

THE USE OF PRE-ADAPTED TITANIUM MESH ON 3D-MODEL WITH BOVINE BONE GRAFT AND PLATELET RICH FIBRIN FOR MANDIBULAR RIDGE AUGMENTATION

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ABSTRACT

Purpose: The aim of this study was the evaluation of using pre-adapted titanium mesh on 3D-model with bovine bone graft and platelet rich fibrin for augmentation of posterior atrophic mandibular ridge.

Patients and methods: Prospective study was conducted on eight (8) patients with posterior atrophic ridge using the Pre-adapted Titanium mesh with bovine bone graft and platelet rich fibrin, then implant installation simultaneously after removing Ti-mesh followed by the insertion of Final restoration. Then, by CBCT evaluated the volume of bone gain in height and width also, Implants were evaluated clinically and radiographically.

Results: Six months post-augmentation, CBCT evaluation revealed a mean horizontal bone gain of 4.828 mm (\pm 0.378), and the mean vertical bone gain of 3.822 mm (\pm 0.828). The most frequent complications were mild postoperative edema and discomfort after surgery; these complications were resolved within one week. Titanium mesh exposure occurred in one (1) patient (1/8: 12.5%): this suffered partial loss of the graft. An implant survival rate of 100 % (implant-based) and a periimplant marginal bone loss of 0.521 mm (\pm 0.15) were recorded after 1 year.

Conclusion: This study suggested that using pre-adapted Ti-mesh and bovine bone graft was considered as optimal treatment modality for augmentation atrophic mandibular ridge.

KEY WORDS: Preshaped Titanium mesh (Ti-mesh) - Guided bone regeneration (GBR) -Bovine bone graft - Implant - Ridge augmentation.

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INTRODUCTION

Rehabilitation of posterior atrophied edentulous mandible poses a great dilemma due to Excessive resorption of alveolar ridge in a vertical and/ or horizontal direction complicating implant installation and prosthetic rehabilitation. Resorptive process of alveolar ridge after teeth loss is accentuated during the first twelve (12) months after extraction of tooth and continued by slowly pattern.¹

Improved dental implantology has led many patients to request alternative approaches with implants. Edentulous patients with a severely resorbed mandible frequently complain of ill-fitting dentures, poor denture retention, so risk of denture falling out and reducing chewing ability.²

Dental implant rehabilitation represents a highly predictable and widespread therapy. But Insufficient length and/or width of alveolar bone making implant installation impracticable without optimum augmentation of alveolar bone that covers and promote implant stability consequently increase durability of final outcome.³

A wide range of treatments modalities have been proposed to augment the volume of the alveolar bone and overcome the inherent limitations of oral implantology. At present, various surgical procedures are employed to increase the size of the alveolar ridge, Onlay bone grafting, Guided bone regeneration (GBR), Alveolar distraction osteogenesis (DO) and Inlay bone grafting (sandwich technique) without long term predictably.^{4,5}

Preshaped Ti- Mesh is one of the most successful modifications of Guided Bone Regeneration. The mechanical properties of Ti-mesh are highly advantageous in stabilizing bone grafts beneath the membrane. These properties include its rigidity, which allows for extensive space maintenance and avoids contour collapse; its elasticity prevents mucosal compression; its stability, prevents graft displacement; and its plasticity permits bending, contouring, and adaptation to any bony defect.⁶

A vast variety of materials are used for bone augmentation and are classified as natural transplants (autograft, allograft, and xenograft) and synthetic materials (alloplasts).⁷ Bone graft materials are used in clinical applications based on its osteogenic properties, osteoinductive, osteoconductive or a combination of those properties.⁸

Bovine bone graft (BIOGAP[®], particle size~1.0-2.0 mm KONEKTBIOPHARM, Russia) was used in our study. Although autogenous bone graft is a gold standard grafting material, Bovine bone graft provides limitless amount in different particle sizes. And prevent another morbidity site. Also, it had low resorption rate in comparison with autogenous ones. It is characterized by osteoconductive properties, being deproteinized and lyophilized, causing no immune response.⁹

