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Comparison of two pre-prosthetic surgical techniques for augmentation of mandibular vertical ridge defects

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KEYWORDS Ceramic membranes; Modified sausage technique; GBR; Mandibular ridge defects.

ABSTRACT

Aim To compare two pre-prosthetic surgical techniques for augmentation of vertical mandibular ridge defects in view of implant placement.

Materials and methods A prospective controlled clinical trial was conducted on 14 patients, having about 7 mm of vertical bone height in the posterior mandible above the inferior alveolar canal. They were then divided into 2 groups of 7 patients each. The first group received customized ceramic membranes with a vertical height 5 mm above the crest of the ridge to tent out the soft tissue matrix, while in the second group, tenting of the soft tissue was done by fixation of two tenting screws, particulate bone graft was packed then covered by collagen membrane that was fixed by bone tacks (modified sausage technique).

Results Three cases out of seven (42.9%) have been detected with wound dehiscence in group 1 during the second week after surgery. Two cases out of seven (28.6%) in group 2 have shown wound dehiscence in the first week. Radiographic examination has shown a mean preoperative bone height of 7.146 ± 0.24 mm from the crest of the ridge to the inferior alveolar nerve. The mean postoperative bone height after 6 months was 10.266 ± 0.97 mm. The mean percentage of change of bone height in group 1 was 52.8204 ± 8.7672 %, while the mean percentage of change of bone height in group 2 was 34.4978 ± 9.1760 %. The difference between the two groups was statistically significant (p=0.002) in favor of the ceramic membrane group.

Conclusion Both methods of GBR either by using customized ceramic membranes or modified sausage technique are effective in 3D augmentation of deficient mandibular ridges especially concerning increase of vertical bone height. Ceramic membranes are relatively easier in application, associated with higher percentage of bone formation. However, wound dehiscence as a result of inadequate soft tissue coverage has to be taken into consideration to ensure more predictable results.

INTRODUCTION

Tooth loss leads to marked changes in the vertical height and horizontal width of the alveolar ridge. These changes lead to difficulties in subsequent prosthetic restoration of the edentulous areas. So, different techniques were proposed for ridge augmentation; however, no single technique has been proved to be solely successful (1, 2).

The concept of guided bone regeneration (GBR) is based on maintenance of space for migration of osteogenic cells into the wound and prevention of undesirable cells from ingrowth into the bone defect. This is usually done by the use of membranes to allow bone regeneration (3).

Expansion of the periosteum and soft tissue matrix by tenting has been described as a method of GBR for reconstruction of atrophic alveolar ridges (4).

Different tenting techniques have been proposed among which is the use of individualized ceramic sheets by Malmstrom et al. (5) who have shown these sheets to be highly effective in regeneration of large bone volumes in both the horizontal and vertical directions. Another tenting technique was described using titanium screws and particulate allograft for reconstruction of mandibular ridge defects (6). The aim of this study is to compare two pre-prosthetic surgical techniques for augmentation of vertical mandibular ridge defects in preparation for implant placement, the first using customized ceramic membranes and the second using tenting titanium screws in conjunction with particulate bone graft and collagen membrane (modified sausage technique).

MATERIALS AND METHODS

The current study is a prospective controlled clinical trial, conducted on 14 patients from those attending the outpatient clinic of the Oral and Maxillofacial Surgery Department, Faculty of Dentistry, Alexandria University. The trial was registered on Clinical trials.gov (Clinical

trials.gov Identifier: NCT04376320). Inclusion criteria are patients of both genders with age range from 40 to 60 years, having about 7 mm of vertical bone height in the posterior mandible above the inferior alveolar canal and requiring prosthetic rehabilitation with dental implants. Exclusion criteria include heavy smokers (> 25 cigarettes/day), patients undergoing radiotherapy or chemotherapy, those having infection or local lesions in the area of surgery, and patients with diabetes mellitus or bone diseases which may compromise the results.

This study followed the Declaration of Helsinki on medical protocol and ethics and the regional Ethical Review Board of the Faculty of Dentistry, Alexandria University approved the study. All patients signed an informed consent before undergoing surgery.

Patients were examined clinically and radiographically by using CBCT to assess the preoperative vertical bone height. They were then divided into 2 equal groups, each consisting of 7 patients. Assignment of the patients to either group was done by random allocation using computer random numbers. The first group received customized ceramic membranes with a vertical height 5 mm above the crest of the ridge to tent out the soft tissue matrix, while in the second group, tenting of the soft tissue was done by fixation of two tenting screws leaving 5 mm projecting out of the bone, particulate bone graft was packed then covered by collagen membrane that was fixed by bone tacks (modified sausage technique).

