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CASE REPORT

CUSTOMIZED TITANIUM MESH RECONSTRUCTION OF A SEVERELY ATROPHIC MANDIBLE WITH SUBSEQUENT IMPLANT-SUPPORTED REHABILITATION:A CASE REPORT

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Abstract

Background: Severe mandibular alveolar ridge atrophy represents a major challenge in implant dentistry, especially when associated with advanced periodontal destruction and extensive loss of supporting bone. In cases where residual bone volume is insufficient for prosthetically guided implant placement, guided bone regeneration (GBR) provides an effective approach for restoring the three-dimensional architecture of the alveolar ridge.

Case Presentation:A systemically healthy female patient with Stage III generalized chronic periodontitis and severe mandibular alveolar bone loss was referred for implant-supported rehabilitation. Six non-restorable mandibular anterior teeth were extracted due to advanced periodontal destruction and poor long-term prognosis. Immediate ridge augmentation was performed following extraction and surgical debridement of the sites.

The deficient mandibular ridge was reconstructed using a graft mixture consisting of 60% deproteinized bovine bone mineral (Bio-Oss®) and 40% autogenous bone. The graft material was stabilized with a patient-specific CAD/CAM titanium mesh designed according to preoperative cone-beam computed tomography (CBCT) evaluation and virtual planning.

During the six-month healing period, the augmented ridge maintained its planned contour without wound dehiscence, infection, graft exposure, or titanium mesh exposure. CBCT evaluation demonstrated adequate bone regeneration for implant placement. After removal of the customized titanium mesh, eight BioHorizons implants were placed in prosthetically planned positions. Primary stability was achieved in all implants, with insertion torque values of approximately 35 Ncm.

Following a three-month osseointegration period, a definitive implant-supported metal-ceramic fixed bridge was fabricated and delivered. Clinical and radiographic follow-up demonstrated stable peri-implant tissues and preservation of the regenerated bone volume. During the three-year follow-up period, no implant failures, peri-implant infections, prosthetic complications, or graft-related complications were observed.

Conclusion: This case demonstrates that customized CAD/CAM titanium mesh-assisted guided bone regeneration combined with a mixture of deproteinized bovine bone mineral and autogenous bone can provide predictable reconstruction of severely atrophic mandibular ridges. The technique allowed stable three-dimensional bone regeneration, successful implant placement, and long-term functional and esthetic rehabilitation.

Keywords: Guided bone regeneration, titanium mesh, Bio-Oss, autogenous bone graft, mandibular atrophy, ridge augmentation, dental implants.

INTRODUCTION

Severe mandibular alveolar ridge atrophy remains a complex clinical challenge in implant dentistry. Following tooth extraction, alveolar bone remodeling is a physiological process; however, this resorptive pattern may become considerably more pronounced in patients with advanced periodontal disease, chronic inflammatory conditions, trauma, or prolonged edentulism[1]. As the remaining bone volume decreases, placement of dental implants in an ideal prosthetic position may become difficult or impossible without prior reconstructive treatment aimed at restoring adequate ridge height and width [2,3]. Different surgical approaches have been described for the management of severely resorbed alveolar ridges. These include

autogenous block bone grafting, ridge splitting techniques, distraction osteogenesis, inferior alveolar nerve repositioning, and guided bone regeneration (GBR) procedures [3–5]. Autogenous bone remains an important grafting material due to its osteogenic, osteoinductive, and osteoconductive properties. Nevertheless, limitations such as donor-site morbidity, limited availability of harvested bone, additional surgical procedures, and possible postoperative volume reduction have led clinicians to investigate alternative or combined regenerative approaches [6]. Over the past decades, guided bone regeneration has become a widely used method for reconstruction of deficient alveolar ridges[7]. The principle of GBR is based on the use of a barrier that prevents the migration of rapidly proliferating soft tissues into the bone defect while maintaining a protected environment that supports the migration and activity of osteogenic cells8. The success of this approach depends on several biological and technical factors, including primary wound closure, sufficient blood supply, stable immobilization of the graft material, preservation of the regenerative space, and protection of the newly forming tissue. These concepts were summarized by Wang and Boyapati as the PASS principles[9].

