https://doi.org/10.48047/AFJBS.6.2.2024.2469-2477

African Journal of Biological Sciences

Journal homepage: http://www.afjbs.com

Research Paper Open Access

Mandibular Ridge Augmentation Utilizing Pre-adapted Titanium Mesh on 3D-Model with Bovine Bone Graft and Platelet-Rich Fibrin

Mohamed Yousry Atia Sherif

PhD candidate, oral and Maxillofacial department, Suez Canal university

Corresponding author: Mohamed Yousry Atia Sherif

Email: Dr.mohamedyousrysherif@gmail.com

Article History

Volume 6, Issue 2, Apr-Aug 2024

Received: 10 August 2024

Accepted: 28 August 2024

Published: 28 August 2024

doi: 10.48047/AFJBS.6.2.2024.2469-2477

Abstract: Purpose: This study set out to assess the efficacy of augmentation of the posterior atrophic mandibular ridge utilizing a 3D-model with pre-adapted titanium mesh, bovine bone graft, and platelet-rich fibrin.

Patients and methods: A study was carried out on eight (8) patients who had posterior atrophic ridge. The patients were given a pre-adapted titanium mesh that had bovine bone graft and platelet-rich fibrin. After the Ti-mesh was removed, the implants were installed simultaneously, and finally, the final restoration was inserted. Clinical and radiographic assessment of the stability of the graft and implant.

Results: The average horizontal bone gain was 4.828 mm (± 0.378) and the average vertical bone gain was 3.822 mm (± 0.828) as measured by cone beam computed tomography (CBCT) six months after augmentation. Though it affected one patient, TI-mesh exposure did not damage the other grafts. The implant-based survival rate is 100%.

Conclusion: According to the results of this study, the best way to treat an atrophic mandibular ridge is with a combination of bovine bone graft and pre-adapted Ti-mesh.

Keywords: *Preshaped Titanium mesh (Ti-mesh) - Guided bone regeneration (GBR) - Bovine bone graft*

Introduction

Problems with implant placement and prosthetic rehabilitation arise when the alveolar ridge undergoes excessive vertical and/or horizontal resorption, which is a common occurrence in patients with posterior atrophied edentulous mandibles. During the first twelve (12) months following tooth extraction, the resorption process of the alveolar ridge is most pronounced, and it continues in a slow but steady pattern.[1]

Thanks to advancements in dental implantology, more and more people are asking for non-traditional implant methods. Denture ill-fitting, poor retention, and diminished chewing ability are common complaints from edentulous individuals with extensively resorbed mandibles.[2]

As a treatment option, dental implant rehabilitation is both common and very predictable.However, without proper augmentation of the alveolar bone to cover and support the implant, which increases the end result's

durability, implant implantation becomes impractical due to insufficient length and/or width of the alveolar bone.[3]

The intrinsic limits of oral implantology have prompted a wide range of therapeutic techniques aimed at augmenting the volume of the alveolar bone. There is currently no long-term predictability in the different surgical treatments used to enlarge the alveolar ridge, including onlay bone grafting, guided bone regeneration (GBR), alveolar distraction osteogenesis (DO), and the sandwich approach of inlay bone grafting. [4]

There were significant inherent flaws in each of these methods that reduced their effectiveness. An example of a delicate treatment that requires high levels of patient compliance and might be stressful for patients is alveolar bone distraction. In cases where there is insufficient bone, the inlay technique has serious challenges, including compromised blood supply and potential injury to the inferior alveolar canal. GBR is not sufficiently stiff to retain the ridge's shape and has a high failure rate associated with premature exposure, which impacts the overall amount of graft. [5]

Thus, among the many effective variants of Guided Bone Regeneration, Preshaped Ti-Mesh stands out. When it comes to maintaining bone grafts beneath the membrane, Ti-mesh's mechanical qualities are invaluable. Its features include qualities that prevent graft movement, elasticity that inhibits mucosal compression, stability that allows for prolonged space maintenance, and plasticity that allows for bending, contouring, and adaptability to any bony defect.[6]

Autograft, allograft, and xenograft are natural transplants; alloplasts are synthetic materials. A wide variety of materials are utilized for bone augmentation.[7] The osteogenic, osteoinductive, osteoconductive, or mixed qualities of bone graft materials determine their therapeutic usage.[8]

In order to promote bone remodeling and integration, platelet-rich fibrin (PRF) is administered. Protecting the gingiva from dehiscence and facilitating the recovery of soft tissue injuries are two benefits of using PRF membrane during bone regeneration surgery. Bone and soft tissue remodeling, regeneration, and revascularization are all enhanced by the bioactive chemicals and growth factors that make up PRF. [9]

Alveolar ridge augmentation can benefit greatly from the virtual 3D models of the jaw that can be printed utilizing a combination of computer-aided design and computer-based imagery (CAD/CAM) in this study. The pre-adapted Ti-mesh and virtual jaw model are created prior to surgery using pre-surgical CBCT.[10]

2 | Purpose

This prospective study sought to assess the clinical and radiographic efficacy of augmenting the posterior atrophic mandibular ridge using pre-adapted titanium mesh on a 3D model in conjunction with bovine bone graft and platelet-rich fibrin.

