Utilization of Trabecular Metal Implants for the Rehabilitation of Maxillary Edentulous Arch: A Case Report

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Introduction: This case report illustrates the use of trabecular metal (TM) implants to rehabilitate a severe atrophic maxillary arch that was successfully augmented by allografts.

Case Presentation: A 68-year-old female was referred to a private practice for severe maxillary alveolar bone atrophy (e.g. subsinus bone height of <1 mm on left and <4 mm on the right side). Allograft bone block augmentation was employed to regenerate ridge deficiency simultaneously with bilateral sinus augmentation. Six implants (4 TM and 2 tapered) were placed and bone specimens obtained 6 months after grafting. Radiography and histologic analysis demonstrated that implants were positioned in non-native bone. Removal torque test, performed at second stage procedure, confirmed the successful osseointegration of implants. The definitive implant-supported full-arch prosthesis was then constructed and placed in function.

Conclusion: The positive outcomes of this case report suggested that the rehabilitation of severely atrophic maxillary arch might be achieved by merging TM with new regenerative techniques without harvesting conspicuous quantities of autogenous graft.

KEY WORDS: Allograft; Bone graft; Bone regeneration; Sinus floor augmentation; Tantalum.

BACKGROUND

The surface topography of implants, mainly consisting of commercially pure titanium, has been thoroughly investigated and significantly improved in the last two decades. Recent advancements have led to the development of a new trabecular metal (TM) implant in tantalum. Tantalum possesses characteristics that confer significant advantages over traditional implant materials: it is chemically stable and biocompatible, and can be manufactured with a three-dimensional architecture similar to that of bone trabeculae. In addition, it presents favorable strength even in its trabecular form. Studies in human and animal have shown excellent bone ingrowth into the trabecular bone holes.

Interestingly, in orthopedics, the use of tantalum is recommended in areas where the bone quality is questionable.
Focusing on implant dentistry, the native implant site may present inadequate quantity and of bone due to previous extractions, periodontal disease and traumatic injuries. When these situations occur, the regeneration of the implant site is often the solution.

The use of human bone for the regeneration of osseous defects has significantly changed implant dentistry in the past 20 years. Autologous bone has been recognized as the gold standard of bone graft material because it possesses osteoconductive, osteoinductive, osteogenic and properties. However, the harvesting of bone from patients presents many disadvantages, including morbidity of the donor site and high risk of severe complications. Moreover, the supply of autologous bone graft may be limited. Clinicians are in pursuit of alternative grafting materials resembling the properties shown by autologous bone. Allografts - which are available in ample quantities and in many different forms, including powders, granules, putty and blocks – enable the clinicians to offer therapeutic solutions that are less invasive and more effective, which minimize significantly biological and economic cost for the patient.

Based on the aforementioned considerations, we hypothesized that TM implants would have shown successful osteointegration whether inserted in purely augmented sites.

**CLINICAL PRESENTATION**

A 68-year-old female was referred to a private dental office in Brescia for the chief complain of maxillary edentulism (Fig. 1). She was systemically healthy and did not neither smoke and nor take any medications. At the time of the first consultation, patient wore removable complete upper denture. Upper and lower alginate impressions were taken. A full diagnostic wax-up was performed on the mounted study model casts (Fig. 1b).

A pre-operative cone beam computed tomography (CBCT) scan was taken (Fig. 2). The 3D CBCT data (Fig. 3) provided the information to fabricate a solid model according to technique described in a previous report.

The clinical and radiographic examination of the maxillary alveolar ridge revealed a Seibert Class III ridge deficiency defect. Moreover, preexisting subsinus alveolar bone height was <1 mm on the left side and was only 1-4mm on the right side.

The patient refused invasive treatment option which required onlay/inlay autogenous grafts; therefore allograft bone block augmentation was planned to regenerate ridge deficiency on both sides of the maxilla, contextually with bilateral sinus augmentation.

A fixed implant-supported full-arch hybrid prosthesis, Toronto bridge type, was planned for the upper arch. The active treatment was carried out from October 2011 to November 2012 by the same operator (C.M.S).

Patient agreed to the intervention and signed a written consent form, according to the Helsinki protocols.

**CLINICAL MANAGEMENT**

Surgical sites were infiltrated by local anesthetic with epinephrine concentration of 1:100,000. Two horizontal mid-crestal incisions were made lightly palatal to the crest of the ridge, from both distal aspects of the maxilla, continuing mesially until they reached each other anteriorly. A buccal full-thickness flap was reflected to expose the residual ridge and the lateral wall of the
right-sided sinus. Transcrestal approach was used to augment the left-sided sinus floor, whereas the right-sided one was approached laterally, as previously reported\textsuperscript{15}. Preparation of the allograft and the onlay grafting technique was conducted according to previous report\textsuperscript{12}. Cortical plate of the recipient bone was perforated to induce bleeding (Fig. 4a).

