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# EFFICACY OF STICKY BONE IN HORIZONTAL ALVEOLAR RIDGE AUGMENTATION IN MAXILLAY ANTERIOR REGION

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## ABSTRACT

**INTRODUCTION:** In order to fulfill the optimum objectives of implant dentistry, there are numerous methods available for effective soft and hard tissue augmentation to present ideal bone volume and quality. The strategy is mostly determined by the severity of the defect and the particular procedures to be carried out for the implant or prosthetic rehabilitation; especially in the anterior esthetic zones.

**AIM OF THE STUDY:** To assess the horizontal alveolar ridge augmentation both clinically and radiographically using cone beam computed tomography (CBCT) after placing sticky bone covered by Concentrated Growth Factor Membrane (CGF) in the anterior esthetic zone.

**MATERIALS AND METHODS:** Ten patients presenting with Seibert Class I ridge classification (labio-palatal anterior maxillary residual alveolar width ranged from 3-4 mm) received horizontal augmentation using Sticky Bone covered by PRF membrane. Patients were post-operatively assessed for pain (using Visual Analogue Scale), edema, and any signs of inflammation or infection. CBCT scans were taken preoperatively, and after 3 and 6 months to assess the changes in horizontal bone quantity and bone density.

**RESULTS:** Clinically, all patients showed normal soft tissue healing. Radiographically, the horizontal bone gain after three months ranged from 2.13 to 3.39 mm with a mean ± SD of 2.86 ± 0.38 mm. At sixth month, bone gain ranged from 2.07 to 3.35 mm with a mean ± SD of 2.84 ± 0.39 mm. At the third month, bone density ranged from 851.01-883.15 HU with a mean ± SD of 868.51±11.07 HU. At the sixth month, the bone density ranged from 1013.72-1198.12 HU with a mean ± SD of 1096.36 ± 54.44 HU. Bone density at the sixth month was statistically significantly higher compared with bone density at the third month (D2 850-1250).

**CONCLUSION:** Based on the study results, horizontal ridge augmentation using sticky bone covered by PRF membrane significantly increased the quantity and quality of bone. Thus, it is a simple technique that can boost the rate bone formation.

**KEYWORDS:** Bone graft, Sticky bone, Ridge augmentation.

**RUNNING TITLE:** Efficacy of sticky bone in anterior maxillary alveolar ridge augmentation

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## INTRODUCTION

Alveolar ridge augmentation is the first treatment choice in the anterior maxillary region for improving functional and aesthetic outcomes and providing a suitable ridge contour for an optimal implant placement (1).

To achieve these outcomes, a variety of bone grafting materials and bone volume enhancement methods have been developed, including traditional horizontal ridge augmentation methods that use particulate or block bone grafting materials (GBR) (2).

Bone grafting is the surgical procedure of inserting an autologous bone graft or biocompatible graft material into the gaps around a broken bone or other bone defect. (3). Defects can be augmented with bone from the patient's own body (autogenous bone) or using an artificial, synthetic, or naturel substitute to fill in defects. The graft aids in both supplementing bone defects and regrowing its own missing bone. (4).

To accelerate the healing process of bone graft in the bony defect, many techniques utilizing platelets and fibrinogen concentrations have been described. Platelets contain high volumes of growth factors, such as platelet-derived growth factor (PDGF), transforming growth factors β1 (TGF-1), vascular endothelial grawth factors (VEGF), epithelial growth factor (EGF), insulin growth factor-I (IFG-I) which stimulate cell proliferation and regulate angiogenesis (5).

Platelet rich plasma (PRP) and plasma rich in growth factors (PRGF) are the first generation of platelet concentrates. PRP and PRGF need chemical additives such as anticoagulants and thrombin or calcium chloride to stimulate fibrin cross-linking before application to the surgical site. Platelet rich fibrin (PRF) as the second generation of platelet concentrate, uses the patient's venous blood alone to trigger platelet activation and fibrin cross-linking (6).

Concentrated Growth Factor (CGF) membrane can be used as barrier membrane over

bone grafts, for acceleration of tissue regeneration. Unlike PRF that uses a regular centrifugation speed, the CGF membrane produces a much larger, denser and richer fibrin matrix containing growth factors by changing centrifugation speeds (7).

To the best of our knowledge, no studies were conducted to assess the horizontal alveolar ridge augmentation after bone grafts covered by CGF membranes in the anterior esthetic zone. Thus, aim of this study was to evaluate the efficacy of using Sticky Bone (autologous concentered growth factors enriched allograft graft matrix covered by CGF membrane) in augmenting narrow maxillary anterior ridges for implant placement.

