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Research Article

Modified Staged Ridge Splitting Technique Versus Conventional Technique for Horizontal Expansion of Narrow Posterior Mandible (Randomized Controlled Clinical Trial)

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Abstract

Background: The present study evaluated the outcome of modified ridge split technique in posterior mandible in comparison to conventional technique.

Material and Method: That was a randomized controlled clinical trial. The study population included 20 patients with edentulous posterior mandibular alveolar ridges (3 - 6 mm). The sample was selected conveniently to fulfil a list of inclusion and exclusion criteria. Then the selected participants were allocated randomly into two equal groups each including 10 patients (study and control group). Both groups have undergone cortectomy procedure in the first stage using piezoelectrical surgical device. One month later, control group undergo conventional ridge split procedure with xenograft and collagen membrane. In study group, modified ridge split procedure was done with no bone graft. Bone chips harvested from ipsilateral retromolar area by trephine bur were crushed and used to maintain the space between buccal and lingual plated after splitting. Assessments included measurements of pain using VAS ($2^{nd,}$ 7^{th}, 14^{th} day postoperative), edema using tape measuring method ($2^{nd,}$ 7^{th}, 14^{th} day postoperative), healing of the tissue ($2^{nd,}$ 7^{th}, 14^{th} day postoperative), and radiographic measurements of buccolingual crestal bone width at pre-operative, immediately post-operative, and 6 months post-operative (CBCT measurements).

Results: The statistical analysis of measurements from both groups showed no significant difference between control and study groups regarding edema, pain, and tissue healing. Also, buccolingual crestal bone width measured six months postoperative phase showed that there was a non-statistically significant difference in the measurements of conventional group ($\mu = 6.02$, SD = ± 0.52) and the modified ridge split group ($\mu = 5.78$, SD = ± 0.90; $p = 0.474$).

Conclusion: It can be concluded that modified ridge split technique in posterior mandible is a simple and predictable procedure with satisfactory results. Moreover, this approach is devoid of foreign materials usage and has a low rate cost, therefore, could be employed more often.

Keywords: Ridge Split; Modified Ridge Split; Posterior Mandible; Piezosurgery; TI-OSS® Xenograft; Collagene-AT®

Introduction

The posterior mandible has been referred to as "the most difficult region for reconstruction and early implant placement in cases of severe alveolar resorption in the maxillomandibular complex" [1].

In addition to complicating anatomic features, such as the inferior alveolar nerve, mental foramen, oblique ridge, and lingual undercut of the mylohyoid ridge, edentulous mandibular ridges have thicker cortices and decreased volumes of vascular trabecular bone than their maxillary counterparts [2,3].

Traditionally, resorbed alveolar ridges of the most severe nature have been treated with autogenous block graft [4]. Although these grafts can provide substantial augmentation, their use has been associated with patient morbidity at donor sites, and possibility of graft failure and, as such, alternative procedures yielding comparable gains to autogenous block grafts have been sought [5].

Ridge split technique in implant dentistry was introduced for the first time by Simion., *et al.* in 1992 [6]. Further modifications of this technique have been done since 1992 [7].

The ridge split is more proper to the maxilla than the mandible owing to the thinner cortical plates and softer medullary bone [8].

For creating split between the cortical plates, different osseous surgical tools such as hand and rotary instruments have been used. Piezosurgery instruments has been used successfully [9.10]. The problems mostly occurring in lower jaw are that cortical expansion is obtained by lingual displacement of lingual plates, and the buccal cortical plates will expand minimally [10]. Also, there is a high risk of malfracture of the osteomized buccal segment because of the lower flexibility and thicker cortical plates [11]. that's why corticotomy of a rectangular buccal segment and staged ridge splitting technique are two ways to overcome these problems [12]. In the mandible, in order to achieve a safe and predictable ridge splitting, there must be no vertical bone defect. Also, there should be at least 3 mm of bone width, including at least 1 mm of cancellous bone. This minimum cancellous bone width is desired to insert a bone chisel and consequently expanding the cortical bones. Moreover, there should be abundant bone height superior to the mandibular canal (> 12 mm) [8].

Once the buccal cortex is laterally positioned after greenstick fracture, the space between the buccal and lingual cortical plates can be filled with either autologous, allogenic, alloplastic graft materials, or without any graft material [13].

