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Amerigo Giudice, MD, PhD
Ferdinando Attanasio, DDS
Francesco Bennardo, DDS, PhD
Alessandro Antonelli, DDS, PhD
Tomaso Vercellotti, MD, DDS

Usefulness of Wedge-Shaped Implants in the Full-Arch Rehabilitation of Severe Maxillary Atrophy: A Case Report

The management of marked horizontal bone atrophy represents a critical challenge for traditional implantology procedures. For this purpose, clinicians have developed several protocols and procedures to allow the most suitable and accurate surgical and prosthetic implant rehabilitation. Despite the development of guided bone regeneration methods and the use of small-diameter implants, the rehabilitation of thin bone areas is a clinical dilemma for the medium- and long-term survival of implant-prosthetic therapies. This clinical case evaluates the use of wedge-shaped implants for the full-arch rehabilitation of an atrophic maxilla with a thin ridge. This treatment choice allowed a minimally invasive rehabilitation, avoiding regenerative bone surgery, while respecting biologic and prosthetic limits. Furthermore, evaluation of the implant stability quotient and marginal bone loss values during the first year of follow-up allowed analysis of the behavior of this rehabilitation in full-arch maxillary cases. *Int J Periodontics Restorative Dent 2024;44:347–355. doi: 10.11607/prd.6453*

Bone quality and quantity are fundamental factors in implant-prosthetic rehabilitation. Tooth loss—especially if due to severe periodontal disease, infectious processes, or improper extraction maneuvers—is the main cause of bone resorption.[1,2] Bundle bone resorption and subsequent shrinkage are the main cause of the reduction in the amount of horizontal bone, usually greater than in the vertical portion.[3] Schropp et al reported that after tooth extraction, horizontal bone loss can be as high as 40% at 6 months and about 50% at 1 year.[4] The amount of bone resorption may be greater in cases of dental trauma or buccal plate fracture following invasive extraction procedures.

Implant-prosthetic rehabilitation of thin edentulous ridges often requires bone augmentation procedures (BAPs), which are performed in one or two surgical steps according to the severity of the bone defect, to obtain the necessary width for implant placement and a sufficient peri-implant thickness. After implant insertion, the buccal and

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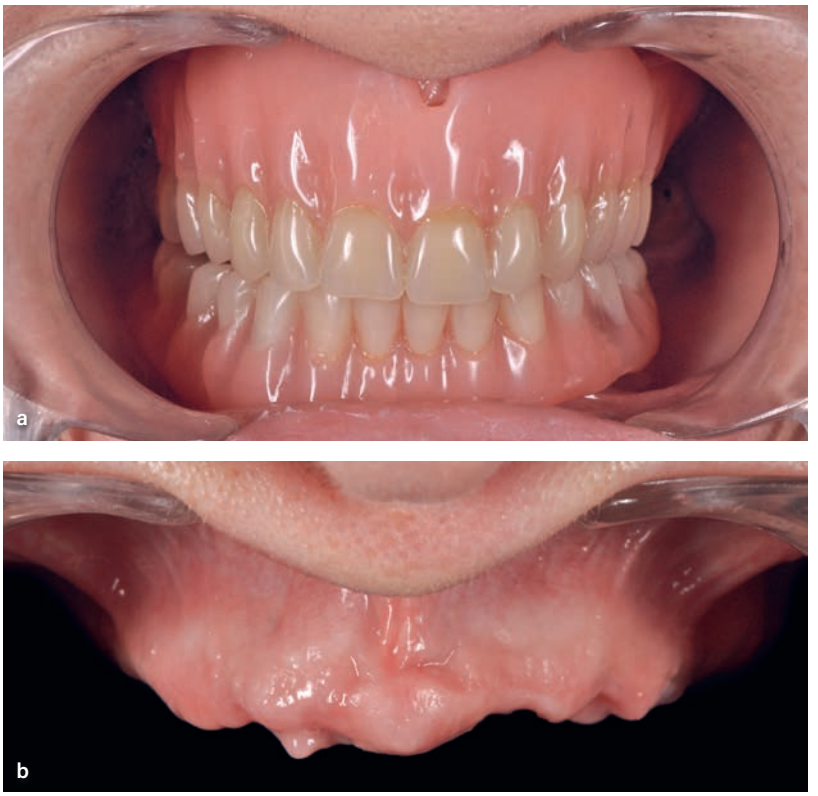

◀ **Fig 1** Presurgical baseline condition. *(a)* Maxillary and mandibular removable prostheses in place. *(b)* Clinical view of the maxilla without prostheses.