## MATERIALS AND METHODS

Ten patients recruited from the Outpatient Clinic of Alexandria University Teaching Hospital and the Oral and Maxillofacial Surgery Department, Faculty of Dentistry, Alexandria University. Ethical clearance was obtained from the Research Ethics Committee, Faculty of Dentistry, Alexandria University, and all patients provided their informed consents. Patients were included if they had one missing maxillary anterior tooth extracted since at least six months, sufficient maxillary residual alveolar ridge height of 14.09 mm +/- 3.78 (8) and insufficient alveolar bone ridge width less than 4 millimeter. Patients should have good oral hygiene, proper compliance to the treatment plan and healthy oral mucosa. Exclusion criteria were alveolar bone pathology, patients with immunological diseases, bad oral hygiene, and heavy smokers.

The Bone Graft

AlloBind particulates (MAXXEUS DENTAL™) (100% human tissue no synthetic or animal ingredients) are freeze-dried powder that once rehydrated, can be handled like a putty. Unlike a putty, the flexibility of AlloBind gives the operator the ability to achieve the required graft consistency.

Preparation of sticky bone and CGF membrane (PRF) (9)

The patient's forearm vein was utilized to collect 20CC of venous blood, which was then divided equally between glass-coated test tubes without anticoagulants to create CGF layer and non-coated vacutainers to create autologous fibrin glue (AFG), which was employed to create sticky bone. (Figure 1A)

For 12 minutes, blood in the test tubs was centrifuged at 2400–2700 rpm with a rotary rotating at a controlled and alternating speed. For AFG, the centrifugation period ranged from 2 to 12 minutes.

After two minutes of centrifugation, the centrifuge was stopped, and the AFG tube was removed first. The tube that was not covered revealed two distinct layers. Red blood cells were gathered in the bottom layer, which was discarded, and the top layer was autologous fibrin glue (AFG).

In order to create sticky bone that is yellow in color, the upper AFG was retrieved with a syringe and combined with bone powder particle (Figure 1B,C). This mixture was then left to polymerize for five to ten minutes (Figure 1D).

Centrifugation was continued to prepare CGF. Three distinct layers can be seen on a silica coated tube following centrifugation (figure 1 A). The middle layer, represented by a vary massive and dens polymerized fibrin block holding the concentrated growth factors, was the fibrin buffy coat layer. The uppermost layer was platelet-poor plasma (Figure 1E). Red blood cells made up the lowest layer. To create a concentrated growth factor enriched fibrin membrane, the concentrated growth factor layer was compressed. (Figure 1F)

Preoperative phase

Treatment planning started with clinical examination and cone beam computed tomography (CBCT) to determine the alveolar ridge dimensions (Figure 2A, 2B).

Surgical phase

The patient rinsed thoroughly for 30 seconds with 0.12% chlorhexidine mouthwash (Listermix Plus, Sigma, Egypt) one minute prior to the surgery. Local anesthesia was achieved by administration of Articaine (D.C.I) 40.00 Mg Hydrochloride, Epinephrine (D.C.I) (Tartrate) 0.01 Mg (INIBSA ARTINIBSA 4% 1:100.000 – brand manufactured in Spain). Incision was made with blade no #15, a fully-reflected mucoperiosteal flap (trapezoidal flap) (figure 3B) was made and the alveolar ridge was exposed. Decortication of labial plate of bone using a small round bur was performed (Figure 3C), then the prepared sticky bone was grafted over the defect and covered by concentrated growth factors enriched fibrin membrane (PRF) (Figure 3 D, E). The wound was closed by silk 0/3 suture. (Figure 3F)

Post-operative phase

Patients were instructed to perform cold fomentations 4 times every 6 hours in the first 24 hours.

Clavimox 1gm antibiotic was prescribed (Amoxicilin 875 mg + Clavulnic acid 125 mg: PHARCO, Egypt) for 8 days twice daily. Metronidazole 500 mg (Flagyl: metronidazole 500mg: GlaxoSmithKlin, UK) was prescribed every eight hours for 5 days. Diclofenac Sodium 50 mg (Vantomor: Diclofnac Sodium 50mg: HIGYNT-Switzerland) was prescribed for 5 days 3 times daily. Warm chlorhexidine HCL (0.12 %) mouthwash (Hexitol, Arab Drug Company) was prescribed 3-4 times daily for 1 week. Sutures were removed 7 days after the surgery.

