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Efficacy of Vented Bone Block Fixed with Laser Sintered Implants Restoring Defects In posterior mandibular zone

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Abstract: Problem statement: Onlay grafting has been used successfully in the correction of vertically deficient edentulous ridges, although the reported two-stage approach results in considerable resorption of the bone graft before implant insertion. Xenogenic bone grafting overcomes the obstacles of autogenic grafting such as amount needed and the second surgery site and have been manufactured by the tutoplast technology. Direct laser metal sintering technology applied in implant production to improve implant success rate in such difficult bone condition. So, this study was directed to evaluate efficacy of using a vented xenogenic bone block fixed directly with direct laser metal sintering implants in posterior mandible. **Patients and Methods**: Forteen patients were selected which are free from any systemic disease, aged from 18-50 years old and have a vertical and horizontal bone defect in the posterior mandibular region ranged from 3 to 5 mm 3 dimensionally. All patients within this study received DLMS dental implant installed in the posterior mandibular region as a fixative screws for the xenogenic block graft and were subjected to delayed loading after 6 month. All patients were evaluated clinically at regular time intervals at 6,9 and 12 months postoperatively regarding to implant stability, periodontal probing depth, Modified sulcus bleeding Index (MSBI) and marginal bone loss (MBL). **Results**: Evaluating this technique in restoring a vertical and horizontal mandibular defect we found that, a statistical significant difference was recorded immediately comparing all the time intervals, at the placement of final crown, 9 and 12 month with ($P<0.001$) regarding to implant stability. Also, a statistical significant difference was recorded comparing all the time intervals with ($P<0.001$) except comparing (T2-T3) there was no statistical deference with ($P=0.06$) regarding the marginal bone loss. Regarding the (MSBI) and the pocket depth a statistical significant differences were recorded between (T1-T2) (T1-T3) with a ($P1=0.027$ $P2=0.002$ \ $P1=0.001$ $P2=0.001$) respectively and no statistical difference between (T2-T3) with ($P3=0.08$\ $P3=0.09$) respectively. **Conclusion**: We concluded that using the xenogenic bone block fixed with DLMS implants in restoring posterior mandibular vertical and horizontal defects have shown a marked graft resorption and graft dehiscence. On the other hand, the DLMS implants has shown a marked increase in stability over time and fast natural bone formation but failed to osseointegrate with the xenogenic block when used at the same time as a fixative screws for the block.

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Keywords: Xenogenic bone block, DLMS implants, mandibular defects

1. Introduction

Tooth extraction normally results in a significant resorption of the alveolar ridge with quantitative and qualitative changes of its profile. [1-3] The height and width reduction of the edentulous site is progressive and irreversible, and it results in difficulty to obtain an excellent functional and esthetic restoration with implant placement. [4, 5]

Insufficient bone height in the posterior mandible, as a result of early teeth extractions, periodontal disease, tumor resection, trauma, or congenital diseases, complicates implant-supported prosthetic rehabilitation due to the reduction of the bone gap between the residual alveolar ridge and the mandibular canal. [6-8]

Many surgical procedures have been proposed to allow dental implant placement in either a simultaneous or staged approach. A lack of comparative studies has made it difficult to choose the most reliable and predictable augmentation technique. A recent review on this topic stated that although vertical bone augmentation is possible, the associated number of complications and failures with the various

described techniques remains unacceptably high (>20%). [9-11]

Onlay grafting has been used successfully in the correction of vertically deficient edentulous ridges, [7,9] although the reported two-stage approach results in considerable resorption of the bone graft before implant insertion. [7-20]Xenogenic bone grafting overcomes the obstacles of autogenic grafting such as amount needed and the second surgery site, but also faces the potential risks of inducing an immune response and transmitting infectious diseases in patients. [21-22] Thus, valid strategies to eliminate the antigenicity of xenograft bones are of vital importance in the development of xenogenic bone graft substitutes. [20]

The xenogenic bone graft is safe, well-tolerated and high-quality alternative to autologous bone donations or synthetic bone substitutes. It passes through a process called tutoplast process making the allograft and xenogenic bone graft safe and applicable. The unique Tutoplast process was developed in 1969 and can now look back on a very successful history. The patented process was one of the first for cleaning, preserving and sterilizing donor tissue. Now Tutoplast is a recognised production process in the world that meets all the requirements for the preservation of tissue and eliminates or inactivates known contagious pathogens. Despite the process, the natural properties of the tissue are retained and the remodeling of the products is not affected. [23-27]

On the one hand, it can be said that the treatment period is raised by a second operation and recovery period when dental implants are taken into consideration after bone grafting.

