

# Evaluation of Modified Shell Technique in 3D Ridge Reconstruction: A Clinical and Radiographic Study

Ramy Richa<sup>1,\*</sup>, Essam Osman<sup>2</sup>, Nahed Attia<sup>3</sup>, Hani Arakji<sup>4</sup>, and Mohamed Shokry<sup>5</sup>

## ABSTRACT

**Introduction:** As a result of tooth loss, alveolar ridge resorption sacrifices bone volume including bone width. In order to replace the lost dentition with implants functionally and esthetically, bone augmentation procedures are carried out.

**Materials and Methods:** Fifteen patients were selected to treat mandibular alveolar ridge resorption with an autogenous block graft harvested using piezoelectric surgical tips and split into two shells using a diamond disk then fixated on the decorticated defective ridge. Particulate xenograft bovine bone was then inserted between the fixated shell and ridge, the second shell was used to roof the bone particles.

**Results:** The modified shell technique could be an alternative to other ridge augmentation techniques. This study shows promising clinical and radiographic results that carry the advantages of being: safe and precise cutting using Piezoelectric tips, the statistical data showed a significant difference in 3D bone volume where no unfavorable complication was detected.

**Conclusion:** The modified shell technique showed a reliable technique in cases of 3D ridge reconstruction since it holds the advantages of autogenous bone properties and the rigidity of the bone shells that maintain the space necessary for augmentation. The use of PRF can accelerate wound healing and minimize the risk of flap dehiscence as well as it can speed up bone formation.

**Keywords:** Bone Shells, Piezosurgery, Ridge reconstruction, Xenograft.

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<sup>1</sup>Oral Surgical Sciences Department Division of Periodontology, Faculty of Dentistry, Beirut Arab University, Lebanon.

<sup>2</sup>Dental Biomaterial Department, Faculty of Dentistry, Alexandria University, Egypt.

<sup>3</sup>Periodontology Department, Faculty of Dentistry, Alexandria University, Egypt.

<sup>4</sup>Oral Surgical Sciences Department, Division of Oral and Maxillofacial Surgery, Faculty of Dentistry, Beirut Arab University, Lebanon.

<sup>5</sup>Oral and Maxillofacial Surgery Department, Faculty of Dentistry, Alexandria University, Egypt.

\*Corresponding Author:

e-mail: ramyricha@gmail.com

## 1. INTRODUCTION

The lack of supporting bone in the posterior mandible region poses a hard challenge for clinicians when the treatment plan involves rehabilitation of this region with dental implants. Several prosthetic and surgical options are available, for both partially and totally edentulous patients, to deal with the presence of the alveolar nerve and the gradual resorption of the mandibular crestal bone both vertically and horizontally [1].

In a variety of clinical situations, bone block grafting is an adaptable and well-researched method for treating alveolar ridge abnormalities [2]. The most common technique, known as onlay grafting, is derived from reconstructive operations in orthopedic and cranio-maxillofacial surgery. It involves firmly attaching a bone block over the recipient site [3].

The only source of nutrition for the bone block during the first three to five days of healing is plasmatic circulation. Then, capillaries start to emerge from the margins of the recipient site and the surrounding soft tissues, penetrating the graft to initiate micro-angiogenesis. After two weeks, there is a significant inflammatory and vascular response that includes hypervascularization of the surrounding tissues, micro-angiogenesis, and bone remodeling. Four weeks later, there is significant remodeling that includes the formation of osteoid and an increase in the size and dimensions of the micro-vessels that penetrate the graft. At 8 weeks, full graft revascularization is finally accomplished; and at 16 weeks bone maturation with no inflammatory cells [4]. These days, the standard of care involves restoring the alveolar ridge's outlines using a thin cortical bone block. As long as bone loss is kept below 10%

[5]. the current standard of treatment involves restoring the alveolar ridge's outlines using a thin cortical bone block (Bone Shells) [6].