Placement of bone substitutes in intercortical space (interposition bone grafting) has advantages of internal perfusion, prevention from particle migration and displacement, omission of the need for donor site and fixation screw and reduction of graft resorption probability [6,14].

Modification of ridge split technique in posterior mandible has done and published in the Annual Journal of Oral and Maxillofacial Surgery 2014 in which the bone plates were maintained in place by using small bone chips inserted deep in between the separated cortical plates. The gap was between 3 and 5 mm and was left to be filled with a blood clot giving the opportunity for normal wound healing resembling an extraction socket. Depending upon the fact that fresh extraction sockets in posterior mandible areas are always wider than 5 mm and they heal by secondary intension without the need for bone grafting or using guided regeneration techniques [14].

There are no available data in literature supporting this modified technique, so this study is intended to solve the following question: Can the modified ridge split technique be as effective as the conventional staged approach for horizontal augmentation of narrow posterior mandible?

Materials and Methods

Study design and setting

This study was carried out as an experimental randomized controlled clinical trial. The sample size was calculated according to the epitool.ausvet.com.au with the aid of a similar study conducted by Blues and Moncler (2006) by inserting the means 1 of ridge width = 3.6 mm, and the mean 2 to be = 5.9 mm. By calculating the variance to be 2.7, setting the confidence level to be 0.95, and the study power to 80%, the calculated sample size was 18 patients. Two more patients have been added to the total sample size in order to avoid the drop-out from the sample throughout the study period. Therefore, the selected sample consisted of 20 patients. They were selected conveniently to fulfil the following inclusion and exclusion criteria from the outpatient Clinic of Oral Surgical Sciences Department/ Division of Oral and Maxillofacial Surgery, Faculty of Dentistry, Beirut Arab University, for ridge split procedure in posterior mandible prior to implant placement.

Both genders were included in the study, aged between 30 and 60 years, with good oral hygiene, having Kinnedy class II lower edentulous ridge with adequate bone height (> 10 mm superior to mandibular canal), but average width (3 - 6 mm) in need for implant supported.

Prosthesis

Patients that had been excluded from this study are those with uncontrolled systemic conditions jeopardizing the surgery, those with psychological problems and/or refusing ridge splitting and future implant therapy. Also, those with vertical bone defect in posterior mandible, those with remaining pathological lesions in the area of surgery, pregnant patients and smoker patients.

Finally, the cases were divided randomly into 2 groups: study (Group I), and control (Group II). They were randomly allocated through tossing a coin, where the heads were assigned to be the study group (Group I), whereas the tales were assigned to be the control group (Group II).

Group I (study group)

Consisted of ten patients with edentulous kinnedy class II mandible. Modified staged ridge splitting procedure was performed one month after corticotomy procedure. The inter-cortical space was not grafted. The gap was stabilized by small autogenous bone pieces harvested from ipsilateral retromolar area.

Group II (control group)

Consisted of ten patients with edentulous Kinnedy class II mandible. Conventional staged ridge splitting was done one month after the corticotomy procedure. The inter-cortical gap was filled with xenograft (Ti-oss® cancellous substitute (Chiyewon, Korea)), and covered with collagen membrane (Collagene-AT, Centro Di Odontoiatria Operativa S.R.L., Italy).

The study took the acceptance of the Institutional Review Board of Beirut Arab University (IRB no. 2017H-0049-D-M-0205) before proceeding in this study. The patients were informed about the nature and aim of the whole procedure, and each patient was

asked to sign a consent from declaring that he/ she accepted to be involved in the study.

Methods

Pre-surgical phase

A.Clinical examination

Medical and dental histories were collected from the patients.

Careful clinical examination was performed for the oral cavity including the teeth, gingiva, tongue and oral mucosa for the presence of inflammation, infections.

The alveolar bone was examined to find if there were any irregularities, exostosis, and vertical defect in the area of surgery.

The patients were informed about the nature and aim of the whole procedure, and each patient was asked to sign a consent form declaring that he/she accepted to be involved in the study.

B.Construction of radiographic stent

Wax up for the edentulous area on the study cast. Then the stent was made using a hard-thermoplastic sheet using a vacuum thermoplastic machine

Cold cured acrylic resin mixed with amalgam powder was poured into the inner surface of the stents, the resin filled the entire volume of the inner surface of the stents.

