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EVALUATION OF RIDGE AUGMENTATION USING STICKY BONE WITH TITANIUM-RICH PLASMA MEMBRANE VERSUS WITH COLLAGEN MEMBRANE FOR SIMULTANEOUS ANTERIOR MAXILLARY IMPLANT PLACEMENT

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ABSTRACT

BACKGROUND: The ability to restore dental function is limited by the resorption of the alveolar ridge after tooth extraction, periodontal disorders, trauma, or congenital anomalies. Therefore, it is often necessary to augment hard tissue. Recently, bone graft and plasma derivatives, including platelet-rich fibrin and Titanium platelet-rich fibrin, have improved success when used in ridge augmentation.

AIM OF THE STUDY: To evaluate the effect of ridge augmentation using sticky bone with Titanium platelet-rich fibrin versus collagen membrane on bone thickness, peri-implant bone density, and implant stability.

METHODS: This study included twenty patients with horizontal ridge defects in the esthetic zone in maxillary anterior teeth. Patients were allocated to two groups: the study group treated with T-PRF and the control group with sticky bone covered with a collagen membrane. Postoperative clinical assessment of implant stability, pain, and edema and radiographic assessment of bone width and density were performed over 6 months.

RESULTS: There was no statistically significant difference between the two groups immediately and after 6 months postoperatively regarding bone density, bone width, and implant stability.

CONCLUSION: Under the limitations of the present study, the study showed that both T-PRF and collagen membranes improved the clinical parameters, indicating that they are helpful in soft and hard tissue healing due to more bone fill percentage by preventing unwanted tissues from growing into the area of bone healing.

KEYWORDS: Bone graft, sticky bone, platelet-rich fibrin.

RUNNING TITLE: Titanium Platelet-Rich Fibrin Versus collagen membranes in dental implants.

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INTRODUCTION

The inadequate alveolar ridge height is one of the most crucial obstacles in placing such implants. When the required amount of the alveolar ridge is more than what is there, this indicates that rather than going for a simple 'standard implant,' it is more prudent to use other techniques. In such severely compromised risks of implants and prosthesis, the following may be employed: horizontally augmenting the deficient alveolar ridge using guided bone regeneration techniques or vertical bone blocks from the autogenous bone, vertical distraction osteogenesis, or vertical reconstruction with titanium mesh incorporating particulate or inlay bone graft(s).(1).

The dentist should use the best methods to get the best results in the least amount of time. The ideal process should be straightforward, barely intrusive, and have a low chance of complications (2). Onlay grafts are frequently performed as guided bone regeneration (GBR) procedures using particulate or block-type autogenous bone grafts to restore one-wall defects (3).

Platelet concentrates have proven advantageous in enhancing bone and soft tissue healing in various dental and maxillofacial procedures. These applications include alveolar ridge augmentation (4).

Platelet-rich fibrin from human blood comprises various blood cells, including platelets, B- and T-lymphocytes, monocytes, stem cells, neutrophilic granulocytes, and growth factors (5).

The coagulation process is initiated through centrifugation, resulting in the formation of a clot. This clot comprises a three-dimensional fibrin network that encapsulates platelets and other blood cells. Within five to ten minutes post-clotting, the Platelet-Rich Fibrin (PRF) clot commences the release of growth factors (6).

The double-spin open technique is recommended for dental applications due to its cost-effectiveness, high platelet yield, and flexibility in producing varying volumes of PRP (7).

Titanium-rich fibrin platelet concentrate (T-PRF), a third-generation platelet concentrate, has a dense fibrin network with a prolonged resorption period. Therefore, we sought to test the effectiveness of T-PRF as an absorbable barrier membrane and evaluate its regenerative potential in bone formation (8).

Collagen materials are used in medicine and dentistry because of their proven biocompatibility and ability to promote wound healing. For guided tissue regeneration (GTR) procedures, collagen membranes are comparable to non-absorbable membranes in terms of reduction in depth of exploration, clinical gain of adhesion, and percentage of filling of the bone (9).

Bone graft and plasma derivatives, including platelet-rich fibrin (PRF) and Titanium platelet-rich fibrin (T-PRF), have been successfully used in ridge augmentation. Research is needed to compare their effectiveness.

