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A CLINICAL AND RADIOGRAPHIC SOCKET PRESERVATION OUTCOMES BY USING BETA-TRICALCIUM PHOSPHATE WITH AND WITHOUT LEUCOCYTES PLATELETS RICH FIBRIN WITH DELAYED IMPLANT PLACEMENT

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ABSTRACT

Aim: The aim of the study was to evaluate the role of using leucocytes platelets rich fibrin in addition to beta-tricalcium phosphate (β-TCP) or the use of B-TCP alone in extraction socket preservation for future implant placement as well it's effect in post implant placement follow up period.

Materials and Methods: Twenty-one candidates with non-restorable premolar teeth at maxilla that should be extracted were involved in the current study. A conservative tooth extraction followed by satisfactory debridement, socket curettage, good irrigation, and the socket left for conventional healing after atraumatic extraction in group A. β-TCP were placed in the extracted socket in group B. In group c, the extracted socket filled with (B-TCP+L-PRF). Both clinical and radiographic outcomes were evaluated at baseline, 6 months later with implant placement at this 2ry stage of surgery was performed in all cases, and prosthetic part was done 3 months later.

Results: Regarding radiographic evaluation, the highest change in bone height (resorption) was detected with control group (A), succeeded by B-TCP group (B), and finally the lowest change in bone height was noted with B-TCP+PRF group(C). For both observations (6 months post- extraction and 3 months post-implant placement), the highest decrease in bone width was noted with group (A), followed by group (B), and the lowest decrease was noted group (C). The highest bone density was observed with group (C), succeeded by group (B), but the worst bone density was noticed

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with group (A). Regarding clinical evaluation, the highest change in bone height (resorption) was seen with control group, succeeded by group (B), and the lowest change in bone height was noted with group (C). The highest change in bone width was noticed with control group, succeeded by B-TCP group, and the lowest change in bone width was noted with (B-TCP+PRF) group. The highest change in socket depth (bone deposition) was observed with group (C), succeeded by group (B), but the lowest change in socket depth was noted with control group.

Conclusion: B-TCP+PRF have significant effect on socket preservation for future implant placement in addition to its valuable effect on post-implant period than B-TCP alone and normal healing process that showed the least bone deposition and density at all stages in addition to all other clinical and radiographic measures.

KEYWORDS: Dental implant, Atraumatic tooth extraction, Socket graft.

INTRODUCTION

Following tooth removal, the remaining alveolar bony ridge typically exhibits a limited dimensions of bone due to the continuous and progressive process of bone resorption. The healing processes occurring within the extraction sockets lead to a gradual decrease in their dimensions over time. Research indicates that there can be a decrease of about fifty percent in both width and height dimensions within a year, with about two-thirds of this reduction occurring in the initial three months [(1)].

The dynamics of bone resorption may be influenced if pathological or traumatic events compromise one or more bony walls of the alveolar socket. As for such cases, granulation tissue may fill a zone of the bony socket, hindering natural healing as well bone regeneration. So morphological alterations can have implications for the successful placement and osseointegration of dental implants [(1)].

To mitigate the rate of dimensional volume changes in the bony ridge, various grafting materials have been employed in fresh extraction sockets, and subsequent assessments have monitored bone volume and linear dimensional alterations [(2)].

Bone grafts have been a staple in reconstructive surgery, primarily aimed at enhancing the volume of bone in areas previously affected by defects. Alloplastic bone grafts exhibit osteoconductive properties, making them a relatively safe and cost-effective option. A significant benefit of utilizing synthetic materials, as opposed to autogenous bone grafts, is the reduced morbidity associated with the augmentation procedure, which represents a notable advancement in the simplification of bone regeneration techniques [(3)].

One of the primary motivations for employing grafted artificial biomaterial is to fix the coagulum to the extraction alveolar socket, thereby preventing a potential decrease in the mineral content volume necessary for effective hard tissue regeneration. Additionally, these grafts serve as scaffolds that facilitate the ingrowth of both cellular as well vascular components, ultimately leading the formation of new hard tissue that meets reasonable standards of quality and quantity [(4)].

