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Efficacy of Ridge Augmentation with or without Ultrasonic Splitting in Pre-Implant Preparation of Narrow Alveolar Ridges Clinical, Radiographic and Histomorphologic study

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ABSTRACT

Aim: This study was carried out to compare clinically, radiographically and histomorphologically between narrow alveolar ridge augmentation using allogenic bone block versus ultrasonic ridge splitting technique combined with bone chips. **Subjects and methods:** Twenty patients were devieded randomaly into two equal groups, by using a flip of coin as the following; Group 1: 10 Patients with narrow mandibular alveolar ridge received allogenic bone block then after 6 month Implants were placed. Group 2: 10 Patients with narrow mandibular alveolar ridge received piezo splitting technique and allogenic bone chips then after 6-month implants were placed. Clinical and radiographic parameters were gathered at baseline and 6 months after ridge augmentation. **Results:** There were statistically significant differences between Group I & Group II at 6,9 months regarding alveolar ridge width, peri-implant probing depth (PPD), implant stability quotient (ISQ), Changes in marginal bone loss (MBL)and bone density measurements (BD) And vice versa, no statistically significant differences at 6, 9 months in modified plaque index (mPI) and modified sulcus bleeding index (mSBI). **Conclusion:** Within the limitations of this study can conclude that, both techniques exhibited successful treatment outcomes in narrow alveolar ridge, ridge splitting technique seems to be a very effective modality for implant placement in narrow alveolar ridge, that this technique is a safe and predictable in thin ridge cases, finally the use of corticocancellous block allografts had given promising results, thus allowing the placement of implants of standard length and diameter, thereby improving the long-term prognosis of the implant-supported reconstruction.

KEYWORDS

Narrow alveolar ridge, bone block augmentation, ridge splitting, allogenic bone block, allogenic bone graft.

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INTRODUCTION

Resorption of alveolar bone occurs as a result of physiologic healing after tooth loss[(1)]. The pattern of resorption often results in a residual knife edge and a palatally or lingually shifted ridge apex, with frail and thin labial cortex[(2,3)]. The estimated structural loss is about 60% of pre-extraction alveolar ridge width; this loss has a detrimental effect on potential treatment with a dental implant[(4)].

Several methods have been described to augment the alveolar crest before or after implant placement to establish at least 1 mm bony wall around screw type implant. Various surgical widening techniques have been described, including lateral augmentation with or without guided bone regeneration (GBR) and horizontal distraction osteogenesis. Expansion of the existing residual ridge is another method and is referred as, bone spreading, ridge expansion, the osteotomy or ridge splitting technique [5].

Ridge splitting technique creates a sagittal osteotomy of the edentulous ridge using instruments such as chisels between the two cortical plates to expand the ridge width and consequently allow for the placement of implants. This approach is used to expand the edentulous ridge for implant placement or insertion of an interpositional bone graft. However, it is only suitable for enhancing ridge width. There must be adequate available bone height for implant placement, and no vertical bone defect should be present. A minimum of 3 mm of bone width, including at least 1 mm of cancellous bone is desired to insert a bone chisel between cortical plates and consequently expand the cortical bones[6] .

One advantage of ridge splitting over other ridge augmentation techniques such as bone grafting is that implants may be placed simultaneously, considerably shortening the treatment time. Unlike guided bone regeneration, which relies on bone forming over the exposed implant surface, ridge splitting repositions the cortical plates around the Implant, then allowing bone to regenerate within the space between the expanded cortical plates [7- 10].

Guided bone regeneration (GBR) is a well-documented procedure that designed to provide narrow alveolar ridge augmentation and correct development of deficient implant sites [11]. The rationale underlying the GBR protocol lies in the prevention of undesirable, non-osteogenic cells from growing into the bony defect by providing a mechanical barrier. There is strong evidence for the effectiveness and predictability of GBR in promoting vertical and lateral bone augmentation of ridge deficiencies [12].

Simultaneous guided tissue regeneration (GTR) procedures, using bone grafts with barrier membranes, are usually necessary to correct peri-implant defects and/or to augment surrounding tissues. This approach can also, achieve successful treatment outcomes of ridge expansion associated with implant placement with high predictability and a low risk of complications [13].

Allogenic bone blocks offer similar osteoconductive properties compared to autologous bone due to the preserved microstructure of human bone, the main advantage of allogenic products is, that there is no need of a donor site and therefore significantly less patient morbidity. Recent study focusing on allogenic bone grafting show overall excellent survival rates of these block grafts of 96.7%, furthermore, the implants placed into allogenic blocks also show a high survival rate of 97.36% [14].

The present study was designed to assess and compare clinically, radiographically and histomorphologically ultrasonic bone surgery with bone block augmentation associated with implant placement in narrow zones.

PATIENTS AND METHODS

This study was designed as a randomized, controlled, clinical trial and carried out on 20 patients (12 males, 8 females, with average age 39±6.3 years) with partial edentulous narrow mandibular alveolar ridge, seeking to receive dental implant. Patients were selected from the outpatient clinics Department of Oral Medicine and Periodontology, Faculty of Dentistry Al- Azhar University – Assiut branch.

Ethical issues

1. Approval to conduct the study was sought and granted by the ethical committee, Faculties of Dentistry, Al-Azhar University (No.AU-AREC20220009-6).

2. Consent from the patients of the study was sought both verbally and in written form before the work.
3. All patients participating in the study were fully informed of the study protocol and the associated risks of the study procedures.
4. Information collected from the diagnostic chart was handled with confidentiality and used for research purposes only.

These patients were divided randomly into two groups

Group 1: 10 implant sites received allogenic bone block then after 6-month implants were placed.

Group 2: 10 implant sites received piezo splitting technique and allogenic bone chips then after 6-month implants were placed.

Presurgical preparation

Each case was evaluated through examination of CBCT to assess bone quality and quantity, to quantify the ridge height and width of the supporting bone, and to locate the major anatomical features. All patients were subjected to proper oral hygiene instructions, scaling and root planning for all teeth and periodontal treatment if needed to provide an oral environment more favorable to wound healing. The pre-operative medications included**;** Augmentin® 1g tablets (Medical Union Pharmaceuticals Co. Egypt) were prescribed for each patient twice daily for 5 days. Analgesics were prescribed as following: Voltaren® (Novartis Pharma, S.A.E., Cairo, Egypt) 75 mg IM once. Brufen® (Khaira Pharmaceuticals and Chemical Industries Company, Cairo, Egypt) 400 mg t.d.s for 5 days was prescribed.

Surgical Procedures

The site of surgery was anesthetized with 1:100,000 epinephrine, once anesthetized, crestal incision was done, and full thickness flap was reflected.

Group I:

The surgical procedures were done in two stages. In the first stage of surgery, a full thickness mucoperiosteal flap was raised on both the facial and palatal aspects **(Figure 1a, b)**. Ridge augmentation was done using corticocancellous allogenic block (BNA KOHCE; METOA, Russia), the allogenic block was shaped to fit the recipient site which are Prior to placement of the allograft **(Figure 1c, d)**, the bone defect was decorticated with a high-speed drill using a #2 round bur with perforations made at 4-mm intervals in the cortical plate and fixated by two fixation screws (Medartis, Modus, Mediartis Holding AG, Basel, Switzerland) **(Figure 1e)**.

A periosteal-releasing incision was used to provide tension-free flap closure. The wound margins were approximated using non-resorbable poly- amide suture (Seralon, Serag-Wiessner GmbH, Naila, Germany) to obtain primary wound closure **(Figure 1f)**. All patients were prescribed an antibiotic regimen with 2g of amoxicillin with clavulanic acid 1 hour preoperatively to be continued as 1g twice daily for 3 days postsurgery. Patients were also prescribed analgesics and chlorhexidine digluconate (0.2%) for chemical plaque control.