The stents were tried in patients' mouth before making cone beam computerized tomography (CBCT). CBCT for edentulous regions were made using the radiographic stents to measure the preoperative Bucco-lingual width at the centers of each tooth to act as baseline.

C.Preoperative preparation

Scaling and root planning, and Chlorhexidine (0.12%) rinsing thirty minutes prior to surgery was done.

Surgical Phase

All procedures were done under complete aseptic sterile conditions and swabbing the site of surgery with povidine iodine solution.

Block technique local anesthesia was used to anesthetize the inferior alveolar nerve, lingual nerve and long buccal nerve, using Ubistesin forte, 3M ESPE (Articaine hydrochloride 4%, Adrenaline 1/100.000).

In both groups, 2 surgeries were performed and the time gap between them was one month. All the procedures were performed by the same surgeon. Patients were instructed to return back to the clinic if any questions or problems arise.

1.1st Surgery

Local block anesthetic technique was used to anesthetize the inferior alveolar nerve, lingual nerve and long buccal nerve at the side of surgery. Midcrestal incision followed by elevating a full thickness mucoperiosteal flap to expose the crest of ridge, buccal plate of bone to a height of at least 10 mm, and slight exposure of lingual plate of bone (3 to 5 mm) (Figure 2). Corticotomies were done using (0T7) insert on piezoelectric device (mectron® cortical mode) under copious sterile saline irrigation: It consisted of one crestal cut, mesial and distal vertical cuts, and one apical cut (Figure 1).

Figure 1: Corticotomy procedure by mectron piezosurgery. Note the crestal, mesial, distal, and apical cut done to aid in ridge split at second stage.

The depth of the crestal cut was two millimetres from the upper border of inferior alveolar canal to prevent any nerve injury, which was measured from the pre-operative CBCT.

The anterior vertical cut was at least one to two millimetres from the tooth mesial to the site of surgery, and the posterior cut should be located few millimetres distal to the future position of the last implant. The two vertical cuts at the periphery of the crestal cut were made to reach the cancellous bone. The three cuts (crestal, and the 2 vertical cuts) were joined by one apical hinge cut at the depth of the two vertical and crestal cuts. The apical cut crossed the cortical bone to reach the cancellous bone. The flap was closed using interrupted sutures (3-0 silk suture material).

2.2nd Surgery: After 1 Month

i.In study group

Same techniques of anaesthesia, incision, and flap exposure are done with exception that the flap wasn't elevated over the buccal cortical plate to preserve its periosteal vascularity. The flap was extended to the retro-molar area to expose it (Figure 2a).

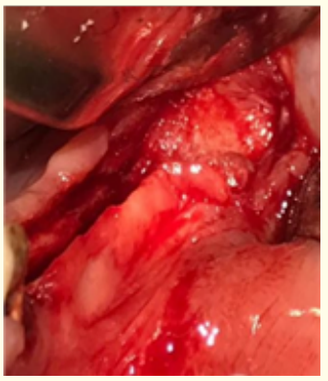

Figure 2a: Midcrestal incision and slight crestal exposure and full thickness exposure of ipsilateral retro-molar area.

Ridge splitting procedure was done by inserting the no. 15 blade in the crestal cut and tapping on the end on the blade handle. Then, graduated ridge split chisels (NURIKON®, Sialkot, Pakistan) were tapped gently with the mallet to reach the measured length (from the preoperative CBCT that is at least 2mm from the inferior alveolar nerve bundle) while firmly supporting the mandible (Figure 2b). During the insertion of the chisels in the crestal cut, the buccal plate with the overlying mucosa began to move laterally.

Figure 2b: Ridge splitting using a series of graduated chisels.

Autogenous bone pieces were harvested using trephine bur (size 4 and 5 mm) (Figure 2c) on low speed handpiece under copious saline irrigation from retromolar area at the ipsilateral surgical site (Figure 2d). These bone pieces were crushed with bone rongeur into smaller ones and soaked in sterile saline in a sterile dish (Figure 2e). These small bone pieces were used as spacer between the buccal and lingual walls after splitting (Figure 2f).

The crushed bone pieces were inserted deeply in the apical region of the gap to prevent the collapse of the lateral plate. The gap between the bone plates was left to be filled with blood clot without the use of bone graft thus resembling a fresh extraction site.

