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EVALUATION OF MINERALIZED PLASMATIC MATRIX VERSUS PLATELET RICH PLASMA IN DEFICIENT ANTERIOR MAXILLARY ALVEOLAR RIDGE: A RANDOMIZED CONTROLLED CLINICAL TRIAL

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ABSTRACT

Introduction: Plasma derivatives have been used widely in the field of dental implantology since the introduction of the first generation platelet rich plasma (PRP) to enhance both soft tissue and bone formation. Recently, mineralized plasmatic matrix (MPM) has introduced the advantage of encasing both the bone graft and the required growth factors in a fibrin meshwork that can maintain its form while enhancing bone formation.

Objective: is to clinically and radiographically evaluate the effect of platelet rich plasma mixed with bone graft versus mineralized plasmatic matrix on peri-implant bone formation and osseointegration.

Materials and Methods: Sixteen patients with missing anterior teeth were included in the study and divided into two groups; in group A, MPM was placed simultaneously with delayed implant placement while in group B, PRP mixed with biphasic calcium phosphate bone graft and a collagen membrane were used to cover the dehiscence after implant placement. Patients were followed up clinically and radiographically for 9 months to assess implant stability and labial bone thickness and density.

Results: Regarding implant stability, there was no significant difference between the 2 groups. However, when it comes to labial bone thickness and the change in labial bone density, there was a statistically significant difference between the two groups in favour of the MPM group.

Conclusion: MPM is a cohesive meshwork of bone graft, fibrin and growth factors achieving better bone formation in terms of quantity and quality when compared with the first generation plasma derivative PRP mixed with biphasic calcium phosphate.

KEYWORDS: Bone augmentation, dental implant, plasma derivatives, PRP, MPM

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INTRODUCTION

Ridge remodelling after dental extraction is unavoidable and affects the residual alveolar ridge volume both vertically and horizontally. The consequence could be a deficient ridge that complicates implant placement especially in the anterior maxilla where esthetics plays a major role. [1]

Throughout the years, many bone augmentation materials were implemented including autografts, allografts, xenografts and alloplasts in the form of block or particulate grafts aiming to improve both bone quantity and quality around dental implants. [2] In addition, distraction osseogenesis and ridge splitting procedures were described and also showed to be effective alternatives. [3, 4]

The most commonly used alloplastic materials are Hydroxyapatite and beta tricalcium phosphate bone grafts. Both materials are osseoconductive materials that proved effective as a scaffold for bone formation. However, Hydroxyapatite bone grafts shows a slow resorption rate; on the other hand beta tricalcium phosphate resorbs rapidly. Therefore, biphasic calcium phosphate bone grafts were introduced to benefit from the rapid resorption rate of beta tricalcium phosphate which allows its replacement by the newly formed bone and at the same time benefit from the slow resorption rate of Hydroxyapatite which provides structural stability for the grafting material. [5]

The first generation of platelet derivatives introduced was platelet rich plasma (PRP); platelets are rich in an array of growth factors that has an osseoinduction effect by inducing cell proliferation and angiogenesis. These include, transforming growth factors β-1 (TGFβ-1), epithelial growth factor (EGF), platelet-derived growth factor (PDGF), vascular endothelial growth factors (VEGF) and insulin growth factor-I (IFG-I). Studies showed that PRP greatly enhances both bone and soft tissue healing and enhances bone formation rate and provides better bone quality. [6]

Since the introduction of PRP, many second generation platelet derivatives were introduced including platelet rich fibrin (PRF), concentrated growth factors (CGF) and recently MPM (mineralized plasmatic matrix).[7] MPM was recently introduced as an autologous blood product formed of a combination of growth factors and bone graft within a fibrin matrix. The result is a coherent mass incorporating bone graft and growth factors; such a composition protects the osseoconductive bone graft material from the invasion of soft tissue and preserves the bone graft volume. In addition, it provides the required osseoinductive growth factors and thus enhancing bone formation and quality. [8]

The null hypothesis of this study was that there will be no significant difference in labial bone thickness and density between patients treated with MPM and those treated with PRP mixed with biphasic calcium phosphate.

To our knowledge, studies conducted on MPM comparing it with other platelet derivatives are scarce. Thus, the aim of this study is to compare both clinically and radiographically the effect of MPM versus PRP on bone formation around dental implants placed in horizontally deficient anterior maxillary region.

MATERIALS AND METHODS

Patient selection

This study is a randomized controlled clinical trial conducted on 16 patients (the sample size is based on a statistical sample size estimation) who were recruited from the outpatient clinical of the Oral and Maxillofacial Surgery Department, Alexandria university and in need for replacement of a previously extracted maxillary anterior teeth. All patients signed an informed consent stating the surgical procedure and the benefits and risks of the study. The study was also approved by the organizational ethics committee.