In patients with post-surgical complications the antibiotic regimen was prolonged. Sutures were removed around 14 days postoperatively. The second stage surgery was performed after a minimal healing period of six months. A paracrestal incision was given to elevate a full thickness mucoperiosteal. The fixation screws from the previous surgery was removed and the implant site was prepared based on the specific requirements of the site.The antibiotic and analgesic regimen and post-surgical care was the same as in the first-stage surgery. Sutures were removed after 14 days. Patient was given oral hygiene instructions and directed to enroll onto a supportive periodontal therapy to monitor oral health.

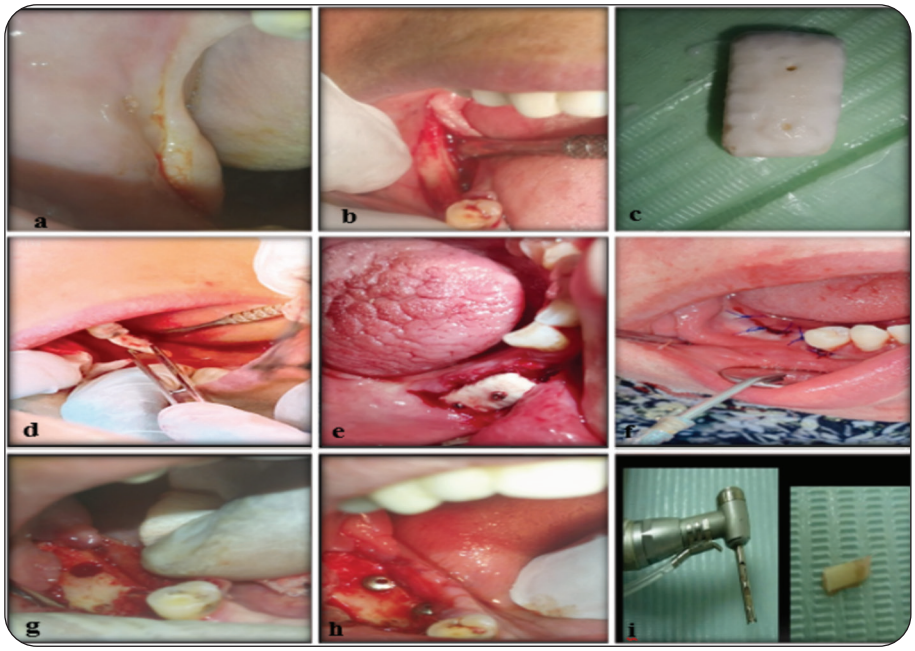

Fig. (1) Showing Clinical photographs for a female patient of 43 years old with a missing lower right posterior teeth (a) clinical photograph of mandibular posterior thin ridge (b) full thickness flap. (c) allogenic bone block. (d) placement of allogenic bone block. (e) Fixation of allogenic bone block by two mini screws. (f) Flap repositioning and interrupted sutures. (g) Showing a trephine bur (internal diameter 2.3 mm/external diameter 3.0 mm) and bone biopsy. (g) Drilling in augmented alveolar ridge. (i) Dental implant placement with cover screw.

Group II:

After local anesthesia, a full-thickness periosteal flap was made to expose the alveolar bone. Alveolar bone width was observed to be about 3 to 5 mm at the alveolar crest with Using piezoelectric surgery unit (piezotome® solo, acteon, satelec, France) **(Figure 2a,b)** a horizontal crestal cut was produced along the crest of the bone.

The cut depth extended through the cortical bone to reach the spongy bone. Guide pins in the crestal osteotomy line were angulated lingually to the axis of premolar teeth. The crestal osteotomy was deepened to around 8 mm of vertical depth. Lateral vertical osteotomies were deepened in the lingual direction through the cancellous bone until the cutting tip reached the lingual bone plate **(Figure 2c)**.

After that, the apical horizontal osteotomy was retracted carefully to avoid complete separation of the buccal bone plate. Lateral hinge movement was performed with bone chisels **(Figure 2d)**. After 5 mm lateral movement of buccal bone plate, allogenic bone chips (BNA KOHCE; ME TOA, Russia) was grafted into the gap between buccal and lingual bone plates **(Figure 2e, f)**. Primary closure was performed with the use of periosteal releasing incisions.

Implant placement:

After 6 months from ridge augmentation. A bone biopsy was performed to evaluate histological findings. A trephine bur (internal diameter 2.3 mm/ external diameter 3.0 mm) was used to obtain bone tissues at the planned implant sites (**Figure 1g**). Then, insertion of implants fixture (IDI implants, France) of diameter ranging from 3.7 - 4.2 mm. according to manufacture instructions. Careful screwing and seating of these tapered implants into the bone was performed until all exposed threads were submerged and the platform remained flush with the crestal bone with gaining primary stability of the implants and fixation in its position. Cover screws were then fixed to the implants **(Figure 1h, i)** and **(Figure 2g, h).** Abutment connection surgery was performed 4 months after the implant placement. Final prosthesis were delivered 3 weeks after the abutment connection surgery.

Oral hygiene recommendations were provided including the use of soft tooth brush. Further advices included adhering to a soft diet and avoiding trauma to the gingival tissue at the implant sites especially in the first few weeks.

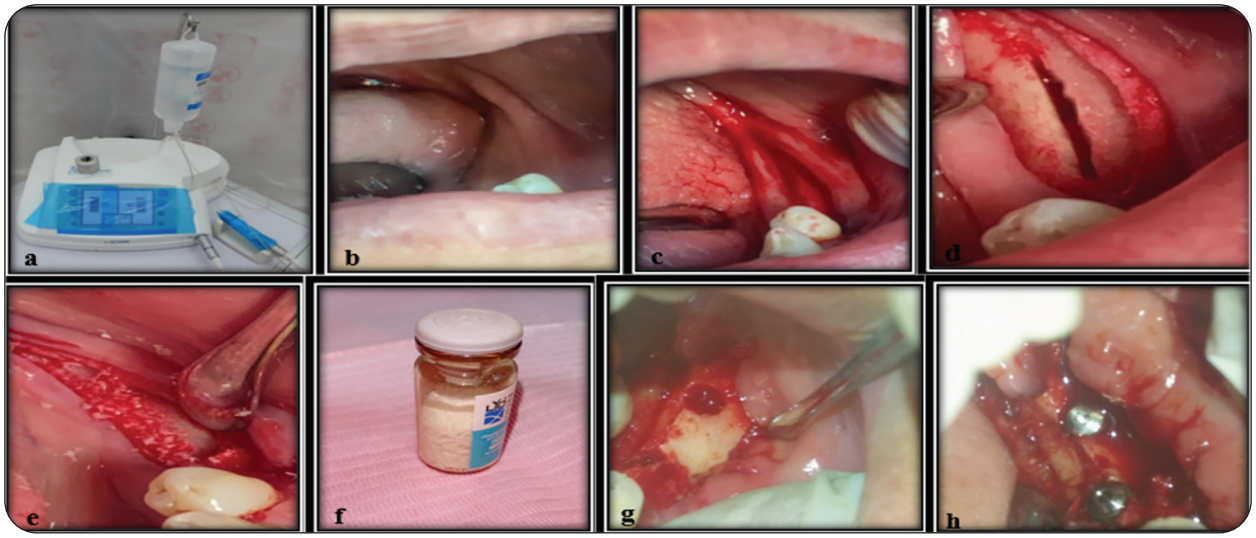

Fig. (2) Showing Clinical photographs for a female patient of 47years old with a missing lower left posterior teeth showing (a) Piezosurgical ridge splitting unit (piezotome). (b) Clinical photograph of mandibular posterior thin ridge. (c) Full thickness flap. (d) Splitting of narrow ridge by (piezotome) device. (e) Filling the gap with allogenic bone chips. (f) Bottle of allogenic bone chips. (g) Drilling in augmented alveolar ridge (h) Dental implant placement with cover screw.

Implant success evaluation

Implant success was determined according to an assessment of implant stability, pain, infection, and radiolucency around the implant.