Platelet rich fibrin (PRF) stimulates the remodeling and integration of bone. The use of PRF membrane during bone regeneration surgery enhances the healing of soft tissue damage and provides protection of the gingiva from dehiscence. PRF is composed of a variety of growth factors and bioactive compounds which promote remodeling, regeneration and revascularization of both bone and soft tissue.¹⁰

In this study we are using combination of CBCT imaging and (CAD/CAM) to print virtual 3D models of jaw which provide many advantages for alveolar ridge augmentation. The virtual jaw model printed from pre-surgical CBCT, and the pre-adapted Ti- mesh is prepared before surgery. Unlike scanners, CBCT considered to be a "low dose" technique, capable of sweeping the entire volume to be explored in one go, while also being less irradiating than conventional CT.¹¹

It can be used to provide an accurate measurement of the available bone volume on the implant site and provide the best possible view, as well as a quantitative and qualitative bone study after assessing the density, and post-surgical monitoring. It can also measure distances to assess the proximity of anatomical structures to be avoided, such as nerves and sinuses, for the purposes of implant placement. 3D modelling can be carried out to virtually simulate the placement of any future implants, by selecting the appropriate size and shape.¹²

Purpose

This prospective study aimed to evaluate clinically and radiographically the use of preadapted Titanium mesh on 3D- model with bovine bone graft and platelet- rich fibrin for augmentation of posterior atrophic mandibular ridge.

MATERIALS AND METHODS

Study design and patient selection

This is a non-controlled prospective clinical trial. It was conducted on eight patients with vertically and/or horizontally resorbed posterior alveolar ridge of the mandible. Their ages ranged from 22-42 years. all patients examined clinically, radiographically and managed at of Oral and Maxillofacial Surgery (OMFs) Department, Faculty of Dentistry, Tanta University.

Eligibility Criteria

Inclusion criteria:

- Medically free Patients with advanced mandibular horizontal and/or vertical bone deficiencies and insufficient bone for standard dental implant even width and/or length.
- 2- The residual bone height of alveolar ridge not more than 5 mm.
- 3- The residual bone width of alveolar ridge not more than 4 mm.
- 4- Adequate density of bone (D2 D4).
- 5- Healthy and sufficient covering soft tissue (keratinized mucosa).

Exclusion criteria:

- 1- Systemic disorder that may compromise bone healing (e.g.: Uncontrolled diabetic).
- 2- Inter-arch space is less than 12 mm.
- Patient with Autoimmune disease or neurologic disorder.
- 4- Heavy smokers (more than 15 cigarettes/day).¹³
- 5- Bad oral hygiene.

All patients were provided with an explanation of the purpose of the study and informed consent was obtained in accordance with the human research guidelines adopted by the Committee. The Research of Ethics Committee (REC) at Faculty of Dentistry, Tanta University approved this study.

Digital planning and device production

A detailed radiographic evaluation was performed prior to surgery to precisely assess the length and width of the residual alveolar process. CBCT scans were taken; then, raw CBCT data were imported into reconstruction software (OnDemand3D), where a careful three-dimensional (3D) evaluation of alveolar process was performed. After printing 3D- model which represents the augmented ridge starting adaptation of Ti-mesh on the model. (Figure 1)

Preoperative evaluation

Patients' medical, surgical, and dental history were recorded. Patients were evaluated for oral hygiene, mucosa (quality, color, and presence of pathology). Occlusion and inter arch space should be checked to exclude over eruption of opposing teeth.

Clinical procedures

There were two major surgical phases in this study: firstly, Augmentation surgery phase, then mesh removal and implant placement in second surgery phase, then implant exposed for healing abutment and final restoration installation.



Fig. (1): Preoperative 3D- models and titanium mesh adaptation in different views (a) Printed virtually augmented site by software, (b) adaptation of titanium mesh in buccal view, (c)occlusal view, (d) lingual view.