Patients were selected according to a set of inclusion and exclusion criteria; the inclusion criteria included: age range from 20-40 year old, missing maxillary anterior tooth, alveolar bone thickness at the crestal part of the ridge less than 4 mm and presence of labial bone dehiscence after implant placement requiring bone grafting. Furthermore patients with parafunctional habits, systemic diseases that affect bone formation, bad oral hygiene and smokers were excluded from this study. [2, 9]

The included patients were divided into two equal groups randomly using a computer generated method (Randomizer.org, Pennsylvania, USA). For group A, MPM was placed simultaneously with delayed implant placement to augment the buccal crestal bone dehiscence. On the other hand, the dehiscence after implant placement was augmented in the group B using PRP mixed with biphasic calcium phosphate bone graft and covered by a collagen membrane.

Blinding was achieved by giving each patient a number by an assistant. A duplicate of this number was kept in an envelope indicating to which group the patient belongs. This envelope was kept by a trial independent individual who was assigned the role of opening it only at the time of intervention; so that the group to which the patient is allocated is concealed from the investigator. [10]

MATERIALS

- Ovis synthetic bone graft (Dentis corp, South Korea): Alloplastic bone graft composed of Hydroxyapatite 20% + β-TCP 80%.
- Dentium super line implant system (Dentium, South Korea): A conventional, two-piece titanium dental implant with an SLA surface treatment (Sand blasted, Large grit, Acid etched). A standardized implant size having length of 12 mm and 3.6 mm diameter were used in this study.
- T Gen resorbable collagen membrane (Sk bioland, South Korea).
- A low speed centrifuge LC-04R (Syntific System, China) has been used for preparation of platelet rich plasma PRP with maximum speed 4000 rotation per minute RPM, maximum relative centrifugal force RCF 1790xg and rotor capacity 20ml x6.
- Vacutest 9 mm plain plastic vacuum tubes (Vacutest kima ltd, Italy).

METHODS

Preoperative phase

History was taken for all patients followed by thorough extraoral and intraoral clinical examination. In addition, radiographic examination was done using cone beam computed tomography (CBCT) to determine the bone quantity and quality and for the purpose of treatment planning.

MPM preparation [8] (Figure 1)

Two tubes of 9 ml blood were collected from the patient followed by centrifugation at 2500 rpm for 12 minutes. The resultant product is formed of two layers; the upper layer is the yellow plasma liquid while the lower layer is formed of red blood cells.

The upper plasma layer is collected and mixed with the biphasic Ovis bone graft for few seconds until setting to obtain the MPM grafting material.

PRP preparation [6] (Figure 2)

9 ml of blood were drawn from the patient into a standardized 10 ml syringe to which one millimetre of anticoagulant dextrose (ACD) was added followed by dividing the collected blood on two disposable 5ml syringes. The two syringes were centrifuged at 3000 rpm for 3 minutes for the soft spin. Plasma was aspirated and transferred to another syringe by an extension tube. The second centrifugation was performed at 4000 rpm for