All patients were operated under local anesthesia using inferior alveolar and long buccal nerve blocks (Articaine hydrochloride 4% and levonordefrin 1:100,000). Mucoperiosteal flap was then elevated exposing the alveolar ridge, followed by performing buccal and lingual tissue releases to allow tension free closure of the soft tissue after tenting. Decortication (perforation of the outer cortex) was done with a small rounded bur (Fig. 1), letting blood and osteogenic cells into the wound.

First group: CBCT images in a DICOM (Digital Imaging and Communications in Medicine) format were exported into

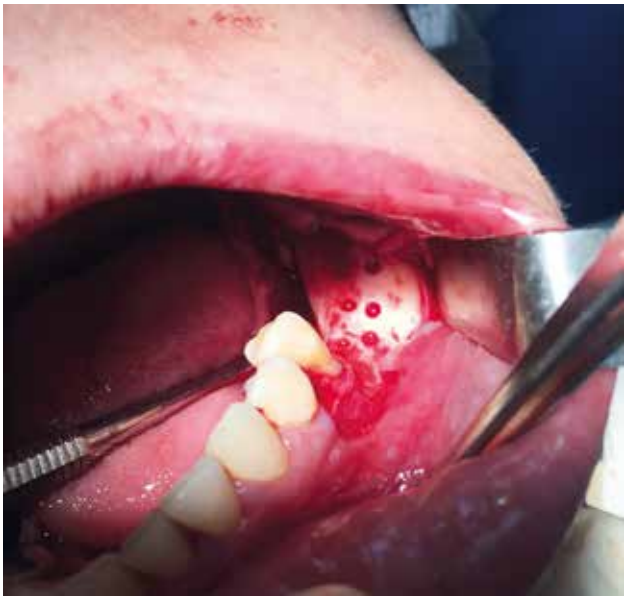

FIG. 1 Perforations in the outer cortex before application of the ceramic membranes.

the segmentation software MIMICS (MIMICS; Materialise NV, Belgium) with surface-based rendering for surgical planning. The resulting STL file after virtual surgical planning (Fig. 2) was then used to mill customized ceramic membranes of zirconia using a milling machine (Sirona mcx5). The membranes were applied on the alveolar ridge (Fig. 3) to allow tenting of the soft tissue for a vertical height of 5 mm. Each membrane was fixed with a titanium screw.

Second group: Fixation of 2.0 mm self-tapping titanium tenting screws (Fig. 4) with a length 9 mm with the screw driver over the alveolar ridge was done, so that approximately 5 mm of the screw length was left exposed. Packing of particulate bone graft (NanoBone® granulate, ARTOSS GmbH, Germany) was done. The vial used comprises 0.6 ml of nanobone graft formed in the ratio of

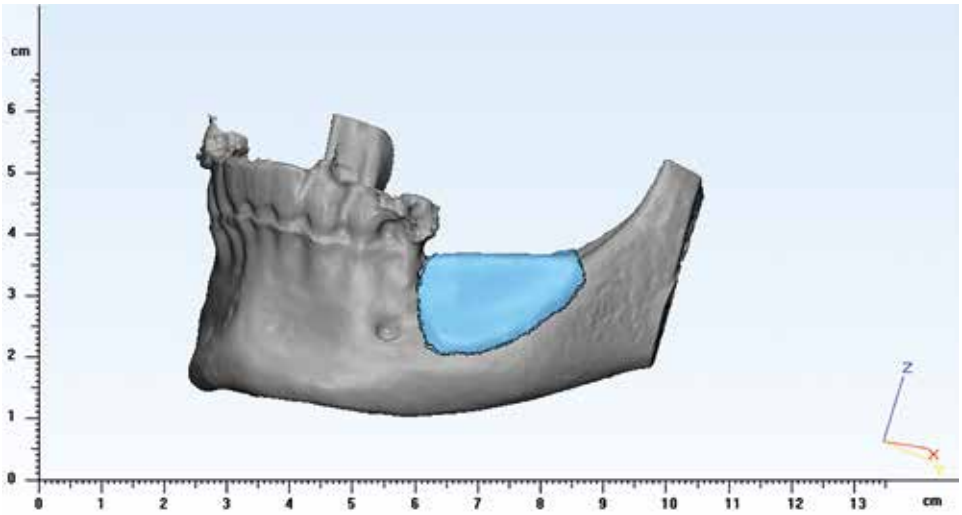

FIG. 2 Design of the customized membrane using virtual planning software.

76% hydroxylapatite and 24% silica. The interconnecting nanopores provide space for vascularization and bone regeneration. Coverage of the screws and graft material was then performed with Hypro-Sorb® F membrane (Bioimplon GmbH. Germany) (Fig. 5). It is a double-layered structure with one smooth side toward the soft tissue and another rough side toward the bone. The collagen membrane was inserted on the lingual surface of the defect then the membrane was rolled, adapted over the screws/graft and fixed on the buccal side with bone tacks (MCT, USA).

