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EVALUATION OF "TENT-POLE" IMPLANT TECHNIQUE FOR SINGLE STAGE MANAGEMENT OF VERTICALLY DEFICIENT POSTERIOR MANDIBULAR EDENTULISM (CLINICAL AND RADIOGRAPHIC STUDY)

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ABSTRACT

INTRODUCTION: Alveolar ridge atrophy is characterized by resorption of alveolar bone due to tooth loss, it is difficult to place an implant in such cases. Numerous techniques were mentioned for reconstruction of the atrophic mandibular ridge. Tenting of the soft tissue matrix allow maintaining space for the graft material.
OBJECTIVES: The primary aim of this trial is clinical and radiographic evaluation of the tent pole implant placement simultaneously with GBR using a mixture of autograft and xenograft material and non-resorbable membrane (PTFE) for single stage management of vertically deficient mandibular alveolar ridge. The secondary aim is to evaluate the soft tissue healing around implant together with the implant crestal bone level.
MATERIALS AND METHODS: Fifteen implants were placed in this clinical trial. Patients had vertical bone augmentation to their mandibular edentulous ridge and implant placement in one step procedure. Patient's age ranges from 30 to 45 years. Implants were placed in the alveolar ridge with an average of 3 to 5 mm of their length were exposed, a mixture of autograft combined with xenograft were placed around implants in a tenting fashion covered with PTFE membrane and pined in place with tack pins.
RESULTS: Bone height showed a statistically significant difference identified by cone beam computed tomography (CBCT).
CONCLUSION: From the results of this study, the single stage management of vertically deficient posterior mandibular edentulism using implant tent -pole grafting technique with simultaneous guided bone regeneration is a technique of high reliability in restoring mandibular vertical bone loss.
KEYWORDS: Tent-pole, Guided bone regeneration (GBR), Mandibular defect.
RUNNING TITLE: Single stage management of vertically deficient mandibular edentulism

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INTRODUCTION

After tooth loss many changes happens to the alveolar bone,since the tooth are lost thus the functional stimulus to the bone is lost which leads to bone resorption. Bone resorption varies from moderate to severe also it changes depending on the location (1,2).
Alveolar bone resorption in the posterior mandible in conjunction with the presence of the inferior alveolar nerve (IAN) makes it one of the most challenging areas to treat using osseointegrated implants (3).
Many techniques were proposed to augment the posterior regions of the mandible, including bone grafts (inlay and onlay), transposition of the IAN, distraction osteogenisis Using titanium mesh, and guided bone regeneration (4, 5).

Inorder to have a successful retentive prosthesis Ridge augmentation is essential many techniques such as distraction osteogenesis, autogenous onlay block or particulate grafts (6, 7), titanium mesh or combination have been used for ridge augmentation.
Vertical alveolar bone augmentation is challenging s the soft tissue covering the graft material contract causing migration and resorption of the graft thus loss of the bone volume, consequently if the soft tissue is expanded surgically and the space for the graft is maintained this will help in preserving the graft and the bone volume by decreasing the pressure of the overly soft tissue on (8-10).
According to the size of the defect and the location of the defect, horizontal or vertical defect,

anatomical structure in the area ton augment and the size of the defect to augment the most suitable technique will be used .Techniques varies from onlay bone grafting with particulate bone graft, block bone graft, barrier techniques using permanent or resorbable membranes, distraction osteogenesis, vascularized ridge splitting techniques, nerve repositioning techniques, short implants, and angled implants (9).

Distraction Osteogenesis is used mainly to gain bone volume in vertical bone defect. This technique can gain bone volume up to more than 12mm. The main advantages of this technique is maintaining the Blood supply of bone, the low risk of infection, also in this technique there is a minimal bone resorption and there is a gain in the soft tissue. One of The main disadvantages of this technique is patient compliance also it has a high cost factor. Through this process the soft tissue goes through various changes during the distraction and the consolidation periods. So, in order to see the better results especially when a large amount of bone is to be obtained, distraction is better divided into several time periods rather than doing all at once (11).