Combining implant placement following ridge augmentation with relining using xenograft particulates and a resorbable membrane should further lower these low resorption rates. The "shell technique" or "plates technique". As space-making tools, thin bone laminae are used to define a regeneration space filled with autogenous bone particulates. This reduces the cortical portion of the graft and facilitates the ingrowth of sprouting capillaries throughout the healing process [7].

Therefore, the aim of this study was to evaluate clinically and radiographically the efficiency of using the bone shells combined with xenograft and PRF for 3D ridge reconstruction of the posterior atrophic mandible.

## 2. MATERIALS AND METHODS

This study was accomplished as a randomized clinical trial following the consort guidelines. The study was carried out at the Oral Surgery Division, Faculty of Dentistry, Beirut Arab University, Lebanon, between January 2023 till September 2022. The institutional review board number (2023-H-0121-D-P-0534) was obtained prior to the start of the study. The study was completed in accordance with the Helsinki Declaration of 1975, revised in 2013. All the patients who participated in this trial were informed about all the steps and any complications that might arise during or after the procedure and signed an informed consent before the work began.

Sample size was estimated using the sample size calculator website; <http://epitools.ausvet.com.au>, by considering the means of bone-to-graft contact and the pooled variance of a similar study [8], and by adjusting the power of the study to 80% and regulating the alpha error to 5%. This generated a total of 13 patients; two patients were added to the final calculated sample size to avoid attrition and dropout from the sample that might occur throughout the follow-up period of the study, so a total of 15 patients of both genders with an age range of 30–60 years were included in the study.

The participants included eligibly in this trial were randomly selected based on their need for posterior mandibular ridge reconstruction to place the dental implant, Mandibular partial edentulism (Applegate-Kennedy class I or II), involving the premolar/molar area, associated with the presence of crestal bone height <7 mm coronal to the mandibular canal. On the other hand, the exclusion criteria were patients with uncontrolled or untreated periodontal disease involving residual dentition, radiotherapy to the head/neck district performed within the past 24 months, chemotherapy for treatment of malignant tumors at the time of the surgical procedure, pregnant females, and heavy smokers [9].

### 2.1. Pre-Surgical Phase

A full examination was performed thoroughly on all patients, including their oral hygiene level, the health of the periodontium, and check the occlusion for future prosthesis. Afterward, cone beam computed tomography (CBCT)

was requested for all patients to assess the bone width and height of the posterior mandible. Additionally, the surgical site was properly examined to guarantee the absence of any pathological lesions, the location of the inferior alveolar nerve canal, and the thickness of bone on the retromolar area. Furthermore, scaling and root planning for the residual dentitions.

### 2.2. Surgical Procedure

On the day of surgery, patients were asked to take 2 tablets of antibiotics (amoxicillin 875 mg and 125 mg clavulanic acid) one hour before the surgical procedure. As for patients who were allergic to penicillin, they were asked to take 2 tablets of Clindamycin 300 mg. All patients were instructed to rinse their mouths with Chlorhexidine gluconate 0.2% mouthwash 30 minutes before the start of the procedure.

The entire surgical procedure was performed under complete aseptic and sterile conditions. Local anesthesia using Articaine HCl 4% with 1:100,000 epinephrine (Ubistesin-3 M). The local anesthesia was dispensed through the inferior alveolar and buccal nerve block, using an autoclaved metallic breech-loaded dental syringe and a long 27 G needle.