The definition of implant success was defined according to the following 4 criteria:[15]

1. Absence of clinically detectable implant mobility.
2. Absence of pain or any subjective sensation.
3. Absence of recurrent peri-implant infection.
4. Absence of radiolucency around the implant.

Evaluations of ridge augmentation and implant placement :

Evaluations were done in many stages:

Firstly: ridge augmentation.

- Clinical evaluation: were done at baseline and 6 months after ridge augmentation including ridge width.
- Radiographic evaluation: were done at baseline and 6 months after ridge augmentation by using of CBCT for assessment of ridge width which 2mm from the crest of the ridge (**Figure 3a, b**), (**Figure 4a, b**) and (**Figure 5**).

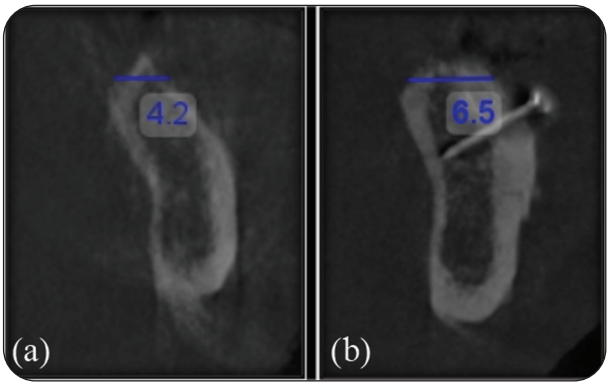

Fig. (3) (a) Preoperative CBCT, (b) 6 months postoperative CBCT in patient site treated with allogenic bone block (group I).

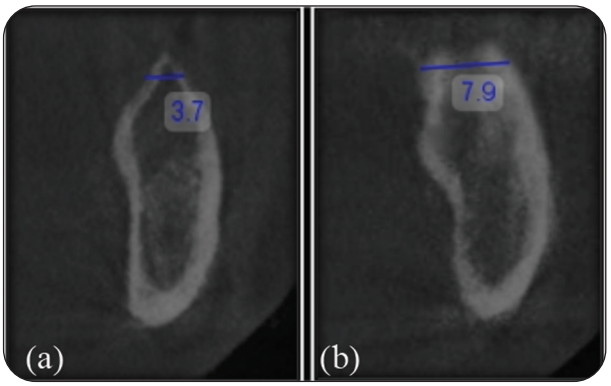

Fig. (4) (a) Preoperative CBCT, (b) 6 months postoperative CBCT in patient site treated with piezourgical ridge splitting with allogenic bone chips (group II).

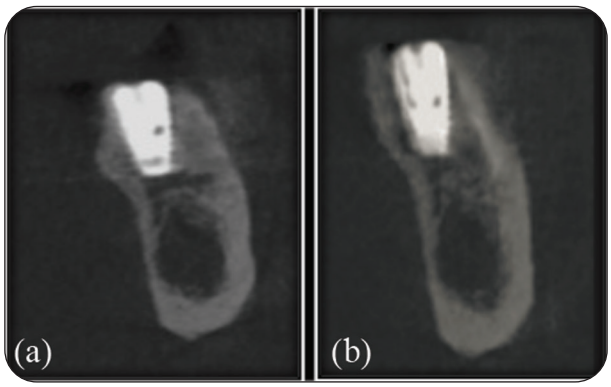

Fig. (5) Radiographic photos showing implants (a) implant after allogenic bone block, (b) implant after piezosplitting with allogenic bone chips.

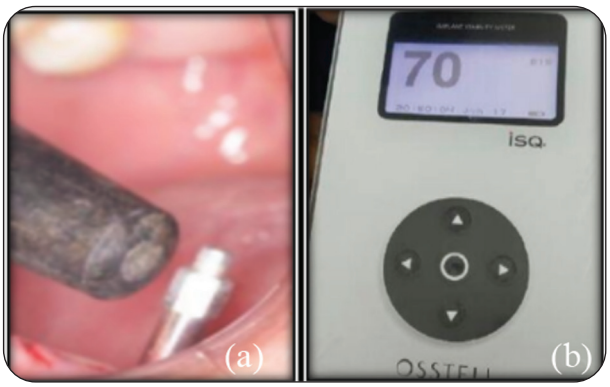

Fig. (6) (a) Primary stability measurement, (b) Osstell reading.

Secondary: implant placement.

Clinical evaluation:

Implant primary stability [16]: All implants were evaluated for primary stability once after implant insertion and after six months from implant insertion for determining the final stability with an Osstell Mentor magnetic resonance device (Osstell; Integration Diagnostics Ltd., Göteborg, Sweden) that uses resonance frequency analysis for determining implant stability (**Figure 6a, b).**

The assessment of soft tissue changes: by using William's periodontal probe® (Medesy srl, Italy), graded in mms. Were done at 6 and 9 months after implant placement including:

Modified sulcus bleeding index(mBI) [17]: at 4 aspects around the implants: score 0, no bleeding when a periodontal probe is passed along the gingival margin adjacent to the implant; score 1, isolated bleeding spot visible; score 2, blood forms a confluent red line on margin; and score 3, heavy or profuse bleeding.

Peri-implant probing depth (PPD) [18,19]: Distance from the crest of gingival margin to the bottom of the gingival sulcus at four sites around implants using a UNC 15 color coded plastic periodontal probe. Distances will be rounded up to the nearest millimeter **(Figure 8)**.

Modified Plaque index (mPI) [17]: To assess plaque accumulation around marginal area around implants as following: 0 (no plaque detected), 1 (plaque recognized only by running a probe along margin), 2 (plaque visible to the naked eye) and 3 (abundance of soft matter).

Radiographic Evaluation:

Measuring of marginal bone loss:

Marginal bone loss around the implant was evaluated using periapical radiographs (image plate sensor size 2 that analyzed by photon collection system of vista-scan®*) that were taken on the day of the implant placement (baseline) and on the follow-up visits at 3, 6 and 9 months. The distance from a reference point at the implant to the most coronal point where the marginal bone contacts the implant was measure. Measurements were made mesially and distally in each implant (**Figure 7a)**.

Measuring of bone density:

Average bone density was determined around implant using CBCT. At the generated cross-sectional view, the area to be measured which called *regions of interest (ROI)*, was selected and traced. The readings were taken in *Hounsfield Unit (HU)*. Bone density was measured in the day of the implant placement (baseline) and on the follow-up visits at 6 and 12 months (**Figure 7b)**.

* Durr Dental GmbH& Co. Bietigheim- Bissingen, Germany.

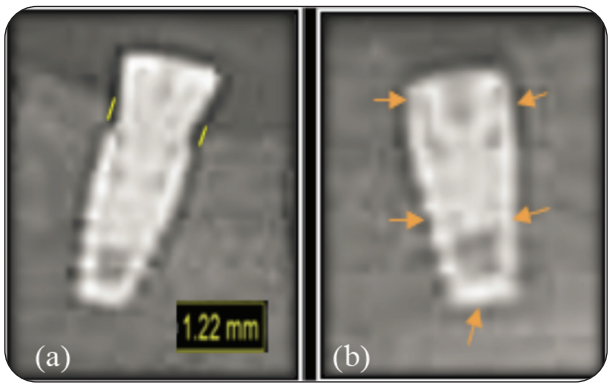

Fig. (7) (a) Showing marginal bone loss evaluation. (b) Showing regions of interest (ROI) for bone density evaluation

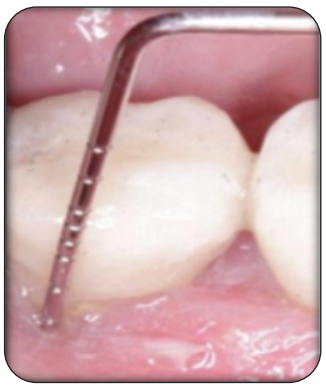
Fig. (8) Peri-implant probing depth measurement with William periodontal probe

Prosthetic procedure

After 4 months from implant placement, under local anesthesia, the surgical covering screw was exposed and removed then healing cap was placed for 3 weeks. After that, Impression was made with the aid of impression post and laboratory analogue using silicone rubber base material to fabricate working cast then the final restoration of porcelain fused to metal was fabricated and cemented on the vabutment.

