hospital, Rome, Italy.
2Department of Biomedical and Neuromotor Sciences, University of Bologna, Bologna, Italy.
3Department of Neurosciences, Reproductive Sciences and Odontostomatology, University of Naples Federico II, Naples, Italy.

Correspondence to: Dr Roberta Gasparro, Department of Neurosciences, Reproductive Sciences and Odontostomatology - University of Naples Federico II, Via Pansini 5 - 80131 Naples, Italy. Fax: +390817462118.
Email: roberta.gasparro@unina.it

Submitted October 22, 2018; February 17, 2019.
©2020 by Quintessence Publishing Co Inc.
the good results with short implants in the posterior arches,\textsuperscript{5–9} could be to combine long interferominal implants and short posterior implants to improve the anterior-posterior prosthetic spread (A–P spread). In the past, when there were basically no short implants, the alternative was to place standard-length implants in the posterior mandible with different possible bone reconstruction approaches.\textsuperscript{10} However, these techniques in the posterior atrophic mandible (inferior alveolar nerve lateralization\textsuperscript{11} and various bone augmentation approaches\textsuperscript{2,12} are technically demanding and associated with complications. Moreover, the final esthetic result appears similar or equal to placing posterior short implants or placing implants only in the interforaminal area.

In other cases, when the fully edentulous atrophic mandible has no vertical residual bone in the interforaminal area to place standard-length tilted implants, one approach could be to augment only the anterior area in order to place long implants in reconstructed bone. Various techniques are used and described in the literature,\textsuperscript{13} including osteogenic distraction, interpositional bone grafting, and onlay block bone grafting. Nevertheless, it is still unclear which techniques are the most efficient, and some degree of bone loss is expected.\textsuperscript{13} Different grafting materials are involved with these procedures, but the belief remains that the autogenous bone graft is the most predictable and successful available biomaterial, especially for the extremely atrophic mandible.\textsuperscript{14} Moreover, these augmentation techniques are associated with complications, morbidities, long rehabilitative times, and some limitations. For instance, the interpositional technique in the anterior mandible should be performed when the residual bone height is at least 6 mm to minimize the risk of mandibular fracture.

Nowadays, with scientific and clinical success using short implants (5 to 7 mm) placed especially in the posterior atrophic jaws, their application could be also useful in the anterior atrophic fully edentulous mandible.\textsuperscript{15,16} However, in some cases the atrophy is so advanced that even in the interforaminal region there is insufficient bone volume for placing short (5 to 7 mm) implants. In these cases, different approaches may be used. A reconstructive approach could be used in the anterior mandible, but it is advised to use onlay calvarial block bone because it has favorable results when there is advanced atrophy. The large cortical component of this bone seems to determine an optimal mechanical behavior and a slight tendency for resorption.\textsuperscript{17} While the calvarial bone graft may lead to a better volume maintenance, the harvesting procedure and the graft modelling and adaptation to the recipient site require an experienced surgeon and can be associated with severe and sometimes life-threatening complications, like calvarial skull fracture, though rare.\textsuperscript{18} If a large quantity of bone is necessary, the iliac crest may also represent an alternative, but the discomfort for the patient is high, and iliac bone crest can be associated with an incidence of partial or total graft loss due to a high percentage of resorption, especially in the mandible.\textsuperscript{19} Moreover, bone augmentation approaches require long treatment times (up to 1 year) and are expensive. An alternative could be to exploit the only residual native bone using transmandibular implants; however, they are associated with quite high percentages of complications and implant failures.\textsuperscript{20}

A minimally invasive approach could be to use ultrashort implants in the anterior heavily atrophic mandible, considering their good results in posterior arches.\textsuperscript{21–24} To the authors’ present knowledge, there are no published studies on 4-mm ultrashort dental implants used in the rehabilitation of a fully edentulous severely atrophic mandible. This case report describes the full rehabilitation of a totally edentulous mandible with immediately loaded 4-mm–long implants, avoiding the need for any bone augmentation.