The PASS concept includes four essential requirements for predictable bone regeneration:

- Primary wound closure
- Angiogenesis and adequate blood supply
- Space creation and maintenance
- Stability of the wound and regenerative site

The selection of an appropriate graft material is an important factor influencing the outcome of GBR procedures. Deproteinized bovine bone mineral (DBBM; Bio-Oss®) is one of the most extensively studied xenogeneic biomaterials used in implant dentistry. Its porous structure, favorable osteoconductive characteristics, and slow resorption pattern allow it to function as a stable scaffold supporting new bone formation and contributing to maintenance of the augmented ridge volume over time [10,11]. In cases involving severe mandibular atrophy, the combination of xenogeneic bone substitutes with autogenous bone may provide additional biological advantages. Autogenous bone contains viable cells and biological factors that may contribute to early bone formation, whereas Bio-Oss® provides a slowly resorbing mineral scaffold that supports long-term volume preservation. Therefore, combining autogenous bone with Bio-Oss® may create a balanced regenerative environment by integrating the biological activity of autogenous grafts with the dimensional stability of xenogeneic materials[12-14]. In the present case, a graft mixture composed of 60% deproteinized bovine bone mineral and 40% autogenous bone was used for reconstruction of a severely deficient mandibular ridge. This combination was selected to provide sufficient biological stimulation while maintaining the structural stability required for extensive ridge augmentation. One of the main challenges in GBR procedures, particularly in large vertical and horizontal defects, is the maintenance of adequate regenerative space. Pressure from the overlying soft tissues may influence graft stability and result in partial collapse of the augmented region16. To overcome this limitation, titanium meshes have been introduced as rigid non-resorbable barriers capable of maintaining graft volume and preserving the intended three-dimensional shape of the reconstructed ridge during healing[17,18]. Titanium meshes provide mechanical stability, excellent biocompatibility, and resistance to deformation. Their ability to stabilize particulate graft materials makes them especially useful in extensive alveolar defects where conventional membrane techniques may not provide sufficient space maintenance[19]. The introduction of digital planning and CAD/CAM manufacturing has further improved the application of titanium mesh-assisted GBR. Patient-specific titanium meshes can be designed from CBCT-based virtual planning according to the individual anatomy of the defect. This allows more accurate adaptation, decreases the need for intraoperative modification, and improves stabilization of the grafted area[20]. Current clinical evidence supports the use of titanium mesh-assisted GBR in complex alveolar reconstruction. Systematic reviews and meta-analyses have reported favorable vertical and horizontal bone augmentation outcomes together with high implant survival rates following titanium mesh-based regeneration procedures[21,22]. In addition, recent studies comparing CAD/CAM-designed titanium meshes with conventionally shaped meshes have demonstrated improved adaptation, reduced surgical adjustments, and enhanced clinical predictability when individualized designs are used[23]. Therefore, the combination of a patient-specific titanium mesh with a graft mixture containing deproteinized bovine bone mineral and autogenous bone represents a biologically supported approach for reconstruction of severely atrophic mandibular ridges. This method provides stable space maintenance, facilitates bone regeneration, reduces the need for extensive donor-site harvesting, and creates a suitable foundation for subsequent implant placement[24].The aim of this case report is to describe the reconstruction of a severely atrophic mandible after

extraction of hopeless teeth using guided bone regeneration with a customized CAD/CAM titanium mesh and a graft mixture consisting of 60% Bio-Oss® and 40% autogenous bone, followed by implant placement and implant-supported prosthetic rehabilitation.