Table 1 Patient Atrophy Class by Arch Region

Location	Class
Anterior maxilla	IV
Posterior maxilla	V
Anterior mandible	III
Posterior mandible	IV

Atrophy was evaluated according to the Cawood and Howell classification.[9]

lingual bone thickness must be > 1.5 mm to avoid future implant dehiscence, an anatomical cause that contributes to peri-implantitis.[5]

This study reports the rehabilitation of severe maxillary edentulism (average bone thickness of approximately 5 mm) using wedge-shaped implants with a rectangular section.

Materials and Methods

The present article is reported according to SCARE guidelines.[6]

Patient Information

A 55-year-old woman was referred to the Oral Surgery Outpatient Unit of the Magna Graecia University of Catanzaro. The medical history showed no significant diseases or surgery and no current or former smoking habit. The dental history revealed tooth loss due to severe periodontal disease. The family dental history revealed that both parents wore full dentures.

Clinical Findings and Diagnostic Assessment

The patient wore complete maxillary and mandibular dentures (Fig 1). An oral cavity inspection showed severe maxillary atrophy (Table 1). A radiologic study was performed for the maxillary implant-prosthetic rehabilitation. A CBCT scan (PaX-i3D Green, Vatech) was performed to analyze the maxillary bone density and volume. In particular, scans were performed for diagnostic purposes with radiologic wax-up to assess an adequate implant-to-implant distance and an appropriate implant-to-bone cortical ratio. A thick periodontal phenotype was identified through CBCT scans, performed according to

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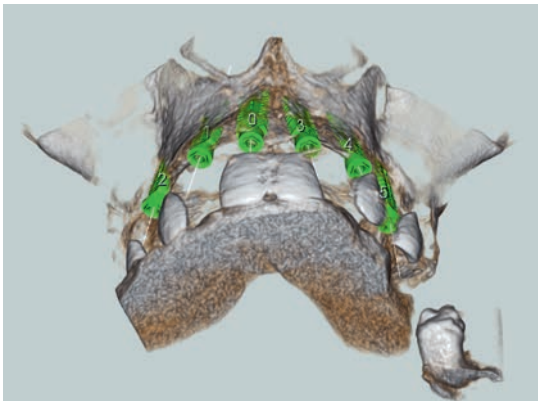
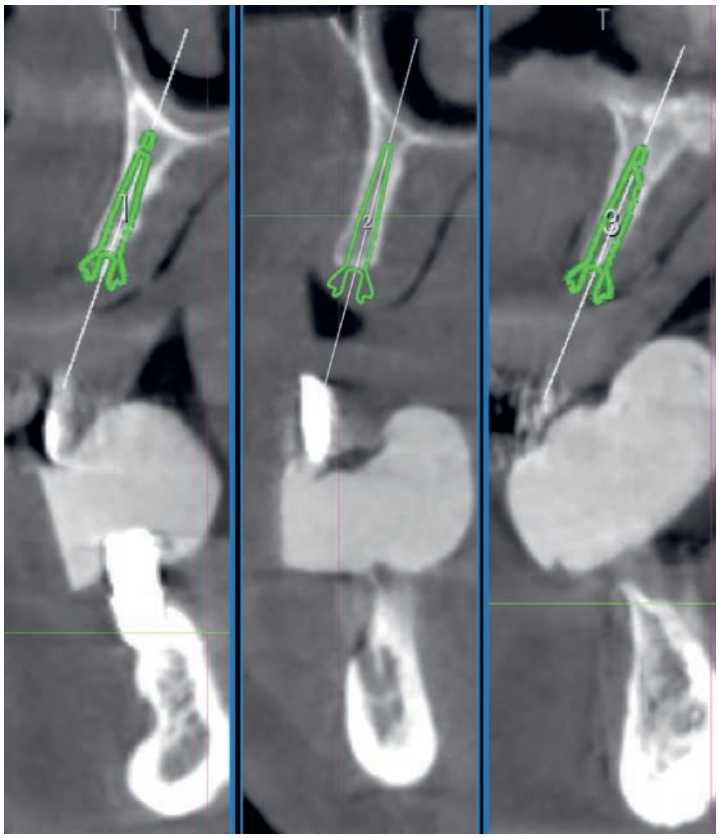
▲ **Fig 2** The occlusal view of the 3D CBCT reproduction shows the marked horizontal atrophy of the maxilla (class IV in the anterior and class V in the posterior, evaluated according to the Cawood and Howell classification[9]).