Synthetic graft biomaterials, such as β-tricalcium phosphate (β-TCP), play a crucial role in maintaining the coagulum's stability within the socket while also preventing the loss of bony content essential to new bone reformation. Moreover, the Synthetic graft biomaterial acts as a matrix for integration of cellular as well as vascular elements, promoting the development of new bones of satisfactory quality as well as quantity. As the particles of the (βeta-TCP) are attached to bloody organized clot at alveolar socket, which is surrounded by alveolar bone walls, cells of osteogenic capacity, involving undifferentiated mesenchymal cells, that are activated through fibronectin, that is a glycoprotein adhesive present in the forming blood clot. These cells begin to migrate from the adjacent bone surface, traversing the area among and above the particles of β-TCP [5, 6].

The sites grafted with β-TCP exhibited a lower level of osteoid formation, with the graft particles showing poor integration with the newly formed bone and minimal signs of angiogenesis [7]. In contrast, the application of platelet-rich fibrin (PRF) resulted in a significant reduction in dimensional shrinkage in the groups utilizing platelet concentrates, alongside observable new bone formation [8].

PRF, recognized as a second-generation platelet concentrate, is an autologous biological material that is both viable and biocompatible. It can be employed independently to preserve ridge dimensions during preservation procedures while simultaneously promoting rapid osseous fill within the socket [9]. Composed of autologous fibrin, PRF contains a substantial quantity of platelets and leukocyte cytokines that are released during centrifugation [10]. The inherent integration of cytokines within the fibrin matrix facilitates their gradual release over a period of 7 to 10 days as the fibrin network disintegrates. Additionally, the fibrin clot serves to maintain and protect the bony substitute grafted material, while fragments of PRF act as bio- connectors among bone particles, fulfilling a mechanical addition [11].

The fibrin network incorporation at site of regeneration promotes the migration of cells, especially endothelial cells, which are essential for neo angiogenesis, vascularization, and the survival of the graft. As the fibrin matrix is resorbed, platelet cytokines including platelet-derived growth factor, transforming growth factor beta, and insulin-like growth factor-1 are gradually released, contributing to an extended healing process [12].

Dental implants insertion to restore lost teeth is a well-known treatment modality. As in the early protocol, it was wise to wait several months post tooth extraction prior insertion of dental implants to permit hard tissue healing [13]. In addition to recommended unloaded era of three–six months to assure bony union of dental implants, this management modality had a drawback of long treatment time. The previous concept has changed at the recent era through decreasing the period among tooth removal and insertion and/or load bearing of a restorable implant [14].

Dental implants are widely used in oral rehabilitation, so it is highly important to preserve a good three-dimensional architecture of the bony socket after tooth removal. Bone resorption of has an adverse outcome of tooth loss. Ridge deformity and bone resorption mostly come after the procedure in shape of hard tissue ridge decrease, both in height as well width. The bone resorption severity has a direct success rate effects on the succeeding procedures of dental implant, as well post-management cosmetic results [15]. Accordingly, the aim of this clinical trial was to compare clinical and radiographic outcomes of using leucocytes platelets rich fibrin in addition to beta-tricalcium phosphate (β-TCP) or the use of B-TCP alone in extraction socket preservation for future implant placement as well it's effect in post implant placement follow up period. The null hypothesis is that there will be no significant difference in the tested outcomes between the different treatment groups.

MATERIAL AND METHODS

Setting of the Study

Patients in this research were selected from oral and maxillofacial surgery department out-patient clinic , Faculty of Dentistry , Delta University for Science and Technology. All the patients were informed about the protocol and objectives of this study before obtaining signed informed consent from each participant. The study protocol had approved by the local committee of ethics at the same faculty under an issue number : 0230509003, at May,2023.

Sample Size Calculation:

Sample size was calculated based on previous research (Das et. al., 2016). Using G*Power program version 3.1.9.7 (Faul et. al., 2007) to calculate sample size based on effect size of 1.014, α error = 0.05 and power = 95%, the calculated total sample size was 21 (7 in each group).