Onlay bone grafting is a technique where a bone graft is positioned and secured on the surface of the alveolar ridge. Onlay bone graft can be either block or particulate, block onlay graft shows less resorption. Few complications can be associated with this technique including soft tissue infection, soft tissue dehiscence which leads to Graft exposure thus losing of grafting material, subsequently this will lead to inadequate bone volume.

Guided Bone Regeneration is a technique that depends on filling the defect space with bone graft and/or bone substitutes then covered with a suitable membrane to prevent the migration of the overlying epithelial and gingival connective tissue cell.

Guided bone regeneration can be done separately in a staged approach where the alveolar bone is augmented first then the implant is placed in a second stage or it can be done in single staged in conjunction with implant placement this is when primary stability of the implant is achieved. Complications that can be faced in this technique are exposure of the membrane and early loss of the grafting material. This technique has limitations where it is mostly used in defects where only about 2 to 7 mm of bone needs to be augmented (9).

The aim of this clinical trial is to evaluate through clinical and radiographical examination the tent pole implant placement simultaneously with GBR using a mixture of autograft and xenograft material and non-resorbable membrane (PTFE) for single stage management of vertically deficient mandibular alveolar ridge.

MATERIALS AND METHODS

Study design: A total of 15 implants will be used in this clinical trial. All patients will have vertical bone augmentation to their mandibular edentulous ridge and implant placement in one step procedure. Bone augmentation will be done using autograft combined with xenograft in a tenting fashion.

Study sample: Selection was done from the outpatient clinic of the Oral and Maxillofacial Surgery Department, Faculty of Dentistry, Alexandria University, Alexandria.

Sample size estimation: A minimal total sample size of fifteen implants placed in patients with mandibular resorbed edentulous ridge is needed to detect an assumed significant difference in the alveolar ridge after the reconstruction procedure with common estimated group standard deviations of 1 mm and with 95% confidence level and 80% power using One-sample t test. (PASS program version 20) (12).

Procedures were done in accordance with Ethic research committee, Faculty of Dentistry, Alexandria University.

Eligibility Criteria's

Patients were chosen according to some criteria: Patients with missing lower tooth or teeth and have a related large vertical bony defect, (Figure 1) patients with 6 to 8 mm residual bone height (from the crest of the ridge to the inferior alveolar nerve) and requiring from 3 to 5 mm rise in the vertical height of the mandibular alveolar ridge for future prosthetic rehabilitation, Patients with acceptable oral hygiene and want to enhance it, male Patients in the age frame between 30 and 45 years old.

Exclusion criteria: Presence of infection or local lesions, Parafunctional habits, current chemotherapy or radiotherapy, heavy smoking, Alcohol or drug abuse and medically compromised patients with diseases that affect passively the clinical procedure or result.

The purpose of this study, the procedures, benefits and the expected complications were illustrated for all the patients. Moreover, every patient signed a consent about this and informed that they had the right to withdraw whenever they want.

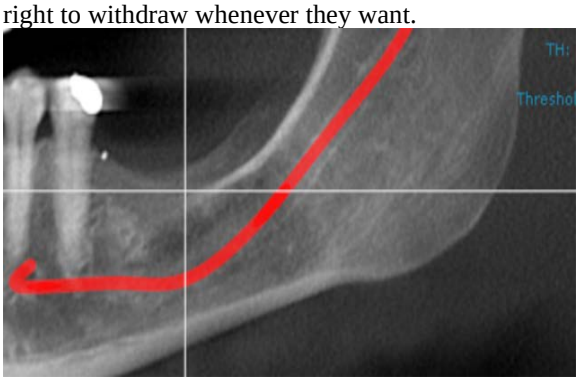

Figure (1): Preoperative view of the defect site.