Histomorphologic Analysis:

The sample was collected during implant site drilling by trephine burs and histological analysis was done using a light microscope.

Specimen Processing:

Every core bone biopsy held both the grafted area, and the local native alveolar bone were fixed using 10% buffered formalin. When submitted for histologic examination, decalcification of the specimen was attained by suspension for fourteen days in EDTA 10% solution with regular rechanging of the solution every day.

Dehydration of the specimen was then achieved using alcohol, followed by clearing in xylol. Afterward it was inserted in paraffin wax to be in a block form. The paraffin block was segmented longitudinally utilizing a microtome into thin paraffin sections, each of approximately 5 microns thick. The sections were stained with Hematoxylin and Eosin. Stained sections were examined in a blind fashion to estimate the bone quality.

Data management and Statistical Analysis:

All data were collected, tabulated and statistically analyzed using statistical package of special science SPSS version 22 (SPSS Inc. Chicago, IL, U.S.A) as follow:

Editing and coding

Data entry in computer.

Quantitative data were expressed as mean ± SD (standard deviation) for parametric data median and range for non- parametric data.

Qualitative data were expressed as frequencies and relative percentage.

Data were tested for normal distribution using Shapiro-Wilk's test.

Data were handled using appropriate statistical tests of significance such as:

Independent t-test and Mann Whitney test were used to calculate difference between quantitative variables in two groups.

Paired t-test was used to compare between two dependent groups of normally distributed variables.

Chi square test ($\chi 2$) and fisher exact was used to calculated difference between qualitative variables.

Regression analysis using the stepwise method was used to determine the potential risk factor of hypomagnesemia.

All statistical comparison were two tailed with significance level of p-value 0.05 indicates significant, p-value <0.001 indicates highly significant difference while p-value > 0.05 indicates non-significant difference.

RESULTS

Twenty patients having narrow alveolar ridge were selected to participate in this study. No abnormal reactions or complications were observed post surgically during the observational period of the study.

By measuring alveolar ridge width there were no statistically significant difference at pre-operative ridge augmentation when comparing between groups while there was statistically significant difference at post-operative (6 months) of ridge augmentation when comparing between groups. Also, there were statistically significant differences at different periods within groups.

In statistically checking to both modified plaque index and modified sulcus bleeding index; this study recorded no statistically significant differences between both groups at any observation period checkpoint and there were no statistically significant differences within the groups in different observation periods.

By measuring peri-implant pocket depth and clinical attachment loss, there were statistically significant differences at 6 and 9 months when comparing between groups. Also, there were statistically significant differences at different periods within groups.

By measuring implant stability quotient (ISQ) there were no statistically significant difference at baseline whereas, there were statistically significant difference at 6 months when comparing between groups. Also, there were statistically significant differences at different periods within groups.

By measuring change in marginal bone loss there was statistically significant difference at 3, 6 and 9 months when comparing between groups. Also, there were statistically significant differences at different periods within groups.

By measuring bone density there was no statistically significant difference at baseline, there was statistically significant difference at 6 and 129 months when comparing between groups. Also, there were statistically significant differences at different periods within groups.

Table (1) *Illustrating mean ± SD values of modified plaque index, modified bleeding index and peri-implant probing depth along with significance level using paired & unpaired t-test.*

Clinical parameters	mPI					mBI					PPD				
	Base line	6 months		9 months		Base line	6 Months		9 months		Base line	6 months		9 months	
G I	0.00	0.467±0.307		0.390±0.309		0.00	0.535±0.257		0.681±0.216		0.00	1.155±0.186		2.330±0.428	
G II	0.00	0.391±0.282		0.347±0.199		0.00	0.532±0.232		0.589±0.231		0.00	1.5±0.440		1.775±0.447	
Unpaired t test	P	T	P	T	P	P	T	P	T	P	P	T	P	T	P
G I Vs G II	1ns	0.576	0.572	0.372	0.714	1ns	0.023	0.982	0.916	0.372	1ns	2.279	0.035*	2.832	0.011*

Table (2) *Illustrating mean ± SD values of implant stability, alveolar ridge width implant stability, Changes in marginal bone loss and bone density measurements along with significance level using paired & unpaired t-test.*

Clinical parameters	ISQ		Alveolar ridge width		MBL			BD		
	Base line	6 months	Base line	6 months	3 months	6 months	9 months	Base line	6 months	12 months
G 1	65.5±2.677	68.4 ±1.349	4.23±0.244	6.45±0.437	0.630±0.124	0.756±0.108	1.088±0.135	681.6 ±13.25	696 ±13.282	701.8 ±16.09
G 2	68.4±1.349	72.5 ±1.957	4.075±0.212	8.1 ±0.444	0.45±0.120	0.611±0.120	0.839±0.159	694.2 ±26.955	803.5 ±49.05	839.2 ±42.02
Unpaired t test	P T	t P T	T P	P T	T P	T P	T P	T P	T P	T P
G I Vs G II	0.011* 2.854	0.64 0.000* 4.548	1.91 0.07	1ns 3.88	3.825 0.001**	4.155 0.001*	3.08 0.006**	1.326 0.201	6.689 0.00**	9.656 0.00**

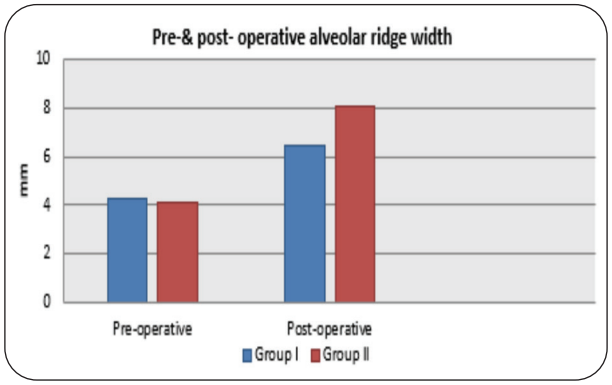

Fig. (9) Histogram representing changes in the means Pre-& post-operative alveolar ridge width between groups.

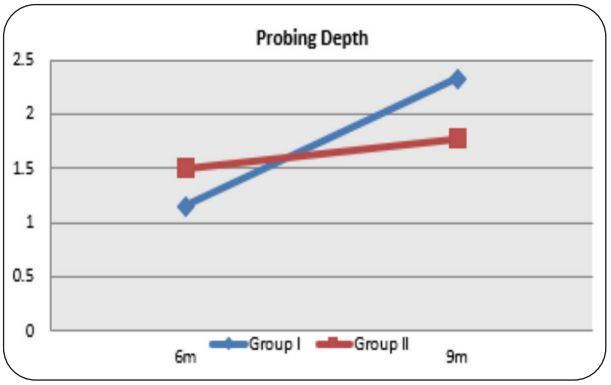

Fig. (10) Diagram showing means of Probing Depth in all groups at 6, 9 months.

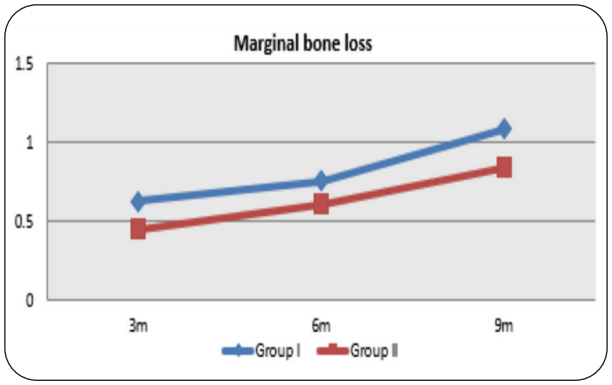

Fig. (11) Diagram showing means of marginal bone loss in all groups in each 3,6and 9 months. Diagram showing means of marginal bone loss in all groups in each baseline,6 and 9 months.