Follow-up phase

*Clinical evaluation*

On the first two weeks after surgery postoperatively we evaluated the following:

Any signs of inflammation, infection or tissue dehiscence (10).

Perceived pain using a Visual Analogue Scale (VAS) ranging from 0 to 10 where pain intensity was scored from 0 (No pain) to 10 (unbearable pain) (11).

Edema resulting from the postsurgical inflammatory response (12).

"Edema was assessed by pressing on the skin using a finger, and if the finger indent remained, then the person had edema. The edema was scored using a scale ranging from 0 (no edema) to 10 (strong edema)"

Three and six months postoperatively, CBCT scans were taken and the change in bone quantity and density were compared with the preoperative measures using a computer software (OnDmand3D, Cybrmed Inc., Korea).

Statistics

Data were collected and entered to the computer using Statistical Package for Social Science (SPSS) program for statistical analyses (Version 21). Data were entered as numerical or categorical variables, as appropriate. Kolmogorov-Smirnov test of normality revealed no significance in the distribution of the variables, so parametric statistics was adopted. Comparisons were carried out between two studied dependent normally distributed variables using paired t-test. Distributed subgroups were compared using Wilcoxon Signed Ranks test. Cochran's Q test was used to verify whether the proportion of successes (response) was the same between the two times of measurements.

During sample size calculation, beta error was accepted up to 20% with a power of study of 80%. An alpha level was set to 5% with a significance level of 95%. Statistical significance was tested at p value <.05.

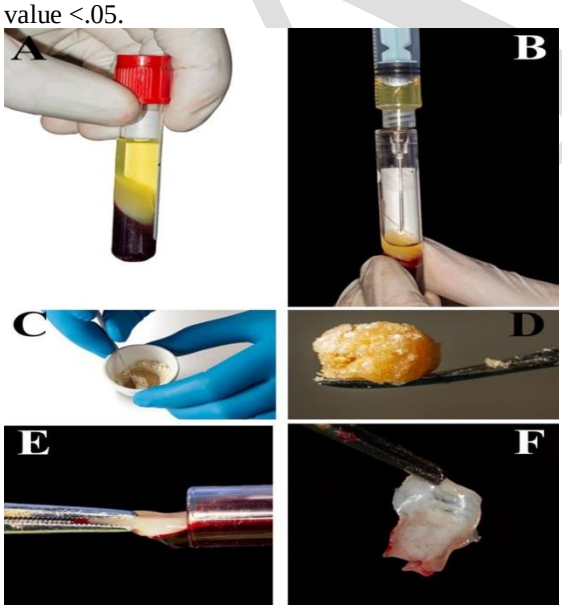


**Figure 1:** Preparation of sticky bone (**A.** 3 different layers, **B**. AFG layer obtained with a syringe. **C**.AFG mixed with particulate bone powder. **D.** sticky bone **E**. dense polymerized fibrin block containing the concentrated growth factors. **F.** CGF membrane (PRF)).

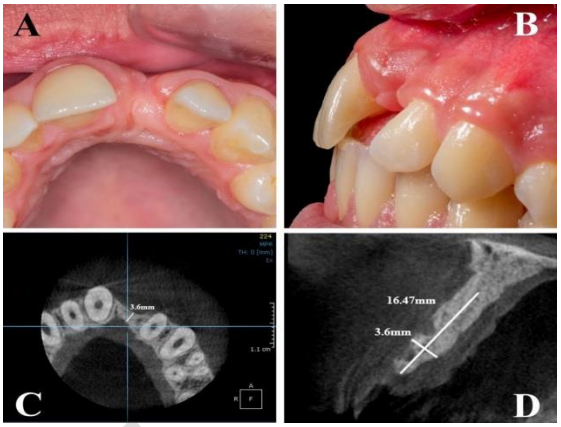


**Figure 2:** Preoperative alveolar ridge (**A&B**. clinical view, **C&D**. radiographical view).

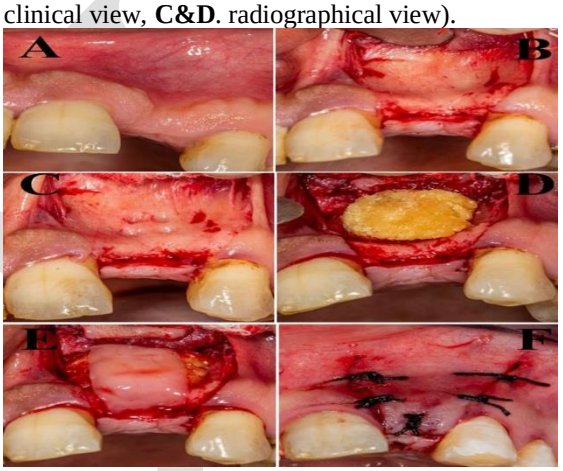


**Figure 3:** Alveolar ridge augmentation (**A**. preoperative clinical view. **B.** incision and reflection of the flap. **C.** decortication of the labial plate of bone. **D**. placing sticky bone. **E.** PRF membrane cover **F**. suture.