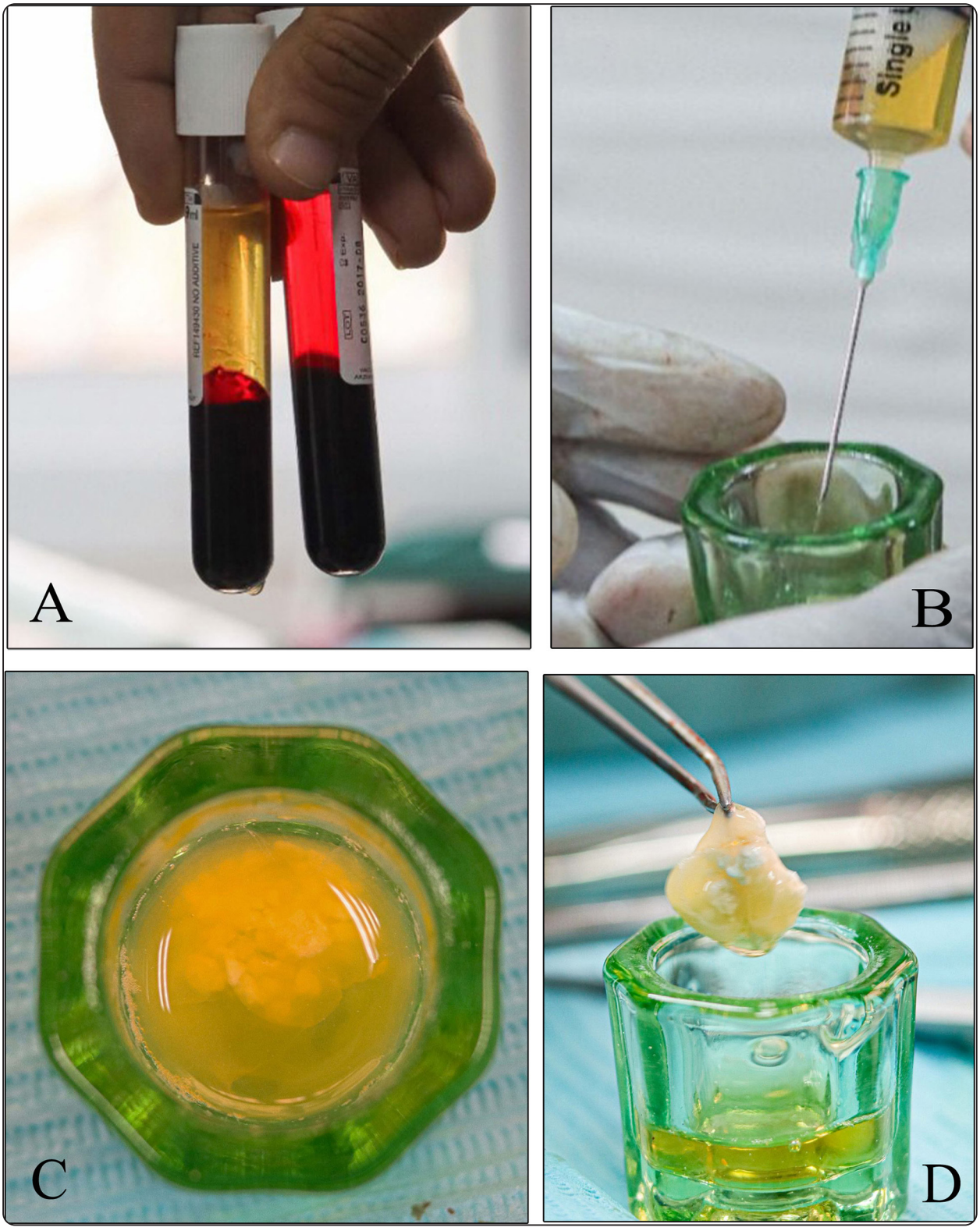

Fig. (1): MPM preparation: A. Upper plasma layer and lower red blood cells layer after centrifugation, B. Adding the plasma to the bone graft, C. After mixing plasma and bone graft, D. MPM after setting.