Histomorphometric evaluation

Histologically, newly formed vital bone, residual allograft bone, and connective tissue were observed in all specimens. The residual allograft bone was distinguished by the existence of empty lacunae and separation lines. The newly formed bone containing viable osteocytes showed close contact with the residual allograft. Osteoblasts were present throughout newly formed bone around the residual cortical block allograft. There was no sign of acute or chronic inflammatory infiltrates. No signs of pathologic inflammation were found. The residual graft particles appeared to be highly osteoconductive. In some specimens, a rim of osteoblasts lined the new bone. The soft tissue resembled bone marrow tissue and consisted of adipocytes.

Histomorphometrically, the mean proportion of newly formed bone in the region of interest was 33.0%, the residual allograft was 37.5%, and that of the marrow and connective tissue was 29.5% (Fig 12, 13, 14, 15, 16 and 17).

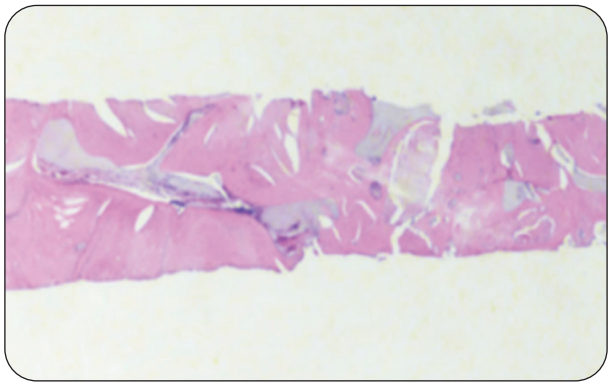

Fig. (12) Photomicrograph of a bone biopsy after allogenic bone graft was used. Residual allograft particles in close contact with newly formed cancellous lamellar bone and connective tissue. (Hematoxylin-Eosin staining x 40 magnification).

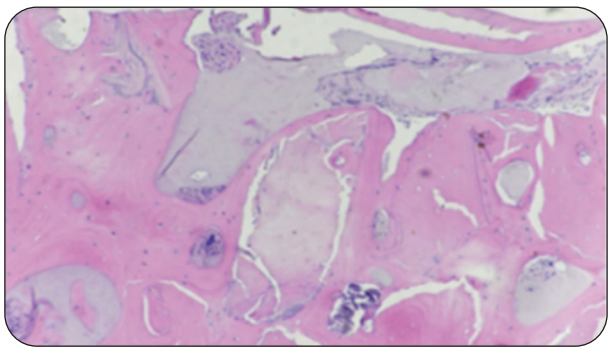

Fig. (13) Photomicrograph of a bone biopsy after allogenic bone graft was used. Residual allograft particles and connective tissue. (Hematoxylin -Eosin staining x 200 magnification).

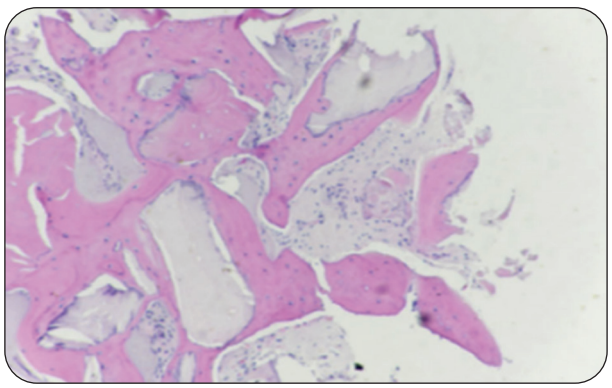

Fig. (14) Photomicrograph of a bone biopsy. Residual allograft particles, newly formed bone and connective tissue. (Hematoxylin -Eosin staining x 200 magnification).

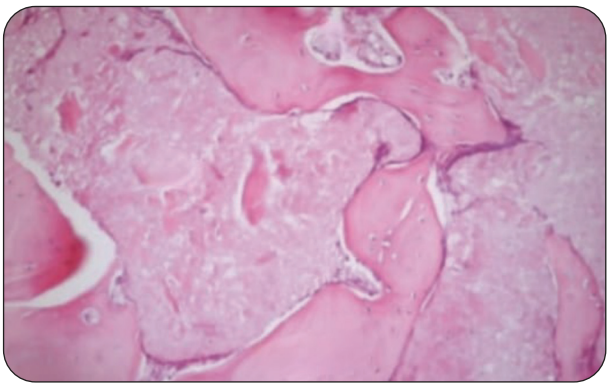

Fig. (15) Photomicrograph of a bone biopsy Necrotic bone in direct contact with viable bone, Osteoblasts is observed. The grafted particles are surrounded by immature woven bone and thus well integrated. A smaller area of the specimen consists of bone marrow tissue. (Hematoxylin -Eosin staining x 200 magnification).

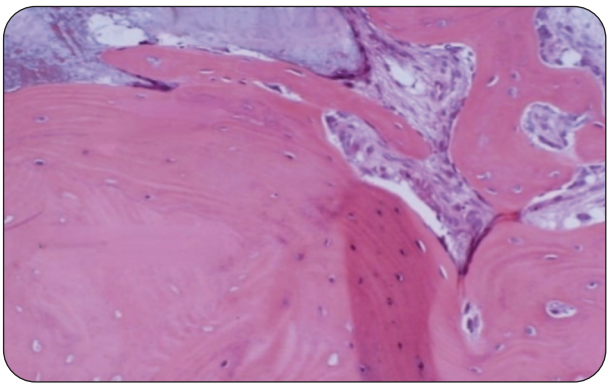

Fig. (16) Photomicrograph of a bone biopsy after allogenic bone graft was used. Residual allograft particles in close contact with newly formed bone (Osteocyte in lacuna), multinucleated giant cells and connective tissue. (Hematoxylin -Eosin staining x 200 magnification).

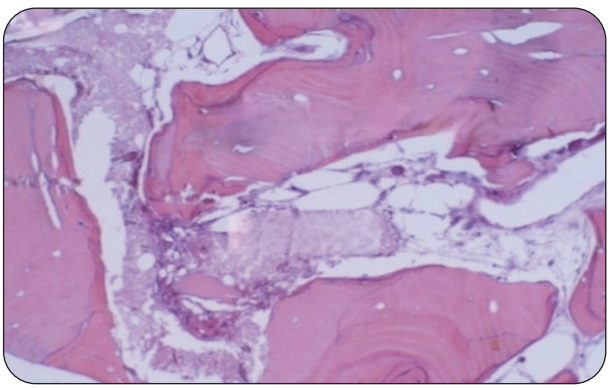

Fig. (17) Photomicrograph of a bone biopsy at 6 months. Residual allograft (empty lacuna) in close contact with newly formed bone (osteocyte in lacuna) and connective tissue (Hematoxylin-eosin staining x 200 magnification).

DISCUSSION

Alveolar ridge resorption following tooth loss is an inevitable and irreversible process. Bone resorption associated with loss of teeth is evident mainly at the expense of the buccal aspect of the jaw, leading to the development of narrow ridge. Resorption resulted in reduced ridge width, which may preclude placement of endosseous dental implants unless properly prepared. As mentioned by Esposito et al (2007) [20], the bone width is crucial for osseointegration and even more important for an aesthetic outcome. In the literature there are some guidelines available which suggested a zone of 1.5-2 mm of bone around the implant.

Successful long-time survival and success of dental implants depend on sufficient amount and quality of bone. In case of severe horizontal bone loss, horizontal ridge augmentation of the mandibular ridge can provide optimum conditions for successful implant placement. [21]. Therefore, the aim of the present study was to systematically examine the clinical efficacy of augmentation procedures in horizontally resorbed mandibular ridges in terms of horizontal bone gain, implant success and survival after a follow-up period after long time.

The results of this study indicate a high variability in types of interventions to gain horizontal bone width. However, all techniques were able to create a sufficient horizontal bone gain. Implant survival was very good.