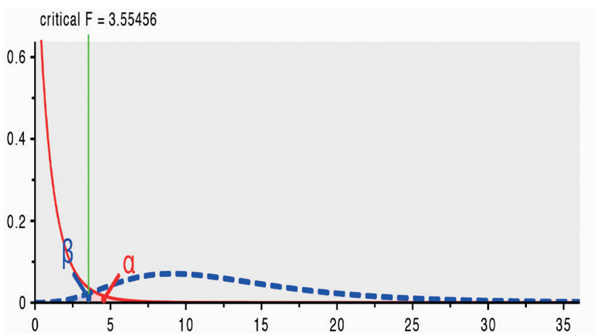

Fig (1). Sample size calculation

Statistical analysis:

Statistical analysis had been done by use of Statistical Package for Social Sciences (SPSS) Version 20 (SPSS Inc., Chicago, IL, USA) Statistical Analysis Software. The Shapiro-Wilk test had used to verify the normality of the distribution. The quantitative data was described by use of mean and the standard deviation. The significance of gained results had judged at 0.05 level. For testing the significance of two means the Student's t-test was used.

Reference for program:

Faul F, Erdfelder E, Lang AG, Buchner A. G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. Behavior Research Methods, 2007;39, 175-191.

Reference for the previous research:

Das S, Jhingran R, Bains VK, Madan R, Srivastava R, Rizvi I. Socket preservation by beta-tri-calcium phosphate with collagen compared to platelet-rich fibrin: A clinico-radiographic study. European journal of dentistry. 2016 Apr;10(02):264-76.[24]

Inclusion criteria :

A total of 21 Patients with age range of 18-60 years old of both genders, medically free, with good physical condition, non-smokers, not suffering from any parafunctional habits as bruxism, with good oral hygiene state, they required at least atraumatic single-tooth extraction in the Upper premolar area, residual extracted dental sockets were possessing an intact alveolar bone in all three dimensions, and a dental occlusion suitable for the planned prosthodontic treatment. The tooth extraction was due to either chronic periapical infection, vertical root fractures, trauma, untreatable caries, endodontic or periodontal failure.

Exclusion criteria:

1) Any systemic disease that may compromise the outcome. 2) patients under radiotherapy or chemotherapy treatement, 3) patients with diabetes mellitus, 4) patients underwent immunosuppressive drugs or intravenous bisphosphonates, 5) patients with a history of untreated periodontitis, 6) patients with bad habits as bruxism or smoking, 7) presence of any active periodontal disease, and 8) any signs of inflammation involving residual dentition, or mucosal disease in the treated region. 9) Bone dehiscence's, and fenestrations. 10) Poor oral hygiene.

Patient grouping and treatment protocol:

Diseased candidates were allocated into one of the three treatment groups in random manner by simple random method through generating number in an excel sheet. Patient identity sealing was done by using at least 2 identifiers as full name of the patient (at least 3), full mother's name, full number of national identification card, insurance number, cellular phone number, home phone number, gender type, birth date, birth location, and address in detail, and use of white wrist circle that contain specific information of the patient. Standardize approaches to patient identification. Encourage patients to participate in identification process. Labelling of patient file and containers. Provide clear protocol for questioning radiological, clinical, and any other investigations. Provide a repeated checking and reviewing to avoid computer entry error. In each group Seven atraumatic teeth extractions with periotomes were gained, dental sockets were debrided, then in :

a) **Group A :** The extraction socket was left for conventional healing.

b) **Group B :** Immediate placement of beta tricalcium phosphate grafting material into the extraction socket.

c) **Group C :** Immediate placement of beta tricalcium phosphate grafting material in addition to leucocytes platelets rich fibrin (PRF) into extraction socket.

Each group contained 7patients as 4 males and 3 females, and age mean was 42y in group A, 51y in group B, and 47y in group C. The extracted tooth number, and subsequent dental implant dimensions are recorded in table 1.

Surgical procedures:

1st stage surgery with atraumatic extraction:

Prior to the surgical procedure, patients were instructed to use chlorhexidine mouthwash* for a duration of one minute. Local anesthesia** containing adrenaline at a concentration of 1:100,000 was administered in the targeted surgical area, followed by the creation of sulcular incisions and the reflection of a full thickness mucoperiosteal flap around the tooth or root designated for extraction, as well as adjacent teeth. The diseased teeth had carefully loosened by use of periotomes. Hence, subsequently tooth forceps was used for extraction, with aim of preserving the facial and lingual bone post-extraction, surrounding soft tissues, and minimizing damage to the interdental papillae. The extraction sockets were thoroughly debrided of granulation tissue and irrigated with saline solution. A comprehensive inspection of all socket walls was conducted to identify any bony dehiscence defects or fenestration, that led to exclusion of patients with such defects from the study.