The present study aims to evaluate the effectiveness of using sticky bone covered with Titanium platelet-rich fibrin versus sticky bone covered by collagen membrane on bone thickness, peri-implant bone density, and implant stability.

MARTIAL AND METHODS

This Randomized Controlled Trial was conducted under the CONSORT[i] standards and was approved by the ethical committee of the Faculty of Dentistry, Alexandria University (approval No is 0708-6/2023).

The minimal sample size is calculated based on a previous study to evaluate the efficacy of sticky bone in horizontal ridge augmentation with and without collagen membrane.(10) Tony et al. (2022)(10) concluded that sticky bone (Xenogenic-bone graft + i-PRF) served as a promising biomaterial in achieving better horizontal bone width gain. The sample size was calculated to detect the difference in the alveolar ridge augmentation. Based on Tony et al. (2022)(10) results, adopting a power of 80% (□=0.20) to detect a standardized effect size in Horizontal Ridge Width (HRW) (Primary Outcome) of 1.572, and level of significance 5% (α error accepted =0.05), the minimum required sample size was found to be **eight patients per group** (number of groups=2) **(Total sample size=16 patients)**(11,12). After adjustment for a dropout rate of 10%, the sample size was increased to **10 patients per group** (number of groups=2) **(Total sample size=20 patients)**.(13) The sample size was calculated using GPower version 3.1.9.2 (14).

A total of 20 patients who underwent implant placement for missing anterior maxillary teeth with horizontal bone defect (lack of adequate bone width) were included in the study. They were allocated into two equal groups: **In the study group,** ten patients received sticky bone covered with titanium PRF, and in **the control group,** ten patients received sticky bone covered with collagen membrane. The study was done at the Oral and Maxillofacial Surgery Department, Faculty of Dentistry, Alexandria University.

The inclusion criteria were as follows: Age from 20 to 40 years, anterior maxillary alveolar ridges with crestal widths smaller than or equal to 4 mm, and healthy gingival tissues. The exclusion criteria were Heavy smokers, usage of alcohol or abused drugs, patients having systemic diseases that could act as impediments to bone healing and patients with parafunctional habits (bruxism).

The materials used in the study are: Electronic Centrifuge machine (Centrifuging machine, China, Medical Store Company), DUAL implant surgery kit (DUAL implant, Egypt, Dual System Company), Collagen membrane (Colla-D) (Collagen membrane (Colla-D), South Korea, Abu Zaid Dental Trust), Beta-tricalcium phosphate Bone substitute (Beta-tricalcium phosphate Bone substitute, Japan, Trade Egypt Company), Titanium centrifuge tubes (Titanium centrifuge tubes, Germany, Magic Dent Company), Osstell I.S.Q (Osstell I.S.Q, Sweden, Doual System Dental Implant Company).

Preoperative phase:

History was taken, including the patient's name, age, profession, address, and contact info. Moreover, previous medical and dental history were taken to exclude any medical condition that may affect the success of the implant. Data regarding the etiology of tooth/teeth extraction was also collected. Radiographical evaluation was done through CBCT to evaluate the dimensions of the alveolar ridge to choose the appropriate implant size (15).

Operative phase:

All patients included in the study were treated under local anesthesia by vestibular and palatal infiltration, using 4 % Articaine and epinephrine (1/100000).

[i] http://www.consortstatement.org

A para-crestal incision was done in both groups. Sequential drilling was performed in both groups, followed by implant insertion using a torque wrench. A qualified nurse prepared PRP by drawing 10 to 20cc of the patient's venous blood and centrifuging by two cycles (soft and hard spin). Soft spin was centrifuged at 3000 rpm for 3 minutes, and after aspirating PRP into a sterile tube, it was centrifuged again at 4000 rpm for 15 minutes (hard spin). Both groups had sticky bone by mixing PRP with bone graft (beta-tricalcium phosphate) (16). Titanium PRF was prepared by centrifuging 20cc of the patient's forearm vein at 2800 rpm for 12 minutes using titanium tubes (17). The study group had sticky bone covered by Titanium PRF **Figure (1)**, while the control group had sticky bone covered by collagen membrane **Figure (2)**. The flap was returned to its normal position and sutured with silk-interrupted (3/0) sutures.