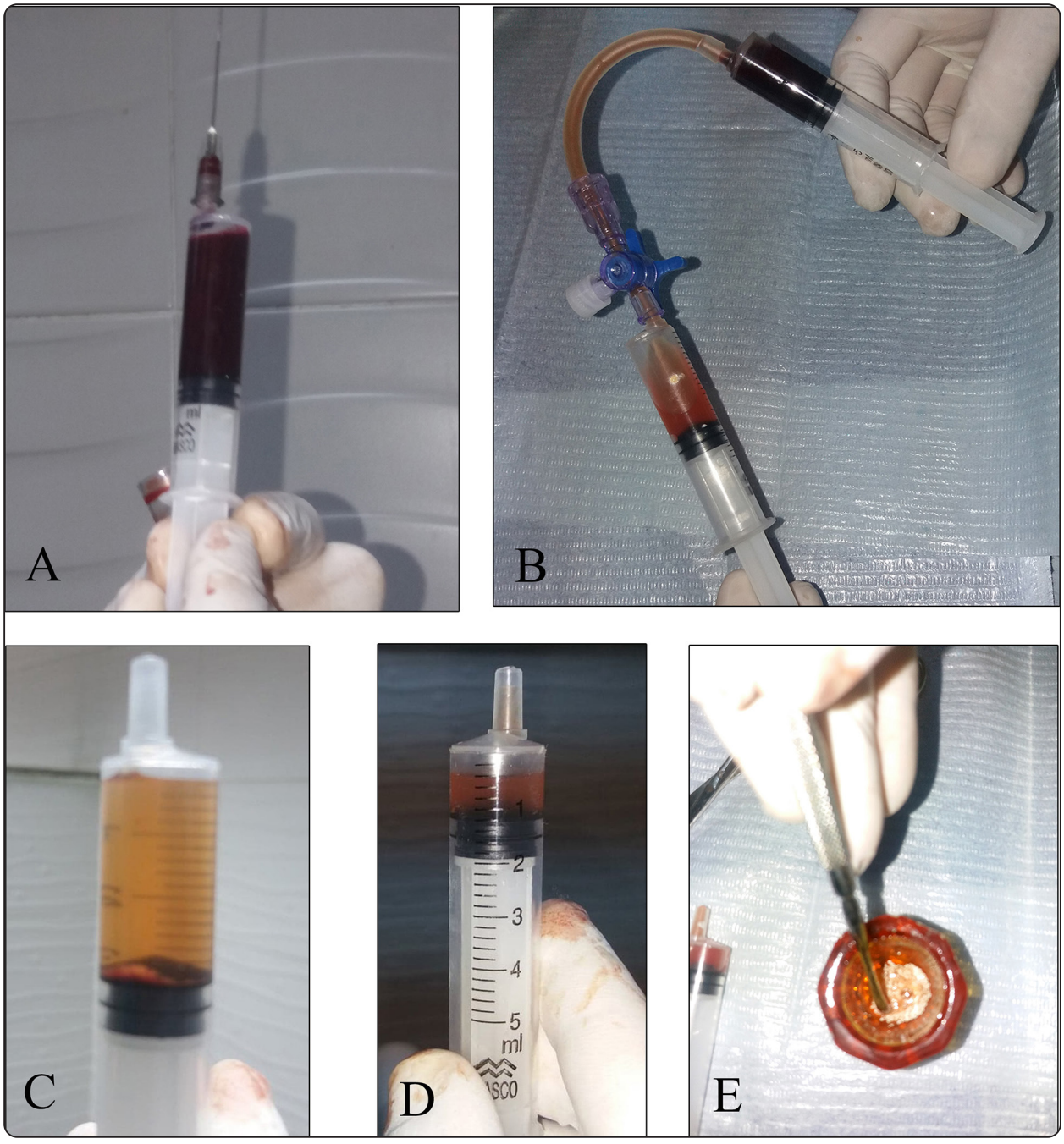

Fig. (2): PRP preparation: A. Collected venous blood, B. Plasma separation using connecting tube after soft spin, C. Upper PPP layer and lower PRP layer after hard spin, D. PRP after discarding PPP, E. Mixing PRP with bone graft.

15 minutes (hard spin) to separate into platelet poor plasma PPP at the upper two thirds and platelet rich plasma PRP at the lower third. Platelet poor plasma PPP was discarded and platelet rich plasma PRP is obtained.

Operative phase [9]

All patients were operated under local anaesthesia; an intraoral paracrestal incision was done for all patients followed by elevation of a full thickness envelope flap. The implant osteotomy was done using sequential drilling up to the final drill followed by implant insertion using torque wrench and screwing the cover screw in place.

For group A: The MPM was prepared and used to cover the crestal dehiscence (Figure 3), while in group B: PRP was prepared, mixed with the biphasic Ovis bone graft and covered by a collagen membrane which was secured in position by the implant cover screw (Figure 4). Wound closure was achieved for all patients using simple interrupted non resorbable 3 0 silk sutures.

Postoperative phase

All patients were instructed to follow oral hygiene instructions and to apply cold fomentations for the first 24 hours followed by warm saline mouth washes from the second postoperative day.

Post operative medications were prescribed for all patient including antibiotics and non steroidal analgesics.

Follow up phase

Clinical follow up

Implant stability was measured immediate postoperatively and after 6 months using Osstell (Osstell AB, Sweden) to measure the implant stability quotient (ISQ) in a range from 1- 100. The higher the ISQ the higher the implant stability. [11]