**Materials and Methods**

A 55-year-old systemically healthy woman was referred to the authors’ attention, requiring a fixed prosthetic rehabilitation of her fully edentulous mandible. Clinical and radiographic (orthopantomography; OPG) baseline data revealed a totally edentulous mandible with an advanced alveolar bone resorption, rehabilitated with a removable full denture. Moreover, a horizontally impacted canine was present in the anterior area (Fig 1). In agreement with the patient before any implant procedure, the impacted canine was
extracted and the implant surgery was planned for 4 months after healing. The preoperative cone beam computed tomography (CBCT) scans confirmed the severe mandibular atrophy (Class VI, Cawood and Howell) with no usable bone volume to place any implants in the posterior areas and with about 4.3 to 5 mm of available vertical bone in the interforaminal zone (Fig 2). The patient refused to undergo any augmentation procedure, and the possibility of a new mobile prosthesis was denied by the progressive superficialization of the IAN that occurred over time. Procedures requiring grafts were also excluded due to the patient's economical situation. Moreover, the patient asked to wear a prosthesis immediately after implant placement in order to have a minimal amount of esthetics.

The only possible clinical choice at this point was to exploit the residual native bone in the interforaminal area: Straight, tilted, or transmandibular standard-length or > 4-mm implants were considered a high risk for mandibular fracture due to the very advanced atrophy. Moreover, tilted implants could be angled only lingually due to the morphology of the defect (Figs 2b to 2d) with a lot of issues in terms of surgical complexity, risks, and prosthetic management. As a consequence, in agreement with the patient, a minimally invasive rehabilitation consisting of 4-mm ultrashort implants placed straight into the interforaminal region was planned in order to try to minimize all possible risks and rehabilitative times (Fig 3).

One week before surgery, both the maxillary and mandibular full dentures were professionally cleaned using a mechanical cleaner that gently brushes the prostheses using a cleaning solution and stainless-steel needles (GD Cleaner, Global D). The patient rinsed for 1 minute with 0.2% chlorhexidine mouthwash before surgery.

The procedure was performed under local anesthesia (4% articaine with 1:100,000 adrenaline). A crestal incision was carried out to ease a full-thickness flap elevation and to identify and isolate mental nerve emergences. Four implant sites were prepared in the interforaminal area using dedicated drills with integrated stops of increasing diameter. All sites were prepared under copious sterile saline irrigation. Four short implants (4 mm long, 4 mm wide; Twinkon 4.0, Global D) were then placed with an insertion torque > 50 Ncm. The implants are made of commercially pure titanium with a roughened surface (airborne particle-abraded and doubly etched) and have a transmucosal design. Flaps were sutured with 4.0 sutures and, as a consequence of the high torque values, an impression was then taken with pick-up copings to immediately load the implants (Fig 4). Postoperative radiographs were taken to verify the correct implant positioning, and an acrylic screw-retained reinforced prosthesis was delivered after 24 hours (Fig 5). Only five crowns were planned for the provisional restoration in order to guarantee at least minimal esthetics,
as requested by the patient and to minimize the length of the cantilevers during the osseointegration period of the implants (Fig 5c). A 2-g dose of amoxicillin with clavulanic acid was administered preoperatively, followed by 1 g twice a day for 5 days postoperatively. Ibuprofen (600 mg) was prescribed to be taken during meals 2 to 4 times a day when needed. A cold and soft diet was recommended for 2 weeks, and sutures

Fig 2 (a) Preoperative CBCT of the fully edentulous severely atrophic mandible 4 months after the extraction of the impacted tooth. It confirms the severe atrophy of the posterior regions and residual bone heights of only (b) 4.5, (c) 5.0, and (d) 4.3 mm in the interforaminal area, preventing the placement of standard-length implants.

Fig 3 Preoperative (a) clinical and (b) OPG views showing the severely atrophic mandible. Note a bone radiopacity in the right premolar region, preventing the insertion of any implant in this site.
were removed 7 days after the surgical procedure. It was also requested that the patient adhere to a soft diet for the first 2 postoperative months.

**Results**

The healing process and the postoperative recovery were uneventful, and the patient was clinically and radiographically (OPG and CBCT) examined just after implant placement and 8 months

---

*Fig 4* Positioning and impression-taking of four 4-mm ultrashort implants. (a) Implant tunnel preparations. (b to e) Implant placement. Note the transmucosal design of the implants. (f) Impression-taking for the immediate loading (torque > 50 Ncm) after placement.
later (Figs 5 to 7). Moreover, the patient was clinically checked every week for the first month, every 2 weeks through the fourth month, and monthly thereafter until 8 post-operative months. Eight months after immediate loading (Fig 6a), a definitive metal-ceramic screw-retained prosthesis replaced the provisional one. The prosthesis was made avoiding canine guidance and lateral loading, trying to reach a balanced and mutually protected occlusion.