CASE REPORT

Patient Assessment

A systemically healthy female patient was referred for implant-supported rehabilitation of the mandible. Clinical examination revealed multiple mandibular teeth with a poor long-term prognosis due to severe mobility, advanced clinical attachment loss, and extensive loss of supporting alveolar bone. The patient was diagnosed with Stage III generalized chronic periodontitis associated with severe mandibular alveolar ridge destruction. The remaining mandibular anterior teeth showed advanced periodontal involvement and were considered non-restorable. The treatment plan included extraction of six mandibular anterior teeth followed by immediate guided bone regeneration (GBR) to reconstruct the deficient alveolar ridge and prepare the site for future implant placement. Cone-beam computed tomography (CBCT) was performed to evaluate the remaining bone volume and defect morphology. The radiographic examination demonstrated severe horizontal and vertical bone deficiency, with insufficient ridge dimensions for placement of implants in a prosthetically appropriate position (Figure 1a,b).

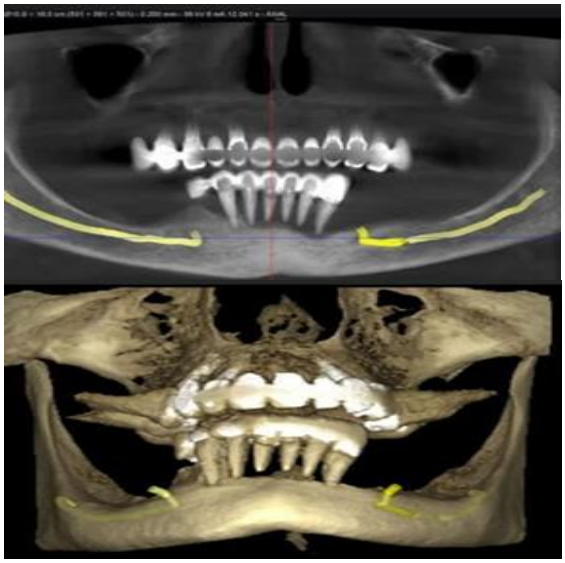

Figure1a,b. Preoperative clinical and CBCT evaluation demonstrating severe mandibular alveolar ridge deficiency and inadequate bone volume for implant placement.

Ridge Augmentation Procedure

Following atraumatic extraction of the six compromised mandibular anterior teeth, the extraction sites were carefully debrided. The sockets were curetted and irrigated with an antiseptic solution to remove residual inflammatory tissue and prepare the recipient sites for bone regeneration. Immediate ridge augmentation was performed using a mixture of deproteinized bovine bone mineral (Bio-Oss®) and autogenous bone. The graft material was placed into the extraction sockets and adjacent deficient ridge areas to restore the lost alveolar contour. The graft mixture was adapted according to the planned implant positions to achieve three-dimensional reconstruction of the mandibular ridge (Figure 2a,b).

Figure 2.a,b Application of the Bio-Oss® and autogenous bone graft mixture (60:40 ratio) for reconstruction of the deficient mandibular ridge.

After placement of the graft material, the augmented area was covered and stabilized with a customized titanium mesh. The mesh was filled with the graft mixture and positioned to maintain the required regenerative space and preserve the planned ridge dimensions during healing (Figure 3).

Figure 3. Placement of the Bio-Oss® and autogenous bone graft mixture (60:40 ratio) within the customized titanium mesh for three-dimensional augmentation of the mandibular ridge.

Placement of Customized Titanium Mesh

The patient-specific titanium mesh was designed based on preoperative CBCT data and virtual planning. The CAD/CAM-fabricated mesh was adapted to the anatomy of the mandibular defect and fixed with titanium fixation screws. The customized mesh provided stable protection of the grafted area and maintained the required space for bone regeneration during the healing period (Figure 4a,b).

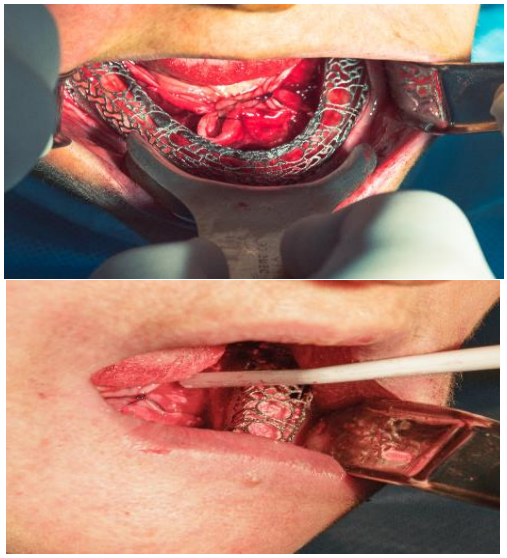

Figure 4.a,b. Placement and fixation of the customized titanium mesh over the augmented mandibular ridge to maintain the planned regenerative volume.

