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EVALUATION OF SPLIT CREST TECHNIQUE FOR NARROW EDENTULOUS ANTERIOR MAXILLA USING MAGNETIC MALLET (RADIOGRAPHICAL STUDY)

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ABSTRACT

BACKGROUND: The alveolar split crest technique is a frequently employed operation in the field of dentistry dealing with narrow ridge conditions to facilitate the placement of implants and proper prosthetic fabrication.

OBJECTIVES: To evaluate the split crest for narrow edentulous anterior maxilla with simultaneous grafted material in increasing the horizontal width of the alveolar ridge using magnetic mallet and to compare the bone density of the ridge before and after applying the surgical technique radiographically.

MATERIALS AND METHODS: Eight patients with narrow anterior maxillary ridge were selected to match a list of inclusion and exclusion criteria. The participants have undergone maxillary split crest technique using magnetic mallet with simultaneous grafted material insertion to fill the expanded gap. Assessment included measurements of horizontal bone width and bone density radiographically using CBCT. Follow up was done over 3 months.

RESULTS: The findings indicated a significant increase in the horizontal bone width immediately postoperative and three months postoperative compared with preoperative (p<0.001, p<0.001; respectively). Regarding bone density, there was a significant increase in the bone density immediately and three months postoperatively compared with preoperative (p<0.020, p<0.013; respectively).

CONCLUSION: Split crest technique using magnetic mallet was found to be an efficient procedure to increase the horizontal bone width and bone density.

KEYWORDS: Narrow maxillary anterior ridge, Split crest technique, Magnetic mallet, Horizontal ridge augmentation.

RUNNING TITLE: Split crest technique for narrow edentulous anterior maxilla using magnetic mallet.

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INTRODUCTION

Following tooth loss, significant changes in the dimensions of the alveolar ridge are identified. Researchers demonstrate that there is a notable occurrence of substantial resorption in the width of the alveolar ridge, potentially reaching up to 50% within the first year. This loss, equivalent to a range of 4-4.5 mm, primarily transpires during the initial three months' post-extraction. Notably, the resorption of the alveolar process is considerably more pronounced on the labial aspect of the jaws compared to the palatal aspect. Moreover, bone loss in the maxillary alveolar ridge is more prominent in terms of width than height. It is worth noting that a greater reduction in the alveolar process is associated with increased complications in implant placement and the creation of appropriate prostheses (1).

In order to rehabilitate the edentulous ridge in the anterior maxillary region, the labio-palatal width should be at least 6mm for proper implant placement to allow 1.5mm or more on the buccal site and a minimum of 0.5mm on the palatal site (2).

With the goal of dealing with the limitations associated with the augmentation approaches, *Simion* et al. (3) proposed an alternative method for narrow ridge augmentation known as the split crest technique.

The corticotomies can be performed with various devices for the cutting of bones, such as osteotome chisels, piezo-electric knives and magnetic mallet. The chisel approach exhibits a deficiency in

accuracy and poses challenges in terms of control. Rotating disks or oscillating disks are considered to be less burdensome for patients, although they do have notable drawbacks due to limited accessibility. These limits increase the risk of damage to the lips, tongue, and adjacent soft tissues. [4] Piezoelectric knives or cutters may be useful tools in this kind of circumstance. Engineered to provide a precise and non-traumatic impact However, the osteotome is still used for the subsequent spreading of the split segment of the alveolar ridge (5).

The Magnetic Mallet is a simplified bone corticotomy procedures. It has the advantage of precise cutting of the hard alveolar bone, and thus avoiding malfracture of the osteomized segment and bone loss. Moreover, better visualization of the surgical field, and less heat generation and postoperative complications. Another aspect of using the Magnetic Mallet is its ability to condense the bone, resulting in bone densification, which is useful for minimizing tissue trauma and increasing the density of bone. It can be used in various dental procedures, including tooth extraction, sinus lift, ridge splitting and preparation of implant sites by osseodensification (6).

There is limited data in the literature regarding the use of magnetic mallet in the split crest technique (SCT) with simultaneous xenograft placement [6]. The objective of this trial was to assess the influence of the split crest technique using the magnetic mallet to increase the alveolar bone width and bone density.