To resolve this situation, alveolar ridge augmentation had been performed by many methods. Types of these methods are ridge splitting and block grafting approach. These procedures had the advantages of enabling simultaneous ridge expansion and placement of implants in a previously relatively narrow ridge.

This study was achieved on posterior mandibular region as a target area as bone loss is an ongoing process following tooth loss affecting the mandible four times more than the maxilla[22]. Also, the lower jaw is more seriously affected than the upper jaw and the posterior segments of both mandible and maxilla show more extensive atrophic phenomena compared to the anterior ones [23].

All patients included in this work were systemically healthy, this was in accordance with a review of selected dental literature on evidence-based treatment planning for dental implants which reported by Wood & Vermilyea (2004) [24] they mentioned that unsuccessful placement of implants was well- documented in patients with a wide variety of systemic conditions that could potentially affect biologic functions, particularly healing mechanisms. Rather than the specific nature of the disease process, the prognosis for a patient's long-term survival and local bone quality at the implant site are more important concerns in implant treatment planning. Also of importance is the overall health and stamina of a chronically ill patient. Patients must be able to tolerate the stressful effects of surgery and extensive restorative appointments.

All patients selected to this work undergone CBCT scans & periapical radiographs for treatment planning; this in accordance with De Bruyn et al (2013) [25] they mentioned that , dental radiographs are used commonly for patient selection, presurgical planning, during surgery in order to evaluate drill location with respect to critical anatomical landmarks such as the floor of nose, during several stages of the prosthetic procedures when evaluating positioning of impression copings, abutments or restorations and for radiographic assessment of the bone-to-implant level in maintenance sessions. A major limitation of periapical radiographs is that only two-dimensional images are obtained, these limitations can be resolved with three-dimensional scanning techniques, such as computed tomography. Also, in The American Academy of Oral and Maxillofacial Radiology (AAOMR) recommended that the evaluation of a potential implant site should include cross-sectional imaging, orthogonal to the site of interest [26].

All the patients in the present study under pre-operative care, which included premedication with antibiotic and non-steroidal anti-inflammatory drugs. This in accordance with the previous studies[27,28], they stated that that systemic antibiotic use prior to the surgical phase of implant placement can reduce the occurrence of infection after surgery and increase the success rates of integration. Also, in a study reported that the use of a course of NSAIDs for patients receiving dental implants resulted in less bone loss in the immediate post-loading period[29].

All patients of this study were undergone periodontal therapy, oral hygiene instructions and reinforcement before surgery and at the end of each appointment, also patients rinsed with Chlorhexidine gluconate 0.1% to reduce the bacterial load. This compatible with a study [24] demonstrated that the most effective local measures to increase implant success include optimal oral hygiene both around implants and teeth, reducing potential reservoirs of periopathogenic bacteria to maximize the potential for successful treatments, also another study [30] used presurgical chlorhexidine gluconate 0.12% oral rinses to reduce infectious complications around implants.

In the present study, full thickness flap reflection of the labial and palatal mucoperiosteal flap was done. This is in line with a previous study [31] they recommended the use of a full-thickness flap helps to avoid excessive bleeding, resulting in better visualization of the operating sites and better handling of the surgical steps. In cases where there is thin connective tissue, the partial-thickness flap procedure becomes extremely difficult, and the remaining tissue over the alveolar bone is too thin to protect the bone adequately. The osteoperiosteal flap is more technique sensitive, as it leads to the blind placement of implants and the failure to be able to visualize the entire length of the alveolar crest, which might lead to improper placement and positioning of the implants.

Allogenic bone graft in the form of corticocancellous block have shown promising results as an alternative for autogenous monocortical block grafts, as this procedure could be performed with less morbidity such as elimination of the need for the patient donor site and reduced surgical time. There have been more reports on the use of corticocancellous blocks, which retains the cortical plate, thereby resisting early resorption. Block grafts being corticocancellous in nature have the ability to maintain the three-dimensional (3D) space needed for bone regeneration [32-36].

Block graft used in this study has proved to be effective by providing adequate space and showed successful bone regeneration. Effective bone regeneration requires simultaneous revascularization and replacement of graft material from host bone without marked loss.

The new bone-substitution quality and pattern are evaluated by graft-material interaction and host bone in the event of healing. Allogeneic bone placement warrants extended time as compared with autologous bone and has no effects on graft incorporation at initial stages and completely depends on the host site to elicit adequate substrate for healing [37,38]. In addition, allogeneic bone functions as a mineral matrix or scaffold for cell migration and proliferation [39]. Moreover, during osteoconduction, the host osteoprogenitor cells and vascular elements use the graft as a matrix for the formation of new bone in the defect. Within the graft, the host cells undergo differentiation and maturation to form a functional skeletal network and thus replace the graft through a "creeping substitution" process [40,41].

As used in this study, the corticocancellous block provides predictable results. The cancellous component allows for vascular infiltration leading to integration, and the cortical component allows for rigid fixation and resistance to resorption: autogenous and allogenic block grafts result similar for manipulation and surgical technique; however, unlike the autogenous block technique, the clinician has the possibility

to use the patient's jaw's stereolithographic model as a template to shape the graft without any visual impediment, concerns about hemostasis, and any pressure to work in a compatible time frame. This can help to enhance the accuracy and the fit of the preparation. It is important to underscore that the allogenic bone blocks need rehydration in saline solution for 45 minutes before insertion. In addition, eliminating the need to prepare the block allograft during the surgical procedures can shorten the time of the entire surgery, which helps to justify the additional costs required for this technique.

Early vascularization of the graft is a major factor in the integration of the graft and the maintenance of its stability [42]. Enneking and Mindell showed that the extent of new bone formation between the graft and the host junction is correlated with revascularization and healing time [43].

Furthermore, the use of screws for the rigid fixation of the graft to the recipient site using titanium mini screws has been found to be essential in the prevention of fibrous ingrowth between the allograft and the host.

The allogenic bone block techniques used in this study yielded predicted effects, including an increase in ridge width which of approximately 2.3±0.2mm. This is agreed with The values reported by a previous study [44] after grafting with an FDBA corticocancellous allogenic bone block material: after 6 months, they observed about 2.3mm width gain measured at the point 2-mm apical to the crest. Furthermore, this findings agree with Acocella et al [45] observed about a 2-4 mm increase in the ridge width following the use of mineralized corticocancellous allograft blocks (without barrier membranes).

In another study [46] showed a 2.6 mm increase in the alveolar ridge width after using autograft blocks. These suggest that the success of the allogenic bone block used in the current study to improve the ridge conditions was comparable to (or better than) that of autografts and other allografts. However, it should be highlighted that, the extent of surface resorption was greater in this study (2.8mm within 6 months) compared with what was seen by von Arx and Buser[47] on autografts (0.36 mm within 6 months). Neither of the two studies on corticocancellous allografts evaluated surface resorption after healing of the graft. This issue might be a potential limitation of allograft blocks and should be assessed in longer follow-ups.

Ridge splitting was made by numerous techniques. Most recent technique is piezo-electric ridge splitting with a complete set of piezo-inserts used alone. After ridge splitting, allogenic bone chips was grafted into the gap between buccal and lingual bone plates.

Ridge splitting and expansion of the mandible were rarely discussed in the medical literature[48]. The lateral ridge expansion technique is more suitable to be carried out on the maxilla rather than on the mandible, chiefly, due to the thinner maxillary cortical plates and soft medullary bone[49]. Also, the rare usage of ridge splitting technique in the lower jaw compared to the upper, mainly due to the rigidity of the mandibular cortical bone [50].