▲ **Fig 3** Surgical planning for implant placement. The implant positions were suggested by the use of a radiographic template during CBCT image acquisition.

▶ **Fig 4** CBCT scans show the correct surgical planning of implant positions in residual bone volumes.



Malpartida-Carrillo et al[7] and Nikiforidou et al.[8] The radiologic images showed severe vertical atrophy of the posterior maxilla (maxillary sinuses extending to the molar region) and a horizontal atrophy of the anterior maxilla, with an average residual bone thickness of about 5 mm (Fig 2). A class IV anterior maxilla and a class V posterior maxilla were detected according to Cawood and Howell classification.[9] The patient refused to undergo BAPs for economic, temporal, functional, and esthetic reasons. As an alternative therapeutic option, an implant-prosthetic rehabilitation with wedge-shaped implants was proposed (Figs 3 and 4).

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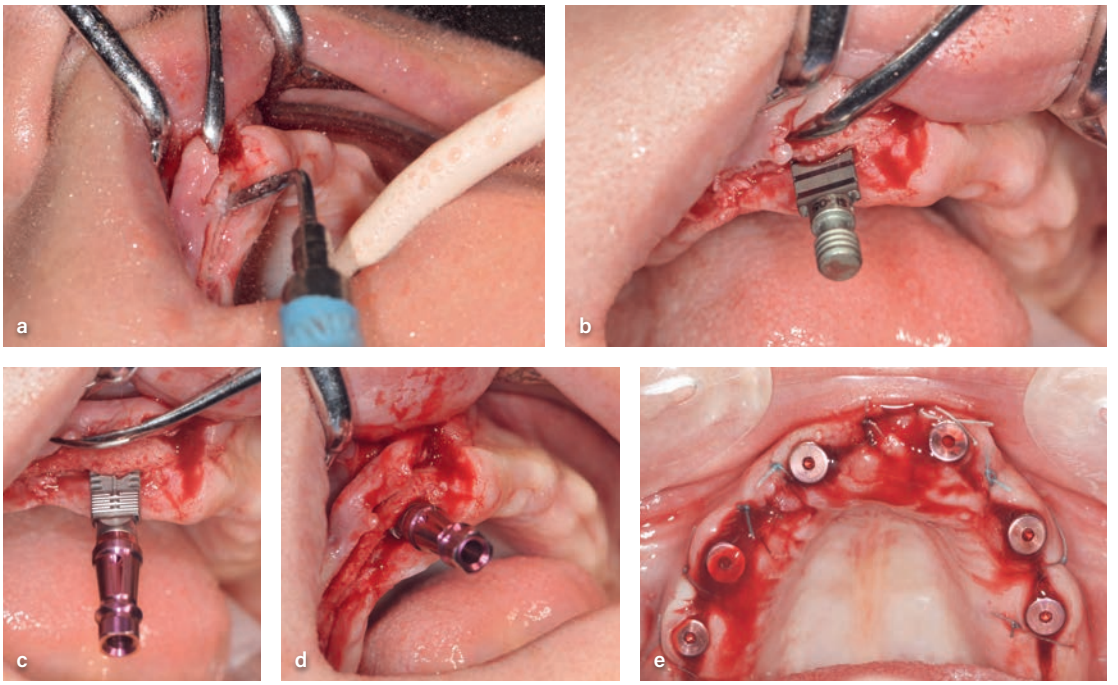

▲ **Fig 5** Surgical procedures. *(a)* The site was prepared via piezoelectric implant preparation using dedicated inserts. *(b)* A fit gauge was performed at the end of the osteotomy to check the correct implant site preparation. *(c to e)* Implants were positioned and placed (Rex TL; 5 × 11 mm).