In both groups, primary closure was finally done using resorbable sutures. All patients were instructed to apply cold pack for 24 hours, follow oral hygiene instructions and keep on a soft diet for at least 2 weeks.

The following postoperative medications were prescribed.

- Amoxicillin clavulanate 1 mg twice daily for 5 days.
- Diclofenac potassium 50 mg every eight hours for 5 days.
- Chlorohexidine antiseptic mouthwash for 1 week starting from the second day.

Postoperative follow up: The sutured wounds were examined clinically after 7 days, 14 days and one month for signs and symptoms of infection including swelling, redness, hotness, pus discharge, and pain in addition to observation for any manifestations of wound healing disturbance, as wound dehiscence and hardware exposure. Radiographically, Cone Beam Computed Tomography (CBCT) was done after six months to evaluate the increase in vertical ridge height. OnDemand3D™ software was used to evaluate vertical height. Measurements were taken as follows: From the toolbar, the ruler was selected from the measurement section. The vertical height of bone from the alveolar crest till the inferior alveolar nerve was measured at specific standard points from the cross-sectional views of the 6 months postoperative CBCT, the distance from the crestal bone to the inferior alveolar nerve was calculated to be compared with the baseline preoperative height of bone.

All data were statistically analysed and presented using the IBM Statistical Package for Social Science (SPSS) software version 21.

RESULTS

This study was conducted on 14 patients (9 females and 5 males, ratio 1.8:1) with age ranging from 41 to 60 years (Mean age: 52.3 ± 5.9 years) and having vertical ridge deficiency in the posterior mandible.

Clinical follow up has revealed uneventful healing in 4 cases of the first group and 5 cases in the second group. Three cases out of seven (42.9%) have been detected with wound dehiscence in group 1 during the second week after surgery. Re-suturing was done in one case while in the other 2 cases, conservative treatment was applied by giving regular antiseptic mouth rinse instructions. Two

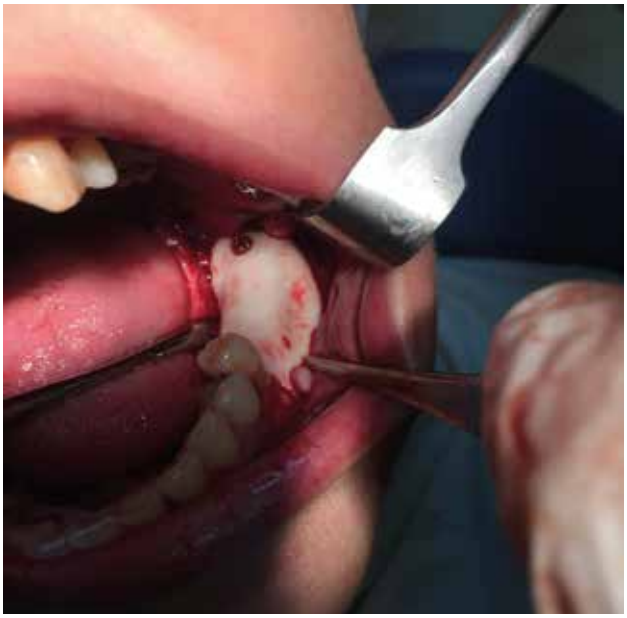

FIG. 3 Application of the ceramic membrane on the atrophic ridge.

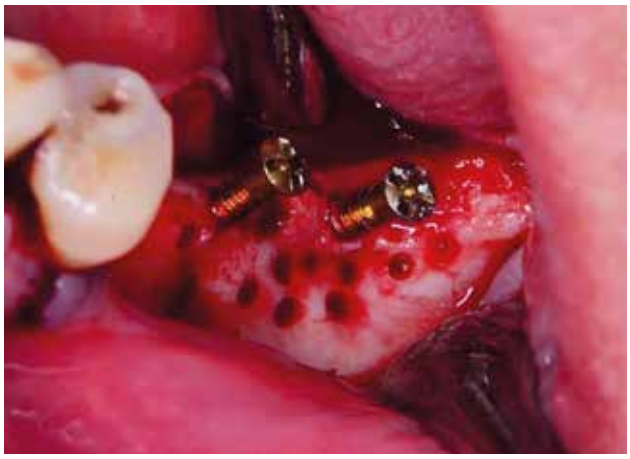

FIG. 4 Fixation of the tenting screws in group 2.