Crestal incision was done in the area of the posterior atrophic mandible (recipient site) where it was extended from the mesial aspect of the adjacent tooth to the retromolar area distally using a Bard Parker Blade Number 15 c. Two vertical releasing incisions were performed mesial and distal, then, releasing incisions were performed and full thickness flaps were reflected buccal and lingual. The recipient's bone was decorticated using a round bur 1 mm diameter on a straight handpiece with irrigation (see Fig. 1a). PRF preparation [10]: A-PRF were prepared from the patient's own blood; drawn (from the median cubital or cephalic vein) into the tubes without anticoagulant and were immediately centrifuged at speed of 1300 rpm for 8 mins. Pliers were inserted into the tubes to grab the fibrin clots with attached RBCs which were scraped away and discarded. A-PRF was placed on the grid in the PRF Box to create A-PRF membranes. Serum exudates collect in the bottom of the box beneath the grid and are used to hydrate graft materials. Some PRF membranes were cut and mixed with the graft material (Cerabone; Botiss, Germany) (see Fig. 1b). Using the piezo surgery inserts OT7a, OT8R, OT8L (Piezosurgery Mectron, Italy), a block graft of 3 mm thickness was harvested from either the retromolar area (see Fig. 1c) and were split into two bone shells using a diamond disc, then all sharp edges were smoothed to prevent any tissue dehiscence. Fixing the bone shells using profix kit (Osteogenics Biomedical, USA) and fixation screws (8–10 mm length, 1–1.5 mm diameter) from the buccal side leveled and positioned depending on preoperative evaluation of alveolar ridge resorption as well as desired vertical and horizontal bone level. The Xenograft-A-PRF mixture was delivered to the recipient site with the bone carrier to fill the gap in between the shells.

The bone shells were stabilized using the profix kit and fixation screws (8–10 mm length, 1–1.5 mm diameter)

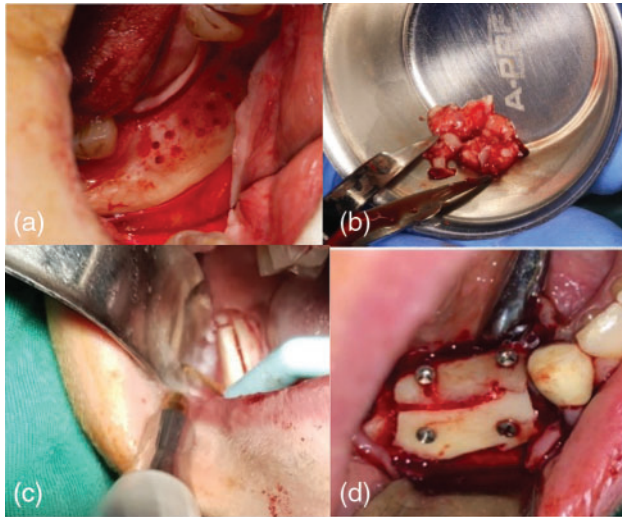


Fig. 1. (a) Decortication at the recipient site. (b) A-PRF preparation. (c) Piezosurgery assisted bone harvesting. (d) Fixation of bone shells over the augmented site.

from the crestal or lingual side depending on preoperative evaluation of alveolar ridge resorption (see Fig. 1d). After proper fixation of the shells, the augmented grafted bone was covered with pericardium collagen membrane (CopiOS membrane, ZIMVIE, Switzerland). The obtained A-PRF membrane was placed to cover the pericardium collagen membrane.

Flaps at the recipient site were released with horizontal peri-osteal releasing incision with mental nerve skeletonization on the buccal side as well as releasing the lingual flap from the mylohyoid muscle to assure enough tension free soft tissue coverage over the grafted site.

Soft tissues at the recipient site were closed hermetically with horizontal mattress sutures at 5 mm from the incision line followed by interrupted sutures to close the edges of the flap, and primary wound closure using polytetrafluoroethylene (PTFE) sutures was ensured. Finally, the vertical incisions were closed with interrupted sutures.

### 2.3. Post-Surgical Phase

The patients were directed to strictly follow the standard post-operative instructions. Dexamethasone 8 mg injection was prescribed immediately postoperatively. Antibiotics were continued and NSAID medication (Diclofenac Potassium 50 mg) was administered to all patients twice daily for 5 days. Patients were asked to continue the chlorhexidine mouthwash for the next 10 days.