This study is a single-arm clinical trial. Eight Participants were selected from the out-patient clinic of the oral and maxillofacial surgery department, Faculty of dentistry, Alexandria University. Research had been approved by the ethics committee at Faculty of Dentistry, Alexandria University. Approval number: 0620 - 02/2023

Study Sample and sample size estimation

The sample size was calculated using Power Analysis and Sample Size Software GPower version 3.1.9.2 (7). Sample size was calculated based on a previous study aimed to present a novel approach to ridge expansion using only autogenous bone blocks (8). Pénzes et al. (2020) (8). The minimum required sample size for this single-arm clinical trial was found to be 6 patients (9-11). After adjustment for a dropout rate of 10%, the sample size was increased to 8 patients (12).

Criteria for patient selection

Inclusion Criteria

Patients age between (25-55) years.

Patients have more than two missing teeth in the anterior maxilla.

The labio-palatal ridge width in the edentulous site is 4mm or less.

The ridge height more than 6mm.

Participants with less than score 2 of plaque index (13).

Exclusion criteria

Patients who had undergone other previous reconstructive or implant procedures in the same area.

Systemic conditions that would prevent successful healing as uncontrolled Diabetes Mellitus, metabolic bone disorders.

Heavy smokers.

Alcohol or drug abuse.

Materials

Magnetic Mallet device (Osseotouch) (META ERGONOMICA-Via Monte Nero, 19-20029 TURBIGO (MI) - ITALY www.osseotouch.com)

Ridge splitting kit of the magnetic mallet consists of 10 tips marked with laser marking from (7-15) mm depth. (two splits straight and curved, two cuts straight and curved, and six expanders straight and curved).

Pilot split blade (SPLIT-F) with a length of 12 mm.

Cut blade as Initial Expander (CUT-F) with a diameter of 1.5 mm and a length of 15mm.

Expanders (EXP-1), (EXP-2) and (EXP-3) with a diameter of 2mm, 3.5 mm, and 4 mm sequentially and a length of 15 mm.

Grafted material (OneXenoGraft®Cortico-Cancallous Bovine Powder) (OneGraft® Cortico-Cancallous Bovine powder, Germany.https://www.onegraft.net/) with (0.2-1) mm particle size. (figure 1)

Methods

Pre-surgical assessment

History

a) Personal history:

Complete personal data was obtained, including name, age, gender, occupation, address and telephone number.

b) Past medical history:

To exclude any medical conditions that affect ridge splitting success.

c) Past dental history:

The participants were asked about the cause and time of extraction and if there were any previous reconstructive or implant procedures in the same area.

Chief complain: Patient seeking for replacement of missing maxillary anterior teeth.

Clinical examination

The extra-oral examination:

Included inspection and palpation for presence of any swelling or signs of infection.

The intra-oral examination:

Inspection: to detect any inflamed or hyperplastic mucosa at the edentulous area, any abnormality in the bone contour and the oral hygiene assessment. (figure 2)

Palpation: to assess the stability of covering mucosa and tenderness and the width and height of the ridge.

Radiographic examination

A preoperative panoramic x-ray (OPG) was done for the patients before the surgery for detection of remaining roots or intraosseous pathology at the site of operation.

A cone beam computed tomography (CBCT) was done for the selected patients before the surgery for evaluation of the ridge width, height and bone density.

Informed consent

Prior to commencing the operation, all patients were given extensive information regarding the advantages and hazards associated with the intervention, ensuring their exceptional well-being and security. Subsequently, they proceeded to affix their signatures to an informed consent document.

Surgical phase (14)

All precipitants were pre-medicated with 1gm of Augmentin (Amoxicillin 875mg + Clavulanic acid 125mg) (Augmentin – GlaxoSmithKline, by Medical Union Pharmaceuticals (MUP)) tablets 30 minutes before surgery.

Chlorhexidine (Hexitol: Chlorhexidine 125mg/100ml concentration 0.125%: Arabic drug company. ADC: https://www.tabletwise.net/egypt/hexitol-mouth-wash) 0.2% mouthwash was utilized for 60 seconds before the patient received the local anesthesia.

All the procedures were done on the dental chair under local anesthesia (4% articaine with 1:100,000 epinephrine) (Alexadricaine anesthetic solution, Egypt) using bilateral infraorbital nerve block on the labial side and nasopalatine nerve block on the palatal side.