## RESULTS

This study included 10 patients presented with alveolar bone defect in the maxillary anterior region and treated with sticky bone and covered by CGF membrane.

Wound Healing

Two weeks postoperatively, all cases showed normal soft tissue healing without any signs and symptoms of infection or tissue dehiscence.

Pain

At the first week, VAS (Visual Analog Scale) ranged from 1.00-7.00 with a mean ± SD of 4.30 ± 1.77, SEM of 0.56 and 95% CI of the mean 3.04, 5.56.

At the second week, VAS ranged from 0.00-3.00 with a mean ± SD of 1.30 ± 1.06, SEM of 0.33 and 95% CI of the mean 0.54, 2.066.

VAS at the first week was significantly higher than VAS at the second week ($p$<0.001).

Edema

At the first week, edema score ranged from 0.00 (none) - 7.00 (moderate) with a median of 5.00, and 95% CI of the mean 3.00 (mild) - 7.00 (moderate).

At the second week, edema score ranged from 0.00-3.00 with a median of 0.00.

Edema score at the first week was significantly higher than edema score at the second week ($p$=.007).

Bone Gain

At the third month, bone gain ranged from 2.13-3.39 mm with a mean ± SD of 2.86 ± 0.38 mm, SEM of 0.12 mm and 95% CI of the mean 2.58, 3.13 mm (Table1, Figure 4).

At sixth month, bone gain ranged from 2.07-3.35 mm with a mean ± SD of 2.84 ± 0.39 mm, SEM of 0.12 mm and 95% CI of the mean 2.56, 3.11 mm (Table1, Figure 4).

Bone gain at the third month was significantly higher than bone gain at the second week ($p$=.007).

The percent difference in bone gain (third month and sixth month) ranged from -2.82 to 0.66 mm with a mean ± SD of -0.86 ± 0.87 mm, SEM of 0.28 mm and 95% CI of the mean -1.49, -0.24 mm.

Bone Density

At the third month, bone density ranged from 851.01-883.15 HU with a mean ± SD of 868.51 ± 11.07 HU, SEM of 3.50 HU and 95% CI of the mean 860.43, 857.31 HU (Table 2).

At the sixth month, bone density ranged from 1013.72-1198.12 HU with a mean ± SD of 1096.36 ± 54.44 HU, SEM of 17.22 HU and 95% CI of the mean 1057.42, 1135.31 HU (Table 2).

Bone density at the sixth month was significantly higher than bone density at the third month ($p$<.001).

The percent difference in bone density (first 3 months and second 3 months ranged from 16.27-35.66 with a mean ± SD of 26.22 ± 5.67, SEM of 1.79 and 95% CI of the mean 22.16, 30.27.

In order to confirm the gray scale values to Howensfield Unit (HU), the Micsh classification was used. The mean bone density value for newly formed bone postoperatively was equivalent to bone density levels of D2 (850-1250 HU) and D3 (350-850 HU) bone types, as proposed by the bone density classification by Micsh. (13)

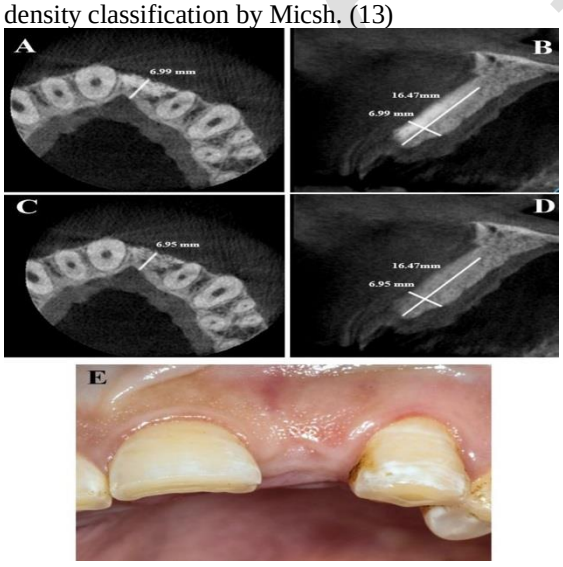


**Figure 4:** Postoperative clinical and radiographic alveolar ridge view (**A&B.** 3 months, **C&D.** 6 months & **E**. Clinical view after 6 months).