Post-operative instruction(18**)**

Starting the day following surgery, apply ice packs for 10 minutes every 30 minutes for 24 hours, and take strict oral hygiene measures such as brushing teeth regularly and using antiseptic mouthwash.

Post-operative medications(19**)**

Amoxicillin-clavulanate (Augmentin: GlaxoSmithKline, UK) 1gm every 12 hours for 7 days. Metronidazole 500mg (Flagyl: GlaxoSmithKline, UK) every 8 hours for 4 days. Antiseptic mouthwash (Chlorohexidine gluconate 0.2%) (Hexitol, Arab Drug Company) 3 times daily for 1 week. Ibuprofen (Ibuprofen Denmark) (tablet 200 mg)2 times daily (Solara Active Pharma)

Outcome Measures: Clinical Outcomes

Patients were followed up to evaluate implant stability measurement for both groups of cases utilizing the resonance Frequency Analysis (RFA) via the Osstell ISQ system (20).

Visual Analogue Scale and Edema (21**)**

Patient assessment of postoperative pain using a VAS was easily accepted. The ability to pit the examiner's fingers into the dependent area for five seconds was used to measure edema, and the pitting was graded on a scale from +1 to +4. Surgical wound examination for any signs and symptoms of inflammation and infection.

Radiographic Outcome (2)

Cone beam computerized tomography was taken immediately after 6 months to assess the Bone width and bone density.

Implant stability:

Utilizing the resonance Frequency Analysis (RFA) via the Osstell ISQ system. The implant stability measurement was examined immediately (primary stability) and after 6 months postoperatively.

Bone width (22) Figure (4) and Figure (3)

The thickness of alveolar bone was measured in edentate sites and buccal and lingual cortical plates of their mesial and distal dentate sites using Cone beam CT by Ondemand software.

Peri-implant bone density. Figure (4) and Figure (3)

Bone density was analyzed using OnDemand software. It can be stated that an objective assessment of site-specific bone density by Hounsfield units (HU) (23).

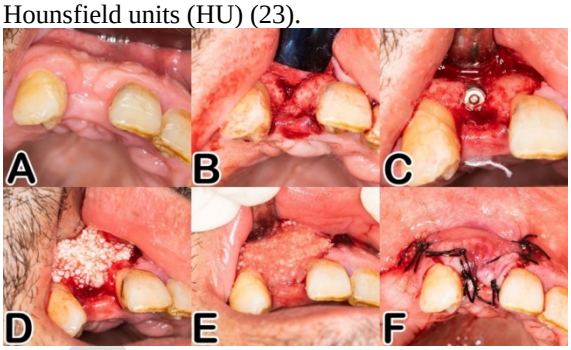

Figure (1): **(A)** preoperative clinical **(B)** FLAB **(C)** Implant with a defect in the bone **(D)** Sticky bone **(E)** implant cover with T-PRF **(F)** suture.

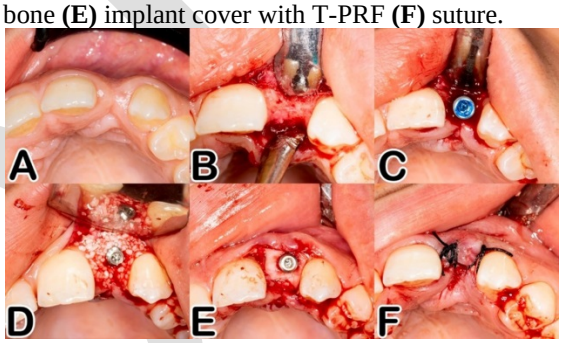

Figure (2): **(A)** preoperative clinical **(B)** FLAB **(C)** Implant with a defect in the bone **(D)** Sticky bone **(E)** implant cover by collagen membrane **(F)** suture.