In group A: The extraction socket was prepared for standard healing following a gentle extraction procedure.

In group B: The extraction socket filled with (β-TCP) synthetic bone grafted granules (0.5-1.0 mm).***

In group C: L-PRF fragments formed and mixed with (β-TCP) bone graft and then inserted into the extraction socket.

TABLE (1) Patients data in the three treatment groups

GROUP TYPE	Age mean in years	Gender	Extracted Tooth number	Dental implant dimensions (Diameter* length) (mm)
Group A	42	3 females + 4 males	4 teeth 2nd premolar+3 teeth 1st premolar	5 implants=3.7*8 mm 2 implants =4*10 mm
Group B	51	3 females + 4 males	5 teeth 2nd premolar+2 teeth 1st premolar	4 implants =3.7*8 mm 3 implants=4*10 mm
Group C	47	3 females + 4 males	3 teeth 2nd premolar+4 teeth 1st premolar	3 implants =3.7*8 mm 4 implants=4*10 mm

*Antiseptol-Cairo-Egypt. **Articaine HCL 4% 3M™ ESPE™ Ubistesin™

*** adbone TCP bone graft –Made in Portugal.

The extraction socket was covered with collagen sponge* and this was achieved by securing the flaps with interrupted 3/0 non-resorbable suture.**

Second stage surgery:

For the 2nd stage surgery at 6 months. Local anesthesia was deposited, followed by sulcular incisions, and reflection of full thickness mucoperiosteal flap were done at the surgical site, to expose the bone for obtaining the same clinical follow up measurements, and implant placement.

Osteotomy preparation for implant placement

The osteotomy bony sites were prepared, then drills were utilized in a proper sequence in accordance with manufacturer's own instructions. Drilling of the surgical site was done by use of a conventional low speed, with high-torque and a coolant contra-angle handpiece by help of surgical motor unit***. Drilling was done using six to eight hundred rounds per minute at the desired angulation; Successive drilling according to manufacturer instructions with copious saline irrigation was used until the wanted dimensions were obtained relying on the chosen implant with maximum bony use.