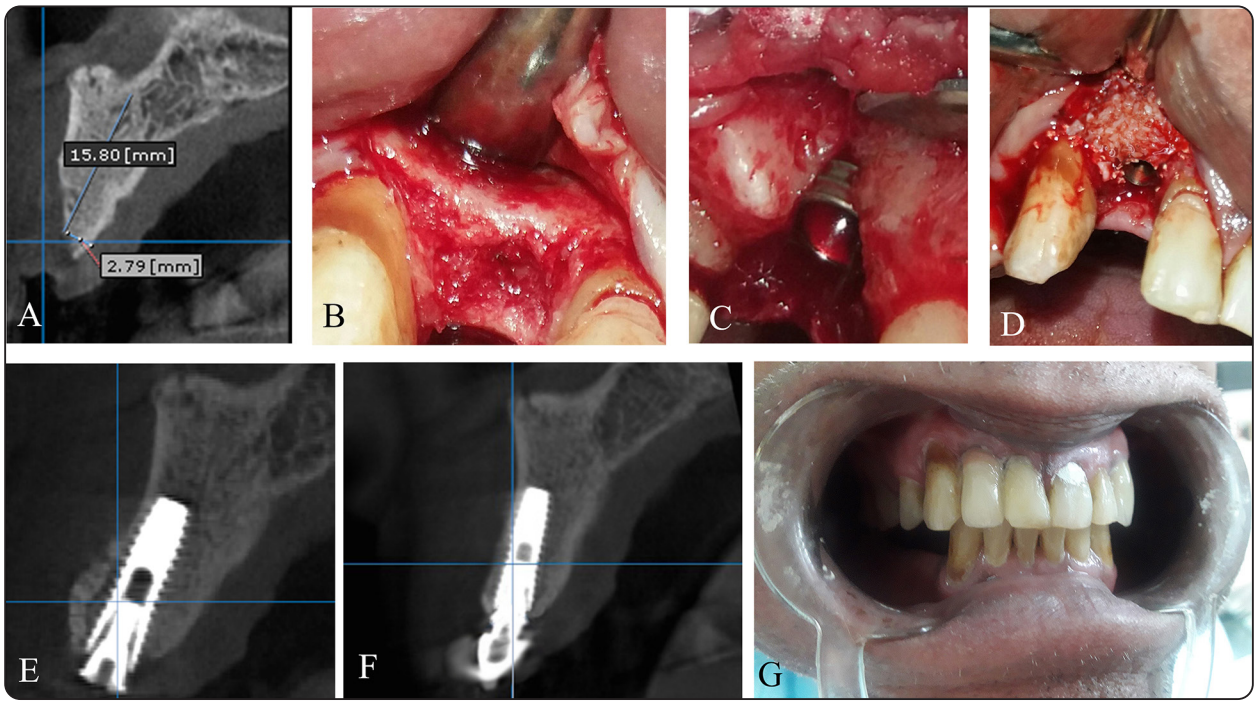

Fig. (3): A. Preoperative CBCT radiograph, B. Flap reflection, C. Implant placed and labial dehiscence, D. MPM covering the dehiscence after implant placement, E. Immediate postoperative CBCT radiograph, F. 9 months postoperative CBCT, G. Final prosthesis.

Radiographic follow up

CBCT was done immediate postoperatively and at 9 months to measure the labial bone thickness and bone density. The labial bone thickness was measured at 9 months postoperatively using the ruler tool in the OnDemand3D software (Cybermed, Seoul, South Korea), while the bone density was measured at immediate postoperatively and at 9 months on the labial aspect of the implant in Hounsfield unit (HU) by measuring the bone density in 5 different fixed points on a line placed on the labial aspect of the implant and calculating the mean. (Figure 5) [12]

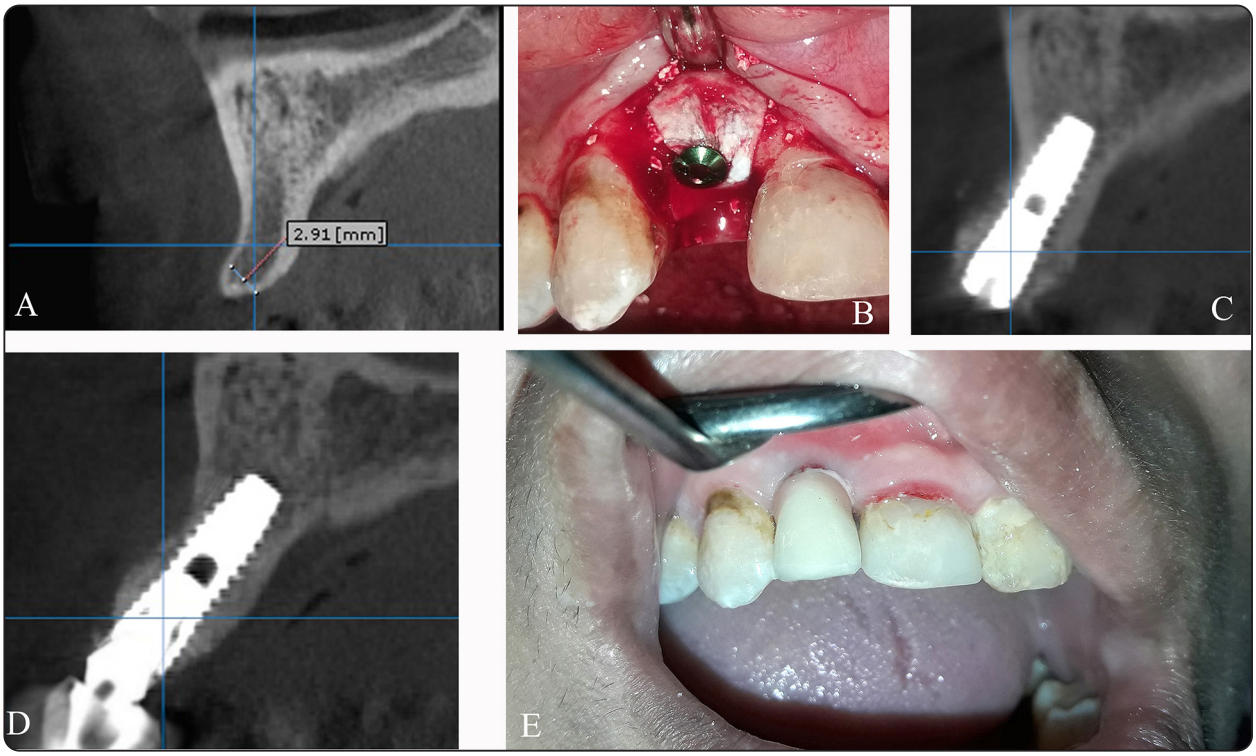

Fig. (4): A. Preoperative CBCT radiograph, B. Flap reflection, C. Implant placed and labial dehiscence, D. PRP mixed with biphasic calcium phosphate covering the dehiscence after implant placement, E. Collagen membrane secured in place using cover screw, F. Immediate postoperative CBCT radiograph, G. 9 months postoperative CBCT, H. Final prosthesis.

