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EVALUATION OF BONE WIDTH RECOVERY AFTER USING MODIFIED RIDGE SPLITTING TECHNIQUE WITH AND WITHOUT BETA-TRICALCIUM PHOSPHATE MATERIAL (A RANDOMIZED CLINICAL TRIAL)

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ABSTRACT

Objectives: This study assessed the use of beta-tricalcium phosphate as particulate bone graft material in alveolar ridge splitting in a horizontally deficient posterior mandible.

Materials and Methods: 5 patients (ten surgical sites) were recruited for this study. They were all bilaterally treated with modified ridge splitting technique once with and once without using beta- tricalcium Phosphate material (B-TCP). Then a delayed implant placement was done after 6 months. Bone gain was assessed radiogarphically using cone beam CT and histologically before and after addition of bone graft. Repeated measures ANOVA test was used to compare between mean buccolingual bone widths pre and post-operatively. The significance level was set at $P \leq 0.05$.

Results: A statistically significant increase in mean bucco-lingual bone width postoperatively at the crestal, middle and apical bone levels in the side which we used (BTCP) as bone grafting material. BTCP group recorded higher values of M= 3.65, 3.41 and 2.65 with statistical significance at level 2mm, 5mm and 10mm respectively than the non-grafting group that recorded 1.84, 0.86 and 0.64 for the same levels tested.

Conclusion: Modified ridge splitting technique with using beta- tricalcium Phosphate material (B-TCP) for horizontal augmentation of the posterior mandibular atrophic ridges provides predictable and reliable results in bone recovery.

KEYWORDS: Beta tricalcium phosphate, bone grafting materials, dental implants.

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INTRODUCTION

Edentulism is an irreversible, debilitating condition that has a series of negative consequences for the individual's oral and general health, beginning with the well-known consequence of residual ridge resorption and progressing to impaired masticatory functions, which results in nutritional deficiency, jeopardizing the individual's overall health. Along with functional damage, aesthetic and linguistic difficulties arise, having a significant social impact on the patient [(1)]. Significant alterations in the alveolar bone occur as a result of the osteoclastic action during bone remodeling, jeopardizing the long-term prognosis of the intended treatment approach and encouraging physicians to choose for reconstruction procedures [(2)].

Inadequate bone height or bucco-lingual breadth is one of the most serious and frequent defects in the posterior jaw. A continuous effort is being made to develop and enhance techniques that will help in the effective insertion of implants in accordance with established standards. In the event of horizontal deficiency, a variety of methods are available, including GBR, onlay graft, and ridge splitting [(3)]. Modified ridge splitting is a relatively novel procedure for treating the posterior mandible [(4)]. In 1979, Schnitman and Shulman developed a set of success criteria for implants, emphasizing the vital importance of enough bone; no more than 0.2mm of bone loss each year [(5)]. This exponential increase in dental implant utilization is primarily due to the development of bone augmentation methods, the advancement of osseointegration, and the innovation of biomaterials used in dental implants [(6)].

By first conducting an augmentation operation and then implanting the graft once it has healed and developed (staged technique). Different types of bone grafting materials are available depending on the recipient location and the source of the bone transplant. There are several types of grafts available, including autogenous grafts, allografts, xenografts, and synthetic materials called alloplasts. Whatever sort of bone augmentation is necessary; the bone graft or bone replacement material employed should be capable of integrating with the host bone and/or the implant itself. Numerous graft varieties each have a unique mode of action, and the properties of the materials used can have an effect on the outcome of bone regeneration [(7)].

Numerous ridge augmentation procedures have been devised to prepare an unsuitable region for implant implantation. Horizontal and vertical bone loss can be treated with GBR and bone transplants. Other techniques that were more specific to the type of discrepancy were proposed; for example, the use of growth factors and tissue engineering, short implants, lateralization of the lower alveolar nerve, and osteogenic distraction were proposed for vertical loss, whereas alveolar crest expansion was proposed for horizontal loss [(8)].