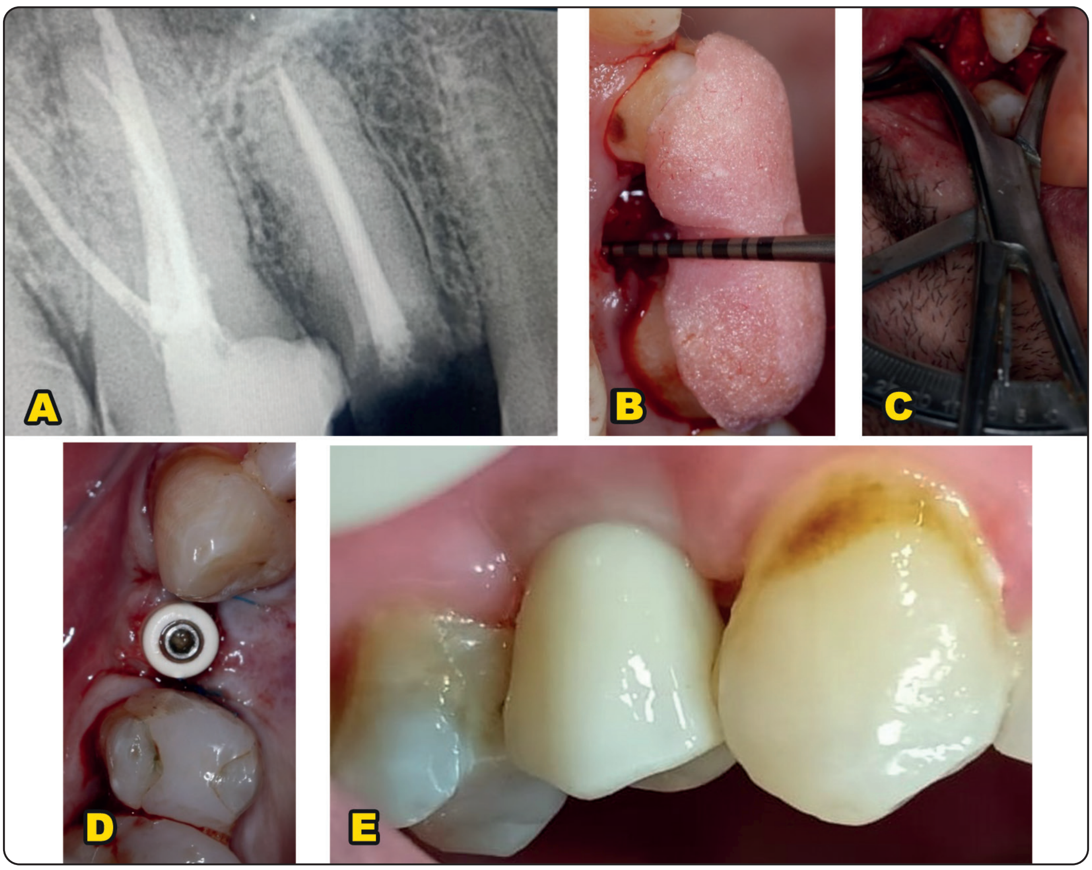

Fig (2) (A to E) is showing A) Preoperative x-ray of upper right first premolar B) Mid-palatal crestal height measured by periodontal probe C) Ridge Mapping Caliper (Bucco palatal (width D) implant placement after osteotomy site preparation and placement of healing abutment E) crown delivery into patient mouth

*NSK Surgic Pro Implant Motor System ** Dentis SQ submerged qualified, Made in Korea.

Implant placement

After the bony sites were prepared, implant placement was done*. The implants width used in the study was 3.7mm to 4mm, and its height was 8-10mm. Sterile implant had guided into its position by using a stable light finger pressure. The ratchet wrench had been utilized to complete total installation of the implant to bone level.

Special attention was paid to correct prosthetic positioning of the implant platform in all three dimensions. The longest possible implants were placed with implant platform placed at the marginal level of the facial wall; 2-3 mm apical to the predetermined gingival margin. At least 1.5 mm distance was maintained among implant and the adjacent tooth. Finally, cover screw was screwed to the crestal module of the implant by its insertion tool. Wound suturing was done and postoperative instructions were given to the patient. The sutures had been removed 2 weeks post-surgery. The patients were recalled after 3 months for placement of healing abutment and Prosthetic rehabilitation.