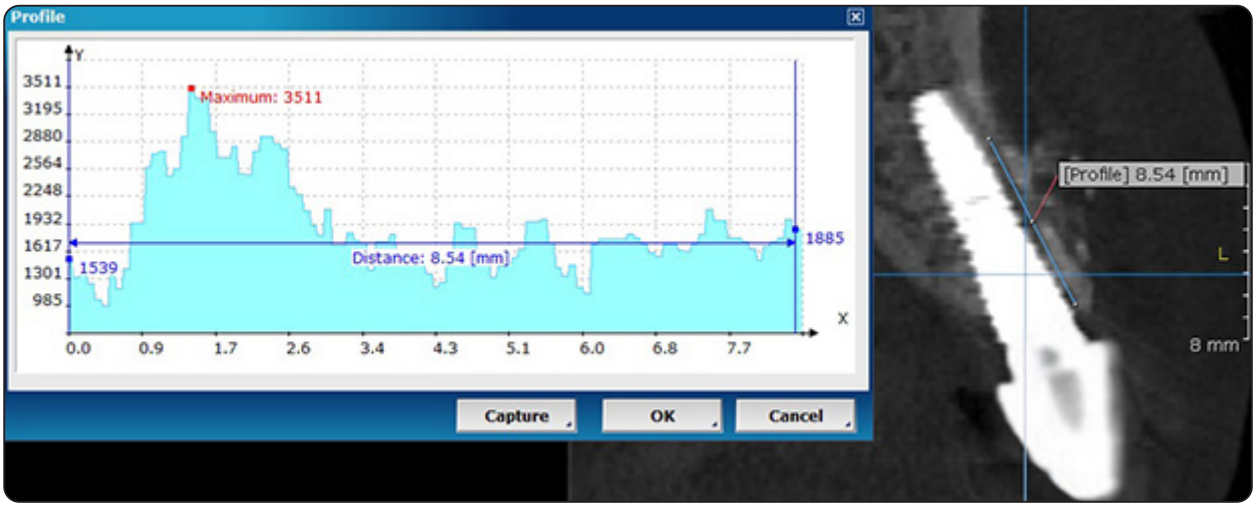

Fig. (5): Labial bone density measurement.

Prosthetic phase

At six months postoperatively, all patients were loaded by fabricating a porcelain fused to metal restoration.

Statistical analysis

Data were fed to the computer and analysed using IBM SPSS software package version 22. (IBM, Chicago, United States). For continuous data, they were tested for normality by the Shapiro-Wilk test. Quantitative data were expressed as range (minimum and maximum), mean, standard deviation and median. Student t-test was used to compare two groups for normally distributed quantitative variables and Paired t-test was used to compare two periods for normally distributed quantitative variables. Significance of the obtained results was judged at the 5% level.

RESULTS

In this study, 16 patient (9 females and 7 males) were recruited from the outpatient clinic of the Oral and Maxillofacial Surgery Department Alexandria University. The ages of the patients ranged from 21 to 38 with a mean of 28.43. All patients were followed up clinically and radiographically for 9 months.

Clinical evaluation (Table 1)

None of the patients showed any sign of implant mobility or infection. However, only one of the patients in group A showed slight soft tissue dehiscence over the implant cover screw at 1 week postoperatively.

The mean implant stability for group A immediate postoperatively was 63.5±6.82 with a minimum of 56 and a maximum of 76. On the other hand, the mean for group B was 62.88±7.16 at immediate postoperatively with a minimum of 55 and a maximum of 74.

Moreover, at 6th month postoperative the mean implant stability for group A was 72.75±6.82 with a minimum of 64 and a maximum of 84. For group B, the mean was 71.62±7.23 with a minimum of 63 and a maximum of 76. There was no statistically significant difference between group A and group B regarding the mean implant stability throughout the study period.

However, the mean implant stability showed a statistically significant difference between immediate postoperative and 6 months in both groups.