### 2.4. Follow-Up Phase

Clinically, healing (presence or absence of infection and dehiscence of the flap) was evaluated over a period of two weeks postoperatively. The swelling was assessed on the 4<sup>th</sup>, 7<sup>th</sup>, and 14<sup>th</sup> postoperative days [11]. Evaluation of pain was performed using the visual analogue scale (VAS) on the 2<sup>nd</sup>, 7<sup>th</sup>, and 14<sup>th</sup> postoperative days [12]. As for Paresthesia, it was evaluated according to the Two Point Discrimination Test (TPD) on the 2<sup>nd</sup>, 7<sup>th</sup>, and 14<sup>th</sup> postoperative days [13].

TABLE I: COMPARISON BETWEEN THE DIFFERENT STUDIED PERIODS ACCORDING TO SWELLING

Swelling	Baseline	DAY 4	DAY 7	DAY 14
Min. – Max	12.0–13.70	13.0–14.50	12.50–14.10	12.10–13.70
Mean $\pm$ SD.	12.68 $\pm$ 0.57	13.69 $\pm$ 0.49	13.20 $\pm$ 0.51	12.84 $\pm$ 0.50
p <sub>0</sub>		<0.001*	0.001*	0.253
Sig. bet. periods.		p <sub>1</sub> < 0.001*, p <sub>2</sub> < 0.001*, p <sub>3</sub> < 0.001*		

Note: SD: Standard deviation. p<sub>0</sub>: p-value for comparing between Baseline and each other periods. p<sub>1</sub>: p-value for comparing between 4<sup>th</sup> post-operative and After 7 days. p<sub>2</sub>: p-value for comparing between 4<sup>th</sup> post-operative and After 14 days. p<sub>3</sub>: p-value for comparing between After 7 days and After 14 days. \*: Statistically significant at  $P \leq 0.05$ .

### 2.5. Radiographical Analysis

Cone beam computed tomography (CBCT) was done directly postoperatively (baseline) and after 6 months to check the amount of newly gained bone volume. All radiographs were evaluated by the same investigator. CBCT analysis was executed using a software program (CS 9600, Carestream, Atlanta, USA). The same sagittal cut on the area with the greatest defect was used at all follow-up periods to measure the bone width and height until the inferior alveolar nerve canal.

The obtained data were fed to the computer using the IBM SPSS software package, version 24.0 to analyze be interpreted (Armonk, NY: IBM Corp.). Numbers and percentages were used to describe qualitative data. The Kolmogorov-Smirnov test was employed to ensure that the distribution was normal. Range (minimum and maximum), mean, standard deviation, and median were used to characterize quantitative data. The significance of the acquired results was assessed at a 5% level.

## 3. RESULTS

### 3.1. Demographic Data

The fifteen participants consisted of 11 females and 4 males ranging in age from 38 to 58 years with a mean of  $49.32 \pm 4.23$  years.

### 3.2. Clinical Results

All the surgeries were successfully performed without complications. All surgical sites showed uneventful healing with no infections or flap dehiscence during the two-week follow-up period.

Table I compares swelling over the follow-up period, swelling reached a maximum value on the 4<sup>th</sup> day postoperatively of 14.50 cm. Values were back to baseline values after 14 days. There was a statistical significance ( $p < 0.001^*$ ) between the baseline and 4<sup>th</sup> day and between the baseline and 7<sup>th</sup> day. Also, a significant difference was present between the 4<sup>th</sup> and 7<sup>th</sup>, 4<sup>th</sup> and 14<sup>th</sup>, and 7 and 14<sup>th</sup> day.

Table II compares the VAS scores during the 3-week follow-up period. The 2<sup>nd</sup> postoperative day showed the highest pain score, values started to decrease after 1 week until they reached minimal values on the 14<sup>th</sup> day.