Materials

1. Xenograft particles (OneGraft, Germany. www.OneGraft.com).
2. Polytetrafluroethylene non-resorbablc membrane (PTFE).
3. Tack pins (MCTBIO, 46chobu-ro Mohyeon-myeon, cheoin-gu, yongin-si, Gyeonggi-do, 17037, Korea). Self-tapping tack pins made of titanium with their width 2.0mm and their length comes in 7,9 mm.
4. Implant with diameter of 3.5 mm and of length of 8.5 to 10 mm (Neo biotech, neo CNI implant, crest cortical. middle cancellous. inferior cortical fixation 27000 E. Foothill Blvd#121, Pasadena, CA 91107, Tel : 213-387-7704 Fax: 213-387-7701 Email: info2neobiotech).

Procedures

I. Preoperative evaluation

1. History

a) Personal history

The patient's name, age, gender, and all the preoperative data were recorded.

b) Past medical and dental history

The patients' medical status and preceding dental treatment was recorded. Also, they were asked if they were smokers.

2.Clinical examination

Extra oral and intraoral examination was done (13).

a) Inspection (extraoral and intraoral)

To reveal any swelling, problems of occlusion, presence of ulceration or hypertrophy.

b) Palpation: Palpation of the buccal and lingual mucosa was performed.

c) Peri-implant probing depth: was done two months after loading of the final prothesis

3. Radiographic examination

CBCT was done to assess the pre-operative bone height.

II. Surgical procedure

Nerve block and infiltration of 4% articaine hydrochloride (ARTINIBSA, Inibsa Dental S.L.U., Spain) was given to the patent at the site of the procedure.

A full thickness mucoperiosteal paracrestal incision was done on the deficient alveolar ridge followed by 2 vertical releasing incisions mesial and distal to the defect followed by reflection of the flap revealing the vertical defect (12).

After flap reflection, implants of diameter 3.5mm and of 8.5 to 10mm long were installed in an appropriate position from a prosthetic point of view according to the previously determined treatment plan where 3 to 5 mm of the implant threads was left exposed (13). (Figure 2)

A round bur was used to perform decortication to the ridge to expose the medullary space and promote bleeding points (12) this facilitates the access of osteogenic and angiogenic cells which are involved in bone formation (13). (Figure 3)

Autogenous bone was harvested by bone scrapper at the distolateral aspect of the mandibular ramus and mixed with xenograft (OneGraft), this mixture was packed in proper way mesially, distally, buccally and lingually to the implant in a tent fashion (12).

The non-resorbable membrane (OneGraft) was adapted over the bone graft and covering the implants, the membrane was trimmed and shaped to overlap the edges reaching the lingual aspect of the bone (13). (Figure 4) It was fixed to the lingual and buccal plates with tack pins (12) to prevent any micro movement during the healing. Undermining of the periosteum was performed by an incomplete horizontal incision in the periosteum at the base of the flap to mobilize the flap and permit complete coverage of the membrane without tension as it must be a tension free flap. Primary wound closure was obtained by horizontal mattress and interrupted sutures(Figure 5) (13).

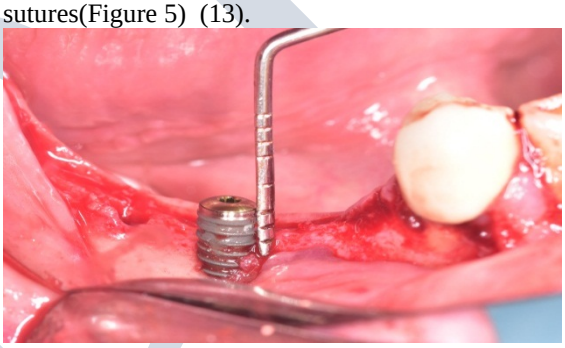

Figure (2): 3 mm of implant threads exposed.

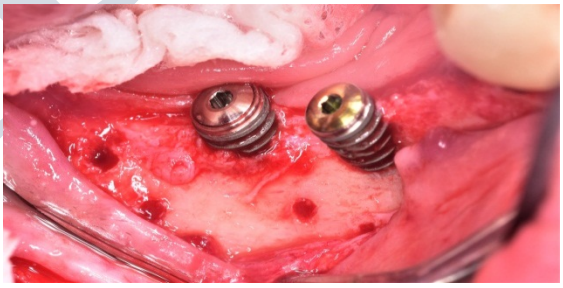

Figure (3): Decortication around implants.