The final follow-up reported is at 2 years after immediate implant loading. Peri-implant marginal bone levels and the clinical prosthetic result appeared stable at 1 and 2 years after loading (Figs 8 and 9). Presently, the patient is satisfied from both the esthetic and functional points of view and is grateful for the fast and minimally invasive rehabilitation.

Discussion

The rehabilitation of the fully edentulous severely atrophic mandible is a real challenge for the clinician. Different techniques have been proposed in order to rehabilitate these patients. Removable prostheses are not recommended in these cases due to their compression on the IAN, which tends to be really superficial.

When sufficient bone volumes in the interforaminal area allow the clinician to place standard-length tilted implants without the risk of mandibular fracture, this can be the ideal solution and can be performed with immediate loading.

Another approach could be to reconstruct bone in order to place standard-length implants. It is the present authors’ opinion that reconstructing bone in the posterior mandible makes very little sense, as the final esthetic result is similar but with many potential risks and complications. Vertical bone augmentation in the interforaminal atrophic area could instead be performed with different techniques and indications. Some techniques require a minimum vertical residual bone height; for instance, the interpositional technique tends to require at least 6 mm of bone height in this zone to minimize the risk of postoperative mandibular fracture due to muscle traction.

When bone height is also minimal in the anterior mandible, as in the present case (4.3 to 5 mm), the authors believe that the only reconstructive approach that can guarantee a stable result over time...
is an onlay calvarial bone graft. However, this procedure requires experienced surgeons and is associated with severe and sometimes life-threatening complications (even if rare) and long rehabilitative times. Moreover, the final esthetic and functional results are similar to the present approach with ultra-short implants; additionally, the present study's patient refused any harvesting procedure, asking for a prosthesis guaranteeing a minimal amount of esthetics after surgery. The problem with a reconstructive approach is also related to the fact that the patient cannot wear a removable prosthesis for several months after surgery, thus it is very hard to propose this kind of solution nowadays. Further, patients sometimes refuse graft procedures for economic reasons, as in the present case.

Consequently, given the good results obtained with short implants in the atrophic fully edentulous anterior mandible and with ultrashort (4 mm) implants in posterior arches, the authors proposed to the patient a fixed rehabilitation on 4-mm short implants placed in the interforaminal area, making the patient aware of all possible risks of this procedure, which was a preliminary case. To the authors' knowledge, this case report, with all of its limitations, is the first to preliminarily evaluate whether the use of 4-mm ultrashort implants with an immediate loading protocol is a possible rehabilitation option for patients with a fully edentulous atrophic mandible; this case report will help to plan more accurate future study designs, like randomized controlled clinical trials (RCTs). Of course, when the bone quantity is higher in the interforaminal area, a good and fast rehabilitative procedure is to distally tilt standard-length implants and immediately load them, if possible. In the present case with extremely atrophic bone height also in the interforaminal area, the implants could have been lingually tilted, but it was believed that this could increase the risk of mandibular fracture and it would have made prosthetic procedures more complicated. Moreover, having the prosthesis placed so lingually and in close proximity to the lingual frenulum and oral floor (which is higher than the crestal bone in the atrophic patient) could have led to ulcerations and mucositis, associated with speech impairments with no respect of the phonatory space.

To the authors' present knowledge, there are no studies on 4-mm ultrashort implants placed in the anterior fully edentulous and severely atrophic mandible; however, there are articles on short implants (5- to 8-mm–long) showing very good results over time. Visser et al compared standard-length implants after augmentation procedures with 8- to 11-mm “short” implants, with excellent results after 15 years. After 2 years, the study showed a survival rate of 93% for the group of standard implants placed in

Fig 6 Clinical appearance 8 months after implant placement: (a) before and (b) after the delivery of the definitive metal-ceramic prosthesis.
augmented bone compared to a 100% rate for the short-implant group. From 5 to 10 years after implant placement, the survival rate dropped to 87% for the standard implants but remained the same for short implant group. This study concluded that “when applicable, non-