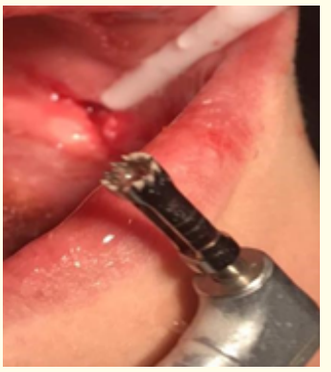

Figure 2c: Trephine bur to harvest bone from ipsilateral retromolar area.

Figure 2d: Bone core harvested from retromolar area.

Figure 2e: Small bone chips after crushing by bone rongeur.

Figure 2f: Bone chips placed in the gap after splitting.

Bucco-lingual crestal bone width was measured using bone caliper while the pre-surgical constructed radiographic stent was in place (Figure 2g and 2h).

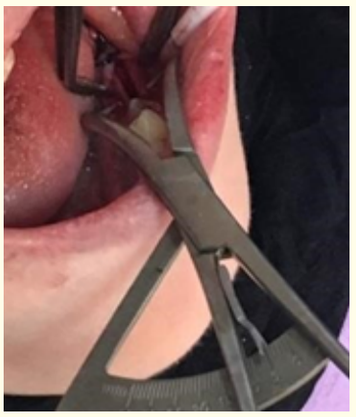

Figure 2g: Measurement of new buccolingual width with bone calliper.

Figure 2h: New ridge width after splitting.

The flap was sutured with no intension for primary closure using interrupted sutures (3-0 black silk suture material). No attempts for edge to edge approximation of the flaps were done (to allow the site to act as a fresh extraction socket).

ii.In control group

In this group, same procedure was done as the study group with an exception that the buccal plate of bone was fully exposed to a height of at least 10 mm.

Ridge splitting procedure was done similar to that of study group.

After splitting procedure, xenograft was mixed with sterile saline in a sterile dish. The barrier membrane was trimmed to proper size, sharp angles were rounded and soaked with sterile saline in a sterile dish.

The gap created between the buccal and lingual plates was filled with xenograft (Ti-oss® xenograft) and covered by barrier membrane (Collagene-AT®).

Bucco-lingual crestal bone width was measured using bone caliper while the pre-surgical constructed radiographic stent was in place.

Periosteum was scored to allow tension free closure of the flap. Then the flap was sutured using interrupted sutures (3 - 0 black silk sutures).

Post-operative Phase

Immediately after the surgery, all patients were given ice packs to be applied extra-orally over the surgical sites at intervals of 20 minutes and rest for 10 minutes for the first 6 hours post surgically. The cold fomentations were replaced by warm ones for the next 5 days.

Fifteen patients were given Amoxicillin 875 mg + Clavulanic acid 125 mg (Augmentin 1000 mg tablets) bid after meal for 7 days.

Five patients had penicillin allergy, so clindamycin 300 mg (Dalacin-C 300 mg) was prescribed bid after meal for 7 days. Patients were given naproxen 500mg non-steroidal anti-inflammatory drug (proxen 500 mg) tid after meal for 3 days.

Chlorhexidine gluconate mouthwash 0.12% (Eludril mouthwash) was started from the second postoperative day for the next 7 days and was instructed to be used twice daily. Sutures were removed one week after the surgery.

Follow-up Phase

This phase consisted of immediate and late follow up phases. Immediate clinical evaluations were done in both study and control groups concerning the facial swelling (by using the tape measuring method), healing of the tissue (colour of tissues, presence or absence of wound infection, flap dehiscence), and pain measurement (by visual scaling analysis VAS), Late follow up phase was performed in both groups through radiographic evaluation using CBCT 6 months post-operative.

A.Immediate follow-up

Clinical Evaluation

Facial Swelling

Swelling was evaluated at the 2nd, 7th, and 14th postoperative days. The facial swelling was determined by a percentage of tape-measuring method, which took into account the sum of the following measures: the distance between the lateral canthus of the eye and the angle of the mandible, the distance between tragus and the outer corner of the mouth, and the distance between tragus and soft tissue pogonion. Their sum was added and divided by 3 and multiplied by 100 to get the percentage of facial swelling.

Healing of tissues

Healing of the tissue was evaluated by the presence or absence of pus, colour of overlying mucosa, and presence or absence of dehiscence within the flaps.