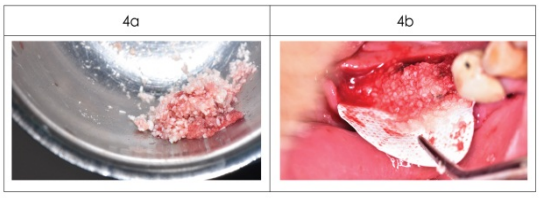

Figure (4) (a,b): (4a)Mixture of autograft and xenograft, (4b) Bone graft placed in tenting fashion around implants and covered by PTFE membrane.

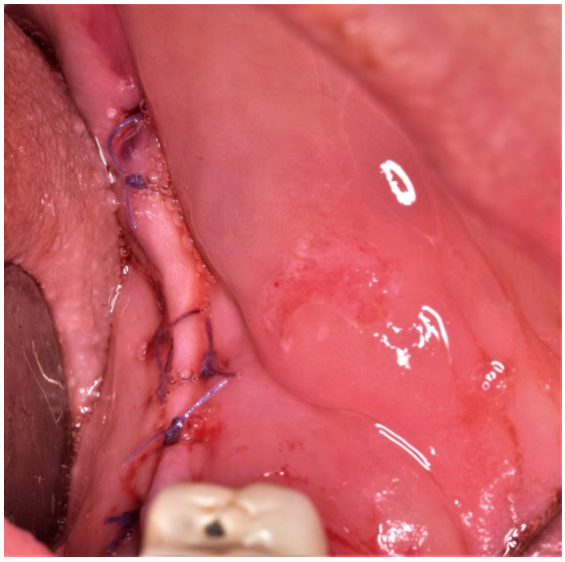

Figure (5): Primary wound closure

Postoperative medication

Extraoral cold fomentations every one hour during the first 24 hours and instructions to maintain the oral hygiene. Also, medications were prescribed including:

- Antibiotic 1gm twice daily for 5 days. Augmentin: (Amoxicillin clavulanate) GlaxoSmithKline, UK.
- Nonsteroidal anti-inflammatory drug three times daily for 5 days. Cataflam 50mg (Diclofenac Potassium): Novartis-Switzerland.
- Antiseptic mouthwash for 1 week starting from the second day. Hexitol (Chlorhexidine): Arabic drug company, ADCO.

Clinical examination

Follow up phase:

For the valuation of the clinical variables: pain, edema and wound healing complications, a systematic follow-up was implemented after 24 hours, 7days and 14 days after surgery.

Radiographic evaluation :

Preoperatively CBCT was performed to assess the bone height. Postoperatively, CBCT was done 2 times, the first time was four months after the procedure to evaluate the increase in vertical ridge height, after this step loading with final prosthesis took place, two months after the loading the second CBCT was done to evaluate the changes that happened to the vertical bone height after the loading.

OnDemand3D™ software was used to assess vertical height. Measurements were taken as follows: From the toolbar, the ruler was selected from the measurement section. From the alveolar crest till the inferior alveolar nerve, the vertical bone height was measured from the cross-sectional views of the immediate post-operative and 4 months postoperative CBCT and 6 months postoperative (2 months after loading), the distance from the crestal bone to the inferior alveolar nerve was calculated.

Statistical analysis of the data

Normality was checked using descriptive statistics, plots and normality tests, and all variables showed normal distribution, so means and standard deviation (SD) were calculated. Comparisons of bone level at different time points and peri-implant probing depth were done using repeated measures ANOVA, followed by multiple pairwise comparisons using Bonferroni adjusted significance level. Significance was inferred at p value < 0.05. Data were analyzed using IBM SPSS statistical software for Windows (Version 23.0).