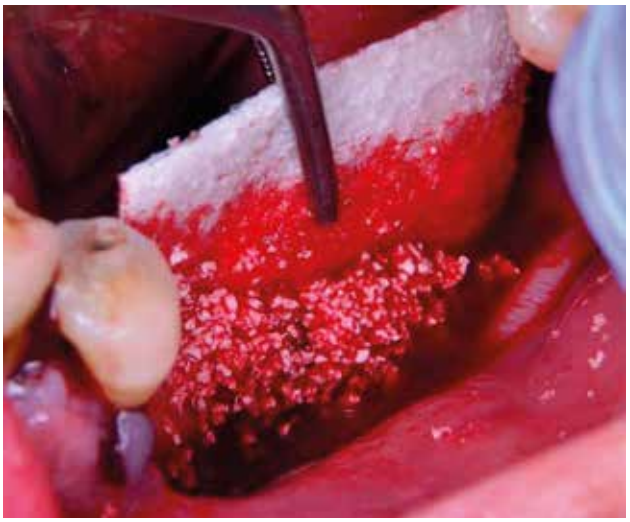

FIG. 5 Packing of Nanobone graft and coverage with collagen membrane.

Variable	Group	N	Mean	Std. Deviation	Std. Error Mean	t	p
Percent of change	Group 1	7	52.8204	8.76720	3.31369	3.820	0.002
	Group 2	7	34.4978	9.17603	3.46821		

TABLE 1:comparison of the percent of change in bone height between the 2 groups.

cases out of seven (28.6%) in group 2 have shown wound dehiscence in the first week which were treated with re-suturing. However, one of them has shown screw head re-exposure through the wound and conservative treatment was implemented.

Radiographic examination showed a mean preoperative bone height of 7.146 ± 0.24 mm from the crest of the ridge to the inferior alveolar nerve. The mean postoperative bone height after 6 months was 10.266 ± 0.97 mm. The mean percentage of change of bone height in group 1 was 52.8204 ± 8.7672%, while the mean percentage of change of bone height in group 2 was 34.4978 ± 9.1760%. The difference between the two groups was statistically significant (p=0.002) in favor of the ceramic membrane group (Table 1).

DISCUSSION

The current study compared two pre-prosthetic surgical techniques that were described in the literature for augmentation of vertical ridge deficiency in the posterior mandible. The first technique was described by Malmstrom et al. (5), while the second technique is considered a modification of the sausage technique originally described by Urban (7, 8).

Both methods used in the present study have yielded a detectable increase of bone height, with the ceramic membranes showing more predictable results, in addition to providing a relatively easier and less technically sensitive procedure.

Different methods have been described in the literature for management of deficient ridges including ridge splitting, distraction osteogenesis, various graft types and guided bone regeneration. The main characteristic for a successful GBR is the stability of the membrane to avoid micromovement under masticatory stresses and allow uninterrupted bone formation (5, 9).

Malmstrom et al. (5) in their study have enrolled only three patients (it was considered as a pilot study) and there was some inconsistency in the applied technique where they used bone chips in one case under the ceramic sheet while they used solely ceramic sheets in the other two cases. In the current study, more patients were included and all the ceramic membranes were used without the use of underlying bone graft. Upon removal of the zirconia membranes, the newly formed bone was found to be covered by fibrous tissue resembling periosteum. Also, in agreement with Malmstrom et al., the biocompatibility of inert ceramic membranes was demonstrated in the absence of adverse inflammatory tissue reaction throughout the follow up period of this clinical trial. In contrast to Malmstrom et al. who demonstrated excellent soft tissue response, 3 cases in the existing study were detected with wound dehiscence. This may be attributed to inadequacy of soft tissue available for coverage as a result of the larger volume occupied by the ceramic membranes. That is why the simultaneous use of soft tissue grafts may be recommended to provide adequate soft tissue coverage in case somewhat "high" ceramic membranes are needed for increase of vertical ridge height.

For the second group, a "modified" sausage technique was applied using tenting screws which proved successful results in several previous studies (6, 10). The presence of tenting screws prevents collapse of the membrane and flattening of the graft. Nanobone alloplast was used as an osteoconductive scaffold around the tenting screws for bone regeneration and to support the overlying collagen membrane allowing 3-dimensional augmentation of the ridge. This was considered a modification from the original sausage technique where autogenous bone is used with or without xenogeneic bone graft (8).

CONCLUSION

Within the limitations of this study, it can be concluded that both methods of GBR either by using customized ceramic membranes or modified sausage technique (tenting screws, bone graft and collagen membrane) are effective in 3D augmentation of deficient mandibular ridges especially concerning increase of vertical bone height. Ceramic membranes are relatively easier in application, associated with higher percentage of bone formation. However, wound dehiscence as a result of inadequate soft tissue coverage has to be taken into consideration to ensure more predictable results.

Conflict of Interest

The author declares that she has no conflict of interest.

Funding: No funding has been received for the current study.

Ethical approval

All procedures performed involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent

Informed consent was obtained from all individual participants included in the study.

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