Therapeutic Intervention

Implant characteristics

For this case, wedge-shaped, tissue-level titanium implants with an external hexagonal connection were used (Rex Piezoimplant TL 1.8H, Rex Implants; 5 × 11 mm). The implant surface features a sandblasting process with hydroxyapatite, acid passivation, and a machined collar, and this rectangular section measures 5 × 1.8 mm.

According to the implant manufacturer's instructions, implant site preparation was performed with a piezoelectric device (Piezosurgery, Mectron) using dedicated inserts (W1 to W4, Rex Implants). A shaped fit gauge (Rex Implants) was inserted at the end of each osteotomy step to verify correct implant site preparation. An electronically controlled magnetic device with dedicated tips (IPD Implant Placement Device, Rex Implants) was used to place implants into the osteotomy sites.

Surgery

The patient signed a specific informed consent. Amoxicillin/clavulanic acid (augmentin 875/125 mg tablet, GlaxoSmithKline) was administered 1 hour before surgery and twice daily for 5 days postsurgery. Immediately before surgery, the patient rinsed with a 0.20% chlorhexidine gluconate solution (Curasept, Curaden) for 1 minute. Local anesthesia with mepivacaine (Optocain, Molteni Dental; mepivacaine 2% and epinephrine 1:100,000) was performed near the emergence of the infraorbital, nasopalatine, and posterior superior alveolar nerves. After performing a crestal incision with a scalpel blade (no. 15C, Hu-Friedy), a mucoperiosteal flap was elevated to expose the alveolar ridge. The flap design included a median relief incision to reduce tension during tissue healing.

The implant site preparation was performed as described in the previous section, and six wedge-shaped implants were placed in the maxilla (Fig 5). After insertion, a customized aluminum SmartPeg (type 4, Osstell) was manually screwed into the implants to record implant stability quotients (ISQs) in mesiodistal (MD) and buccolingual (BL) directions through a cordless device (Beacon, Osstell). ISQs were also recorded at 6-month and 1-year follow-ups.

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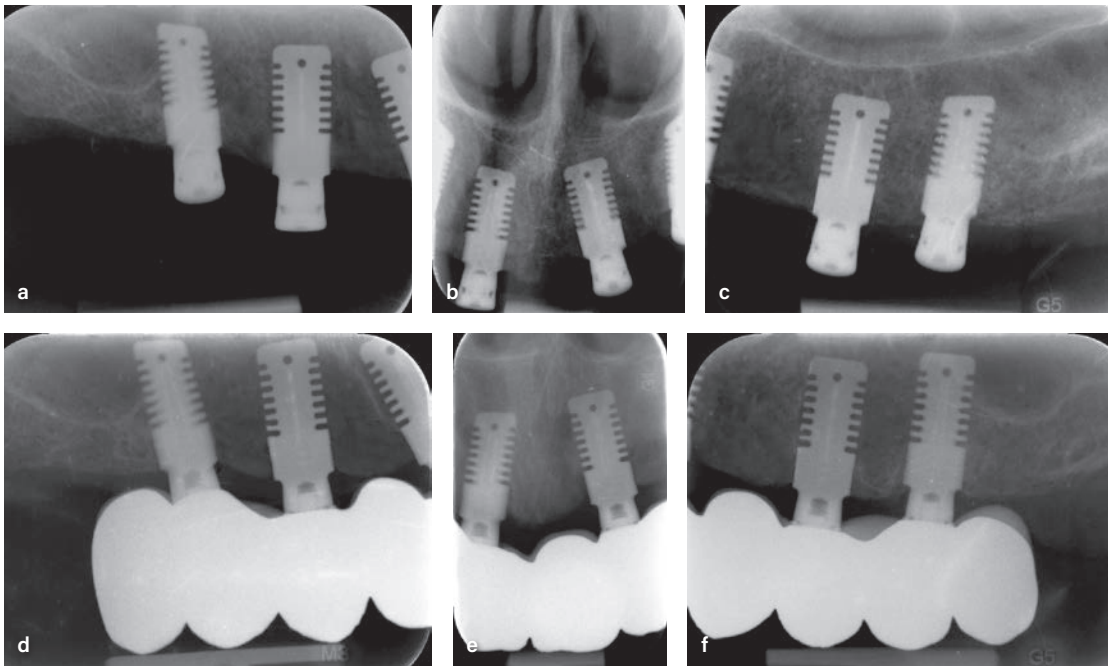