Radiographic evaluation (Table 1)

Regarding the labial bone thickness, the mean for group A at 9 months postoperatively was 1.98 mm ± 0.31 with a minimum of 1.5 mm and a maximum of 2.34. For group B the mean was 1.346 mm ± 0.36 with a minimum of 0.8 mm and a maximum of 1.79. Furthermore, the mean labial bone thickness in group A was statistically significantly higher than that of Group B. (Figure 6)

Furthermore, the mean labial bone density for group A at immediate postoperatively was 651.5 HU ± 144.2 and increased to 964.1 HU± 84.89 at 9 months postoperatively. While that of group B was 610.9 HU ±161.4 and increased to 821.3 HU ± 107.9 at 9 months postoperatively. The mean labial bone density was statistically significantly higher at 9 months postoperatively when compared with immediate postoperative in both groups. In addition, the increase in labial bone density from immediate postoperatively to 9 months postoperatively was statistically significant higher in group A than in group B. (Figure 7)

TABLE (1): Comparison between the two studied groups according to different parameters.

	Group A (n = 8)	Group B (n =8)	t	P
Implant stability				
Immediate postoperative	63.50 ± 6.82	62.88 ± 7.16	0.179	0.861
6 months	72.75 ± 6.82	71.62 ± 7.23	0.320	0.754
Increase after 6 months	9.25 ± 1.49	8.75 ± 1.58	0.651	0.525
t_0 (P_0)	17.582* (< 0.001 *)	15.652* (< 0.001 *)		
Labial bone thickness at 9month	1.98 ± 0.31	1.35 ± 0.36	3.724*	0.002*
Labial bone density				
Immediate postoperative	651.5 ± 144.2	610.9 ± 161.4	0.531	0.604
9 months	964.1 ± 84.89	821.3 ± 107.9	2.944*	0.011*
Increase after 9 months	312.6 ± 98.07	210.4 ± 85.93	2.218*	0.044*
t_0 (P_0)	9.017* (<0.001 *)	6.925* (<0.001 *)		

Data was expressed by using Mean ± SD. ***SD: Standard deviation***
t: Student t-test ***t_0: Paired t-test***
p: p value for comparing between the two studied groups
P_0: P value for comparing between Immediate postoperative and 6 months
****: Statistically significant at p ≤ 0.05***

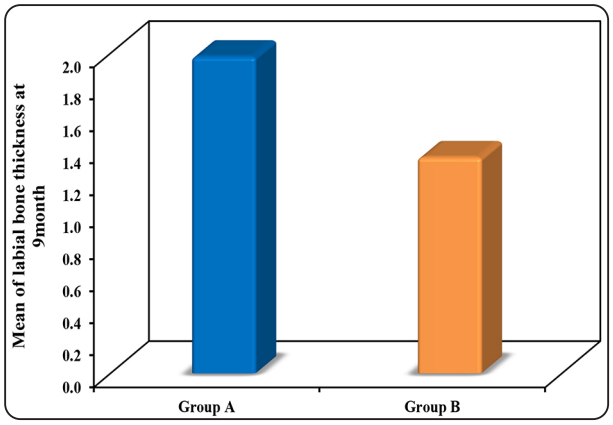

Fig. (6): Comparison of labial bone density between the two groups throughout the study period.

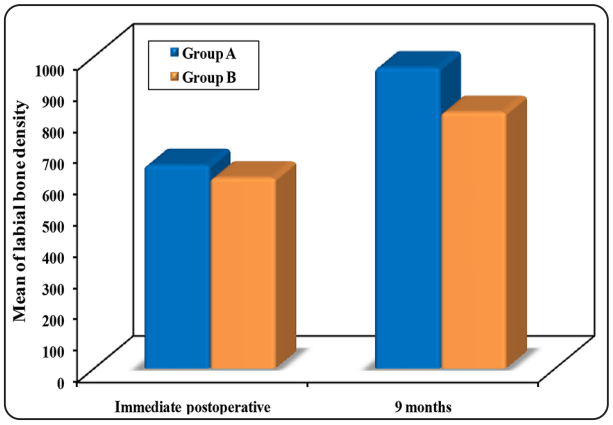

Fig. (7): Comparison of labial bone thickness between the two groups at 9 months postoperative.

DISCUSSION

In this study, implants were placed together with horizontal ridge augmentation in the same visit and thus avoiding exposing the patient to two surgical procedures. Moreover, it allows early implant placement and thus shortening the overall time of the treatment procedure. Furthermore, none of the patients in this study showed any signs of implant mobility or infection. However, one of the patients in group A showed early soft tissue dehiscence which disappeared in the subsequent follow ups and this could be owed to the patient not following the oral hygiene instructions

This coincides with Kuchler et al [9] who stated in their systematic review on studies comparing simultaneous implant and bone augmentation with

the staged approach that both approaches shared a high implant survival and success rate. In addition, Buser et al [13] in their 3 year long follow up of 20 implants placed simultaneously with autogenous bone grafting in anterior maxillary esthetic zone reported a 100% success rate.