All patients were prescribed antibiotics prior to surgery, in form of 1g of Cefotaxime (third generation cephalosporin antibiotic, Egyptian Int. Pharmaceutical Industries Co. (E. I. P. I. CO.) 10th of Ramadan City), vial form, intra-venous (IV), every 12hrs. starting one hour before surgery and for the following 5 days after surgery hydrocortisone 100mg (Solu-Cortef[®]100mg hydrocortisone as sodium succinate, Egyptian. Pharmaceutical Industries CO. (E.P.I.CO.)-Egypt), vial form, intra-venous (IV) given twice every 12 hrs. only the day of operation starting one hour before surgery.

First phase / Augmentation surgery, all patients were treated under local anesthesia (LA) (Mepicaine HCL 2% with Levonordefrin 1\20000). A Full thickness flap retracted labial para crestal incision made through buccal mucosa respecting emergence of mental nerve and dissection performed to expose atrophic ridge.

Subsequently, Pre-adapted Ti-mesh was taken from their sterile envelopment and inserted in its adjusted site in the alveolar ridge to ensure extension of the flap buccally and lingually.

Corticotomies (small holes through the cortical plate) were made at the recipient site to allow blood vessels to grow into the graft from medullary bone. Decortication with surgical long shank rose head carbide bur #2 bur (corebur, stryker) in low-speed handpiece with copious amount of irrigation.

Bovine cancellous bone graft particles ~ 1.0-2.0 mm (BIOGAP[®], KONEKTBIOPHARM, Russia) material mixed with saline to get appropriate consistency then placed in inner surface of Timesh. and inserted in the recipient site. self-tapping micro surgical screw (1.6 mm thickness and 5,7 mm length) used to fix the Ti- mesh for proper stability, ensuring no movement and to avoid any gap.

PRF prepared from an autologous venous blood sample taken from antecubital vein. PRF membranes were additionally used to cover fixed Timesh. Finally, water sealed closure of surgical flaps by sutured without tension by Vicryl 3.0 sutures as it has predictable absorption and strength, very little tissue reaction and long-lasting strength.

Postoperative care: Cold ice packs applied extraorally over the site of surgery and maintain good oral hygiene measures using BETADINE 1% Mouth Wash 5 times. Non-steroidal anti-inflammatory Diclofenac sodium (Olfen-75; Medical Union Pharmaceuticals, Ismailia, Egypt) were prescribed every 12 hours for 5 days. A soft diet and gradually progress to semi- solid diet at least one month. Removable prostheses were not allowed to wear.



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 Ti- mesh after inserted in recipient site (f) incisions sutured by Vicryl 3.0.

Follow up assessment

Clinically: Patients recalled after 10-14 days for follow-up examination wound healing and ensuring oral hygiene. The sutures were removed after 2 week avoiding wound contamination after antiseptic irrigation.

They recalled for additional postoperative follow ups weekly in the first month, and monthly in subsequent 5 months for evaluation of wound healing, exposure (dehiscence) of graft infection and edema.

Radiographically: Six months post augmentation, CBCT was taken to evaluate height and width of the augmented site.

Second phase / Mesh removal and implant placement,

Six months post augmentation, CBCT was obtained, for accurate implant size selection, and printing digital surgical guide. micro-screws and Ti- meshes removed after augmented sites exposed. Then, implants installed in accurate position through the digital surgical guide. OSSTELL was used to assess implant's primary stability. Implants were allowed to osseointegrated for 3-4 months.

Statistical analysis:

All data was documented, tabulated, and statistically analyzed using computer software Statistical Package for social science (IBM Corp. Released 2013. IBM SPSS Statistics for windows, version 22. Armonk, NY: IPM Corp).

For each continuous variable, the mean, median, standard deviation (SD), interquartile range (IQR), and the 95% confidence interval (95%CI) were

reported. Test of normality was carried out with the Skewness/Kurtosis tests (normal distribution if p-value >.05). For continuous numerical variables, the mean and the median were reported, highlighting the data that best represent their distribution.