Block bone grafts\textsuperscript{¶} were positioned to augment the buccal side of the residual ridge and at the same time to cover the crestal window (Fig. 4b). Allografts were stabilized in place with miniscrews\textsuperscript{**} (Fig. 5b). Remaining voids between blocks were filled with particulate graft\textsuperscript{††}. Bone graft materials were covered with pericardium membrane\textsuperscript{‡‡} to prevent epithelial ingrowth (Fig. 5a). Flaps were repositioned following buccal perioisteal incisions and stabilized with single interrupted sutures\textsuperscript{§§} to achieve primary wound coverage. A CBCT scan was taken immediately after grafting (Figs. 4c, 4d, 5c and 5d). Patient was given amoxicillin 500 mg \textsuperscript{‖‖} twice a day for 7 days to control infection and naproxen 550 mg\textsuperscript{¶¶} for pain and inflammation. Patient was instructed to use 0.12\% chlorhexidine\textsuperscript{##} twice a day for 2 weeks. Sutures were removed 12 days after the surgery. Monthly follow-up was scheduled to check the wound healing up to implant insertion.

Post-operatory healing was satisfactory and no sign of complications was noted. Six months after surgery, a CBCT scan was taken. The 3D radiographic examination revealed adequate bone formation which allowed for the proper prosthetically driven implants placement. At the time of implant installation, a significant amount of newly formed bone gain was appreciated. A surgical guide was fabricated to guide the position of initial osteotomy (Fig. 6a).

Next, a trephine drill\textsuperscript{***} (external diameter of 4 mm and internal diameter of 3 mm) was utilized under saline jet at 600 rpm to collect bone core specimens in 4 sites (molar and premolar sites) before implant insertion (Fig. 6b). A total of 6 fixtures\textsuperscript{†††} were placed (Fig. 6d and Table 1). Flaps were repositioned and secured with single interrupted sutures\textsuperscript{§§} to achieve primary closure. A second-stage procedure was performed 3 months later to uncover implants (Fig 7). The reverse torque testing\textsuperscript{‡‡‡} at 25 Ncm (Figs. 7b and 7c) and radiography (Fig. 8) confirmed the osseointegration implants. Finally, the rehabilitation on implants was finalized using fixed implant-supported full-arch hybrid prosthesis (Fig.9). The torque value used to tighten the abutment screws was 20 Ncm, as recommended by the vendor.

**HISTOLOGIC PREPARATION**

Bone core biopsies were fixed, embedded in polymethyl methacrylate (PMMA) and sectioned as described by Soardi et al.\textsuperscript{16}. Microradiographs, toluidine blue or trichrome Gomori staining of 5-\mu m-thick sections, photographs, and bone and graft amount evaluations were performed as previously reported\textsuperscript{16}.  

**CLINICAL OUTCOMES**

All the implants were integrated, retained and functional up to the time of the completion of this manuscript. At second stage procedure, all implants successfully tolerated a 25 Ncm torque test.

CBCT scans, taken at baseline and immediately after implant placement, were superimposed according to a previously published method\textsuperscript{17}. This confirmed the implant were embedded into purely augmented bone (Fig. 10).
HISTOLOGIC OUTCOMES

Six months after grafting, all biopsies showed a formation of a newly formed trabecular bone mixed with allograft residual particles (Figs. 11 and 12). The graft residues were in direct connection with the newly formed bone (Fig. 12). No presence of native bone was found in all samples. The histomorphometric evaluation of the amount of the newly formed bone and residual graft per tissue volume of all biopsies ranged from 21.1 to 23.6 and from 3.0 to 5.2 %, respectively.

DISCUSSION

This clinical case report illustrated that a newly introduced TM implants could be successfully integrated in the purely augmented ridge sites by allografts. This study also revealed that the 3D block technique was a viable option in augmenting Seibert Class III ridge defects without relying on the traditional autogenous block grafts.

Various surgical techniques have been developed to enter the sinus cavity elevating the sinus membrane and placing bone grafts. In this report, the decision to apply the lateral or the transcrestal techniques was based on the low amount of residual bone available. It has been pointed out that the amount of residual bone height significantly influenced the implant survival after sinus floor elevation\textsuperscript{18}, therefore it is paramount in treatment planning to identify an appropriate approach in achieving a predictable outcome. In this case report, the right-sided sinus was approached via a traditional maxillary lateral wall osteotomy since the residual floor ranged from 1 to 4 mm. On the other hand, a crestal approach was adopted for left-sided sinus, which seemed to increase overall implant success rate in extremely atrophic sinus floors as reported by Soardi et al.\textsuperscript{15,6} Three months after implant placement, all six implants successfully withstand the 25 Ncm reverse torque test. We argued the TM implant configuration could have yielded additional resistance to reversal rotational force, given that bone ingrowth into the midsection of the implant. This phenomenon was and also extensively documented in orthopedic literature.\textsuperscript{3-4} The superimposition of CBCT scans showed that a prosthetically driven implant placement would have not been possible without relying on bilateral sinus augmentation and the 3D block grafts.