**Table (1):** Bone Gain (H) in the studied group.

| Bone Gain (H) mm | |
|---|---|
| At third month | |
| n | 10 |
| Min-Max | 2.13-3.39 |
| Mean ± S.D. | 2.86±0.38 |
| SEM | 0.12 |
| 95% CI for mean | 2.58-3.13 |
| At sixth month | |
| n | 10 |
| Min-Max | 2.07-3.35 |
| Mean ± S.D. | 2.84±0.39 |
| SEM | 0.12 |
| 95% CI for mean | 2.56-3.11 |
| Independent t test | $t_{(df=9)}$= 3.446 |
| $p$-value | $p$=.007* |
| Percentage change (%) | |
| n | 10 |
| Min-Max | -2.82 – 0.66 |
| Mean ± S.D. | -0.86±0.87 |
| SEM | 0.28 |
| 95% CI for mean | -1.49 - -0.24 |

**Min-Max**: Minimum – Maximum
**S.D.**: Standard deviation
**SEM**: Standard error of the mean
**CI**: Confidence interval

**Table (2):** Bone density (HU) in the studied group.

| Bone density (HU) | |
|---|---|
| At third month | |
| n | 10 |
| Min-Max | 851.01-883.15 |
| Mean ± S.D. | 868.51±11.07 |
| SEM | 3.50 |
| 95% CI for mean | 860.43-857.31 |
| At sixth month | |
| n | 10 |
| Min-Max | 1013.72-1198.12 |
| Mean ± S.D. | 1096.36±54.44 |
| SEM | 17.22 |
| 95% CI for mean | 1057.42-1135.31 |
| Independent t test | $t_{(df=9)}$= 14.374 |
| $p$-value | $p$<.001* |
| Percentage change (%) | |
| n | 10 |
| Min-Max | 16.27-35.66 |
| Mean ± S.D. | 26.22±5.67 |
| SEM | 1.79 |
| 95% CI for mean | 22.16-30.27 |

## DISCUSSION

Changes in the edentulous alveolar ridge dimensions have been previously reported. According to Tan et al., in 2012, vertical alveolar ridge resorption ranges

from 11% to 22%, while horizontal bone resorption ranges from 29% to 63%, with two-thirds of the ridge lost in the first three months after teeth loss. To achieve maximum primary implant stability and osseointegration, residual alveolar ridges must have appropriate bone volume and quality (14).

In the last several decades, guided bone regeneration techniques have significantly advanced. A basic GBR method entails using a barrier (membrane) to separate the site and shield the underlying blood clot and bone graft. It had been disclosed that an optimum barrier stabilizes the graft, and also prevents epithelial and connective tissue cells from seeping into the grafted location from the bordering soft tissues.

Our study focused on radiographic changes of the bone graft material volume evaluated using CBCT analyses after horizontal alveolar ridge augmentation in the maxillary anterior region by an allograft bone graft (100% human tissues without synthetic or animal ingredients). Particulates were packaged as a freeze-dried powder, and the bone graft was covered by a CGF membrane. The concept of "Concentrated Growth Factors (CGF)" was introduced as the third generation to Choukroun's PRF and gave the revolution of fabricating growth factors-enriched bone graft matrix (also known as "sticky bone") using autologous fibrin glue as demonstrated by Sohn (2010). Sticky Bone may be molded into numerous shapes and is hence well fitted over many types of bone defects. Thus, the volume of bone augmentation is maintained during the healing process, minimizing the need for block bone and titanium mesh. This prevents micro and macro movement of the grafted bone. To release growth factors, the fibrin network entraps platelets and leukocytes, promoting bone and soft tissue regeneration (9).

According to our results, at the first week after surgery, the patients experienced slight pain at the surgical site which subsided totally by the second week . Patients did not experience any signs of pain on the first week. These limited postoperative signs after using the second generation of platelets concentrates agree with the studies done in 2006 by Choukron et al. (15), in 2007 by Grosi et al. (16) and in 2008 by Baqian et al. (17).

The patients in our study experienced excellent wound healing gradually after the surgery without any signs and symptoms of inflammation, infection, or tissue dehiscence up to 6 months postoperatively.