Fig. 2 shows the mean values of numbness over the follow-up period of 2 weeks. Paresthesia was apparent on



TABLE II: COMPARISON BETWEEN THE DIFFERENT STUDIED PERIODS ACCORDING TO PAIN

Pain	2 <sup>nd</sup> Postoperative	7 <sup>th</sup> day	14 <sup>th</sup> day
Min. – Max.	6.0–9.0	2.0–5.0	0.0–2.0
Mean $\pm$ SD.	7.60 $\pm$ 0.99	3.33 $\pm$ 1.11	0.40 $\pm$ 0.63
Sig. bet. periods.	p <sub>1</sub> = 0.006*, p <sub>2</sub> < 0.001*, p <sub>3</sub> = 0.006		

Note: SD: Standard deviation. p<sub>1</sub>: p-value for comparing between 2<sup>nd</sup> post-operative and After 7 days. p<sub>2</sub>: p-value for comparing between 2<sup>nd</sup> post-operative and After 14 days. p<sub>3</sub>: p-value for comparing between After 7 days and After 14 days. \*: Statistically significant at  $P \leq 0.05$ .

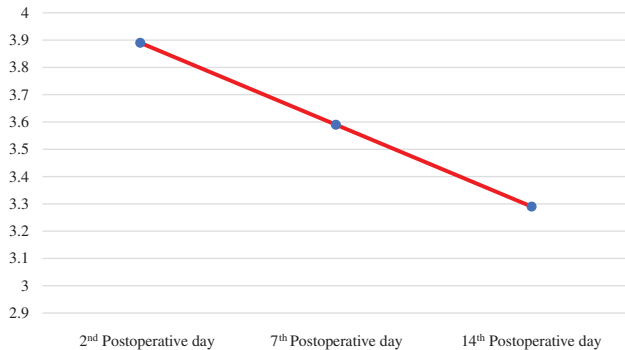


Fig. 2. Comparison between the three studied periods according to numbness.

TABLE III: COMPARISON BETWEEN THE DIFFERENT STUDIED PERIODS ACCORDING TO BONE QUANTITY

Bone height in mm	Preoperative	Baseline	After 6 months
Min. – Max.	4.0–7.0	9.5–12.5	9.0–12.5
Mean $\pm$ SD.	5.79 $\pm$ 0.92	11.55 $\pm$ 0.75	11.32 $\pm$ 0.82
Sig. bet. periods.	p <sub>1</sub> < 0.001*, p <sub>2</sub> < 0.001*, p <sub>3</sub> = 0.062		

Note: SD: Standard deviation. p<sub>1</sub>: p-value for comparing between Pre-operative and Baseline. p<sub>2</sub>: p-value for comparing between Pre-operative and after 6 months. p<sub>3</sub>: p-value for comparing between Baseline and after 6 months. \*: Statistically significant at  $P \leq 0.05$ .

the 2<sup>nd</sup> postoperative day, but the values were decreasing gradually from after 1 week till the 2<sup>nd</sup> week. All patients had a full sensory recovery after 6 months.

### 3.3. Radiographic Results

Table III and Figs. 2a, 2b, and 3 show the comparison of mean bone height during the 6-month follow-up. Significant differences existed in mean ridge bone height preoperatively and directly postoperatively, and preoperatively and after 6 months ( $P < 0.001^*$ ). The mean value after 6 months was less than the baseline, but a non-significant difference existed between the two periods ( $P = 0.62$ ).