In the last few years, DLMS (Direct Laser Metal Sintering) implants have been manufactured by focusing a high energy laser beam allowing a localized region of thin layer metal powder to fuses with the titanium rod repeatly joining very thin sections (from 0.2 to 0.6) together which in turn permits very complex geometrical structure to be created on the titanium rod from 3D computer aided design with a gradient of porosity perpendicular to the long axis of the implants. [28,29]

DLMS implants displays a unique manufacturing technique by which provides a external surface porosity allow for faster bone in growth. Such a technology is expected to provide a solution to humans with poor bone quality (type IV) However, there is few histological information about the DLMS technology placed in poor bony conditions.

The fact that autogenous, allograft and xenograft have osteoinductive, osteoconductive and volume enhancement properties makes them ideal for the reconstruction of three-dimensional alveolar bone defects. [30]

2. Materials and Methods

Fourteen patients were selected from the Outpatient Clinic in the Oral and Maxillofacial Surgery Department, Faculty of Dentistry, Mansoura University for replacement of mandibular molar or premolar teeth by dental implant.

Inclusion Criteria

Patients that were included in our study was medically free from systemic diseases that absolutely contraindicate implant surgery with age ranged from 18-50 years old. The posterior mandbibular defect vertically and horizontally ranged from 3-5 mm from 3 to 5 mm.

Materials:

A. Dental implants: Two-piece DLMS (Direct Laser Metal Sintering) titanium dental implant system *.

B. Bone Substitute: Xenogenic bone block.

Methods

Presurgical procedures:

- Radiographic examination using cone beam CT scan will be used to evaluate the bone defect three dimensionally.
- Study cast analysis to evaluate teeth inclinations, inter-arch space and occlusion.
- Diagnostic waxing up of missing tooth.
- A 3D printed model to the defect area was printed prior to surgery so that we can shape and adjust the bone block to the model before implant placement surgery.

Surgical procedures:

1-After evaluating the bone defect three dimensionally, a suitable disk has been used to slice the xenogenic bone block to the needed size three dimensionally which will restore the defect accurately to its normal diameter then the bone block will be vented using a fine tapered bur all over the bone block.

2- The bone block has been hold at the implant placement site restoring the defect vertically and horizontally then a surgical pilot drill was used to penetrate the bone block along with the jaw bone, then the bone block and the jaw bone were drilled to the desired implant size separately so that the implant will fit passively through the bone block and tightly through the jaw bone avoiding the block fracture.

3- The reception bed has been prepared by making a hole through the cortical bone ensuring the blood supply to the block graft. The bone block was hold in its place restoring the surgical site defect and the implant was fixed to the alveolar bone during implant insertion.

4- The implant has been slightly submerged below the block crest with about 0.5 mm and the

remaining small gaps between the bone ring and the alveolar bone was filled with xenogenic bone chips without using a membrane then a releasing incision has been made to elongate the flap length to cover the xenogenic bone block completely ensuring a primary closure.

5- The prosthetic procedures for all patients was made at 6 months after implant placement by surgical exposure and healing cap placed then the abutment was connected after 2 weeks and the final coverage has been made from porcelain fused to metal and crown was cemented.

Evaluation:

➢**Clinical Follow-up:**

All patients have been seen at regular time intervals for evaluation within the first year at 6, 9 and 12 months of implant placement where the following criteria will be evaluated:

1) Clinical evaluation:

Parameters recorded are:

Implant stability: (31-53)

The stability of each implant has been measured in ISQ units using the Osstell Mentor with implant placement.

Modified sulcus bleeding Index (mBI):

Clinical signs and symptoms of inflammation of peri-implant mucosa were graded using criteria of modified sulcus bleeding index (mBI) by mombelliet al (36).

o Peri-implant pocket depth:

The distance between the base of the pocket and the gingival margin has been measured using a graduated probe (37).