RESULTS

There were no systemic diseases that can reversely affect the success of bone augmentation. Fifteen implants were placed in patients with residual ridge atrophy in the posterior mandible simultaneously with guided bone regeneration where the bone graft was placed in a tenting fashion around implants. Implants acted as "Tent Poles" to maintain the space for the graft material. Clinical and radiographic follow up was done at 4 months and 6 months. Was done 14 days postoperatively, four months postoperatively and six months postoperatively. Clinical evaluation:

clinical evaluation for any signs of infection was done after 14 days ,after four months and two months after loading where the perimplant probing depth was measured and recorded

Wound healing complication

1. Infection: One case showed infection in the early stage and was excluded from the study. The excluded case contained a single implant in the lower 2nd molar area and was excluded in the early stages of the study.
2. Dehiscence:

There were no wound dehiscence occurrence in any of the cases.

3. Peri-implant probing depth

Readings of the peri-implant probing depth was taken 6 months post operatively (2 months after loading) with mean 0.59±0.22 with min of 0.3 and max of 0.39. (Table 2)

II. Radiographic evaluation

a. CBCT for measurement of bone height

Cone beam computed tomography was used to assess the increase in vertical bone height above the inferior alveolar canal. It was taken three times throughout the study; the first time was preoperatively to evaluate the amount of the present bone, the second time was four months postoperatively to evaluate the increase in the bone height, the third time was two months after the loading of the final prosthesis (six months postoperatively). (Figure 6)

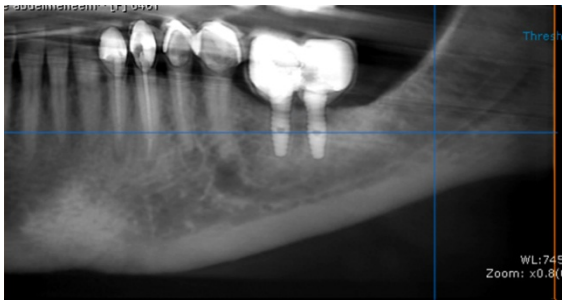

Figure (6): Post-operative view of the implants 2 months after loading.

Preoperatively, the mean vertical bone height value was 6.69±0.56 mm with the lowest value of 6.01mm and the highest value of 7.75 mm. (Table 3a)
Four months later, the mean bone height value was 9.41±0.80 with a minimum value of 8.31 and a maximum value of 11.39. There was statistical significant difference between the mean bone height value immediately after augmentation and four months later ($p3<0.001$), also there was statistical significant difference between the mean bone height value preoperatively and after 4 months. ($p2 <0.001$). (Table 3.a)
Six months later (two months after loading), the mean bone height value was 9.03±0.80 with a minimum value of 8.02 and a maximum value of 11.02. There was statistical significant difference between the mean bone height value immediately after augmentation and six months later ($p3<0.001$), also there was statistical significant difference between the mean bone height value preoperatively and after 6 months. ($p2 <0.001$). (Table 3.b)