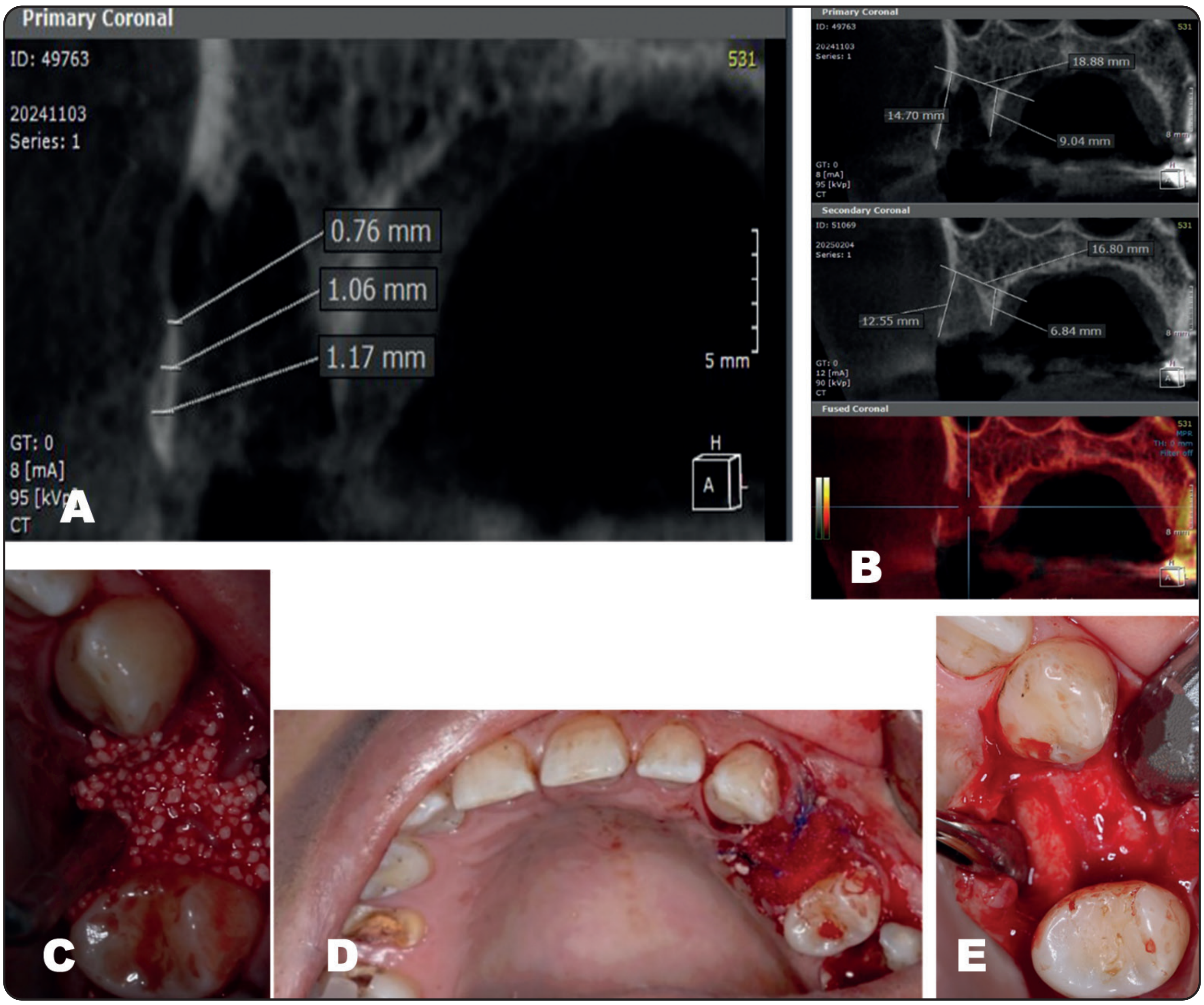

Fig (3) (A to E) is showing A) Buccal bone plate thickness at 3 different levels (one mm, three mm and five mm down crest of lingual bone) (Buccal Bone Plate-one, Buccal Bone Plate -three, Buccal Bone Plate -five)as (at level of baseline only) B) Mid-buccal and mid-palatal alveolar Height aspects in control group soon post- extraction and after six months C) Socket filled with the bone substitute D) collagen sponge application and Interrupted (3/0) polypropylene suture to close the flap E) sulcular flap elevation

* 3shape intra-oral scanner, Made in Poland.