▲ **Fig 6** Bone-level evaluation immediately before prosthesis delivery *(a to c)* and at the 1-year follow-up *(d to f)*.

Finally, six healing caps were screwed onto the implants (15-Ncm torque), and the soft tissues were sutured (Vicryl 4-0, Ethicon). Marginal bone loss (MBL) around implants was assessed by intraoral radiographs using the long-cone periapical parallel technique immediately before prosthesis delivery and at the 1-year follow-up, performed according to Wallner et al[10] (Fig 6).

The patient was instructed on the oral hygiene procedures to be performed in the postoperative period (rinsing with a 0.12% chlorhexidine gluconate mouthwash and application of a 1% chlorhexidine gel twice daily for 2 weeks). Sutures were removed 1 week after surgery.

The patient was asked to report daily discomfort on a visual analog scale (VAS; scored from 0 to 10, with 0 indicating no pain and 10 indicating the worst possible pain) as well as any need for analgesic therapy during the first postsurgical week. Before delivering the fixed prosthesis, the patient was recalled monthly to assess any potential complications.

Prosthetic procedures

The patient's maxillary denture was relined with a soft-tissue conditioner (F.I.T.T., KerrHawe) at the end of the surgery and periodically until delivery of the fixed denture. The final prosthesis manufacturing phase began 6 months after surgery (Fig 7) with the dental impression procedures. A fixed screw-retained full-arch dental prosthesis was realized.

First, a prototype of the final restoration was designed using a computer-aided design (CAD) program (DentalCAD, Exocad). Then, the prototype was milled (Fig 8) from a polymethyl methacrylate (PMMA) disc (Multilayer PMMA Disc, Dentsply Sirona). The prosthetic connections were molded into the prototype, and no temporary titanium abutments were used at this stage. After 1 month of functional and esthetic checks, the final work was carried out (Fig 9). A monolithic structure was milled from a multilayer yttrium-stabilized zirconia disc (Disk ZR Lucent Supra, Shofu) to copy the design of the provisional fixed prothesis.

During clinical evaluations, Sheffield test was performed to verify the passivity of the framework, and intraoral radiographs were taken. The restoration was stained and veneered with the application of liquid microlayering ceramic (MiYO Liquid Ceramic System, Jensen Dental). The prostheses were cemented to the titanium abutments with resin cement (Panavia F 2.0, Kuraray).

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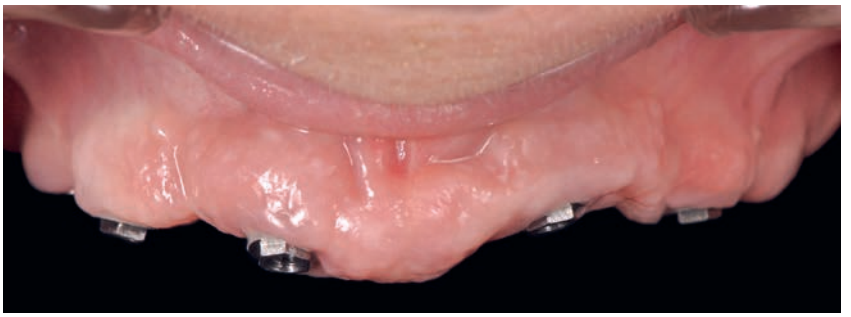

◀ **Fig 7** Peri-implant mucosal healing at 6 months postsurgery.