A paracrestal (slightly palatal to the mid-crest) full-thickness horizontal incision using a Bard Parker blade no. 15 was made along the alveolar crest to increase visibility without needing of any extra incision. The reflection of the envelope flap was done using a periosteal elevator to expose the crest of the alveolar ridge.

A small initial groove was made by a carbide surgical bur along the crest the exposed ridge to facilitate the insertion of the pilot split blade.

The alveolar ridge was splitted using the MM pilot split blade, setting the force from 2 to 4 degree according to bone density. This will create a precise and thin invitation on the ridge without losing any bone.

Then the initial expander of the MM was utilized, followed by expanders 1, 2, and 3 until the desired width was reached, while the depth of the blade was limited according to the original height of the ridge.

Grafted material was mixed with saline and blood from the splitted area and filled in the expanded gap.

Repositioning of the flap margins after superficial horizontal cutting of the periosteum and suturing using black silk 3-0 with one horizontal mattress at the midline and interrupted sutures for the rest of the flap (Suture – RELI® Non-Absorbable, Silk. Myco medical, Canada) for closure of the wound. (figure 3& 4)

Post-surgical phase

Postoperative instructions

All the patients were instructed to apply cold fomentation for 5 minutes every one hour for the first 24 hours, followed by warm mouthwash the next day until the end of the week. Oral hygiene instruction and informing the patients to be in direct contact if there is any unexplained pain, bleeding, or suture interruption. Sutures will be removed after 7 days of the procedure.

Postoperative medication

Amoxicillin 875mg + Clavulanic acid 125mg, one tablet/12 hours, for 5 days. (Augmentin: GalaxoSmithKline, UK)

Diclofenac potassium 50 mg, one tablet/8 hours, for 3 days, then when needed. (Cataflam: Diclofenac potassium 50mg: Novartis. Switzerland)

Chlorhexidine mouth wash the next day of surgery for one week.

Follow up phase

Radiographic evaluation (figure 5)

A cone beam computed tomography (CBCT) was performed preoperatively, immediately postoperative and three months postoperatively to assess the horizontal bone width and density. According to the following:

Measurement of horizontal bone width

Horizontal bone width was measured by Using OnDemand 3D™ software from the labial or buccal bone crest to palatal crest.

Measurements were based on 3 reference points, the first one (point M) was on the midway of the space. The second reference point (point R) was on the midway between the point M and the first tooth in the right area. The 3 rd reference point (point L) was on the midway between the point M and the first tooth in the left area. (figure 6)

Measurement of the bone density

The bone density was measured in the (point M, point R and point L) including the newly formed bone after ridge splitting. In each point it was measured in three areas (area A at the crest, area B at the middle of the ridge and area C at the apex).

It was measured using OnDemand 3D™ software in Hounsfield Unit (HU).

The measurements of each patient have been compared preoperatively, immediately postoperative and 3 months postoperatively.

To minimize potential errors, all cone-beam computed tomography (CBCT) scans were conducted at a single radiology center.

Statistical analysis

The statistical analyzing of the obtained data

Data were collected and analyzed using Statistical Package for Social Science (SPSS) program version 20.0. (Armonk, NY: IBM Corp). The Shapiro-Wilk test was used to verify the normality of distribution Quantitative data were described using range (minimum and maximum), mean, standard deviation. Significance of the obtained results was judged at the 5% level.

Used tests were: **ANOVA with repeated measures** for normally distributed quantitative variables, to compare between more than two periods or stages and Post Hoc Test **(adjusted Bonferroni)** for pairwise comparison.

RESULTS

Demographic data

Eight patients were enrolled in this study. They seeking for replacement of missing maxillary anterior teeth. The participants age ranged from 25 to 53 years with a mean±SD 44.38±8.96 years, they were 5 males 62.5% and 3 females 37.5%.

Radiographic results

Horizontal bone width

Evaluation of horizontal bone width follow up have been measured as: (Table 1)

Preoperatively, the horizontal bone width ranged from 2.91 to 4.74mm with a mean±SD of 4.01 ± 0.61mm.

Immediate postoperatively, the horizontal bone width ranged from 5.31 – 7.59mm with a mean±SD of 6.29 ± 0.83mm.

Three months postoperatively, the horizontal bone width ranged from 5.0 – 7.12mm with a mean±SD of 5.80 ± 0.82mm.

The pairwise comparison revealed a significant increase in the horizontal bone width immediately postoperative and three months postoperative compared with preoperative (p<0.001, p<0.001; respectively).