Primary tension-free closure was achieved by flap advancement and periosteal releasing procedures. The surgical site was closed with appropriate suturing to provide stable soft tissue coverage (Figure 5).

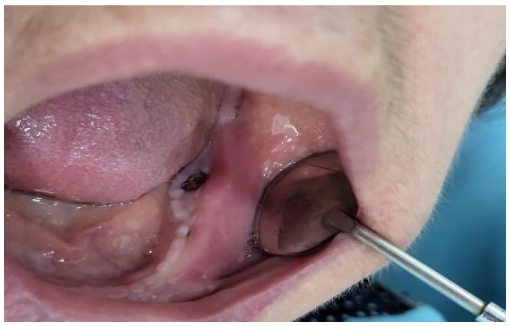

Figure 5. Tension-free repositioning of the mucoperiosteal flap and primary closure of the surgical site after placement and fixation of the customized titanium mesh.

Healing Phase

Healing following the augmentation procedure was uneventful. Postoperative treatment included systemic antibiotic therapy with amoxicillin/clavulanic acid for seven days, analgesic medication, and antiseptic mouth rinses with chlorhexidine during the early healing period. The patient was followed clinically and radiographically throughout the healing phase. Soft tissue healing was satisfactory, and the surgical site remained stable. No infection, wound dehiscence, graft exposure, or titanium mesh exposure was observed. After six months, CBCT evaluation demonstrated progressive mineralization of the augmented area and sufficient bone formation for implant placement. The reconstructed ridge maintained its planned shape and volume. During implant placement, the customized titanium mesh was removed. The regenerated bone appeared clinically mature, well vascularized, and suitable for implant insertion.

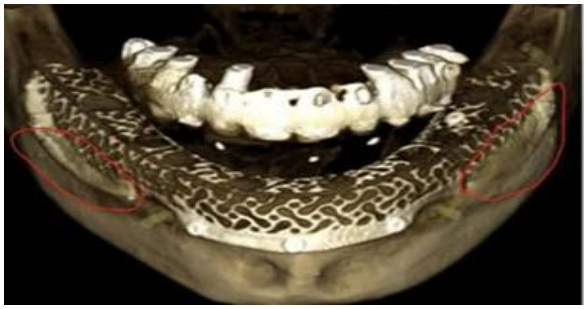

Figure 6. Postoperative CBCT evaluation demonstrating stable positioning of the customized titanium mesh and preservation of the augmented mandibular ridge volume during the healing period.

Implant Placement

Implant placement was performed six months after augmentation following confirmation of adequate bone regeneration by CBCT. Eight BioHorizons dental implants were placed in the regenerated mandibular ridge according to the prosthetically planned positions. (Figure 7). Primary implant stability was achieved in all implant sites, with insertion torque values reaching approximately 35 Ncm.

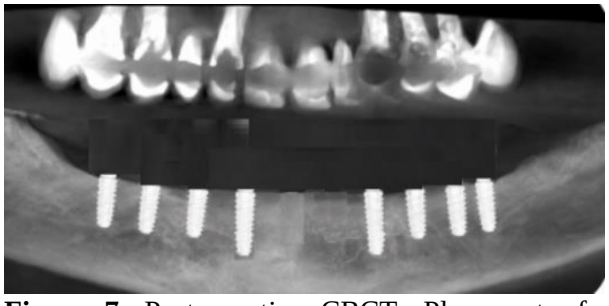

Figure 7. Postoperative CBCT, Placement of eight BioHorizons implants in the regenerated mandibular ridge demonstrating appropriate positioning and primary stability.