Alloplasts can be resorbable, which results in increased microporosity, or non-resorbable, which is rarely utilized. Resorbable alloplasts are made of hydroxyapatite (HA), tricalcium phosphate (TCP), polymers, and/or bioactive glasses. They are chemically identical to human bone, which inhibits the host immune response and decreases inflammation. Tricalcium phosphate has long been used in lieu of bone. It is available in two crystallographic configurations: -TCP and -TCP, with the latter being the more common. It has been described as having a high degree of biocompatibility and osteoconductivity, in addition to being quite affordable. It is commonly used as a partly resorbable filler to facilitate bone regeneration [(9)].

Thus, the aim of the study is to assess the use of beta-tricalcium phosphate only as particulate bone graft material in modified alveolar ridge splitting technique in posterior mandible versus modified alveolar ridge splitting technique without grafting material of horizontally deficient posterior mandible.

MATERIALS AND METHODS

This in-vivo investigation was conducted with approval of the Research Ethical Committee in the Faculty of Dentistry - Cairo University.

1. Specimen grouping:

Five patients (ten surgical sites) were randomly selected, then divided into 2 groups: 1. Beta-tri calcium phosphate as a grafting material, 2. No grafting material.

2. Patient preparation and pre-surgical preparation

Inclusion criteria

- Patients indicated for horizontal augmentation procedures due to lack of Bucco-lingual bone width in the posterior mandible.
- Insufficient Bucco-lingual width (less than 5mm) and with minimum residual bone height of 8 mm
- No soft and hard tissue pathology.
- No systemic condition that contraindicates splitting procedures and future implant placement
- Both sexes.

Exclusion criteria

- Heavy smokers more than 20 cigarettes per day.
- Patients with systemic disease that may affect normal healing.
- Uncontrolled diabetic patients.
- Pregnant patients.
- Disorders to implant are related to history of radiation therapy to the head and neck neoplasia, or bone augmentation to implant site.

Each patient got a preoperative evaluation that included a medical and dental history, a clinical examination, and a radiographic examination. A comprehensive medical and dental history was gathered from the patient during a talk. Additionally, each patient signed an informed consent form.

General mucosal and periodontal health, as well as accessible inter-arch space, was determined when instances with prosthetic choices **(FP1-FP2-FP3)** were considered [10]. Palpation of the ridges was performed to rule out any aberrant contours that would limit implant implantation availability. All patients underwent a panoramic x-ray as a primary assessment to determine weak regions to rule out any pathological lesions or residual roots. A CBCT **(Planmeca ProMax® 3D Max, Helsinki, Finland)** was prescribed only for qualified patients. Preoperative, immediately after surgery and six months post-operative CBCT scans were performed with the mouth closed in a centric occlusion.

Surgical procedures

For eligible patients, CBCT scans of the mandible were performed to determine the precise remaining alveolar bone height and breadth. The CBCT field of view was limited to the area of interest using low dose CBCT. The same surgeon did all of the operations. All surgical operations were conducted in stringent aseptic circumstances, and all patients received local anaesthetic through infiltration (Articaine 4% 1:100 000 epinephrine).

Fig. (1): clinical preoperative view Right and Left.

To get access to the alveolar ridge and buccal plate of bone, a crestal incision was created and a complete mucoperiosteum flap lifted. A crestal osteotomy was performed utilizing piezoelectric points, followed by two vertical osteotomies and a single inferior incomplete osteotomy. To enlarge the crestal incision, ridge expansion chisels were employed successively. Beta-tricalcium phosphate substance was condensed in the gap. The control group received no grafting material.

Micro screws (BMK) were used to secure and maintain the two groups. To achieve stress-free primary closure, a periosteal releasing incision was made. Suturing the flap was the final procedure, during which we employed 4/0 propylene sutures, beginning with horizontal mattress suture and then reinforcing the seal with simple interrupted suture to ensure close contact between both flaps. After six months, a second procedure was performed to monitor main results, collect histopathological samples, and put the chosen implants.