Bone density

Evaluation of bone density follow up have been measured as: (Table 2)

Preoperatively, the bone density ranged from 356.1 – 775.9 HU with a mean±SD of 550.2 ± 132.2 HU.

Immediate postoperatively, the bone density ranged from 553.1 – 886.0 HU with a mean±SD of 673.5 ± 112.0 HU.

Three months postoperatively, the bone density ranged from 573.1 – 890.0 HU with a mean±SD of 693.3 ± 105.4 HU.

The pairwise comparison revealed that there was a significant increase in the bone density immediately and three months postoperatively compared with preoperative (p<0.020, p<0.013; respectively).

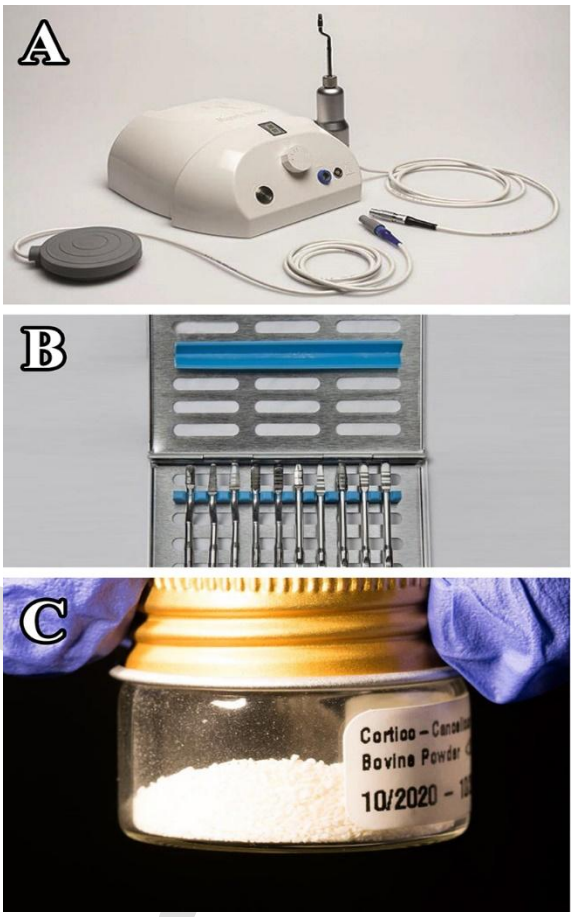

Figure (1): (A) Photograph showing the magnetic mallet device (MM). **(B)** Photograph showing the ridge splitting kit. **(C)** Photograph showing the xenograft material.

Figure (2): Photograph showing the preoperative alveolar ridge.

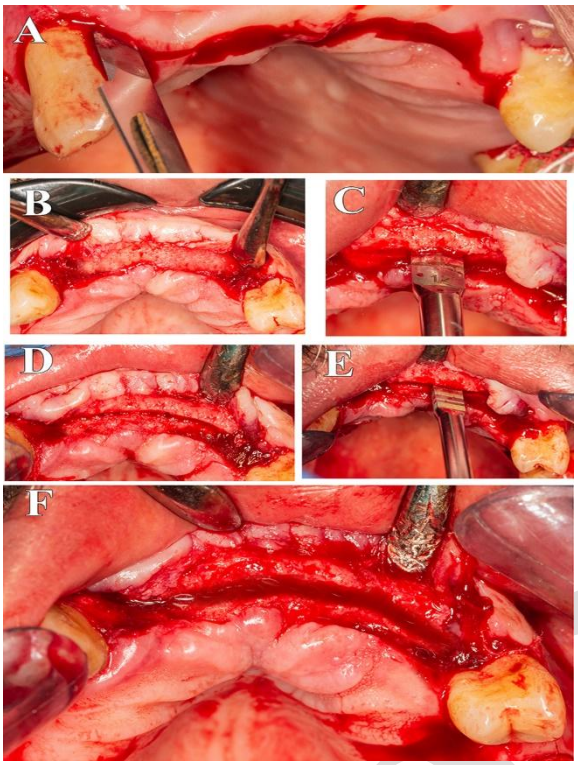

Figure (3): (A) Photograph showing the crestal incision. **(B)** Photograph showing the flap reflection. **(C)** Photograph showing the initial ridge splitting blade. **(D)** Photograph showing initial osteotomy. (E) Photograph showing the final ridge splitting blade. **(F)** Photograph showing final osteotomy gap.