◀ **Fig 8** Clinical appearance 1 month after provisional prosthetic loading.

◀ **Fig 9** The final restoration was delivered after 1 month of provisional prosthetic conditioning.

To avoid holes in the anterior zone of the prosthesis, an angled canal with a dedicated screw (GenTek Hexalobular Screw, Zimmer Biomet) was used for implants in positions 11 and 22 (FDI numbering system). After prosthesis delivery, follow-up visits were scheduled at 1, 3, and 6 months and at 1 year to assess any complications.

Results

Follow-up and Outcomes

The patient reported slight discomfort during surgical procedures and did not require analgesic therapy during the first postsurgical week.

The VAS score was 3 at the end of the surgery day and gradually decreased during the week

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(scores of 3, 2, 2, 1, 1, 0, 0, and 0 on days 0, 1, 2, 3, 4, 5, 6, and 7, respectively). Immediately after implant placement, the mean ISQ values were 63.83 ± 3.86 MD and 42.5 ± 2.25 BL. At the 6-month follow-up, the mean ISQ values were 65.83 ± 1.47 MD and 45.16 ± 2.48 BL. At the 1-year follow-up, ISQ values were 68.66 ± 2.50 MD and 48.5 ± 2.42 BL.

Radiographic evaluation showed a mean MBL of 0.83 ± 1.04 mm (0.91 ± 0.99 mm mesial; 0.74 ± 1.17 mm distal). No surgical or prosthetic complications were reported at scheduled follow-up visits.

Discussion

The different patterns of bone resorption in edentulous arches represent a severe challenge for clinicians who have to plan a specific treatment protocol for each scenario.[3] The pattern of bone loss varies according to the anatomical site, patient age, previous pathology, and trauma. Progressive bone loss after tooth extraction can lead to horizontal bone loss, especially in the anterior maxilla.[9] The "knife-edge" alveolar ridge pattern represents a critical scenario for fixed full-arch implant rehabilitation. Dental implants require an adequate bone envelope and good implant stability values to ensure long-term success.[2,11–13]

Current solutions for managing narrow ridges are limited to BAPs or placing narrow-diameter implants (NDIs).[14,15] BAPs (guided bone regeneration, bone block grafting, split crest procedure) have shown satisfactory long-term functional and esthetic results, with an average implant survival rate > 90%.[16,17] However, regenerative approaches require advanced surgical skills and may be associated with greater morbidity, longer treatment times, and higher biologic and economic costs than standard implant rehabilitation.[18] NDIs with a diameter < 3.5 mm are considered a reasonable alternative treatment when it is not possible to place standard-diameter implants (SDIs; > 3.75 mm) due to severe bone atrophy.[19] The use of NDIs has prevented BAPs and achieved positive results in terms of esthetics, satisfaction, and quality of life.[19] However, an unfavorable prosthetic load distribution, resulting in more significant peri-implant bone resorption and a higher fracture rate than SDIs, obliges the clinician to carefully consider the use of NDIs where the occlusal load is higher.[20]

Although Linkow et al[21] proposed a blade implant to rehabilitate atrophic ridges and avoid BAPs in 1968, Farronato et al[22] observed that the long-term results of this therapeutic solution have not been promising, and the use of these devices has progressively decreased over time. However, there is still a dilemma on how to simultaneously achieve good residual bone thickness, low surgical comorbidity, and satisfactory medium- to long-term therapeutic results. The discrepancy between bone width and implant diameter is associated with an increased risk of cortical dehiscence during implant placement, and the loss of peri-implant bone tissue can increase the risk of mucositis and peri-implantitis.[23]

The use of wedge-shaped implants may represent an appropriate alternative in conditions of severe horizontal atrophy,[24] as in the present case. Previous studies have evaluated the influence of the unconventional shape of these implants on stability, showing ISQ values of 68.0 ± 5.4 MD and 55.5 ± 5.8 BL after implant placement and 68.93 ± 6.51 MD and 52.10 ± 7.79 BL after 6 months.[24] Although slightly lower, similar ISQ values were recorded in the present case. The higher MD values compared to the BL values may be explained by the BL implant thickness.