DISCUSSION

Severe vertical alveolar ridge defects are 3-dimensional and are tricky to be handled by the implant surgeon. Horizontal ridge defects are usually associated with the vertical defects, and they have to be restored in all dimensions to give a better esthetic and functional results (14).
The vertical augmentation of atrophic ridges has always been controversial, many techniques have been suggested and no regenerative technique has been effective in all cases (15, 16).
The tenting technique, which was originated from the principles of guided bone regeneration which involves raising the periosteum like a tent to allow osteoblasts to migrate into the gap to start osteogenesis. The gap that is made is then filled with osteoconductive or osteoinductive materials, and in some cases, both. In order to prevent the migration of the of epithelial cells a barrier-like collagen membrane or other component is placed (17).
Marx et al., 2002 used implants as “tent pole” with iliac crest graft and he successfully obtained A mean gain in bone height of 10.2 mm using tentpole (8).
The present study was conducted by placing 15 implants in patients with posterior mandibular alveolar defect (Table 1). The implants were placed simultaneously with vertical bone augmentation using the implants to tent the soft tissue matrix for bone. Their ages were 30 and 45 years with a mean age of 41.6 years. Follow up for 6 months was performed first follow up was done four months postoperatively and another follow up was done 2 months after loading.
Preoperatively, the medical status of the patients was taken as the proper case selection is important element in the success of this procedure. The (uncontrolled) diabetic patients and (heavy) smokers were excluded from this trial as they are not considered an ideal choice for this procedure (18).
It can be particularly hard to restore the vertical alveolar dimensions because of the collapse of soft tissue over the graft (10).
In vertical ridge augmentation, it is necessary to maintain a space for the grafting material to reduce the rate of graft migration and resorption and permit for uniform bone healing. In the present study, we chose to use the implants to tent the soft tissue resembling. Marx et al presented, 2002 technique (8).
Pre-operative CBCT was done for every patient. Several studies stated that using CBCT in implant surgery differs from preoperative analysis concerning definite anatomical considerations and treatment planning to postoperative evaluation (19, 20). Furthermore, relatively low costs, less doses of radiation, after 4 months and after 6 months (2 months after loading) CBCT was done to measure and to evaluate the changes in the bone height.
About the surgical procedure, under local anesthesia, A full thickness mucoperiosteal paracrestal incision will be done with no015 blade on the deficient alveolar ridge followed by 2 vertical releasing incisions mesial and distal to the defect.
A sharp end periosteal elevator was used to perform mucoperiosteal flap and gentle elevation of the flap. Releasing incision is done to enable tension-free closure. This is in accordance with Le et al., 2008 (21).
Louis et al., 2008 (22), and Le et al., 2010 (18), all used standard crestal incisions with vertical releasing incision and a flap with a broad base to allow maintenance of blood supply. This was different from other studies that employed the tenting of soft tissue. Marx et al., 2002 (8), used a transcutaneous submental approach and Akoush et al., 2014 used vestibular incision (23).
An average of 3-5 mm of the implants was left exposed supra-crestally. According to Le et al., 2010, these implants will act as tent pole to prohibit soft tissue contraction around the particulate graft thus helping maintain the volume of the graft and subsequently decreasing the resorption or displacement of the grafting material (18).
Several kinds of materials are utilized in ridge augmentation: autologous bone, xenografts, alloplastic materials and several mixtures of these materials with acceptable outcomes in terms of biocompatibility and stimulation of bone formation (24).

Each bone grafting material has benefits and drawbacks. Autogenous bone grafts have osteogenic, osteoconductive, and osteoinductive properties, so they believed to be the gold standard. Nevertheless, requiring a second donor site and the associated rapid resorption are the disadvantages of this type of grafting (25).

In the GBR procedure, perforation (decortication) of the cortical bone layer has been promoted (26), as it was assumed that this increases the wound vascularity with the release of growth factors and cells with angiogenic and osteogenic potential. In agreement with Delloye et al., 2002 (27) they found that there was increase in the amount of the newly formed with decortication in comparison with a non-perforated cortical bone.

Nevertheless, some studies with adverse results were also stated that cortical perforation did not improve the amount of bone formation in rabbits (28, 29).

In the present study, a good mucoperiostal incision was performed to ensure a tension free closure to prevent any wound dehiscence. This is in coincidence with Louis et al., 2008 (22) who noticed a high incidence of wound dehiscence with using titanium mesh to tent the mucoperiosteum.

"Tent pole" grafting technique was performed with the mean preoperative bone height was 6.69±0.56mm with the lowest value of 6.01mm and the highest value of 7.75 mm. The mean bone height after 4 months was 9.41±0.80 with the lowest value of 8.31mm and the highest value of 11.39mm. This difference was statistically significant (p-value ≤ 0.05).

Our results are consistent with the study conducted by Le et al., 2010, using mineralized allograft with autogenous particulate graft around titanium screws for tenting the soft tissue matrix and the mean vertical augmentation was 9.7 mm, wound dehiscence occurred in two patients causing loss of the graft and a secondary grafting was required. Second stage grafting procedures were also needed for five cases to attain ideal ridge height before implant placement (18).