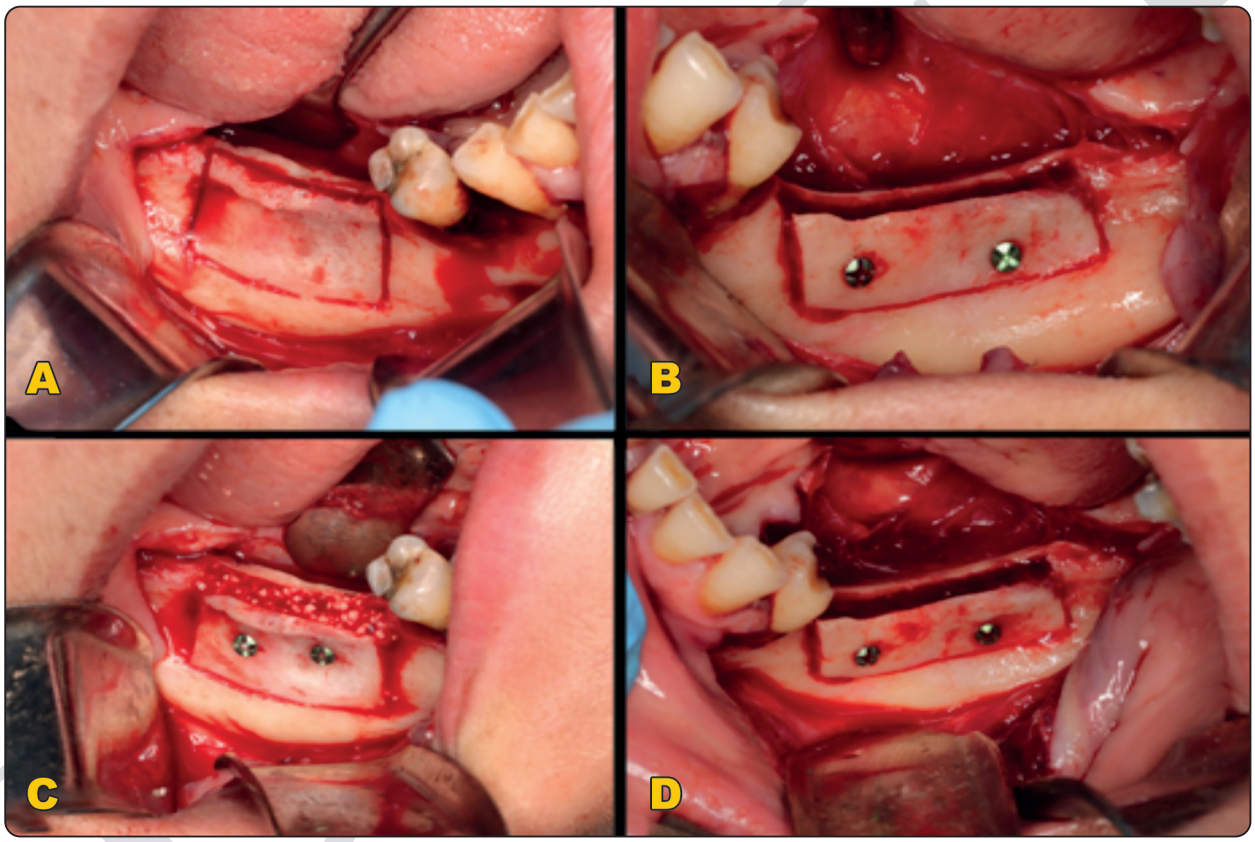

Fig. (2): (A) Four osteotomeis are done using piezo tips 4 osteotomies was done 1 crestally, 2 vertically and 1 incomplete cut inferiorly in both Right & Left sides. (B) Horizontal gap gain, and micro titanium screws for fixation and gap maintaining for both plates (C) Gap creation is filled with (BTCP) as a grafting material in the right side. (D) Left side was left without (BTCP) as grafting material

Second stage surgery after 6 months: To determine bone gain, to remove fixating screws, to take core biopsies, and to insert implants. After six months, a second CBCT was performed before to the second operation, during which the new measurements were read and utilized to plan implant placement. A conservative incision was made without doing an anterior oblique incision (just a crestal incision). Then, using a screw driver designed specifically for this type, screws were gradually removed from the bone. After drilling the implants osteotomies, a core bone sample was collected in the region between the two implants osteotomies using a 3 mm diameter trephine bur. The biopsy was stored in 15% formalin.