RESULTS

Clinical results: A total of (8) partially edentulous patients with vertical and/or horizontal bone defects. Concerning the surgical complications, no failures to move the surgical flaps over the mesh and closure by primary intention were observed; moreover, no vascular or flap lesions occurred during surgery; wound healing was satisfactory in all patients at augmentation site except only one patient (1/8 : 12.5%) who showed partial wound dehiscence with mild inflammation; this case

managed by antiseptic irrigation, and oral hygiene measures (daily irrigation of the wound) to decrease contamination.

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	Alveolar bone width for All patients		Bone
	Preoperative	After 6 months	Height gain	Preoperative	After 6 months	Width gain
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.



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

The Osstell measurement:

Primary and secondary stability measurements (ISQs) were taken by Osstell device produced by Osstell AB, Goteborg, Sweden. The resonance frequency value of the implant fixture was measured through transducer (smart peg) with maintain a distance of approximately 1-3 mm with angle of 90 degrees for 3-5 seconds, The measurements were performed in the mesial, distal, buccal, and palatal/lingual directions, for each inserted implant. All implants showed satisfactory stability with mean values \pm SD 71.08 \pm 2.871 ISQ and as 86.08 \pm 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)

 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		

DISCUSSION

Rehabilitation of posterior mandibular atrophic ridge is a common clinical issue and a prosthesis supported by implants would be the ideal solution. However, patients with inadequate bone volume due to alveolar ridge resorption often require bone augmentation procedures prior to implant installation^{3.}

Many authors have confirmed the efficacy and the predictability of GBR for vertical ridge augmentation. As an alternative to non-resorbable membranes, some authors introduced the use of titanium meshes for reconstruction of localized and extensive defects in alveolar process.¹⁴

Ti- meshes preferred to be used in our present study because it meets almost all of the following requirements: indeed, they are biocompatible, they integrate effectively with tissue, and they can effectively prevent colonization of the site by the connective tissue this also noticed by Lyford RH. ¹⁵ Due to the simplicity of the application and adaptation of the membrane, accelerate surgery by 30 minutes, so promotion of chances of success of regenerative therapy this reported by El Chaar E. ^{16,17}

Also, Ti- mesh design, porosity and thickness have a great role in microvascular penetration and (50 mm) diameter macro-pores accelerate bone formation, facilitate angiogenesis, vascular permeability, osteoconductivity and supporting bone growth over micro- pores Ti-meshes. The recently developed 100μ m Ti- mesh appears to be the most suitable material for guided bone regeneration.^{18,19}

As Torres J, PRF 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

In our study, Radiographic assessment after 6-month post augmentation showed average bone height gained was 4.322 ± 0.8286 mm and average bone width 4.8283 ± 0.6780 mm and the mean values of primary and secondary stability

Conical implant-abutment can guarantee high stability, as demonstrated by several recent works.²⁴ In addition, these implants possess had integrated platform switching; this is useful to maintain and preserve the tissue volumes, as previously reported; accordingly, a minimal bone resorption was found around implants, with a mean overall peri-implant marginal bone loss of (0.5067 ± 0.1879) 6 months after the implant placement; this bone loss increased to 0.521 mm (±0.15) at the 1-year follow-up.²⁵

Healing complications (Dehiscence) of titanium meshes represent the most severe adverse events that often lead to partial or complete failure of the bone augmentation; other surgical techniques, such as GBR or bone block grafts, have been reported to have similar post-operative complications. Other complications such as the resorption of the bovine bone graft , the thinning of covering mucosa, long treatment period (at least 9 month) and it a costly and sensitive technique this also reported by Cucchi A et al. ^{26,27}

CONCLUSION

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

- 1. GBR, by using Pre-adapted Ti-Mesh on 3D-Model with bovine bone graft and (PRF) in atrophic posterior mandible augmentation, providing optimum bone graft incorporation and less rate of bone resorption, hence stable alveolar ridge dimension, and adequate implant osseointegration was observed.
- It can be concluded that bovine bone is an acceptable substitute for autogenous bone. and may be preferable according to our clinical and radiographical results. as it provides a less invasive technique and avoids morbidity at the donor site, also available in unlimited quantities.

 CAD-CAM technology by combination with CBCT are useful in printing 3D-model and helpful in implant instillation.

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