In order to reduce rehabilitative times, the immediate loading of short implants could be an additional challenge. In a study by Cannizzaro et al, immediately loaded short and long implants were compared. Four 5-mm short implants were placed flapless in the interforaminal area of fully edentulous mandibles and immediately loaded compared to 11.5-mm–long implants. Despite the limitation that implants were placed in non-atrophic interforaminal areas, the results showed that short implants achieved results similar to those of long implants when supporting immediately loaded cross-arch prostheses up to 5 years after loading also with unfavorable A-P spreads. In the present case, placing an implant longer than 4 mm would have increased the risk of mandibular fracture; thus, given the good outcomes with 4-mm-short implants in atrophic arches, it was decided to place four 4-mm short implants. Moreover, distal to the first, right 4-mm–long implant, there was a radiopaque area with a bone hardness preventing placement of any implant, allowing only four implants to be placed.

In a recent RCT by Bolle et al, a group of 40 patients with atrophic posterior mandibles with a 5.0- to 6.0-mm bone height above the mandibular canal were randomized according to a parallel group design to receive between one to three 4.0-mm–long implants or one to three implants of at least 10.0-mm length placed after interpositional augmentation surgery is preferred as no general anesthesia is needed and the morbidity is low.”

Fig 7 (a) OPG taken after the delivery of the definitive prosthesis and (b to e) CBCT scans showing the correct implant positioning in bone volumes.
block bone augmentation surgeries. One year after loading, the 4.0-mm implants achieved similar results, if not better, than longer implants placed in augmented jaws and were affected by fewer complications. However, those implants have a transmucosal design, and some patients had a tendency after placement to push the implant head with their tongue, leading to fibrointegration and implant failure. As a consequence, especially to avoid nonintentional and non-axial forces in patients with extreme atrophies, authors are testing supershort implants with immediate loading protocol when sufficient torque values are reached; at present, this has received good clinical results. Due to the high torque values (> 50 Ncm) reached for every implant in the present case, the authors decided to immediately load them with only five crowns in order to guarantee a minimal amount of esthetics for the patient and to reduce the possibility of non-axial forces. Moreover, it is the authors’ opinion that wearing a full removable denture would have placed implants at a risk higher than immediately loading them. Eight months later, a definitive prosthesis with cantilevers was delivered to the patient, taking into consideration the fact that the patient had a full maxillary removable denture. However, the occlusal scheme in the prosthetic rehabilitation of short implants should be carefully planned; for instance, due to unfavorable A-P spread values in the present case, the authors avoided canine guidance and lateral loading, and balanced loads as much as possible.

Fig 8 OPG taken 1 year after loading, showing quite stable peri-implant marginal bone levels.

Fig 9 (a) Clinical and (b) OPG views 2 years after loading. Note the stability of the marginal bone level and the bilateral vertical bone growth in the posterior mandible compared to the baseline.
Comparing the risks associated with this fixed treatment with another possible solution (calvarial bone harvesting and onlay block bone grafts), the authors and patient agreed to try for a less invasive and faster option with benefits in terms of invasiveness and rehabilitative times for this specific patient. However, further information on the predictability of this approach requires future RCTs comparing 4-mm–long, immediately loaded implants with standard-length implants placed after bone reconstruction.

Conclusions

Within the limitations of this case report, 4-mm–long ultrashort implants placed in the interforaminal area used to immediately rehabilitate a fully edentulous and severely atrophic mandible could reduce operative times, costs, complications, and postsurgical morbidity compared to bone augmentation procedures and achieve a similar final esthetic result. Of course, RCTs with long follow-ups are needed to evaluate whether this could be a preferable option compared to bone augmentation techniques in patients with severely atrophic and fully edentulous mandibles.

Acknowledgments

Prof Felice receives research grants from Global D. The other authors declare no conflicts of interest.

References

7. Felice P, Barausse C, Pistilli V, Piattelli M, Ippolito DR, Esposito M. Posterior atrophic jaws rehabilitated with prostheses supported by 6 mm long × 4 mm wide implants or by longer implants in augmented bone. 3-year post-loading results from a randomised controlled trial. Eur J Oral Implantol 2018;11:175–187.
8. Gostalci G, Felice P, Pistilli V, Barausse C, Ippolito DR, Esposito M. Posterior atrophic jaws rehabilitated with prostheses supported by 5 × 5 mm implants with a nanostructured calcium-incorporated titanium surface or by longer implants in augmented bone. 3-year results from a randomised controlled trial. Eur J Oral Implantol 2018;11:49–61.