## 4. DISCUSSION

Following tooth extraction, an inevitable sequence of events occurs that can occasionally result in deficiencies of the vertical and horizontal ridges. Within the first three months following extraction, 50% of the horizontal ridge displacement and roughly 0.7 mm of the vertical volumetric changes, respectively, were observed [14]. A systematic review done by [15] demonstrated that a mean

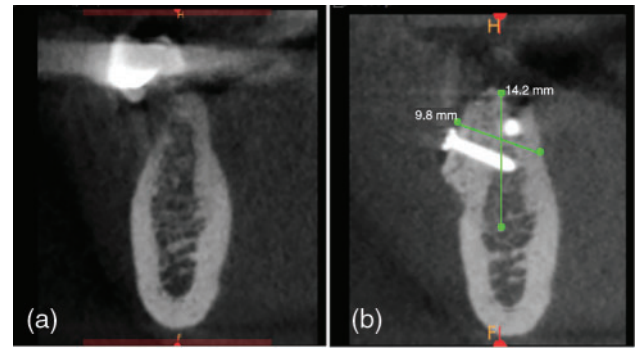


Fig. 3. (a) Preoperative CBCT, (b) 6 months post operatively CBCT showing available bone quantity.

buccal-lingual/palatal dimension of 3.87 mm and a vertical reduction of 1.7 mm may prevent oral rehabilitation because there is insufficient support to achieve implant stabilization in an appropriate position after all resorptive events have ended.

This study is a randomized controlled clinical trial, where fifteen consecutive patients were enrolled with an age range from 30 to 60 years. 3D ridge reconstruction was performed using bone shells technique, where a thick bone block graft was harvested from the ramus area and sectioned with a disc into 2 shells that were fixed with fixation screws at the recipient site. A-PRF-Cerabone mixture was used to fill the gap and was covered with a crosslinked membrane (pericardium) followed by A-PRF membranes.

Clinical & radiographic evaluation was performed immediately and for a follow-up period of 6 months. Assessment of soft tissue healing took place by evaluating the soft tissue dehiscence, as well as infection over different follow-up periods. All wounds exhibited complete closure on the 14<sup>th</sup> day with no signs of soft tissue dehiscence recorded among all patients in both groups throughout the evaluation period of this study.

This can be well explained [16] who conducted a study to evaluate the benefits of using PRF in alveolar ridge augmentation, however, his study came out to demonstrate that the presence of A-PRF membrane can improve soft-tissue healing and reduce tissue dehiscence. Furthermore, the management of soft tissue as flap design, dissection, and suturing technique are considered as keys of success in primary wound closure.

In the course of early follow-up evaluating patients for swelling, the results revealed a statistically significant difference between the follow-up period of 4<sup>th</sup>, 7<sup>th</sup> and 14<sup>th</sup>. Those readings run in parallel with [17] who explained in a study the effect of block graft harvesting on the facial swelling. With three points difference in the VAS, swelling, and discomfort due to swelling were significantly higher in patients with autologous bone blocks. The swelling was perceived as the main reason for discomfort in both groups and therefore seemed to be a highly relevant factor for patients' comfort and satisfaction.

When evaluating the presence or absence of pus or infection, no statistically significant difference was found at all during the follow-up period. Upon evaluating the intensity of pain, this study showed a statistically significant difference between different periods of the 2<sup>nd</sup> and 7<sup>th</sup> day respectively where the p-value = 0.01 < 0.05 in favor of

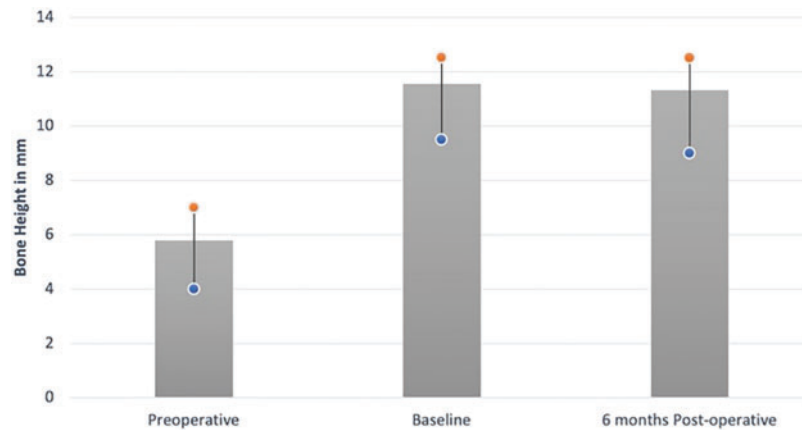


Fig. 4. Comparison between the three studied periods according to bone quantity.

the control group. These findings can be well explained due to the presence of a second wound at the donor site where bone block harvesting can intensify the pain in the early stage of healing due to extensive flap design, hematoma, or exposure of the inferior alveolar nerve.