Based on the promising results gathered by this clinical report, we propose that the rehabilitation of severely atrophic maxillary arch may be achieved by merging TM implant with new regenerative techniques (e.g., 3-dimensional planned human allogenic bone block), thus eliminating the need for bone donor site, long-term investigations are warranted to verify whether our findings are consistent.

SUMMARY:

- Why is this case new information?
  - To the best of our knowledge, this is the first published clinical case report of a fully functional TM implant.

- What are the keys to successful management of this case?
  - Thorough treatment plan
- Surgical skills
- Sufficient financial resources
  - What are the primary limitations to success in this case?
- Lack of long-term studies to show the benefits of trabecular implant versus conventional implants with regards to timing of loading and amount of bone in-growth.
- Short-term follow up

CONFLICT OF INTEREST AND SOURCES OF FUNDING STATEMENT:
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REFERENCES
1. Saulacic N, Bosshardt DD, Bornstein MM, Berner S, Buser D. Bone apposition to a titanium-zirconium alloy implant, as compared to two other titanium-containing implants. *Eur Cell Mater* 2012;23:273-86.


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**TABLE 1 Implant site, diameter and length.**

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<td>7</td>
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††† Tapered Screw-Vent, Zimmer Dental Inc., Carlsbad, CA; ‖ Trabecular metal implant, Zimmer Dental Inc., Carlsbad, CA.

‡‡ Zimmer Dental Inc., Carlsbad, CA.

¶Ultracain D-S forte, Sanofi-Aventis Deutschland GmbH, Frankfurt am Main, Germany.

#Puros Block Allograft, Zimmer Dental Inc., Carlsbad, CA.

**Osteomed Micro System, Addison, TX.
††Puros Cortical, Zimmer Dental Inc., Carlsbad, CA.
‡‡CopiOs Pericardium Membrane, Zimmer Dental Inc., Carlsbad, CA.
§§Gore-Tex 5.0, W. L. Gore & Associates, Flagstaff, AZ.
|| || Ratiopharm GmbH, Ulm, Germany.
¶¶Synflex, Recordati, Milan, Italy.
##Corsodyl, Glaxo SmithKline, Verona, Italy.
***Stroma GmbH, Emmering-Liptingen, Germany.
†††Tapered Screw-Vent, Zimmer Dental Inc., Carlsbad, CA.
‡‡‡Implantmed, W & H, Bürmoos, Austria.
FIGURE 1  1a Initial situation.  1b Diagnostic wax-up.
662x204mm (72 x 72 DPI)
FIGURE 2 Preoperative CBCT scan.
549x230mm (72 x 72 DPI)
FIGURE 3 Sinterized models. 3a Front view. 3b Front view: prepared segments are attached to the sterile sinterized model. 3c Occlusal view. (BEFORE)
FIGURE 4 - 4a Corticotomy. 4b Allograft segments are transferred from the model to the recipient site. 4c and 4d Immediate post operative CBCT scan.
439x245mm (72 x 72 DPI)
FIGURE 5 5a A resorbable membrane is placed over the grafted site. 5b Allograft segments stabilized with miniscrews. 5c and 5d Immediate post operative CBCT scan.
FIGURE 6 6a Initial osteotomy. 6b Bone sampling. 6c Implant insertion. 6d Panoramic film taken immediately after surgery.
633x381mm (72 x 72 DPI)
FIGURE 7 7a Occlusal view, 3 months after implant surgery. 7b and 7c Torque removal test. 7d Occlusal view immediately after second stage procedure.
389x291mm (72 x 72 DPI)
FIGURE 8 8a and 8b periapical and 8c panoramic X-ray taken immediately after final restoration. (AFTER)
446x331mm (72 x 72 DPI)
FIGURE 9 Final restoration. 270x95mm (72 x 72 DPI)
FIGURE 10 Superimposed CBCT scans taken at baseline and immediately after implant placement. 9a Surface reconstruction of native bone (white) and the implants (pink). 9b Surface reconstruction of native bone (white), implants (pink) and the augmented bone (dark gray).

670x196mm (72 x 72 DPI)
FIGURE 11 Microradiograph (A) of a section of commercially available mineralized human bone allograft block (a) and of a bone biopsy harvested 6 months after grafting (b). Note in (a) the more ordered spatial arrangement of the bone trabeculae. Note in (b) how the graft (lighter than the bone) has been greatly replaced by the newly formed bone.

100x76mm (300 x 300 DPI)
FIGURE 12 Images illustrating histology of a biopsy harvested 6 months after grafting. Microradiograph (a), toluidine blue (b), trichrome Gomori stain under ordinary (c) and polarized light (d). Note in (a) the presence of allograft bone block residues (G). The arrows in (b) indicate layers of active osteoblasts (China-ink label = crestal bone on the right). Note also in (c) and (d) how the newly formed bone presents a woven or parallel-fibered structure which differs greatly from the lamellar structure of the residual particles (G). 124x93mm (300 x 300 DPI)