B.Late follow up

Radiographic evaluation was performed after 6 months post-surgical to measure the buccolingual crestal bone width at the centers of the teeth by CBCT using the pre-fabricated radiographic stent (Figure 2j). The results were compared to those of pre-operative baseline measurements taken at the same points from CBCT (Figure 2i). The measurements of the Bucco-lingual crestal bone width for each patient at the different follow up periods were recorded and statistically evaluated and analysed.

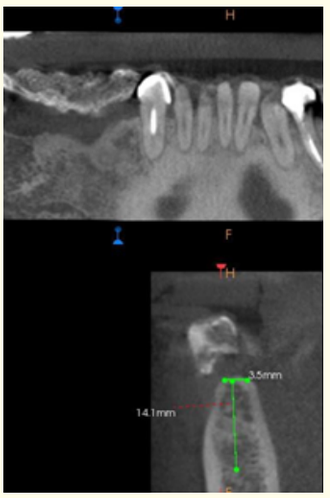

Figure 2i: Pre-operative Bucco-lingual width (modified technique).

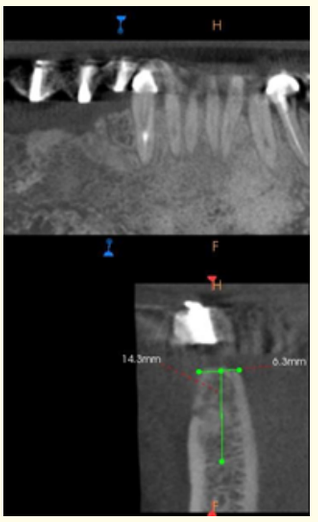

Figure 2j: New Bucco-lingual width at 6 month post-operative (modified technique).

Results

The independent-samples t-test conducted to compare the pain measurements in conventional group vs modified ridge split group at day 2 postoperative showed that there was a non-statistically significant difference in the measurements of conventional group (μ= 4.40, SD = ± 1.78) and the modified ridge split group (μ = 3.50, SD = ± 1.84, p = 0.281). Also, at day 7 postoperative showed that there was a non-statistically significant difference in the measurements of conventional group (μ = 1.80, SD = ± 1.03) and the modified ridge split group (μ = 1.40, SD = ± 1.17, p = 0.429). At day 14 postoperative, there was a non-statistically significant difference in the measurements of conventional group (mean rank = 10.50) and the modified ridge split group (mean rank = 10.50); U = 50.00, p = 1 (Figure 2k).

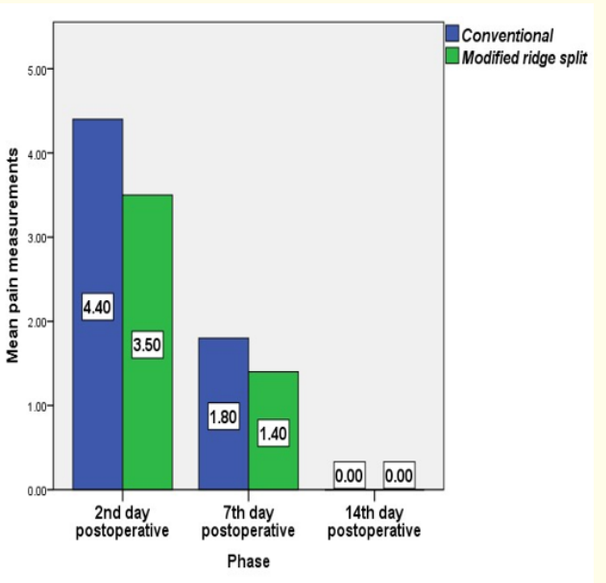

Figure 2k: Bar graph showing comparison of mean pain measurements between conventional and modified ridge split techniques at the 3-time phases.

The independent-samples t-test conducted to compare the measurements of edema measurements in conventional group vs modified ridge split group at Day 2 showed that there was a no statistically significant difference in the measurements of conventional group (μ = 12.23, SD = ± 0.58) and the modified ridge split group (μ = 12.28, SD = ± 0.66, p = 0.841). Moreover, at Day 7 postoperative, there was a non-statistically significant difference in the measurements of conventional group (μ = 11.96, SD = ± 0.50) and the modified ridge split group (μ = 11.96, SD = ± 0.67, p = 1). Also, at day 14, there was a non-statistically significant difference in the measurements of conventional group (μ = 11.65, SD = ± 0.50) and the modified ridge split group (M = 11.69, SD = 0.68, p = 0.883) (Figure 2l).