Reference [17] a study to evaluate morbidity-related parameters between autologous and allogeneic bone grafts for alveolar ridge augmentation found that the majority of patients felt that the harvesting was more painful than the insertion, and over half of those who had autologous bone blocks enhanced became aware of the second wound. Compared to patients getting allogeneic bone blocks, the autologous group experienced twice as many nerve irritations from surgery, and their strain rating was higher.

Reference [18] examined the early postoperative problems following lateral ridge augmentation utilizing adhesive bone or the shell approach in comparative clinical research. They discovered that the shell group had more discomfort overall, ranging from mild to moderate; surprisingly, the harvesting technique may have an impact on the degree of pain: Using piezo surgery can significantly minimize pain and morbidity at the donor site. All signs of pain has been subsided during healing time and all patients exhibited normal feelings on day 14.

When evaluating the persistence of paresthesia results have shown that the study group recorded more time for recovery from numbness than unusual over the follow-up period of 4<sup>th</sup>, 7<sup>th</sup>, and 14<sup>th</sup> days which can be explained due to the technique of flap management, dissection, and mental nerve skeletonization as well as harvesting of the block graft. That was confined to [19] those who justified in his study that temporary and permanent paresthesia have been described after harvesting autologous bone grafts.

On the other hand, [20] concluded in his study that temporary mental paresthesia after harvesting chin grafts ranges from 10% to 50%, whereas the mandibular ramus ranges from 0% to 5%.

Noticing that all patients in both groups showed complete recovery over the period of one month. Cone beam computed tomography was performed immediately after bone augmentation surgery, and at 6 months before placement of the implant, to measure the bone gained after the surgery. Where a statistically significant difference was noticed when comparing bone quantity at baseline and at 6 months (Fig. 4).

These results run parallel with [21] those who showed comparable results regarding vertical and horizontal augmentation gain when using the autologous and allogeneic bone shells.

Moreover, A comparative study between different bio-material, mixed with autogenous bone in vertical ridge augmentation [22] advocated that xenograft mixed with autogenous bone provide a reliable material to significantly improve bone quantity and increase bone for optimal implant success. Furthermore, a study [23] comparing GBR using autogenous bone mixed with concentrated growth factors and bone shell technique showed a non-statistical significant difference between both groups in regards to the amount of gained bone, both groups showed an increase in bone quantity after augmentation.

[24] recently published a retrospective analysis that included 117 consecutively treated patients with 128 transplanted sites that were followed for up to 17 years, as well as 88 patients and 97 augmented sites that were followed for at least 10 years. the mean vertical bone gain in this study was  $7.4 \pm 2.6$  mm, whereas the results following a 10-year follow-up period remained largely stable, accounting for a mean vertical ridge augmentation of  $6.7 \pm 2.6$  mm.

## 5. CONCLUSION

Within the limitations of this study, it can be concluded that the modified shell technique demonstrated promising clinical and radiographic results. Bone harvesting was safe using Piezoelectric tips with all the advantages of autogenous bone properties, and the rigidity of the bone shells that maintain the space necessary for augmentation. Furthermore, a PRF/xenograft mixture might improve bone height within the augmented posterior mandible as well as enhance soft tissue healing. To generalize these findings, more research with a larger sample size is recommended.

## CONFLICT OF INTEREST

Authors declare that they do not have any conflict of interest.

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