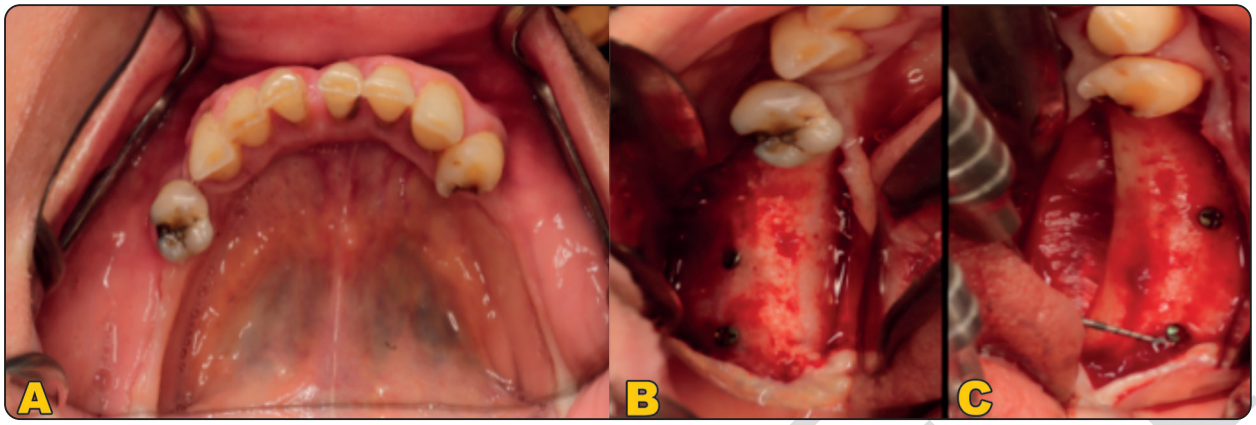

Fig. (3): (A) Clinical view after 6 months of the first surgery. (B) Micro -screws exposed for right and (C) left sides