The width of the ridge in this study was 3-5 mm. that concur with Scipioni A. et al. [51] who discussed that when the bucco-lingual bone width is 3 mm or greater but <6 mm, to allow implant placement, augmentation of the alveolar ridge using a ridge splitting and bone expansion technique is a viable option. The 3 mm of bone should have at least 1 mm of trabecular bone sandwiched between the cortical plates. That will ensure 1.5 mm of bone (cortical and cancellous) on either side of the split ridge and allow the bone to spread and maintain a good blood supply. Several ridge split techniques have been developed in past few decades and includes split crest osteotomy[51] and ridge expansion osteotomy[52]. Moreover, fundamental and specific requirement for the alveolar ridge split technique was considered; the presence of cancellous bone between the two cortices which ensures a good

blood supply with adequate bone height for implant placement because the splitting of the crest will not increase bone volume vertically [53].

A staged approach in this study was aggrement with a study performed in 2006 [54] reported that the staged ridge splitting technique. Implants were placed in Stage 2, but their placement was postponed by 3-6 months, to allow for mature bone formation and ensured primary stability of the implants.

A staged approach allowed the formation of the immature bone callus at the splitting site, which was flexible enough to perform the ridge split procedure. In Stage 1, the lingual periosteum and, in Stage 2, the buccal periosteum were preserved to ensure adequate blood perfusion to the bone. Because this procedure was divided into two steps, the location of greenstick fracture was predictable and predetermined. A substantial increase in width was obtained on both right and left sides with this technique.

Thus, the staged ridge splitting approach is a safe and predictable approach as compared to single-stage ridge split, especially when combined with the use of piezosurgery. This technique is not technique sensitive and presents minimal risk of damage to adjacent hard and soft tissues. Additionaly this technique can be successfully used for augmentation of compromised mandibular alveolar ridges.

In this study, ridge splitting and expansion was completely performed by piezoelectric inserts. These procedures were agreed with the previous study [55] demonstrated that 98% bone regeneration in the intercortical gap (implant sites) and 100% implant survival rate (delayed implant placement) after more than 2 years of follow-up, confirming the validity of these techniques.

In a study [56] compared the use of an immediate versus delayed lateral ridge expansion technique that was used on 32 patients (84 implants were placed) with a narrow edentulous posterior mandibular ridge and concluded that the delayed approach (performed on 9 patients) was safer and more predictable in patients with denser bone and a thick cortex (typical for mandibular ridges). One of the complications of an immediate approach (performed on 23 patients) was an intraoperative malfracture of the thin buccal cortical plate (occurred in 5 patients or 22%).

In this work, ridge splitting and expansion has 4.01±0.40 mm. These procedures agreed with the original studies by Simion et al [57] and Scipioni et al,[58] in 1992 and 1994, respectively, which showed an alveolar width gain about 4 mm after the split-crest procedure.

The status of surrounding soft and hard tissues is indicative of the safety and effectiveness of split-crest technique with ultrasonic bone surgery for narrow ridge augmentation as reported with Anitua et al (2013)[59]. So, in the present study, modified plaque index, modified bleeding index and probing depth were used to clinically evaluate the implant that was placed.

The modified plaque index (mPI) was used in this study to monitor oral hygiene in a quantitative method. In the previous study[60], they found a significant relationship between oral hygiene and bone resorption observed over a 6-year period. In the current study, there were no statistically significant differences between the groups at any time during the observation period, and the mean modified plaque index (mPI) in the two groups showed minimal plaque accumulation around the implants and good oral hygiene practices by the patients.

According to a previous study[61] stated that bleeding on probing has high specificity but low sensitivity meaning that its absence indicates disease stability. In the current study, the mean modified bleeding index (mBI) did not reach 0.9 at end of the observation period in any of the groups indicating that minimal inflammation and tissue stability around the implants. Additionally, there were no statistically significant differences between the groups throughout the time intervals.

In the current investigation, the average probing depth was not exceed 2.33 mm at all observation periods in all groups. This studyis consistant with a previous study [62], which concluded that successful implants generally allow probe penetration of approximately 3 mm after implant loading measured from the crown margin to the base of the sulcus.

Peri-implant probing depth (PPD) is heavily dependent upon the conditions of the peri-implant tissue. At healthy sites the probe tip stopped at around the level of the most coronal aspect of the connective tissue adhesion to the implant neck to be around 3mm. At inflamed sites the probe consistently reached close to or was in contact with the bone level [63].

During assessment of peri-implant pocket depth (PPD) showed good values at all points of exploration. This study declared that, there were a significant difference of peri-implant pocket depth between the two groups with the mean (PPD) were 1.15±0.18 and 2.33±0.42 mm at 6 months and 9 months respectively in group I and 1.5±0.44 and 1.77±0.44 mm at 6 months and 9 months respectively in group II .In addition, Koldsland et al.[64] used two PDs, ≥ 4 mm and ≥ 6 mm, accordingly, to distinguish different levels of peri-implantitis severity. Peri-implant probing is essential for establishing a diagnosis of periimplant disease [65].

Marginal bone loss (MBL) around dental implants is a serious problem [66,67], and extensive bone loss has long been regarded as one key factor contributing to implant failure [68,69].

Both biological and biomechanical factors may be related to MBL during bone healing. Host-related factors include plaque control, smoking and wound-healing capacity [70,71]. Implant design characteristics related to MBL may involve platform switching[72], the implant surface[73] and neck microthreads[74]. Furthermore, other contributing factors, such as surgical trauma and different restorative protocols, may also play a role in this process [75].

In evaluating the marginal bone level (MBL), this study found that, the mean (MBL) were 1.08±0.13 in group I and 0.83±0.15 in group II through the whole MBL assessment periods (3 to 9 months). These findings are consistent with the previous study[76], which discussed that the most widely accepted success criteria establish 2 mm as the maximum acceptable MBL after 1 year of loading for considering an implant to be a success. Other authors have claimed that an MBL loss in the first year of 1.5mm[77], 1.8mm[66], or 1.5–2 mm[78] represents a good outcome.

There was a statistically significant increase in marginal bone loss in block grafting group when compared with ridge splitting group. The bone loss occurred may be a result of natural bone remodeling around the implant as a sequel for placement of final prosthesis that may be associated with increased load and in turn increased transferred stress on bone implant interface [79,80]. Similarly, it may be attributed to subcrestal placement of implant by 1mm [81].

Bone density is a concept that evaluates bone quality [82]. The mechanical competence of bone, which is referred to as bone quality in implant dentistry, comprises bone mass, structural properties, and material properties [83,84]. Consequently, greater failure of implants is likely associated with poor bone mineralization or limited bone resistance on tactile assessment while drilling [85,86].

This study showed a moderate significant difference in the measurement of bone density around the implant at base line, 6 and 12 months between the two groups.

This clinical trial reported that optical bone density during all observation periods in all groups; which highly increased in group II caused by splitting with allogenic bone chips in gape than in group I which due to bone block grafting.

High values of initial bone density in current study corresponding to a clinical densitometric study[87] showed that higher bone density around

implants inserted following piezo-surgical osteotomy than observed around implants inserted following other protocols current study.

The bone density in the bone surrounding implants was assessed in this study using image J analysis software which was in line with a study that considered the relative bone densitiy measurements is a method to evaluate healing processes of the jaws by measuring the mean grey values of certain areas on different digital radiographic images during the postoperative progress [88]. The relative bone density is determined by measuring the mean grey value of the bone defect and the healthy surrounding bone which is not overlapped by other anatomic structures [88].

Osstell™ was used in the present study to measure implant stability at day of placement and after 6 months to evaluate the degree of osseointegration and success.This compatible with Turkyilmaz & McGlumphy (2008) [89] histomorphometric study showed that resonance frequency analysis (RFA) values correlated well with the amount of bone-to-implant contact. The implant is excited with an oscillating transducer screwed onto the implant and the resonance specific to the resonance system 'implant/bone' is captured electronically over a range of 5 to 15 kHz. Resonance frequency analysis (RFA) values have clinically been correlated with changes in implant stability during osseous healing, failure of implants, and to integrate supracrestal dimensions of the implant. These findings support the use of RFA in evaluating changes in the bone healing and osseointegration process following implant placement.