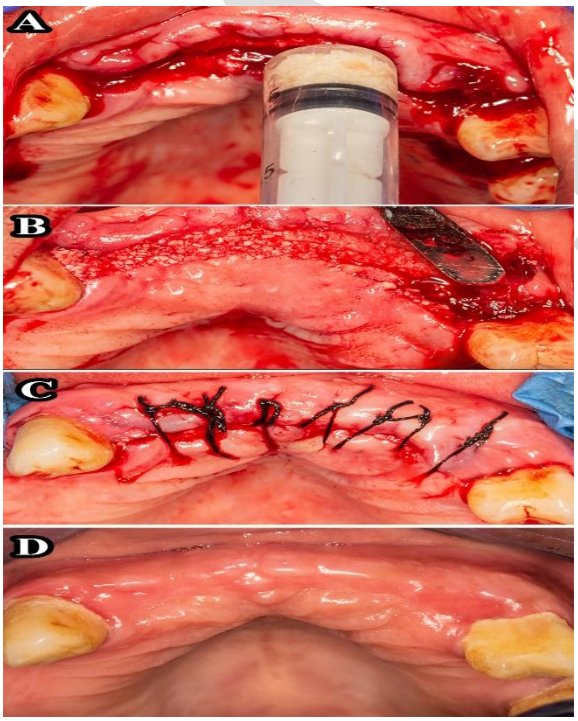

Figure (4): (A) Photograph showing the placement of grafted material into expanded gap. **(B)** Photograph showing the grafted material full the expanded gab. **(C)** Photograph showing the closure of the wound with black silk suture 3-0. **(D)** Photograph showing the alveolar ridge three months postoperatively.

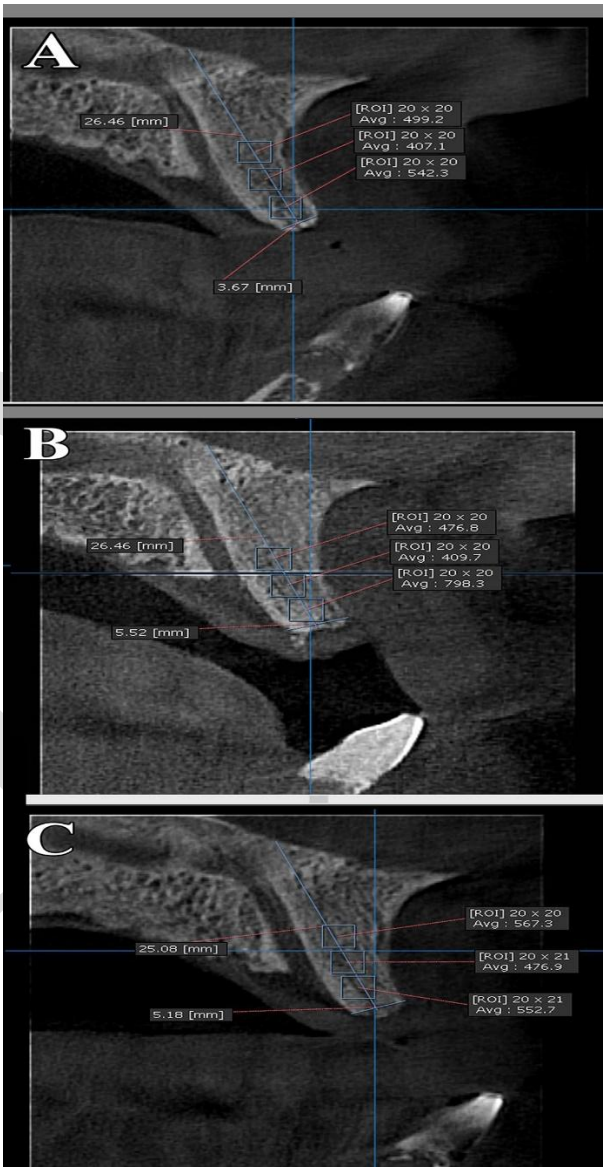

Figure (5): (A) Radiography showing the preoperative ridge width and bone density. **(B)** Radiography showing the immediate postoperatively ridge width and bone density. **(C):** Radiography showing the three months' postoperatively ridge width and bone density.