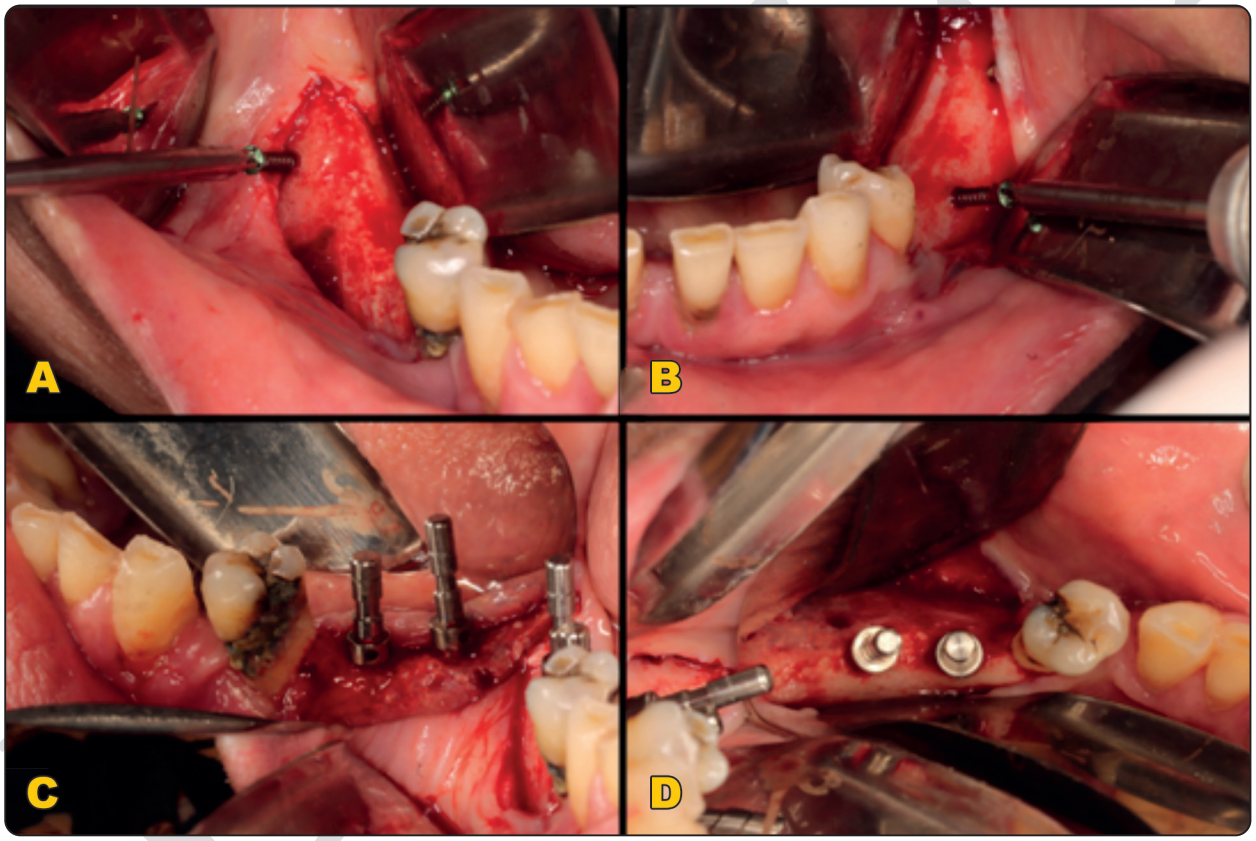

Fig. (4): Removing micro –screws from right (A) and left (B) sides. (C) Checking parallelism and implant insertion for left side and (D) right side.

3. Radiographic assessment of bone gain

A panoramic curve was constructed on the axial image of the preoperative CBCT, running across the alveolar ridge's centre and the tooth centres. A tangential line was formed from the reconstructed panoramic picture linking the two apices to the teeth next to the edentulous region, and then five cross-sections were selected at preset distances distal to the most mesial tooth to determine the alveolar ridge width.

The width of the alveolar ridge was measured at 2, 5, and 10 mm from the crest for each cross-section. The average of all the measurements was then determined to reflect the pre-operative average width of the alveolar ridge. The same measures were taken for the six-month follow-up CBCT.