In this study, the average initial implant stability quotient (ISQ) values at surgery for both groups were 65.5 and 68.40 respectively. The implant stability quotient (ISQ) values at the time of surgery can be viewed as a high number with values than after 6 months 68.40 and 72.50. This is expected since the implants placed later after the ridge augmentation procedures may have high primary stability due to bone gain. These results were comparable with a study[90] assessed the implant stability in expanded ridges, reported that bony micro-architecture had no consequence on implant stability, initial bone density, presence of a cortical layer. They also reported that the application of the spreaders significantly increased implant stability quotient (ISQ) values over the study period. In contrast, another studies [91 ,92] demonstrated that primary stability mean value was 59.60 ISQ and secondary stability was 61.50 ISQ which were smaller to the results of the present study; but their results were only obtained after 3 months.

In present trial, high implant stability quotient (ISQ) observed at time of surgery might be occurred due to bone gain and long implant used; contrary to this explanation Ostman et al (2005) [93] they found that decreasing stability with increasing implant length. This may be explained that some long implant designs have a reduced diameter in the coronal aspect to reduce friction heat and facilitate easy insertion.

At 6 months, this observation showed less implant stability quotient (ISQ) in group I and more in group II. These results might be explained by a correlation between bone quality and primary stability as easy bone allogenic block graft resorbed in group I rapidly than in group II and more amount of bone formed in group II. This agreement with a previous study [94] they concluded that implants in soft bone with low primary stability showed a marked increase in stability compared to implants in dense bone. They indicated that the stiffness of the implant - bone interface is high in dense bone and low in soft bone.

There was gradual increase in bone density during all observation periods of the study in all groups. This study showed a significant change in the measurement of bone density around the implant throughout the period of evaluation in all groups which indicating successful integration; this is in agreement with a study [95] observed successfully osseointegrated implants which increased bone

density. Higher bone density around implants inserted following piezosurgical osteotomy than observed around implants inserted following bone block grafting has been reported [96] and mean (BD) was significantly correlated with stability values [97].

In the present study, there was direct correlation between bone density and implant stability, this in agreement with a study reported a strong correlation between bone density based on CBCT images and the resonance frequency of the dental implant [98], as well as with another study [99] demonstrated that a higher implant stability measured in ISQ values. Hounsfield units can be used as a diagnostic parameter to predict possible implant stability. Moreover, a statistically significant difference between groups during different intervals. This can be explained by the main bone density which referred to the presence of both buccal and lingual plates of bone in group II with splitting than in group I with buccal block grafting.

The histomorphometric analysis in this work showed that the 20 biopsy specimens consisted of bone (allograft material plus new bone) and soft tissue. However, the formation of connective tissue was predominant, as shown by histomorphometrical analysis. This study highlighted that the allogeneic bone rather serves as a scaffold and space holder for the ingrowth of bone by osteoconduction, instead of undergoing a full remodeling. In this context, it must be mentioned that in general healing period needs to be prolonged in case of horizontal augmentation of larger volumes to allow sufficient vessel ingrowth within the augmentation ridge [100,101].

The average proporations percentages of new freshly formed bone, residual graft material, and fibrous or bone marrow tissue in the regions of interest were 33%, 37.5% and 29.5%, respectively. Our results in agreement with a study [103] applied corticocancellous bone block allograft technique were the mean percentages of the newly formed bone and residual graft material were 30.6% and 28.9%, respectively. In the present study, about 70.5% bone was observed in specimens biopsied from the implant socket. Although the rate of the newly formed bone was within the range reported by study available on corticocancellous allograft by Amooian et al [44] evaluated corticocancellous blocks like those used in our study and reported about 33% was newly formed vital bone and about 37.5% was nonvital fragments of the graft, which obtained biopsy cores from the buccal plate and filled the new socket with allograft materials.

Finally, this study was limited by some factors. It was better to acquire a control group of autografts in order to better evaluate the outcome of allografts. Moreover, the sample size might be argued as small. Nevertheless, it was estimated based on power calculations, and the significant results verified the validity of the sample size. Another limitation was the lack of standardization of radiographs, reducing the reliability of the assessment of radiolucency when determining the implant success. Patients' radiographs might differ from case to case, depending on overall clinical needs of each patient. For ethical concerns, we could not take radiographs solely for research purposes. Also, it would be better to determine how much of each new bone was formed over the host bone surface or within the graft.

CONCLUSIONS

Within the limitations of this study can conclude that,

1. Both techniques exhibited successful treatment outcomes in narrow alveolar ridge.
2. Ridge splitting technique seems to be a very effective modality for implant placement in narrow alveolar ridge, that this technique is a safe and predictable in thin ridge cases.
3. The use of corticocancellous block allografts had given promising results, thus allowing the placement of implants of standard length and diameter, thereby improving the long-term prognosis of the implant-supported reconstruction.

RECOMMENDATION

1. More studies restricted to use of piezo-electric surgery alone for ridge splitting will be needed for long observation period.
2. More researches should be conducted to evaluate efficacy of allogenic bone block for ridge augmentation.
3. This study may need more advanced software to measure both bone density and MBL without depending on manual tracing of target areas.
4. Future studies will focus on expanding the sample size as well as the timeline of the study to allow investigation of long-term prognosis of these technique

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فعالية زيادة النتوءات مع أو بدون الانقسام بالموجات فوق الصوتية في تحضير النتوءات السنخية الضيقة قبل الزرع الدراسة السريرية والشعاعية والنسيجية)

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الملخص :

الهدف: أجريت هذه الدراسة للمقارنة سريريًا وشعاعيًا ونسيجيًا بين زيادة الحيد السنخي الضيق باستخدام كتلة العظام الخيفية مقابل تقنية تقسيم الحيد بالموجات فوق الصوتية مع رقائق العظام.

المواد والاساليب: تم تقسيم عشرين مريضاً عشوائياً إلى مجموعتين متساويتين، باستخدام رمي العملة على النحو التالي: المجموعة 1: 10 مرضى يعانون من ضيق الحافة السنخية الفكية السفلية تلقوا إحصارًا عظميًا خيفيًا ثم تم إجراء زراعة لهم بعد 6 أشهر. المجموعة 2: 10 مرضى يعانون من ضيق الحافة السنخية للفك السفلي تلقوا تقنية تقسيم بيزو ورقائق عظمية خيفية ثم تم وضع زراعة لهم لمدة 6 أشهر. تم جمع المعلمات السريرية والشعاعية عند خط الأساس وبعد 6 أشهر من زيادة التلال.

النتائج: كانت هناك فروق ذات دلالة إحصائية بين المجموعة الأولى والمجموعة الثانية عند 6.9 أشهر فيما يتعلق بعرض الحافة السنخية، وعمق الفحص المحيط بالزرعة (PPD)، وحاصل ثبات الغرسة (ISQ)، والتغيرات في فقدان العظام الهامشية (MBL) وكثافة العظام. القياسات (BD) والعكس بالعكس. لا توجد فروق ذات دلالة إحصائية عند 6، 9 أشهر في مؤشر البلاك المعدل (MPI) ومؤشر نزيف التلم المعدل (MSBI)

الاستنتاج: في حدود هذه الدراسة يمكن استنتاج أن كلا التقنيتين أظهرتا نتائج علاجية ناجحة في الحيد السنخي الضيق، ويبدو أن تقنية تقسيم الحيز هي طريقة فعالة للغاية لوضع الزرع في الحيد السنخي الضيق، وأن هذه التقنية آمنة ويمكن التنبؤ بها في حالات التلال الرفيعة. أخيرًا أعطى استخدام الطعوم القشرية السرطانية نتائج واعدة، مما سمح بوضع غرسات ذات طول وقطر قياسيين، وبالتالي تحسين التشخيص على المدى الطويل لإعادة البناء المدعومة بالزرع.

الكلمات المفتاحية: الحافة السنخية الضيقة، زيادة كتلة العظام، تقسيم الحافة، كتلة العظام الخيفي، الكسب غير المشروع للعظام.