All patients experienced edema of varying degrees ranging from mild to moderate edema grade in the first week after surgery which gradually subsided in the second week to disappear completely by the end of second week.

Our studies revealed a significant increase in bone width after six months, which is consistent with several studies evaluating the impact of PRF using various grafting materials. According to Choukroun et al. (15), the combination of PRF that contain CGF and bone transplant (allograft) can promote greater bone regeneration.

Our hypothesis in this study, which has been supported by the study's findings, was that employing membranes would not provide any further benefits. Numerous investigations had shown that a GBR membrane is meant to enclose and shield the graft material during the delicate bone-remodeling phase and its fusion with the original bone (18). However, there are a number of drawbacks to using GBR membranes, including the difficulty in stabilizing the membrane, its astronomical coast, and its rapid and unpredictable disintegration (19) that can lead to a weakened barrier effect as well as the presence of chemical residues that might trigger an unfavorable host immunoinflammatory response during the healing phase.

The results of our study are comparable with those of Aboelela et al. (2021) (20) who evaluated the efficacy of inorganic bovine bone and autogenous bone combination with CGF and showed a mean gain of 2.4 mm, whereas, in our study, the mean gain achieved was 2.43 mm after three months, and 2.84 mm after six months.

The results obtained were also in agreement with Tony et al. (2022) (21), who assessed the effect of sticky bone in horizontal ridge augmentation without collagen membrane and used The Bio-OSSTM (Geistlich®, Switzerland) bone graft in augmentation of the resorbed ridges with mean horizontal bone gain of 2.8 mm. The PRF matrix prevents early epithelial ingress onto the defect site, leading to significant new gains in horizontal dimensions and serves as a scaffold and favors new bone formation by osteoconduction. In addition, the sticky bone matrix covered by PRF may have led to adherence of the grafted material to the recipient sites without micro and macro movements.

There was a noticeable increase in bone density after six months. This is in line with the findings of Ozeimir et al. (22), who showed that the usage of PRF can improve the quality (density) of newly produced bone and sped up the process of bone formation. This may be attributed to the concentrated growth factor present in PRF, which is consistent with our findings.

According to Kumar and Shubhashini (23), platelet-rich fibrin (PRF), a second-generation platelet concentrates, had been utilized extensively to speed up the heeling of both soft and hard tissue. This may be because PRF contains growth factors as well as inflammatory and healing cytokines. This outcome is consistent with our findings.

According to Roy et al. findings, the usage of PRF matrix effectively increased wound angiogenesis and endothelial cell proliferation in

chronic wounds, and this is in line with our results (24).

Membrane exposure exacerbates the issue by leading to infections, which has an impact on the effectiveness of treatment. Garcia et al. (2018) reported in a systematic review and meta-analyses that using a collagen membrane for GBR sites with membrane exposure resulted in a considerably lower horizontal bone growth (25). Additionally, Lee et al. in 2013 and Eskane et al. in 2017 came to the same conclusion that early membrane exposure caused a considerable decrease in the width of the alveolar ridge. We further noted that there was no membrane exposure in our trial, and all locations healed well (26,27).

Atia et al. evaluated the efficacy of using Autologous Concentrated Growth Factors (CGF) Enriched Bone Graft Matrix (Sticky Bone) and CGF-Enriched Fibrin Membrane in management of dehiscence defects around dental implants in narrow maxillary anterior ridges and their research revealed that the vertical dehiscence defect was adequately repaired in five implant sites, and was reduced in the remaining six sites to a mean (SD) value of 1.25 (0.69) mm. The defect coverage in six implants occurred with a mean (SD) value of 4.59 (0.49). Additionally, the study findings revealed that the mean (SD) implant stability was 59.89 (3.92) mm. These findings demonstrated that combining PRF with CGF and bone transplant (allograft) can improve the density and quality of newly generated bone while speeding up the process (28).

As an alternative to titanium mesh or block bone, CGF enriched bone matrix with CGF enriched fibrin membrane may be employed. They can be molded, which makes them ideally suited to cover a variety of bone defects. The volume of bone augmentation is maintained during the healing process because micro and macro movement of the grafted bone is minimized. The release of growth factors by platelets and leukocytes from the fibrin network speeds up bone and soft tissue regeneration (9).

## CONCLUSION

The combination of CGF enriched bone graft matrix (sticky bone) and CGF enriched fibrin membrane (PRF) can be very effective for augmentation of alveolar bone defects.

Sticky bone not only enhanced the rate of new bone formation, but also increased the quality (density) of the newly formed bone.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

FUNDING STATEMENT

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