3 | MATERIALS AND METHODS

3.1 | Study design and patient selection

This clinical trial is an RCT, which stands for randomization, non-control, and prospective. The study included eight individuals who had the posterior alveolar ridge of their mandibles resorbed either vertically or horizontally. They were between the ages of 22 and 42. The Oral and Maxillofacial Surgery (OMFs) Department of Tanta University's Faculty of Dentistry evaluated and cared for all patients through clinical and radiological examinations.

Patients were medically clear, cooperative, and motivated, but they lacked the bone density (D2 - D4) necessary for a standard dental implant, had a residual bone height of no more than 5 mm, and a residual bone width of no more than 4 mm on the alveolar ridge.

Participants who met any of the following criteria were not included in the research. First, systemic diseases (such as uncontrolled diabetes) that might hinder bone repair. (2) The distance between the arches is smaller than 12 mm. (3) Individual suffering from an autoimmune disease or neurological disorder. (4) People who smoke heavily, about fifteen cigarettes daily.11. Lack of proper dental care.

Following the Committee's established protocols for human subjects research, we made sure to tell all patients of the study's goals and sought their permission before proceeding. The Faculty of Dentistry at Tanta University's Research and Ethics Committee (REC) gave their stamp of approval to this research project.

3.2 | Digital planning and device production

Preoperative Work-Up complete radiographic examination was undertaken, to precisely assess breadth of (residual) alveolar process (CBCT) scans were collected; subsequently, raw CBCT data were imported into reconstruction software, where a rigorous three-dimensional (3D) evaluation of alveolar process was performed. After printing 3D- model which represent the increased ridge starts adaptation of Ti-mesh on the model. (Figure 1)

Fig. (2): Preoperative 3D- models and titanium mesh adaptation in different views (a) augmented site by software, (b) adaption of titanium mesh in buccal view, (c)occlusal view, (d) lingual view.

3.3 | Preoperative evaluation:

The dental, surgical, and medical records of the patients were documented. The patients' oral hygiene and mucosa were examined for signs of pathology and quality and color. Over eruption of adjacent teeth can be prevented by checking the occlusion and interarch space.

3.4 | Clinical procedures

In this study, there were two main surgical steps: the first was the augmentation surgery, and the second was the insertion of the implants and removal of the mesh. After that, the implant was exposed for healing while the abutment was installed, and finally, the restoration was installed.

Before surgery, all patients were given antibiotics. One dose of Cefotaxime, 1 g, was administered intravenously every 12 hours beginning one hour before the procedure. For the next five days, patients were given 100 mg of hydrocortisone, or Solu-Cortef®100 mg hydrocortisone as sodium succinate, by Egyptian Pharmaceutical Industries CO. (E.P.I.CO.) in Egypt. On the day of the operation, patients were given 100 mg of hydrocortisone twice every 12 hours beginning one hour before the procedure.

In the phase of the procedure where the implants were placed, all patients were given local anesthetic (LA) using a mixture of 2% mepolin with 120,000 levonordefrin. To reveal the atrophic ridge, a full-thickness flap retracted labial para crestal incision was made through the buccal mucosa, with respect to the emergence of the mental nerve. Dissection was then carried out.

Then, to make sure the flap extended buccally and lingually, pre-adapted Ti-mesh was removed from its sterile envelopment and placed in its modified location in the alveolar ridge.

The recipient location underwent revascularization of the bone transplant through the creation of corticotomies, which are tiny holes cut through the cortical plate. Using a low-speed handpiece and an excessive amount of irrigation, decorate with a #2 bur (corebur, stryker) with a surgical long-shaft rose head carbide.

Chondrous bone transplant from bovines (BIOGAP®, KONEKTBIOPHARM, Russia) materials with particles ranging in size from approximately 1.0 to 2.0 mm combined with saline until it reaches the desired consistency.