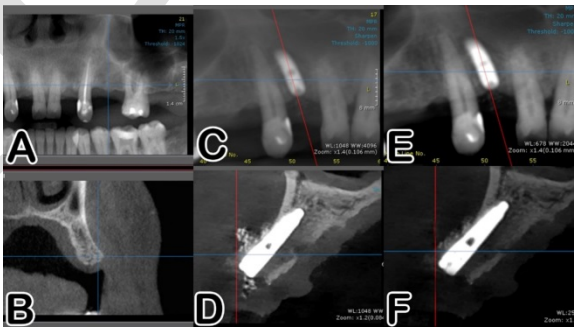

Figure (3): T-PRF group: **(A)** Pre-operative cone beam computed tomography (Panoramic view). **(B)** Pre-operative cone beam computed tomography (cross-section view). **(C)** CBCT (Panoramic view) immediately. **(D)** CBCT (Cross-sectional view) immediately. **(E)** CBCT (Panoramic view) after six months. **(F)** CBCT (Cross-sectional view) after six months.

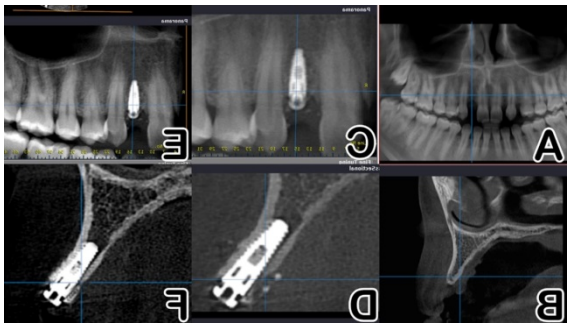

Figure (4): Collagen membrane group: **(A)** Pre-operative cone beam computed tomography (Panoramic view). **(B)** Pre-operative cone beam computed tomography (cross-section view). **(C)** CBCT (Panoramic view) immediately. **(D)** CBCT (Cross-sectional view) immediately. **(E)** CBCT (Panoramic view) after six months. **(F)** CBCT (Cross-sectional view) after six months.

RESULT

Group I (study group): 10 patients had the defect grafted by sticky bone and covered by a titanium PRF membrane. **Figure (1)**

Group II (control group): 10 patients had the defect grafted by sticky bone and covered by collagen membrane. **Figure (2)**

Clinical Evaluation:

Evaluation of VAS and edema:

In comparison between the two studied groups (T-PRF and Collagen membrane) regarding Visual analogue scale (VAS) and edema, it was found that there was no statistically significant difference between the two studied groups regarding VAS and edema (p >0.303 – P >0.400).

Evaluation of implant stability:

Regarding implant stability at different periods in each group. In the T-PRF group, there was a statistically significant difference after 6 months (p=0.0001). In the Collagen membrane, there was a statistically significant difference after 6 months (p=0.0001), as shown in **Table (1)**

Comparing implant stability at the same time between the two studied groups. There was no statistically significant difference between the groups (T-PRF and Collagen membrane) immediately postoperative and after six months (p=0.9281 & 0.1395), respectively, as shown in **Table (1)**

Radiographic Evaluation:

Bone width*:*

Regarding Bone width at different periods in each group: in the T-PRF group, there was a statistically significant difference after 6 months (p=0.0013). In the Collagen membrane, there was a statistically significant difference after six months (p = 0.0053) (**Table 2).**

Regarding Bone width at the same periods in different groups, There was a no-statistically significant difference between both groups immediately & after 6 months (p = 1.000 & 0.2138), respectively **(Table 2).**

Bone density:

Comparison between the two studied groups regarding bone density immediately and after 6 months. At the same time, in different groups. There was a no-statistically significant difference between both groups immediately & after 6 months (p = 0.8016 & 0.5981), respectively (**Table 3).**

Comparing both groups at different times: There was a statistically significant difference between both groups immediately & after 6 months (p = 0.0003& 0.0315), respectively (**Table 3).**

Table (1) Comparison between the two studied groups according to implant stability at each time.

	Implant stability		t	p
	Immediate Postoperative	After 6		
T-PRF	63 ± 5.395	84.9 ± 4.306	10.0328	0.0001*
Collagen membrane	62.8 ± 4.315	82.2 ± 3.458	11.0944	0.0001*

Table (2) Comparison between the two studied groups according to bone width.

	Bone width		t	p
	Immediate postoperative	After 6		
T-PRF	2.058 ± 0.081	1.941± 0.054	3.8006	0.0013
Collagen membrane	2.058 ± 0.134	1.902 ± 0.079	3.1713	0.0053

Table (3) Comparison between the two studied groups regarding bone density immediately and after 6 months. At different times.