2) Radiographic evaluation:

The marginal bone level has been evaluated by a standard periapical radiograph using the paralleling cone technique within first year at 6, 9 and 12 month of implant placement will be evaluated.

3) Statistical Evaluation:

Data were fed to the computer and analyzed using IBM SPSS software package version 22.0. Qualitative data were described using number and percent. Quantitative data were described using mean, standard deviation for parametric data after testing normality using Shapiro–Wilk test. Significance of the obtained results was judged at the (0.05) level.

Data analysis

Paired t test to compare between 2 studied periods of parametric continuous variables.

3. Results

Demographic data:

A total of 14 patients who received 16 dental implants were included in this study for replacement of missing single tooth in the mandibular posterior region with delayed loaded dental implant. The average age was 34 years (range from 21 years to 55 years).

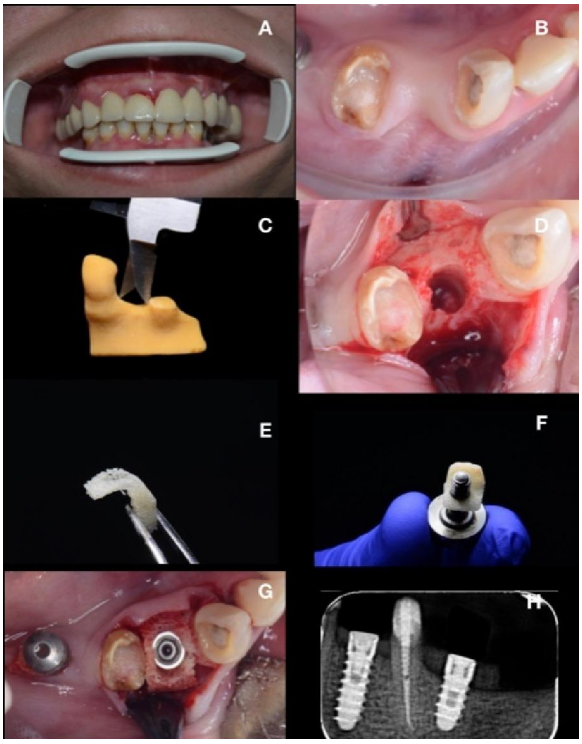

Figure (1) A: preoperative frontal photo B: Occlusal view of the surgical defect C: 3D printed model D: ossteomy & site preparation E: xenogenic bone block F: xenogenic block fixed to the implant G: occlosal view for the block graft fixed with the implant H: immediate postoperative periapical xray.

Replaced teeth were distributed according to the following: Four 1st mandibular premolars, eight 1ST mandibular molar four 2nd mandibular molar. All patients received porcelain fused to metal crown restorations after 6 months from implant placement. Patients were evaluated clinically and radiographically at regular time intervals at 6, 9 and 12 months postoperatively.

According to the survival rate criteria, 14 implants were stable and 2 implants in the same patient were lost during the 2nd stage surgery due to infection.

A. Radiographic Evaluation

Marginal bone loss:

Results related to the marginal bone loss showed that the mean ISQ values were 1.81±0.48 at 6 month 2.18±0.51 at 9 month 2.40±0.54 at 12 month.

Comparing the different time intervals, there was a significant difference P1<0.001 between the placement time values (T0) and 6 month values (T1), between (T0) placement time values and 9 month values (T2), between (T0) placement time and 12

month values (T3), between (T1) 6 month values and 12 month values (T3), between (T1) 6 month values and 9 month values (T2), between (T1) 6 month values and at 12 month values (T3). There was no statistical significant difference (P6=0.06) between (T2) 9 month values and 12 month values (T3).

B. Clinical Evaluation

1. Implant stability:

Results related to the Implant stability showed that the mean ISQ values were 60.38±5.16 at placement time 70.85±4.49 at 6 month 75.23±4.64 at 9 month 77.15±4.51at 12 month.

Comparing the different time intervals, there was a significant difference P1<0.001 between (T0-T1) the placement time values and 6 month values, between (T0-T2) placement time values and 9 month values, between (T0-T3) placement time and 12 month values, between (T1-T2) 6 month values and 12 month values, between (T1-T2) 6 month values and 9 month values, between (T1-T3) 6 month values and at 12 month value sand a statistical significant difference (P6=0.001) between (T2-T3) 9 month values and 12 month values.