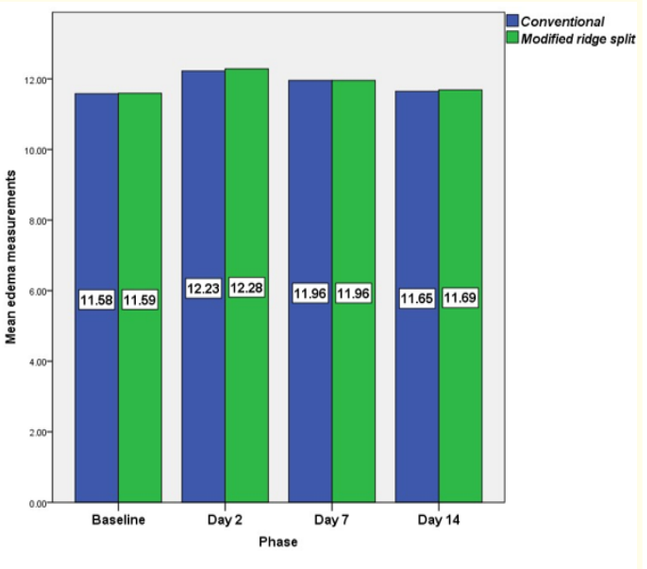

Figure 2l: Bar graph showing comparison of mean edema measurements between conventional and modified ridge split techniques at the 4-time phases.

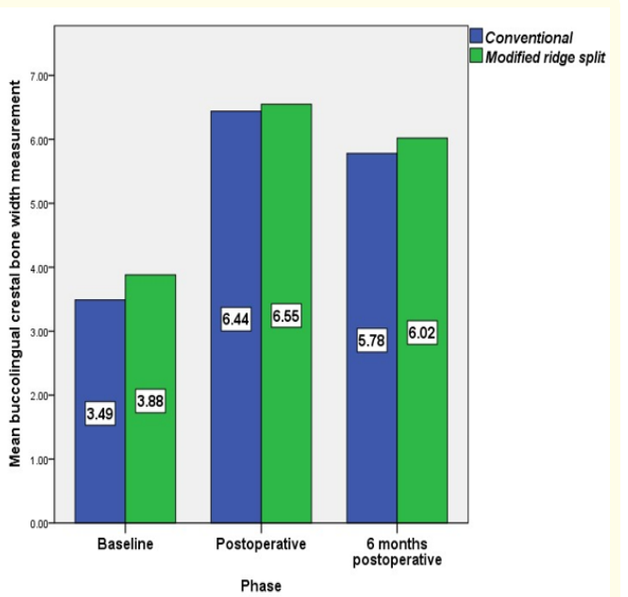

Figure 2m: Bar graph showing comparison of mean buccolingual crestal bone width measurements between conventional and modified ridge split techniques at the 3-time phases (baseline, immediate post-operative, 6-month post-operative).

The independent-samples t-test conducted to compare the measurements of buccolingual crestal bone width in Conventional group vs modified ridge split group at postoperative phase showed that there was a non-statistically significant difference in the measurements of conventional group (μ = 6.55, SD = ± 0.60) and the modified ridge split group (μ = 6.44, SD = ± 0.80, p = 0.732). At 6 months postoperative phase, there was a non-statistically significant difference in the measurements of conventional group (μ = 6.02, SD = ± 0.52) and the modified ridge split group (μ = 5.78, SD = ± 0.90, p = 0.474) (Figure 2m).

Discussion

This study was carried out as an experimental, randomized, controlled clinical trial on patients with kennedy class II that need horizontal ridge augmentation for future implant placement with adequate vertical bone height.

The procedure was done in two stages. Stage I was corticotomy procedure to weaken the buccal cortical plate and will guarantee the success of the stage-2 procedure [15]. Stage II consisted of splitting and grafting. This was delayed to 4 weeks from the first procedure to give more safe and predictable results with good horizontal bone gain and less risk of buccal plate fracture in patients with high bone quality and thick cortex and a narrower ridge in the mandible [9,11,16,17].

In the current study, an additional apical osteotomy connecting the apical ends of the two "bony verticals" cuts in cases of more cortical mandibular bone was used [18].