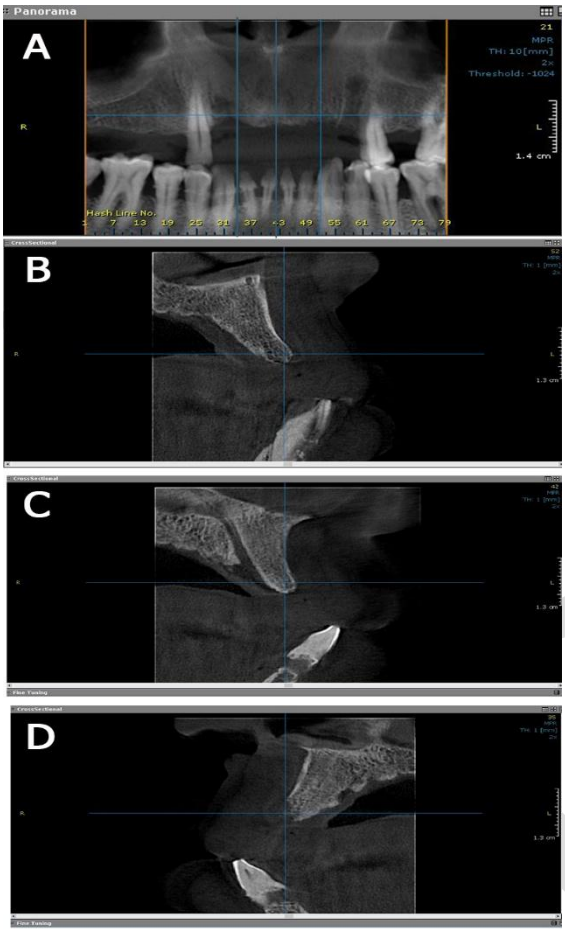

Figure (6): (A) Radiography showing the (point L), (point M) and (point R) in panoramic view. **(B)** Radiography showing the (point L) in cross-sectional view.
(C) Radiography showing the (point M) in cross-sectional view.
(D) Radiography showing the (point R) in cross-sectional view.

Table (1): Comparison between the three studied periods according to radiographic width.

	Pre-operative	Post-operative		F	p
		Immediate	3 months		
Radiographic width Min. – Max. Mean ± SD.	2.91 – 4.74 4.01 ± 0.61	5.31 – 7.59 6.29 ± 0.83	5.0 – 7.12 5.80 ± 0.82	58.083*	<0.001*
Sig. bet. grps.	$p_1<0.001^*$,$p_2=0.001^*$,$p_3<0.001^*$				

SD: Standard deviation
F: F test (ANOVA) with repeated measures, Sig. bet. periods were done using Post Hoc Test (adjusted Bonferroni)
p: p value for comparing between the studied groups
p_1: p value for comparing between Pre-operative and Immediate post-operative
p_2: p value for comparing between Pre-operative and 3months post-operative
p_3: p value for comparing between Immediate and 3months post-operative
*: Statistically significant at $p \leq 0.05$

Table (2): Comparison between the three studied periods according to bone density.

	Pre-operative	Post-operative		F	p
		Immediate	3 months		
Bone density (HU) Min. – Max. Mean ± SD.	356.1 – 775.9 550.2 ± 132.2	553.1 – 886.0 673.5 ± 112.0	573.1 – 890.0 693.3 ± 105.4	15.845*	0.005*
Sig. bet. grps.	$p_1=0.020^*$,$p_2=0.013^*$,$p_3=0.060$				

SD: Standard deviation
F: F test (ANOVA) with repeated measures, Sig. bet. periods were done using Post Hoc Test (adjusted Bonferroni)
p: p value for comparing between the studied groups
p_1: p value for comparing between Pre-operative and Immediate post-operative
p_2: p value for comparing between Pre-operative and 3months post-operative
p_3: p value for comparing between Immediate and 3months post-operative
*: Statistically significant at $p \leq 0.05$

DISCUSSION

The occurrence of bone resorption following tooth extraction might result in inadequate alveolar bone ridge width specially the maxillary anterior segment, hence posing challenges for the optimal placement of dental implants. In such cases, additional procedures involving the augmentation of hard and/or soft tissues may be necessary to facilitate successful implant placement. The procedure of bone splitting and expansion has demonstrated its reliability and relatively low invasiveness in the correction of thin edentulous ridges (15).