In addition, the bone compaction obtained in the present case by inserting the implant with the IPD may cause the bone trabeculae to spread, allowing better anchorage of the device to the surrounding tissue.[25] This can lead to higher ISQ values immediately after implant insertion, especially in the premaxilla.[26] Recent histomorphometric studies have suggested that new bone formation is greater and occurs earlier in osteotomies performed in mainly cancellous bone sites compared to cortical ones.[27] Due to the greater amount of trabecular bone, the use of wedge-shaped implants may represent an additional advantage in maxillary rehabilitation. The ISQ values recorded herein may be lower than other reports on wedge-shaped implants due to the marked atrophy in the present clinical case and the limited evaluation of implants placed in the maxilla.[24]

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The use of a piezoelectric device for osteotomies allowed for great control of surgical phases in the present case, and this is especially true in cases of severe ridge atrophy.[28–30] For this patient, the preservation of the buccopalatal plates, combined with the innovative wedge implant shape, helped achieve and maintain good ISQ values during the follow-up. Further, as suggested in a recent meta-analysis with trial-sequential analysis, piezoelectric implant site preparation seems to have a more favorable influence on the osseointegration process than conventional drilling procedures.[30] Results after a 1-year follow-up might suggest that using piezoelectric surgery for wedge-shaped implant site preparation could improve early bone healing around the implant.[24,30] A study on wedge-shaped implants showed that the bone was stable around implants at the 1-year follow-up.[24]

Moreover, the present patient reported slight intraoperative and postoperative discomfort, highlighting the minimal invasiveness of the surgery. The current VAS scores are similar to those reported in previous studies on the use of wedge-shaped and conventional implants.[24,31] The minimally invasive surgical osteotomy and reduced surgical steps suggested less discomfort than GBR procedures, where tissue edema and prolonged surgical times negatively affect the patient's postoperative period.[32,33]

The main limitation of the present study is the short-term follow-up. Although no complications were recorded during the first year of masticatory loading, a long-term follow-up and a case series are necessary to validate this surgical approach. However, to the best of the authors' knowledge, this case represents the first full-arch rehabilitation of a marked atrophic maxilla using wedge-shaped implants.

Conclusions

Although only evaluated in the short to medium term, the use of wedge-shaped implants could be a good therapeutic alternative for managing severe horizontal atrophy. In particular, this approach would avoid BAP procedures, which are necessary to place SDIs in an adequate volume of bone. In addition, the recorded ISQ values, reduced discomfort indicate that wedge-shaped implants are suitable for the successful management of severe maxillary atrophy.

Due to the limited availability of scientific data in the literature, there is no clinical information on the long-term survival of wedge-shaped implants. Long-term follow-ups, further multicenter studies, and randomized clinical trials are needed to evaluate the reliability of this implant form in different clinical scenarios.

Acknowledgments

All authors contributed substantially to the study. Dr Tomaso Vercellotti states that he is a scientific advisor to Rex Piezoimplants (Columbus, Ohio). He certifies that he has no equity interest and has no shares of the company. He was invited to participate in this article done in total independence by the University of Catanzaro (Italy) as a clinical expert in the field. The other authors declare no conflicts of interest.

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Amerigo Giudice, MD, PhD
Ferdinando Attanasio, DDS
Francesco Bennardo, DDS, PhD
Alessandro Antonelli, DDS, PhD
School of Dentistry, Department of Health Sciences, Magna Graecia University of Catanzaro, Catanzaro, Italy.

Tomaso Vercellotti, MD, DDS
Department of Surgical Sciences and Integrated Diagnostics, University of Genova, Genova, Italy.

Correspondence to:
Dr Alessandro Antonelli, alessandro.antonelli@unicz.it

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