2- Modified Sulcus Bleeding Index

Results related to the Implant stability showed that the mean ISQ values were 1.85±0.69 at 6 month 2.31±0.63 at 9 month 2.54±0.52 at 12 month.

Comparing the different time intervals, there was a significant difference (P1=0.027) between (T1-T2) 6 month values 9 month values. There was a statistical significant difference (P2=0.002) between (T1-T3) 6 month values and 12 month values. There was no statistical significant difference (P3=0.08) at 9 month values and 12 month values.

3- Pocket depth

Results related to the Implant stability showed that the mean ISQ values were 2.28±0.49 at 6 month 2.65±0.55 at 9 month 2.77±0.56 at 12 month.

Comparing the different time intervals, there was a significant difference (P1=0.001) between (T1-T2) 6 month values 9 month values and between (T1-T3) 6 month values and 12 month values. There was no statistical significant difference (P3=0.09) at 9 month values and 12 month values.

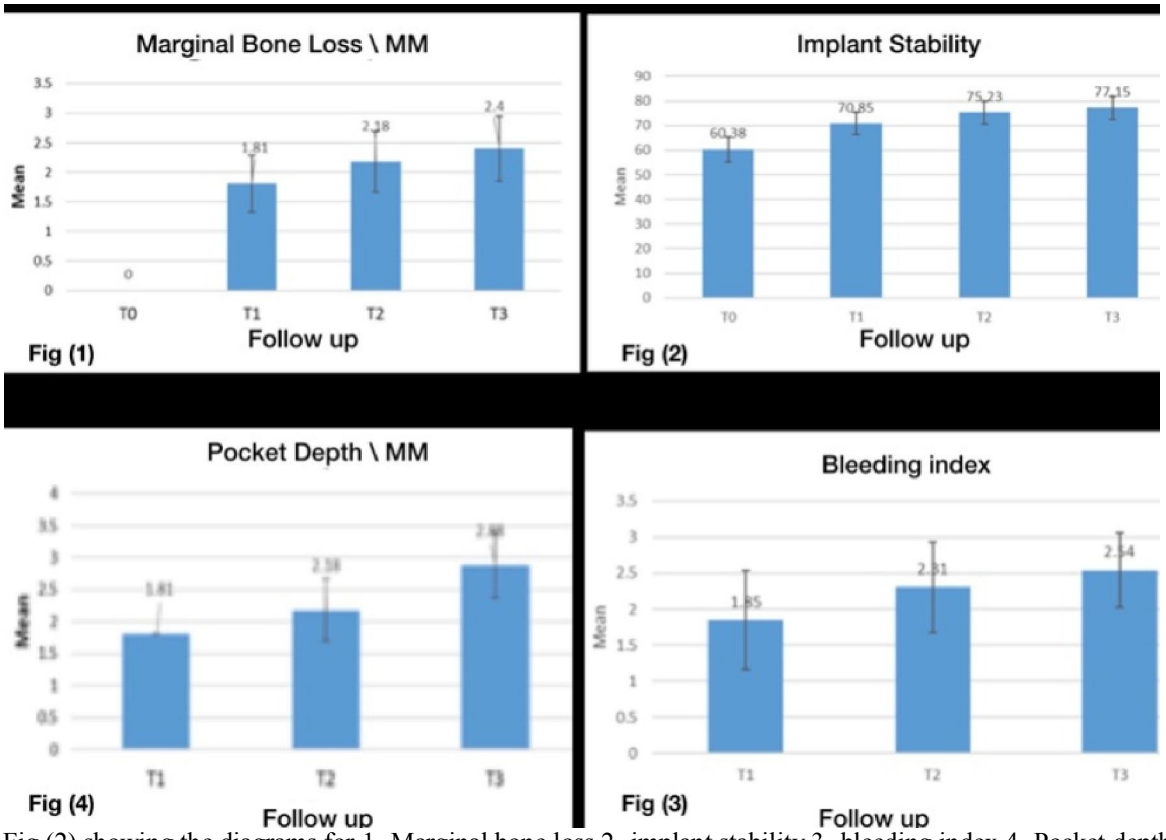

Fig (2) showing the diagrams for 1- Marginal bone loss 2- implant stability 3- bleeding index 4- Pocket depth.