Eight patients with narrow anterior maxillary edentulous alveolar ridge were selected in this study with assurance of absence of any systemic disease that

would prevent successful healing of the bone and soft tissue. The ages of the patients ranged from 25 to 53 years with a mean±SD 44.38±8.96 years, they were 5 males 62.5% and 3 females 37.5%. All the patients had undergone the alveolar ridge splitting technique using magnetic mallet with simultaneous grafted material to fill the expanded gap.

The alveolar ridge splitting technique used in this study is a documented approach for restoring the width of the alveolar ridge to facilitate proper implant insertion, which is in agreement with *Sculean A et al.* (16), who found that the alveolar ridge splitting technique (ARST) fulfills all necessary criteria for optimal bone healing and regeneration in cases of bony defects. These criteria include the presence of bony walls, a healing environment that is properly sealed off, enough space for regeneration, and the mechanical stability of the wound.

In this study, the magnetic mallet device was used to perform the corticotomy. This was due to its advantages over conventional bone cutting methods, which include minimal invasiveness with an accurate calibrated force that reduces the bone plate fracture, highly precise cutting without pressure, reducing the amount of bone loss, mitigating heat generation during its operation, thereby obviating the need for irrigation additionally, the ability of bone densification. This was supported by Crespi et al. (14) who found that the use of an electrical mallet provided some essential clinical advantages during crest splitting in comparison with a hand mallet. BENNARDO (17) et al. in 2023, who found that when using the magnetic mallet for surgical tooth extraction, less time was needed to complete the surgery compared with conventional instruments and piezo-surgery.

A paracrestal (slightly palatal to the mid-crest) full-thickness horizontal incision was made along the alveolar crest to increase visibility without need to extra incision. This provided better vascularity, as the periosteum remains attached to the alveolar ridge, preserving buccal bone plates, improving healing and reducing postoperative complications. This was in agreement with *CORTESE* et al., [18] who found that using paracrestal incisions with eliminating any extra incisions helped preserve a double-nourished alveolar bone wall.

In this study, cone beam computed tomography (CBCT) scan was obtained for each patient pre-operatively, immediate postoperatively and 3 months postoperatively. The purpose of these scans was to assess the effectiveness of ridge splitting used in this study upon the alveolar ridge width and bone density.

In the current investigation, there was a significant increase in the horizontal bone width immediately postoperative and three months postoperatively compared with preoperative CBCT (p<0.001, p<0.001; respectively). which is consistent with *Starch-Jensen & Becktor* in 2019 (19) who did a systematic review comparing the alveolar ridge splitting technique with autologous lateral ridge augmentation, after 4 months, an average increase in alveolar ridge width ranging from 3.3 to 3.5 mm was observed following maxillary alveolar ridge widening with the split-crest technique. Also, with *Mahmoud* ZT et al. (20) an increase in the horizontal bone width was found immediately postoperative and six months postoperatively by the flapless split crest technique using piezotome.

In this trial, a significant decrease in the horizontal bone width three months postoperative compared with immediately postoperative CBCT. which is compatible with *Guo* et al. (21) performed a study on 56 healthy patients and underwent the split-crest technique (SCT) to augment the alveolar ridge width. He found that the average initial alveolar ridge width was increased after SCT. Three months later, this width declined slightly, but still, there is a significant increase between the baseline width and after 3 months. This was due to a fact that the SCT healing resembles normal bone healing of an extraction socket, so these slightly width alternations occurred (22).

Regarding the bone density, it was found that there was significant increase in the density of bone after 3 months' postoperative (P <0.013), which was compatible with the findings of *Gianmario* et al. (23), who conducted a comprehensive analysis of the bone sites that were prepared for dental implants using a magnetic mallet (MM). He found that the power of the magnetic mallet to induce osteocondensation in the bone tissue has the potential to enhance the initial stability of the dental implant. Based on these considerations, it can be asserted that magneto-dynamic technology emerges as a preferred treatment for preparing the maxillary implant site, particularly in instances of reduced bone quality (density) or in case of thin or low-quality cortex.

CONCLUSION

From the results of this study, it was concluded that the split crest technique for narrow edentulous anterior maxilla using the magnetic mallet with simultaneous grafted material is a successful treatment to increase the horizontal bone width of the alveolar ridge to produce an improvement in the bone density.

CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

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