However , in our study one case showed infection in the early stages of the study and was excluded and non of the cases showed wound dehiscence.

Moreover Akoush et al., 2014 (23) performed a study for evaluation of the "Tent Pole" grafting technique for vertical alveolar ridge augmentation using dental implants. There was no new bone induced at both mesial and distal surfaces of the implants. However, there was new bone induced at both buccal and lingual surfaces of the implants.

Which is the opposed to our findings where new bone covers the four surfaces of the implants.

Furthermore, according to these findings, there was a statistically significant difference in bone height after vertical ridge augmentation, so we reject the null hypothesis of this study.

Table (1): number of patients, number of implants and implant type

Number of patients	Number of implants	Implant location and dimensions	Implant type
p 1	2	Lower 1st molar (L: 10mm) (W:3.5mm) Lower 2nd molar (L:8.5mm) (W:3.5mm)	Neobiotec implant
P 2	2	Lower 1st molar (L:8.5mm) (W: 3.5mm) Lower 2nd molar (L: 8.5mm) (W: 3.5mm)	Neobiotec implant
P 3	2	Lower 1st molar (L:10mm) (W: 3.5mm) Lower 2nd molar (L: 8.5 mm) (W: 3.5mm)	Neobiotec implant
P 4	2	Lower 1st molar (L:8.5mm) (W: 3.5mm) Lower 2nd molar (L: 8.5 mm)(W: 3.5mm)	Neobiotec implant
P 5	2	Lower 1st molar (L: 10mm) (W: 3.5mm) Lower 2nd molar (L:8.5mm) (W: 3.5mm)	Neobiotec implant
P 6	2	Lower 1st molar (L:8.5 mm) (W: 3.5mm) Lower 2nd molar (L: 8.5mm) (W: 3.5mm)	Neobiotec implant
P 7	2	Lower 1st molar (L: 10) (W: 3.5mm) Lower 2nd molar (L: 8.5) (W: 3.5mm)	Neobiotec implant
P 8	1	Lowe 2nd molar (L: 10mm) (W: 3.5mm)	Neobiotec implant

Table (2): Peri-implant probing depth

	Mean ± SD	Median (IQR)	Min - Max
Buccal	0.55 ± 0.29	0.50 (0.50)	0.20 – 1.00
Mesial	0.67 ± 0.19	0.65 (0.20)	0.30 – 1.00
Distal	0.70 ± 0.21	0.65 (0.50)	0.40 – 1.00
Lingual	0.43 ± 0.23	0.35 (0.40)	0.20 – 0.80
Average	0.59 ± 0.22	0.50 (0.45)	0.30 – 0.93
Repeated measures ANOVA p value	F= 23.88 **P <0.001**		

Min: Minimum, **Max:** Maximum, **SD:** Standard Deviation, **IQR:** Interquartile range

*****statistically significant at p value <0.05, **n**:number of implants (n=15)

Table (3): Bone level at different timepoints and Post-hoc pairwise comparisons of bone level at different timepoints

(3a): Bone level at different timepoints

	Mean ± SD	Median (IQR)	Min - Max
Baseline	6.69 ± 0.56	6.60 (0.78)	6.01 – 7.75
4 months	9.41 ± 0.80	9.10 (0.89)	8.31 – 11.39
6 months	9.03 ± 0.80	8.97 (0.74)	8.02 – 11.02
Difference (6 months – baseline)	2.34 ± 0.55	2.33 (1.00)	1.41 – 3.37
Repeated measures ANOVA p value	F= 275.81 **P <0.001***		

Min: Minimum, Max: Maximum, SD: Standard Deviation, IQR: Interquartile range

*statistically significant at p value <0.05 , n:number of implants (n=15)

CONCLUSION

From the results of this study, the single stage management of vertically deficient posterior mandibular edentulism using implant tent-pole grafting technique with simultaneous guided bone regeneration is a technique of high reliability in restoring mandibular vertical bone loss.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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