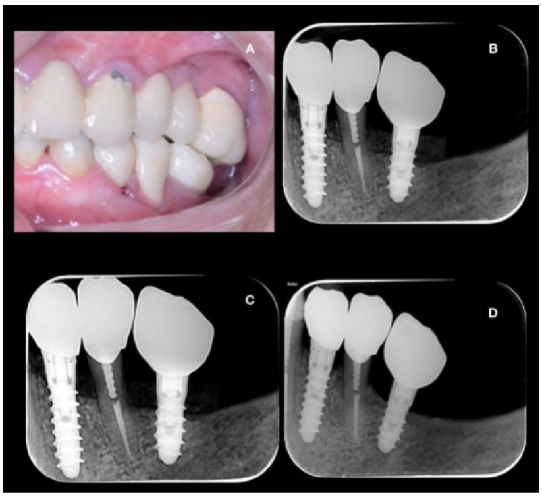

Figure (3) A: lateral view to the final prothesis B: periapical xray for 6 month follow up C: periapical xray for 9 month D: periapical xray for 12 month.

4. Discussion

The aim of this study was to evaluate the efficacy of using a xenogenic vented bone block fixed to the posterior mandibular jaw bone using a laser sintered implants restoring a 3-dimensional bone defects. The indication for such technique is the lack of adequate alveolar bone, a condition that a correct implant placement of the desired length and width is difficult.

A lot of techniques have been introduced for alveolar ridge augmentation such as harvesting bone blocks and plates from intraoral or extraoral donor sites and placed simultaneously with the implant surgery or fixed to the desired implant area several months before implantation to increase the bone quality and quantity. [38,39] All these techniques have shown problems as secondary donor site operation, insufficient bone quantity obtained and increased operation time, so searching for other solution to minimize these problems and make the surgeical operation much more easier is considered. [39]

One of these alternative lines of treatment was ridge augmentation using xenogenic bone block fixed to the ridge, most of these techniques required the block to be fixed with bone screws for several months before making the implant surgery. Using the xenogenic bone block have made the augmentation procedure easier for both the surgeon and the patient by eliminating secondary donor site problems, making this method much more preferred by the patients with ridge defects. Although it is easier technique than using an autogenic bone graft, the implant surgery still delayed for 6 to 12 month after block fixation the jaw bone.

Our study has proposed a new technique to minimize the time needed to restore the posterior mandibular defect using the xenogenic bone block made by tutoplast technology fixed directly by the dental implant itself, minimizing the time needed to restore the defect with implants. According to our study, fixing the xenogenic bone block by the implant itself will eliminate the need for a second surgery after augmentation surgery minizing the required number of operations.

Also, in our study a membrane barrier was not used as the xenogenic block according to the tutoplast technology is hard enough and take longer time to resorb and slightly resist the invation by the soft tissue. Using a membrane barrier in slighty large vertical or horizontal augemtation have shown several problems. [40,41]

The bone particles and the barrier membranes used for ridge augmentation procedures either in staged approach or during the implant placement. [41] Using thesis membranes with the bone graft particles in augmentation was proved to be effective in obtaining a very good bone either around the implants or before placing one. [40,41]

However using thesis membranes with the dental implantation procedures sometimes may lead to membranes exposure or soft tissue dehiscence and in very rare cases we may have to remove the membrane itself [41,42]. Using the allograft or xenograft with the barrier membranes in small bone defects was found to be very useful but on the other hand the major bone defects require a major reconstruction procedures in vertical or lateral augmentation of the crest in partially edentulous patients. [42]

Also using the autograft, allograft and xenograft with barrier membrane have shown controversial results. According to Buser, if a staged approach is used, complications involving membrane exposure, suture dehiscence and loss of the graft are minimal [31]

A study done by Fugazzotto in 1997[42] using the dental implant simultaneously with TCP graft covered by non-reabsorbable membranes showed that the there is a need to remove the membranes because of premature exposure and infection in 21.5% of patients included in the study. ([42]