Prosthetic Rehabilitation

After a three-month osseointegration period, definitive implant-supported prosthetic rehabilitation was completed. The prosthetic restoration was designed to restore occlusion, masticatory function, phonetics, and esthetic appearance. Clinical and radiographic examinations after prosthetic loading demonstrated stable peri-implant tissues and satisfactory functional conditions(Figure 8).

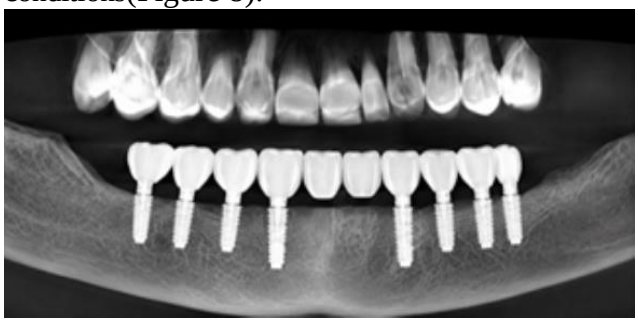

Figure 8. CBCT evaluation demonstrating A metal-ceramic fixed bridge supported by the 8 implants

During the three-year follow-up period, all implants remained clinically stable and functional. No implant loss, peri-implant infection, prosthetic fracture, screw loosening, or graft-related complications were observed. Radiographic evaluation confirmed maintained osseointegration and preservation of the regenerated bone volume. Marginal bone changes around the implants remained within physiological limits, with no evidence of progressive peri-implant bone loss. The final rehabilitation provided stable occlusion, improved masticatory efficiency, satisfactory phonetic function, and acceptable esthetic integration.

DISCUSSION

The present case demonstrates the clinical application of guided bone regeneration using a customized CAD/CAM titanium mesh combined with a mixture of deproteinized bovine bone mineral (Bio-Oss®) and autogenous bone for reconstruction of a severely atrophic mandible.

Severe mandibular ridge atrophy remains a challenging condition in implant dentistry, particularly when bone loss is associated with advanced periodontal destruction. Progressive alveolar resorption after tooth loss may result in combined horizontal and vertical defects, making implant placement in an ideal prosthetic position difficult or impossible without prior reconstruction [25]. Several surgical approaches have been proposed for management of severe alveolar defects, including autogenous block grafting, ridge expansion, distraction osteogenesis, and guided bone regeneration[26–31]. Although autogenous bone remains an important graft material because of its osteogenic, osteoinductive, and osteoconductive properties [32–34], its use may be limited by donor-site morbidity, restricted graft availability, additional surgical procedures, and increased patient discomfort [35,36].

For this reason, GBR has become an established technique for reconstruction of deficient alveolar ridges. The biological basis of GBR is the maintenance of a protected regenerative environment that prevents soft tissue invasion and allows bone-forming cells to repopulate the defect area.

The principles described by Wang and Boyapati in the PASS concept emphasize the importance of primary closure, angiogenesis, space maintenance, and stability for successful regeneration [9].

In the present case, these principles were applied during the entire regenerative procedure. Following extraction of the non-restorable teeth, the deficient mandibular ridge was immediately reconstructed using a combination of Bio-Oss® and autogenous bone in a 60:40 ratio.This combination was selected to provide both biological activity and long-term volume stability.

The use of a mixed graft material may offer advantages in large defects. Autogenous bone contributes viable cells and growth factors that may support early bone formation, while deproteinized bovine bone mineral provides a slowly resorbing scaffold that helps maintain the regenerated volume over time [12–14]. In this case, the regenerated ridge demonstrated sufficient volume and quality to allow placement of implants in prosthetically planned positions.

A key factor in the outcome was the stabilization of the grafted area with a customized titanium mesh. Titanium meshes have been widely used in GBR because they provide mechanical support and maintain the regenerative space required for bone formation [17–19]. However, conventional meshes often require intraoperative adaptation, which may increase surgical manipulation.