Moreover, only patients with alveolar bone thickness at the crestal part less than 4 mm were included in this study. This coincides with Milinkovic et al [14] in their systematic review on the indications of different types of augmentation procedures. They reported that simultaneous implant grafting protocol is indicated in patients with overall alveolar ridge width less than 4mm; however, if the alveolar bone thickness is lesser than 3.5 mm a staged approach is recommended.

This study compared between two plasma derivatives; MPM was applied simultaneously with implant placement in group A with no membrane coverage, while in group B PRP mixed with biphasic calcium phosphate was used to augment the dehiscence and was covered by collagen membrane. This could be owed to the cohesive nature of MPM which gives it a solid stable structure and protects the incorporated bone graft from soft tissue invasion. In contrast, PRP provides the bone graft with necessary growth factors but has no cohesive constitution and thus requires a membrane to protect the bone graft from soft tissue invasion.

This matches with Abdel Fadil et al [15] who stated in their study comparing horizontal ridge augmentation using MPM in anterior maxilla with and without membrane coverage. They reported no statistically significant difference between the two groups regarding alveolar ridge thickness.

In this study, the mean implant stability quotient showed a statistically significant increase from immediate postoperative to 6 months. However, there was no significant difference between the two groups through out the study period. This could be attributed to that the implant stability depends on the bone quality, primary stability and osseointegration of the implant and not on the bone dehiscence augmentation procedure.

This comes in agreement with Monov et al[16] who compared implants placed after injecting the osteotomy site with PRP with those placed without injecting PRP. In their study, they found no statistically significant difference regarding the mean implant stability quotient between the two groups.

Furthermore, Kundu et al [17] in their study compared immediately placed implants dipped in PRP before placement with implants that were not dipped in PRP and measured implant stability in both groups using periotest. They reported no statistically significant difference between the two groups regarding the implant stability at the first and third postoperative months.

In addition, Ibrahim et al [18] reported no statistically significant difference in implant stability measured by Osstell between implants placed simultaneously with horizontal ridge augmentation using xenograft mixed with PRP and those placed simultaneously with xenograft without PRP. However, they stated that there was a statistically significant difference in implant stability between immediate postoperative and six months postoperatively.

Moreover, in this study the mean labial bone thickness was statistically significant thicker in group A treated with MPM than that of group B treated with PRP mixed with biphasic calcium phosphate. This could be related to the more stable MPM form which does not allow the bone graft particles to disperse and therefore get the optimum effect on bone formation.

This matches with Sghaireen et al [19] who evaluated in their study the effect of MPM in ridge preservation. They compared between two groups, maxillary sockets of the first group were filled with MPM after extraction. On the other hand, sockets

of the other group were only filled with bone graft; they reported a statistically significant difference between two group regarding ridge thickness and height.

Moreover, our results come in agreement with Abdelfadil et al [15], who evaluated the effect of MPM on alveolar ridge width when used in horizontal ridge augmentation. They found that the alveolar ridge width increase from one week to four months postoperatively was statistically significant.

Furthermore, Ibrahim et al [18] in their study found that PRP when mixed with xenograft had a statistically significant impact on buccal bone thickness at the sixth months postoperatively. Additionally, Eskan et al [20] conducted a randomized clinical trial in which they compared horizontal ridge augmentation using PRP mixed with allograft versus allograft alone; in both groups the graft was covered by a membrane. They reported that the alveolar ridge width with statistically significantly thicker in the PRP group when compared to the other group.

In addition, MPM showed a statistically significant higher mean increase in labial bone density in this study at 9 months postoperative when compared to group B. However, the mean labial bone density in both groups were statistically significant higher at 9 months then immediately postoperative. This result supports that MPM has a greater impact on bone quality when compared with the first generation plasma derivative PRP.

This coincides with the clinical and histological study conducted by Cinar el al [21] in which they compared maxillary sinus augmentation using MPM in one group versus beta tricalcium calcium phosphate in the other group. They concluded that the fibrin bound MPM showed better bone formation in terms of quantity and quality then beta tricalcium phosphate used alone.

Furthermore, Cakir et al [8] in their study on sheep tibia, they created five defects per animal and filled them randomly with MPM, PRF mixed with beta tricalcium calcium phosphate, Beta tricalcium phosphate, autogenous bone graft and the last was left empty as control. At 6 weeks postoperative, MPM showed a higher percentage of bone formation with better quality than the other groups except the autogenous bone group which showed better results than the MPM.

In conclusion, MPM is a cohesive meshwork of bone graft, fibrin and growth factors achieving better bone formation in terms of quantity and quality when compared with the first generation plasma derivative PRP mixed with biphasic calcium phosphate. It is recommended to conduct further studies with larger sample and longer follow up periods.

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