One of the major problems in using block grafts is graft resorption, Also studies showed a higher number of complications related to soft - tissue dehiscence have been shown. [43] Several attempts have been made to improve the graft behavior, using barrier membranes, covering with graft particles of different types. [44, 45]

Chiapasco et al 2010 [46] have proved that Mandibular bone block grafts used in to restore severe horizontal defects shown that they are effective in the reconstruction of atrophic ridges. On the other hand, Cordaro et al. 2002, 2010; Donos et al. 2002 proved that there are disadvantages related to horizontal

augmentations with bone block grafts, there is the resorption of a significant part of the graft. [47]

The xenogenic block have been evaluated from several angles of success. We have found that there is an increase in the block resorption around our implants from the time of surgery up to 12 months of follow up (P <0.001). We have suspected the graft stability when fixed by the implant itself not by screws. Fixing the xenogenic bone blocks by bone screws have shown a mild block resorption compared to our study. May be using a barrier membrane have promoted the result or even the implant itself have allowed the graft micromovement which resulted in graft resorption around the implants.

The direct laser metal sintering (DLMS) technology used in manufacturing and surface treating the dental implants was introduced by Deckard and Baeman [163] to be used in problematic patients offering a highly porous, uniform rough surface with isoelastic properties and showed a great osseointegration in a short time interval when compared with the conventional types of implants. [49,50] Smiler DG, Johnson PW et al showed that the effectiveness of DLMS implant in fast bone healing and it can be loaded earlier than the conventional one.

Although using such a superior implant design was expected to undergo a fast bone healing with the jaw bone and the block graft itself, a marked bone resorption over time ((T0) at the placement time and (T3) 12 month) have been seen in our study (P3<0.001) between the implant and xenogenic block. On the other hand, the ossteoinegration between the natural jaw bone and the implant surface was sufficient to produce highly marked ISQ values (P3<0.001).

Regarding the Implant stability, a marked statistical significance differences between all-time intervals was found (P<0.001). The increase in the implant stability overtime may be due to the DLMS technology which have the ability of fast in growing bone, increasing the stability over time. The DLMS technology have proven it's efficacy in achieving fast bone healing allowing for faster loading protocols. [49,50]

All implants included in our study were subjected to delayed loading protocol (6 months) in agreement with Carlo Mangano et al 2009. Carlo Mangano shown that DLMS dental implants has a great histological and histometrical results which were superior to those obtained with conventional surface treatment methods such as sandblasted, acid etched and machined implants. [51] Also DLMS implants stimulate and support new bone apposition after unloaded healing period of two months. [51]

Regarding to the modified sulcus bleeding index a marked statistical significant differences between (T0-T1) and (T0-T3) was found (P=0.027,0. 002) respectively and no statistical significant difference between (T2-T3) P=0.08. A study made by Palmer and Wilson showed that there is a prolonged inferior periodontal condition caused by bone graft itself or sometimes a tissue dehiscence from the graft which resulted in increased gingival inflammation which in turn increase the gingival bleeding. [52,53] However, the individual variations during the application of the examination tool can give a false result. [36]

Regarding the pocket depth a marked statistical significant difference between (T0-T1) and (T0-T3) was found (p= 0.001) and no statistical difference between (T2-T3) was recorded (P=0.09). the pocket depth was found to be related to the bleeding index the marginal bone level which have shown a similar result.

Conclusion

We concluded that using the xenogenic bone block fixed with DLMS implants in restoring posterior mandibular vertical and horizontal defects have shown a marked graft resorption and graft dehiscence. On the other hand, the DLMS implants has shown a marked increase in stability over time and fast natural bone formation but failed to ossteointegrate with the xenogenic block when used at the same time.

Recommendations

1- When using Xenogenic bone block in restoring a posterior mandibular defect it is better to use a fixation screws to insure the graft stability.

2- Using the implants as a fixative screw is not recommended as it allows graft micromovements which in turn will lead to graft resorption.

3- It is better to follow a two stage technique in restoring defect, as it will be easier to evaluate the graft resorption and the bone dimensions before using the implant.

4- Further studies are needed to evaluate if using Implants as a fixative screw in autogenic bone blocks will show a different results or not.

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