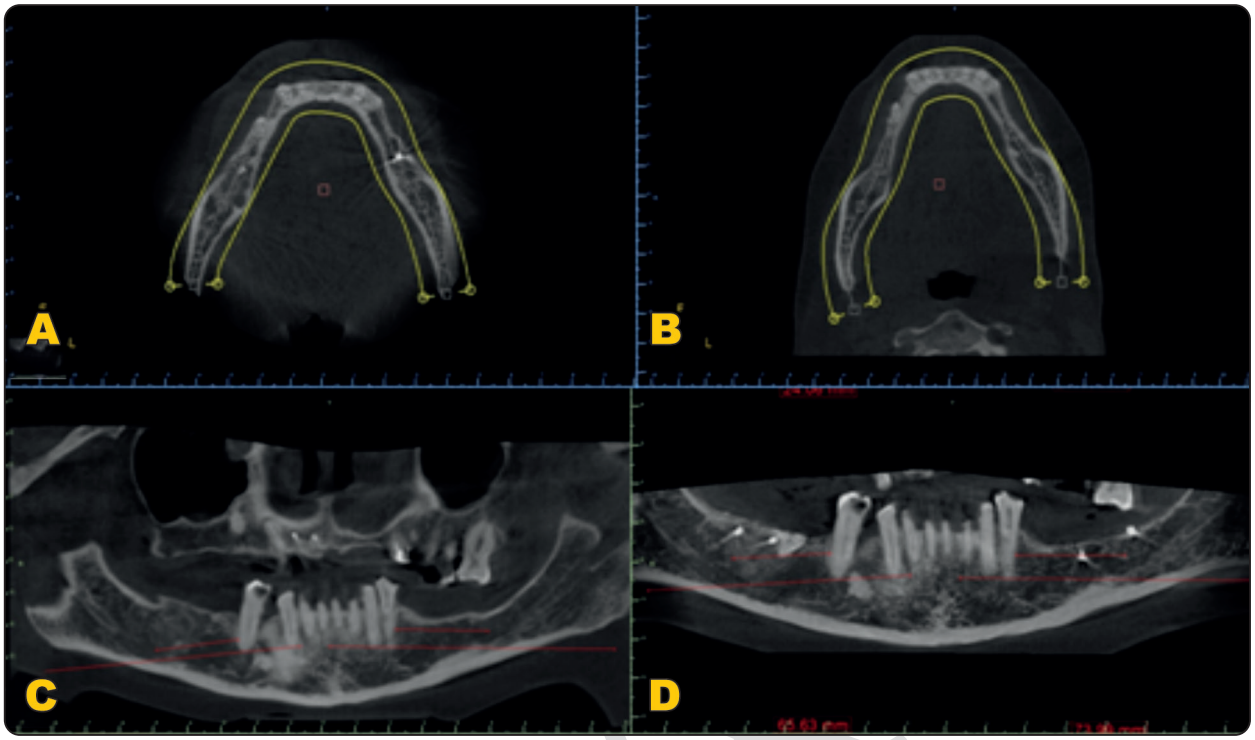

Fig. (5): (A, B) CBCT axial cross-section (C,D) Reformatted panoramic view

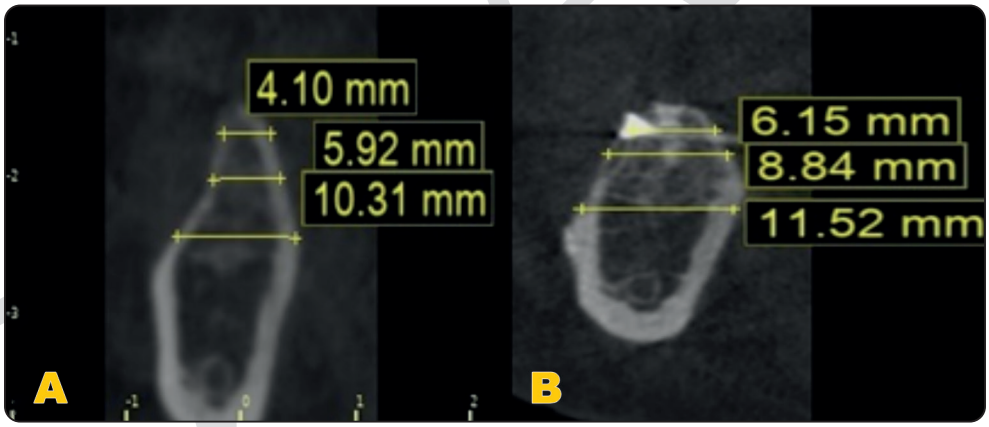

Fig. (6): CBCT cross-section (A) pre-operative (B) post-operative (after 6 months)

Statistical Analysis

Numerical data were explored for normality by checking the distribution of data and using tests of normality (Kolmogorov-Smirnov and Shapiro-Wilk tests). Data showed normal (parametric) distribution. Data were presented as mean, standard deviation (SD) and 95% Confidence Interval for the mean (95% CI) values. Repeated measures ANOVA test was used to compare between mean Buccolingual bone widths pre and post-operatively. The significance level was set at $P \leq 0.05$. Statistical analysis was performed with IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp.