In this study a series of chisels and mallet were used for ridge splitting [15,19-21]. Many studies advocates using osteotomes to avoid unwanted complications like unwanted fracture lines in the buccal or lingual cortical plates [22], less resonance frequency [23], less heat generation, less bone loss and higher implant stability [24].

In this study piezosurgery was used for performing corticotomy. Using piezosurgery allowed selective cutting of the bone without affecting the soft tissue (nerves and blood vessels) may be carried out [27] further, an oscillating tip with an irrigating fluid provided a cleaner working area and greater visibility (cavitation effect) at the surgical site without causing bone heating (compared to conventional devices) [9].

In this study, a modification for the conventional ridge split technique was done for atrophic posterior mandible with bone width not adequate for implant placement. In the second stage, the mucoperiosteum was kept attached to buccal and lingual bone to maintain the vasculature to the bone and prevent bone loss after splitting [14,15,28,30,31,35].

In contrast, Dohiem., *et al.* (2015) showed weak evidence of flap design and immediate implantation on marginal bone loss and survival rate [32].

Also, in the present study, no bone graft was used to fill the gap created after ridge splitting which runned parallel to other studies done by Phatke., *et al.* (2017) [33], Santagata., *et al.* (2008) [34]. Agabiti., *et al.*(2017) [35], that showed that this technique can yield predictable bone gain. The present study runs parallel to study done by Abu Tair (2014) [14], who use two-stage modified ridge split technique to widen the ridge in posterior mandible. After splitting, small bone chips harvested from retromolar area were used.

No significant patient discomfort was observed for any of the included studies, except in one case that showed vertigo [25].

In the present study, the independent-samples t-test conducted to compare the measurements of edema measurements in conventional group vs modified ridge split group at Day 2, 7, and 14 showed that there was a non-statistically significant difference in the measurements of conventional group, and the modified ridge split group ($p = 0.841$, $p = 1$, $p = 0.883$ respectively). The results of the present study are in agreement with results of study done by Moro., *et al.* (2017) [7,26], that shows that soft tissue healing after ridge splitting was uneventful and pain and swelling were comparable to usual dento-alveolar procedures.

In the present study, the modified ridge split technique elicits a highly statistically significant increase in bucco-lingual crestal bone width at the postoperative and the six months postoperative phases compared to the baseline and a highly statistically significant decrease in bucco-lingual crestal bone width at the six months postoperative phase ($p < 0.0001$) compared to the immediate postoperative phase. This was detected by cone beam computed tomography (CBCT) taken at six months post-operative period.

The independent-samples t-test conducted to compare the measurements of the buccolingual crestal bone width in Conventional group vs modified ridge split group at the six months postoperative phase showed that there was a non-statistically significant difference in the measurements of conventional group ($\mu = 6.02$, SD = ± 0.52) and the modified ridge split group ($\mu = 5.78$, SD = ± 0.90, $p = 0.474$). The average bone gain at six-month post- operative is 2.14 mm for modified and 2.29 mm for conventional technique. This is parallel to results of study done by Abu Tair (2014), who used two-stage modified ridge split technique to widen the ridge in posterior mandible. Bone width gain has been observed in all cases with an average width gaining of 3.22 ± 0.97 mm, which varied between 2 and 5 mm. The present study is in parallel to study done by Agabiti., *et al* [35]. In his study, the mean initial width of the alveolar bone crest measured 4.1 ± 0.5 mm, reaching 6.8 ± 0.9 mm after ridge expansion ($P < .01$).

The present study is parallel to study done by Holtzclaw., *et al.* [27,29], where 13 patients with 17 horizontal alveolar ridge deficiencies of the posterior mandible were treated with the piezoelectric hinge-assisted ridge split procedure. Overall mean gain in horizontal width was 4.03 mm (± 0.67). For single implant-site augmentations, the mean gain was 3.38 mm (± 0.25). For multiple adjacent implant-site augmentations, mean gain was 4.25 mm (± 0.62).

Conclusions

The results of this study showed that the modified approach for mandibular ridge split as presented, is a successful technique for augmenting narrow mandibular ridges. Rehabilitation of long standing edentulism in posterior mandible with horizontal bone loss can be performed with relative ease by modified ridge split technique. It omits the need of second surgical site or any foreign materials. Modified ridge split technique is simple and predictable with satisfactory results, minimal morbidity and low cost.

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