The mixture is then put into the recipient site after being placed on the inner surface of a Ti-mesh. To secure the Ti-mesh and prevent any movement or gaps, a self-tapping micro surgical screw measuring 1.6 mm in thickness and 5.7 mm in length was utilized.

Platlet-rich plasma (PRF) is generated from a patient's own blood drawn from the antecubital vein. PRF membranes were also utilized to envelop the Ti-mesh that had been installed. Lastly, the surgical flaps were closed with tension-free Vicryl 3.0 sutures to create a watertight seal.

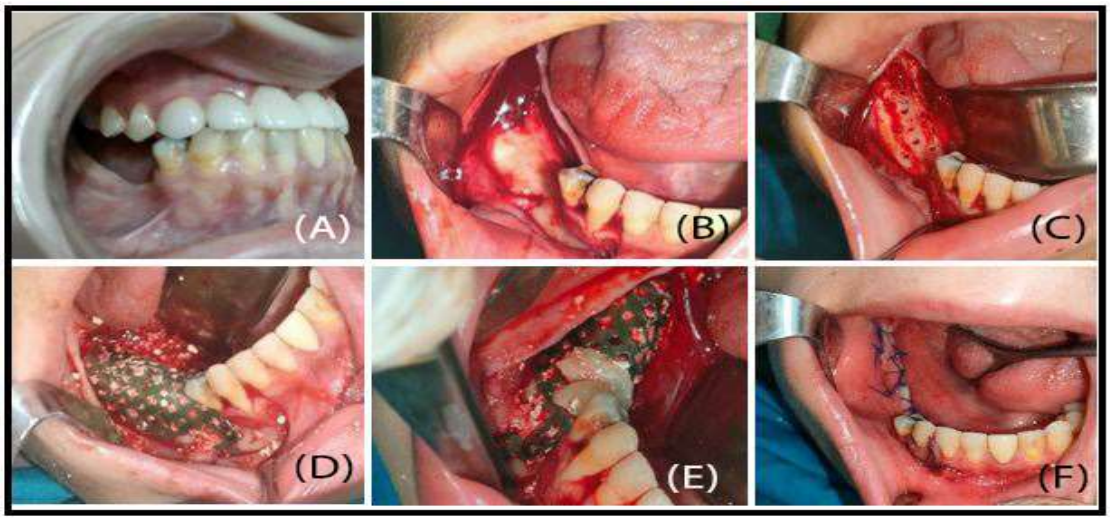

Fig. (2): Intraoperative photograph showing (a) Preoperative atrophic alveolar ridge (b) para-crestal incision and Mental nerve exit from its foramina.(c) Corticotomies in recipient site (d) Adaptation of Ti-mesh with bone graft on the alveolar defect and fixed by titanium micro-screws (e) (PRF) placed on the Ti- mesh after inserted in the recipient site (f) incisions were perfectly sealed without any tension with Vicryl 3.0 sutures.

The postoperative care: Use a cold ice pack outside of the mouth on the surgical site for at least five consecutive days, and be sure to wash your mouth thoroughly with BETADINE 1% Mouthwash. For five days, the patient was instructed to take Diclofenac sodium, a non-steroidal anti-inflammatory medication (Olfen-75; Medical Union Pharmaceuticals, Ismailia, Egypt), every twelve hours. Starting with a soft diet and working up to a semi-solid one for at least a month. They forbade the use of removable prostheses.

3.5| Follow up assessment.

Clinically: Once a week, patients are called back in for a follow-up appointment to have their sutures removed (because the sutures were already removed, vicryl sutures aren't necessary). In order to assess wound healing, graft infection exposure (dehiscence), edema, and paresthesia of the lip, they were recalled for extra postoperative follow-ups once weekly for the first month and once monthly for the following five months.

Radiographically: A CBCT scan was performed six months after the augmentation to measure the expanded site's width and height.

Mesh removal and implant placement in second phase, The CBCT was acquired, and the enhanced locations were revealed; the micro-screws and Ti-meshes were extracted. utilizing a digital surgical guide to place implants following precise specifications. OSSTELL was utilized to evaluate the main stability of the implant. After three to four months, the implants should have Osseo integrated.

Statistical analysis: Statistical Package for the Social Sciences (IBM Corp., 2013) was used to record, tabulate, and analyze all data. Version 22 of IBM SPSS Statistics for Windows was published by IPM Corp. of Armonk, New York.

All data was collated, and statistically evaluated with the aid of Statistical Package for Social Sciences, a computer software program.

4 | RESULTS

Clinical results Concerning surgical complications, wound healing was satisfactory in all patients at augmentation site with the exception of only one patient showed partial wound dehiscence with mild inflammation, antiseptic irrigation, and oral hygiene measures. by the second week, there was gradual improvement of wound healing. And not need for removal any Ti-mesh.