RESULTS

Statistical Results for Radiographic Examination

Statistical analysis of the horizontal bone gain in the study groups were calculated and reported. By comparing the 2 study groups at level of 2mm,

the bone gain was recorded with higher values in group1 (BTCP) of M=3.65 (SD=0.18) than in group 2 (non-grafting) M=1.84 (SD=0.0.38) as shown in figure (6). Also the horizontal bone gain at level of 5mm was recorded with higher values in group 1 of M=3.4100 (SD=0.17) than in group 2 of M=0.86 (SD=0.20). Finally the horizontal bone gain was checked at level of 10mm and the reported values was detected to be higher in group 1 of M=2.65 (SD=0.37) than in group 2 M=0.64(SD=0.21) as shown in table (1).

To test the hypothesis that group 1 and group 2 were associated with statistically significant difference of their mean values, an independent t-test was performed as seen in table (2). Additionally, the assumption of homogeneity of variance was tested via Levene's test and reported at level of 2mm with F=7.97, P=0.011indicating the variances are assumed to be not equal. But the levene's test reported values at level of 5mm with F=1.02, P=0.32 and at level of 10mm with F=2.6and P=0.12, indicating that the variances are assumed to be equal. Independent t- test revealed a statistical significant difference at level of 2mm, 5mm and 10mm with recorded Pvalue= 0.000 between group 1(BTCP) and group 2 (non-grafting).

TABLE (1): Comparing the mean area percent of compact bone formation in the study groups (Independent t- test).

Group Statistics					
	Study group	**N**	**Mean**	**Std. Deviation**	**Std. Error Mean**
Bone gain at 2mm	1	10	3.6580	0.18189	.05752
	2	10	1.8410	0.37852	.11970
Bone gain at 5mm	1	10	3.4100	0.16633	.05260
	2	10	0.8580	0.20514	.06487
Bone gain at 10mm	1	10	2.6520	0.36823	.11645
	2	10	0.6360	0.21120	.06679

Level of Statistical Significant at p<0.05

TABLE (2): Comparing the results of t-test between the study groups

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Bone gain at 2mm	Equal variances assumed	7.974	.011	13.682	18	.000	1.81700	.13280	1.53800	2.09600
	Equal variances not assumed			13.682	12.946	.000	1.81700	.13280	1.52998	2.10402
Bone gain at 5mm	Equal variances assumed	1.024	.325	30.557	18	.000	2.55200	.08352	2.37654	2.72746
	Equal variances not assumed			30.557	17.262	.000	2.55200	.08352	2.37600	2.72800
Bone gain at 10 mm	Equal variances assumed	2.623	.123	15.018	18	.000	2.01600	.13424	1.73398	2.29802
	Equal variances not assumed			15.018	14.343	.000	2.01600	.13424	1.72873	2.30327

DISCUSSION

The alveolar ridge split is a method of bone expansion used to treat atrophic ridges with horizontal defects. The option of introducing an interpositional graft, reducing the risk of uncontrolled vestibular cortex fractures, and assessing bone augmentation, enhanced stability, and implant osseointegration are all advantages of the phased alveolar ridge split technique [11]. Four guiding osteotomies performed using piezoelectric devices were employed in this work to produce an incomplete fracture of the labial segment, retaining it partly linked to the apical section and so minimizing vitality or vascularity loss [12].

This approach is preferable to the onlay blocks technique because it reduces postoperative discomfort and edema, lowers the cost, shortens the treatment duration, and has a higher compliance rate with the patient [13]. Patients were randomly assigned to one of two groups based on their surgical sites: the first group got beta-tri calcium phosphate as a grafting material, whereas the second group received any grafting material. After six months, a second operation was conducted to evaluate the primary results histopathologically and to implant the chosen implants. To provide proper access to the alveolar ridge and buccal plate of bone, complete mucoperiosteum flaps were done [14]. To separate alveolar ridges, chisels and hammers, rotary burs, diamond discs, reciprocal saws, and piezoelectric devices have all been employed [15, 11]. Bone chisels are time-consuming to operate and need technical proficiency in addition to a significant learning curve [11].