	T-PRF	Collagen membrane	T-test	P value
Immediate Mean ± SD	459.03 ± 107.61	474.66± 161.16	0.2551	0.8016
After 6 m Mean ± SD	685.47± 82.82	652.07±178.57	0.5366	0.5981

DISCUSSION

Collagen membrane is used in medicine and dentistry because of its proven biocompatibility and ability to promote wound healing. For guided tissue regeneration (GTR) procedures, collagen membranes are comparable to non-absorbable membranes in terms of reduction in depth of exploration, clinical gain of defect, and percentage of filling of the bone (9). T-PRF is a third-generation platelet concentrate and contains a dense fibrous network with a long resorption time. We test the effectiveness of T-PRF as a resorbable barrier membrane and evaluate its regenerative potential in bone formation (8). Management of bone defects is a real challenge. These defects have a significant clinical and economic impact, and high rates of complications and reoperations and poor

functional results limit the results. There is still no consensus on definitions, reliable models, and best practices for the surgical management of bone defects. According to what was stated in a study by **Kim et al.** (1), in bone defects such as height and/or width, the successful placement of dental implants is difficult because it requires maintaining an ideal pathway and avoiding important anatomical structures. Vertical and/or horizontal ridge augmentation may be necessary using various bone substitute materials and bone graft procedures. However, effective one-wall reconstruction has been challenging due to poor blood supply and insufficient graft stability. Our study has shown that T-PRF can be used for guided bone and tissue regeneration. Shravanthy **Ravi et al.,** (24) Study showed that the PDGF release profile from different platelet concentrate forms (L-PRF, A-PRF, and T-PRF) according to their mechanical and chemical characteristics, and he found that T-PRF owned the highest modulus of elasticity and tensile strength. Collagen membranes have been widely used in medicine and dentistry because of their high biocompatibility and capability of promoting wound healing. Several treatment modalities for regenerating bone, including guided bone regeneration (GBR), where barrier membranes play an important role by isolating soft tissue and allowing bone to grow. According to Luca **Sbricoli et al.** (25), Not all membranes biologically behave the same way, as they differ from their origin and structure, with reflections on their mechanical properties and clinical performance. Therefore, our study was a comparison between collagen membranes and T-PRF. It is also worth noting that the collagen membrane is relatively expensive, which is one of the difficulties we faced during the study, so we must consider that the treatment should also be economical. According to Aureen Ruby **DCunha's** (26) study, he compared the Human Amniotic Membrane vs Collagen. HAM is inexpensive and simple to prepare and store; it is an excellent choice for use in economically disadvantaged areas where collagen may be unavailable. This also applies to the T-PRF, as it is an inexpensive option for the patient compared to the collagen membrane. The results of our study were clinical in comparison between the two studied groups (T-PRF and collagen membrane) regarding visual analogue scale (VAS) and edema; it was found that there was no significant difference between the two studied groups. This was evidence of the benefit of T-PRF and collagen membranes in helping wounds heal and restore everyday life as quickly as possible. According to Esra **Ercan et al.** (27), T-PRF is a completely autologous biomaterial, enhancing wound epithelization and reducing postoperative discomfort at extraction sockets. According to Hom-Lay **Wang et al.** (28), Collagen membranes lead to better wound healing by promoting primary wound coverage, angiogenesis, space creation and maintenance, and clot stability.

Evaluation of implant stability: in different periods in each group, both groups showed a statistically significant difference after 6 months.

Regarding implant stability in different groups, There was no statistically significant difference between the groups (T-PRF and collagen membrane). No complications were observed at the surgical sites except for some swelling and pain after the operation. The implants were found to be clinically immobile and were defined as osseointegrated. Our study agreed with **Lee et al.** (29), that two different collagen membranes for dehiscence defects around implants are used in conjunction with autogenous or allogenic bone, followed by xenogeneic bone particles for dehiscence defects around implants in humans. At implant insertion and uncover surgery, measurements of the dehiscence bony height, width, and surface area were made. Before applying the membrane to defects, guided bone regeneration was performed. Both membranes exhibited satisfactory results on dehiscence defects. Our study was not limited to clinical evaluation. Also, Radiographical evaluation was done by assessing the bone width immediately after the surgery and after six months, as well as evaluating the bone density.