Radiographic results CBCT scans were taken for all patients preoperatively after six months of augmentation which showed integration of xenogenic graft, density, amount of ridge height gain, virtual measurement of implant length that facilitate dental implants installation and amount of graft remodeling.

Comparing preoperative and 6 moths post augmentation values of alveolar bone gain either height and width showing significant increasing by 3.822 ± 0.828 and 4.828 ± 0.378 respectively. And All implants were inserted with resistance which gave sufficient primary stability in all patients. .(Table 1) &(Fig. 3,4)

Table (1): Comparison of preoperative and six months post augmentation measurements for alveolar ridge.

	Alveolar bone hight of All patients		**Bone height gain**	**Alveolar bone width forAll patients**		**Bone width gain**
	Preoperative	**After 6 months**		**Preoperative**	**After 6 months**	
Mean ± S. D	5.783± 0.392	10.83± 0.4082	3.822 ± 0.8286	2.508±0.7530	6.337±0.5919	4.8283 ± 0.3780
T test	-	14.82	1.408	-	5.368	1.174
P-value	-	0.0001***	0.1894 ns	-	0.0030	0.2675 ns

p*< 0.05 (significant), p<0.01 (moderate), p***<0.001 (high)**

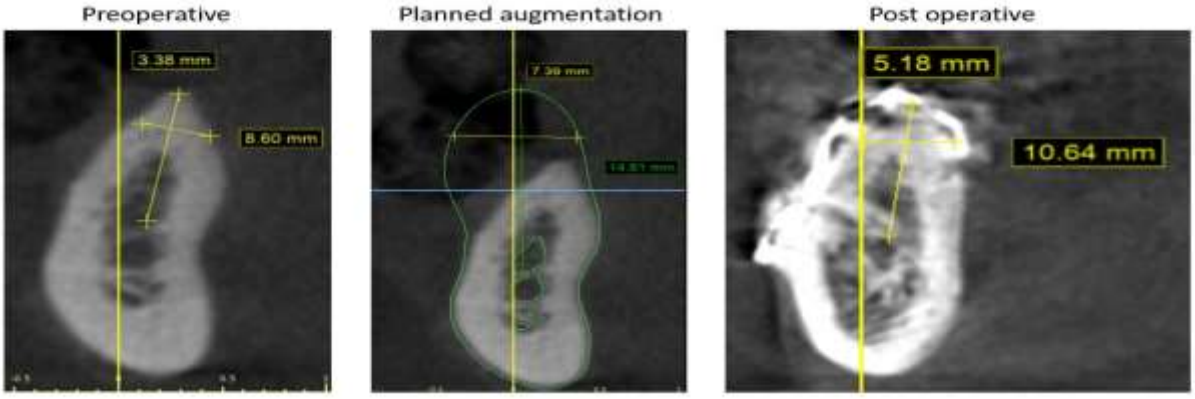

Fig. (3): a) Coronal preoperative CBCT showing deficient alveolar height for lower right seven, b) Planned augmentation and green outline represent the stitched 3d planning of future augmentation, c) Six months postoperative coronal CBCT photo-radiograph showing increase height of ridge immediately before Ti-mesh removal and implant installation.

OSSTELL (Resonance Frequency Analysis) was used to measure the primary and secondary stability (time of measure???????) of the implants. All implants showed satisfactory stability with mean values ± SD 71.08 ± 2.871 ISQ and as 86.08 ± 3.871 ISQ respectively (P. value >0.05). All patients were rehabilitated with fixed prostheses after abutment placement, which were stable, hygienic and with good occlusal relationship. (Table 2)

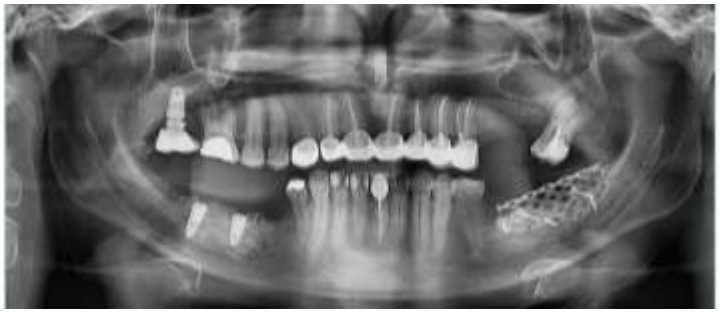

Fig. (4): Postoperative panorama showing proper implant in position and showing the bone graft around the implant.