While splitting the alveolar ridge with burs or spinning saws is quicker, soft tissues and sensitive anatomical structures may be injured, access to neighboring teeth may be difficult, and there is an increased risk of losing control of the cutting tools. On the other hand, the introduction of piezo surgery stretched the bounds of manual instrumentation, resulting in a more easy and reliable procedure. The primary benefits of the piezoelectric instrument are their capacity to perform precise and specific cuts in mineralized tissues and their ability to inflict less tissue damage, resulting in improved healing. As a result, it was chosen as the device; it assures both precision and safety. It is non-irritating to the skin and protects nerves, mucosa, and sensitive tissues [14, 11]. Prior to performing the alveolar ridge split method, the patient must be carefully selected. Oral hygiene is critical to the outcome of surgery and prosthesis rehabilitation. As a result, the research eliminated heavy smokers, as smoking has been shown to significantly increase the likelihood of implant failure [11].

There are two possibilities for implant placement in terms of timing: single stage surgery, in which implants are implanted on the same day, or two stage surgery (delayed), in which implants are placed after a few months of recovery. We chose two-stage surgery because it has a higher success rate and provides a better chance of achieving primary stability, resulting in more promising results. This is consistent with the findings of **Sohn et al.** [15].

Two screws were utilised in this investigation to achieve the requisite fixation, which is critical for successful grafting and to prevent rotational micro movements that might result in failure, which is consistent with **Khoury** [4] [16].

The section was not thinned in our investigation because it was not completely detached from its base. It maintained the graft's confinement and prevented unwanted epithelial cells from migrating to it.

The literature has several ways for bridging the splitting gap (autogenous particulates, mixture of autogenous with xenografts, autogenous block, PRP). Under the condition that the splitting gap is favorable for bone healing (lacks a single wall; similar to extraction sockets), those materials show promise. Beta-tricalcium phosphate was employed as a grafting material in this study solely during the healing phase (6 months), as xenografts are known

to resorb and rebuild more slowly than autogenous grafts.

When beta-tricalcium phosphate is used as a bone graft material, it has a number of advantages, including ease of handling, radiopacity, which allows for the monitoring of the healing process, stimulation of fibrovascular growth and osteogenic cell adhesion due to its high osteoconductivity due to macroporosity, adequate resorbability in comparison to other bone graft materials, and low immunogenicity and risk of disease transmission [(9)]. By utilizing Beta-tricalcium phosphate material, the process would be shortened and donor site morbidity would be avoided, making it less difficult and user-friendly for both the surgeon and the patient. Additionally, Beta-tricalcium phosphate material is less expensive than xenograft. In comparison to utilizing the alveolar ridge splitting approach alone, employing the alveolar ridge splitting method in conjunction with horizontal augmentation preserved more buccal bone height and width [(17)].

Horizontal bone gain was found to be extremely high at the 2mm, 5mm, and 10mm levels, with values of (3.65±0.18), (3.41±0.0.38) and (2.65±0.37) respectively. At the 2mm level, a statistically significant difference was seen between the comparing groups on comparing these outcomes to the outcome achieved by **Holtzclaw, Toscano and Rosen 2010**; onlay Block (4 ± 0.77 mm) and alveolar ridge splitting (4.03mm). In terms of outcome, we may consider our technique to be a prospective competitor to the others. However, it is preferable since it requires only one surgical site and does not require autogenous bone or membrane, making it a competitive and reliable procedure for horizontal bone augmentation [(12)].

This encouraging outcome is consistent with the findings of **Altiparmak et al. 2017, Atef et al. 2019, and Pénzes et al. 2020**, who discovered that this procedure produced superior results when compared to onlay grafts and autougenous bone blocks, respectively [(13, 18, 19)].

CONCLUSION

From the current study with all its limitations we can get the following conclusions:

1. Beta tricalcium phosphate was found to be a biocompatible and excellent type of grafting material with no side effect.
2. Horizontal bone gain was found to be enhanced accompanied using Beta tricalcium phosphate as a grafting material than when using no grafting material

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