The use of CAD/CAM technology allows fabrication of patient-specific titanium meshes based on CBCT data and virtual planning. This approach provides accurate adaptation to the defect anatomy and facilitates reconstruction of the desired ridge contour [20,23].

In this patient, the customized titanium mesh acted as a rigid framework that protected the graft material from soft tissue pressure and prevented collapse of the augmented area during healing. The stable maintenance of the regenerative space contributed to the formation of an adequate ridge for subsequent implant placement. The clinical findings are consistent with previous reports describing favorable outcomes with titanium mesh-assisted GBR. Recent systematic reviews have demonstrated that titanium mesh techniques can provide reliable vertical and horizontal bone augmentation with satisfactory implant survival rates [21,22]. Another important aspect of this treatment protocol was the reduction of the amount of harvested autogenous bone by combining it with Bio-Oss®.

This approach allowed preservation of the biological advantages of autogenous bone while avoiding extensive donor-site procedures.

The three-year follow-up after prosthetic loading represents an important finding of this case. Many augmentation reports focus mainly on bone formation and implant placement, while long-term evaluation after functional loading is less frequently described. In the present case, the regenerated bone remained stable after prosthetic rehabilitation, with maintained peri-implant tissue health and no evidence of progressive bone loss.

The integration of digital planning, CBCT-based evaluation, and patient-specific titanium mesh fabrication has expanded the possibilities for management of complex mandibular defects. These technologies allow more accurate treatment planning and may improve control over the final reconstructed ridge morphology [43]. Nevertheless, successful bone regeneration should not be evaluated only by the amount of newly formed bone. Long-term clinical stability depends on maintenance of regenerated volume, implant function, peri-implant tissue response, and biological adaptation under loading conditions [44,45]. The current case demonstrated stable clinical and radiographic conditions throughout the follow-up period. No implant failure, peri-implant infection, prosthetic complication, or graft-related instability was observed. Overall, this case supports the use of customized titanium mesh-assisted GBR combined with Bio-Oss® and autogenous bone as a treatment option for severe mandibular ridge deficiencies. The combination of rigid space maintenance, biological enhancement from autogenous bone, and the volume-preserving properties of Bio-Oss® provided suitable conditions for implant-supported rehabilitation.

LIMITATIONS

This report describes a single clinical case; therefore, the findings cannot be generalized to all patients with severe mandibular atrophy.

Although clinical and radiographic outcomes were satisfactory, quantitative volumetric analysis of bone gain was not performed. Three-dimensional measurements using digital imaging methods could provide more detailed information regarding the amount and stability of regenerated bone.

Histological evaluation of the regenerated tissue was also not available; therefore, the exact proportion of newly formed bone, residual graft particles, and connective tissue components could not be determined. Further studies with larger patient groups and longer follow-up periods are required to evaluate the long-term effectiveness of this approach and compare it with other augmentation techniques.

FUTURE DIRECTIONS

Future clinical studies should compare customized CAD/CAM titanium meshes with conventional titanium meshes and alternative regenerative approaches. Additional research is needed to evaluate long-term volumetric stability, patient-reported outcomes, surgical morbidity, and cost-effectiveness of combined grafting protocols. The continued development of digital dentistry, virtual planning, and patient-specific biomaterials may further improve the management of complex alveolar defects and enhance the predictability of reconstructive procedures.

CONCLUSION

Within the limitations of this case report, reconstruction of a severely atrophic mandible using a combination of deproteinized bovine bone mineral (Bio-Oss®) and autogenous bone stabilized with a customized CAD/CAM titanium mesh resulted in adequate bone regeneration and allowed successful implant-supported rehabilitation.The regenerated ridge provided sufficient volume for prosthetically planned implant placement and remained stable during the three-year follow-up period.The combination of autogenous bone, Bio-Oss®, and customized titanium mesh created a stable regenerative environment that supported functional and esthetic rehabilitation in a patient with severe mandibular atrophy.

DECLARATIONS

Competing Interests

The authors declare no conflict of interest.

Funding

None.

Ethical Approval

Informed consent was obtained from patients. Clinical case approved in accordance with ethical standards.

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