Table (2): Comparison of mean values of (ISQ) between primary and secondary stability.

	Primary stability	**secondary stability**
Mean ± S. D	71.08 ± 2.871	86.08 ± 3.871
T test	0.05070	0.05070
P- value	0.9607 ns	0.9607 ns

5 | DISCUSSION

A typical clinical concern is rehabilitation of the posterior mandibular atrophic ridge. While partial removable dentures are a viable option for tooth replacement, not all patients find them comfortable or stable enough to be a good fit.1,3 and the best option would be to use implants to support the prosthesis. Bone augmentation operations are often necessary before implant implantation in patients with insufficient bone volume caused by alveolar ridge resorption3.

Because they are biocompatible, integrate well with tissue, and may successfully inhibit colonization of the location by the connective tissue—a property noted by Lyford RH—ti-meshes were the material of choice for our current work.12

Senoo M states that the design, porosity, and thickness of Ti-meshes greatly affect microvascular penetration. Additionally, she states that macro-pores with a diameter of 50 mm promote angiogenesis, vascular permeability, osteoconductivity, and the acceleration of bone formation when grown over micro-pore Ti-meshes. The best material for directed bone regeneration seems to be the newly created 100μm Ti-mesh.13,14. Avoiding the collapse of the overlying soft tissue during healing is possible because Ti-mesh material is capable of retaining space efficiently and successfully containing regeneration material (e.g., bone or biomaterials). The last benefit is that they facilitate the regeneration of alveolar tissue contours while being easy to work with, adapt to the site, and secure. El Chaar E. 15,16 indicated that the membrane's adaptability and ease of use could shorten surgery time by 30 minutes, increasing the likelihood of a successful regeneration treatment.

While autogenous bone transplant is considered the gold standard, our study utilized bovine bone graft since it is available in an infinite variety of particle sizes. And stop the spread of disease to another unsafe place. The study by Cruz et al.17 confirmed that it had a lower resorption rate than the autogenous one, which is beneficial for primary stability and gives the bovine bone plenty of time to integrate before any remodeling occurs.

According to Jensen SS, the augmentation techniques and bone growth are significantly impacted by the high particle size of bovine bone transplant. The results of our study show that ridge augmentation with big particle bovine cancellous bone graft (with a particle size of around 1.0-2.0 mm) increases angiogenesis expression, prevents escape from Ti-mesh pores, increases bone volume, and initiates new bone production six months after the procedure.[18.]

Our investigation found that out of all the enhanced locations, only one (12.5%) had titanium exposure. But you don't have to rush to pull the exposed mesh off. Partially exposed meshes also had no effect on the end augmentation outcome. In the worldwide literature, exposure rates to Ti-mesh range from 0% to 23.3%, making it a common problem.[19.]

As Torres J, is a biodegradable scaffold that encourages development of micro vascularization and epithelial cell migration to its surface [20]. several clinical studies and systematic reviews show the promising potential of PRF for bone and soft tissue regeneration.[21,22] and Torres et al. examined the effect of PRF in preventing mesh exposure by using it to cover conventional meshes.[23]

The registered disadvantages of pre-adapted Ti- mesh on 3D-model with bovine bone graft and PRF for mandibular ridge augmentation are the need of the collaboration of the patients as the period of treatment ranged from 9 months up to one year, programming more visits in the dental office and the costs.[24]

One case involved dehiscence, which was treated with irrigation and encouragement to practice good oral hygiene. Over eruption of the opposing molar was the cause, and a composite bottom was used to create a vertical stopper. The exposed area is covered by the periodontal pocket. Another group of researchers, Cucchi A. et al., found other issues, including the covering mucosa thinning and the bovine bone graft resorption.[25]

6| CONCLUSION

Based on the results of this study, we can conclude that:

1. In atrophic posterior mandible augmentation, GBR was able to achieve optimal bone graft incorporation and decreased rate of bone resorption by employing pre-adapted Ti-Mesh on a 3D model with bovine bone graft and (PRF). This resulted in stable alveolar ridge dimension and adequate implant osseointegration.
2. Bovine bone can be used as a suitable alternative to autogenous bone. This, based on our radiographic and clinical findings, might be the better option. given that it offers a less intrusive method, prevents donor site morbidity, and is available in infinite amounts, not to mention.
3. Printing 3D models and facilitating implant instillation are both aided by CAD-CAM technology when used in conjunction with CBCT.

Funding: No specific funding was provided to the authors for this work.

Conflicts of interest: Authors declare that they do not have any conflicts of interest.

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