Our study showed the following: Through radiological evaluation regarding bone width during the different periods in each group (collagen membrane and T-PRF), there was a statistically significant difference after 6 months regarding bone width at the same periods in different groups. There was no statistically significant difference between both groups immediately & after 6 months, respectively. Regarding bone density during the different periods in each group (collagen membrane and T-PRF), there was a statistically significant difference after 6 months regarding bone density at the same periods in the two groups. There was no statistically significant difference between both groups immediately & after 6 months, respectively.

According to **Lajos et al.** (30), collagen membranes can play a key role in guided bone regeneration surgeries (GBR) in dentistry as they have a high biological value and contain a lot of cytokines and growth factors. The study also explained that the resorbable collagen membranes do not have such an attractive biological value but have their advantages. They serve as a natural protective biological scaffold for tissue morphogenesis.

According to Cristine D'Almeida **Borges et al.** (31), bone formation and tissue remodeling are the major challenges in implantology today. However, soft tissue healing is technically sensitive to the surgical procedure. The combined usage of collagen membrane evaluates the influence of collagen membrane on the quality of the new bone formation

in guided bone regeneration (GBR) procedures with different titanium meshes. All groups showed a spongy bone formation after 30 days. Moreover, according to **Cucchi et al.** (32), the resorbable membrane is assessed to minimize the process of soft tissue genesis in bone-damaged areas so that a combination of biomaterials is obtained to form bone tissue of good quality. It is worth noting some studies have indicated that T-PRF creates new bone with connective tissue in a wound healing model where regeneration was not predicted, like the study by Tunalı, **Mustafa, et al.** (33). The T-PRF membrane began to be absorbed into the rabbit tissues on day five and was able to remain in the tissues.

After the positive results of T-PRF, we agree with Dohan, **David et al.** (34) that Titanium Platelet-Rich Fibrin (T-PRF) is a novel platelet concentrate membrane, whose preparation methodology rests on the assumption that titanium tubes are more efficient than glass tubes in activating platelets. This material aimed to prevent the short or even long-term harm that might arise from using dry glass or glass-encased plastic tubes and to remove any ambiguity regarding silica. Such distinct properties of T-PRF as enhanced biocompatibility are determined by using titanium tubes instead of silica particles to activate platelets.

When manufacturers use T-PRF, fibrin enriched with platelet cells and leukocytes is similar to fibrin produced using the conventional PRF procedure. We agreed with **Patel et al.** (35), **Singh et al.** (36), **Indurkar et al.** (37), and **Vrotsos et al.** (38) that one such factor is sticky bone, which receives a lot of focus in numerous studies and is now easily disregarded. While this experiment was conducted, the type of sticky bone used for both groups was identical, as it produced good outcomes for both groups. Bones may be developed through distraction osteogenesis, GBR with various barrier membranes, particulate grafting material, en-block grafting, ridge splitting technique, and future use of substances that accelerate bone growth rate, among others.(39). There is no doubt that the studies included the evaluation of T-PRF are few. Our study was relevant to that, and it is one of the unique studies that evaluated T-PRF with the collagen membrane. Our evaluation of both mentioned was clinically and radiologically. In general, the results showed that both groups had positive results. Some studies indicate that T-PRF not only reduces bone loss around the implant but also has a role in tissues, as **Gumus et al.** (40) confirmed that the use of T-PRF in combination with the placement of an implant at the same time improves the thickness of the soft tissue in the region of the implant and might serve as a different method to achieving connective tissue.

Finally, I would like to state that qualitatively, as a product, collagen membrane could be said to be more costly than T-PRF preparation. Also, the time aspect should be addressed as the time required for T-PRF preparation is longer than when using collagen membrane because blood needs to be taken and spun to prepare the plasma, which takes a fair amount of time.

CONCLUSION

Considering the limitations of the present study, the study revealed that both T-PRF and collagen membranes enhanced the clinical parameters, which means that they assist in soft tissue as well as hard tissue healing owing to a greater percentage of bone fill since the unwanted tissues do not grow into the area of bone healing.

CONFLICT OF INTEREST

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