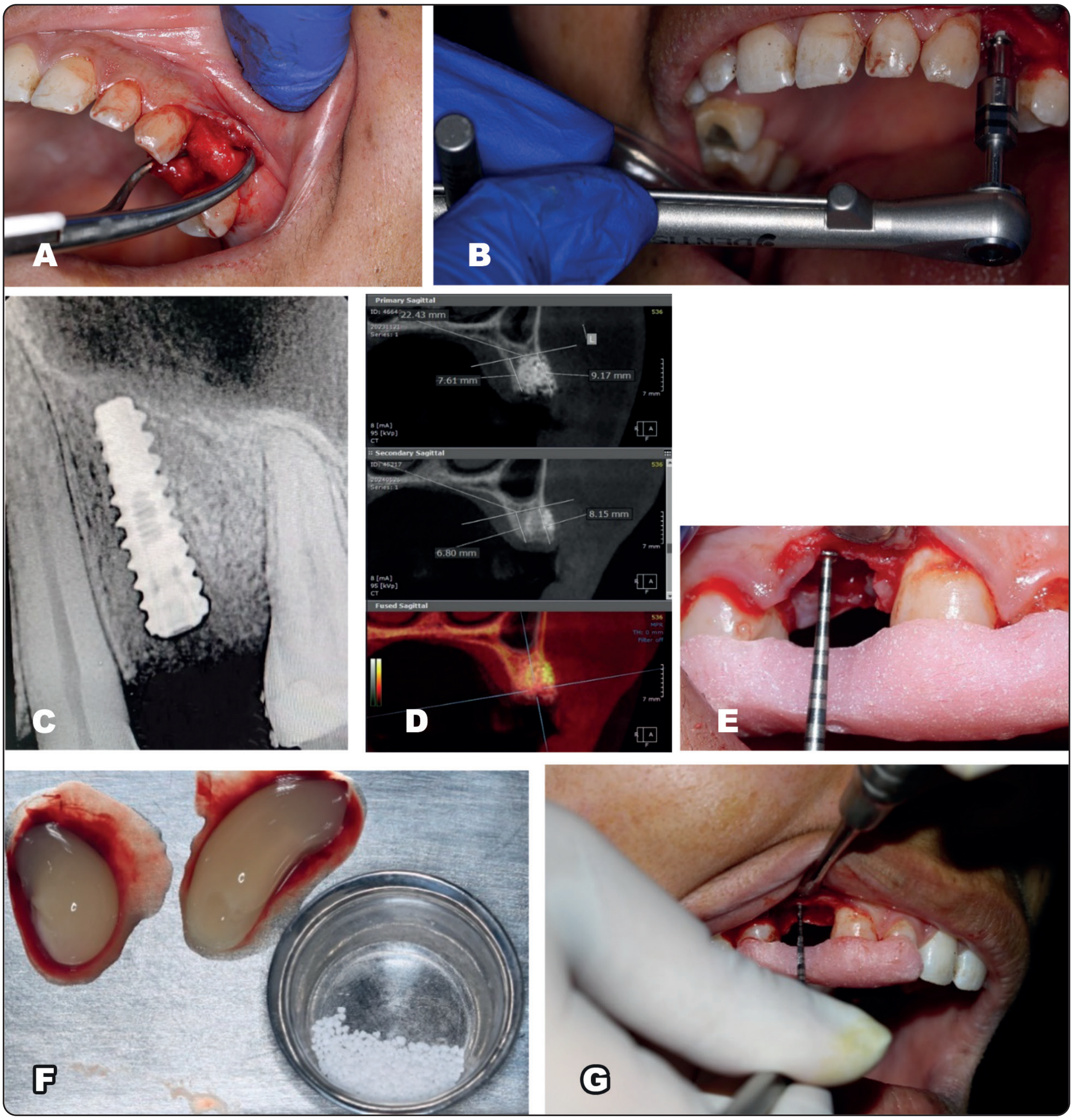

Fig (4) (A to G) is showing A) Ridge Mapping Caliper (Bucco palatal (width B) implant placement after osteotomy site preparation C) implant restoration of upper left first premolar tooth D) Midbuccal and midpalatal alveolar Height aspects immediately after extraction and 6 months later E) mid buccal crestal height measured by periodontal probe F) L- PRF membrane Preparation G) Mid-buccal crestal height measured by periodontal probe after 6months follow up

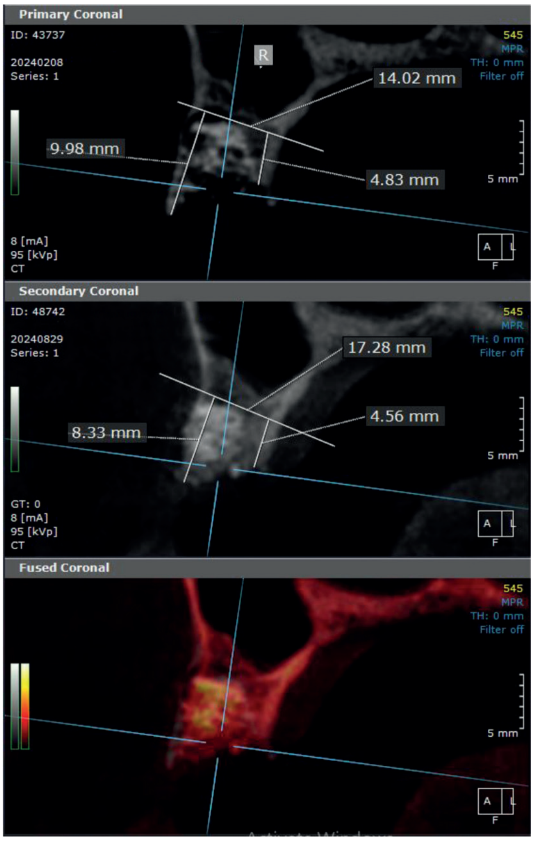

Fig (5) Midbuccal and midpalatal alveolar Height aspects immediately after extraction and 6 months later

Prosthetic rehabilitation:

The healing abutment was removed then replaced by the intra-oral scan body. Digital implant Impression was made with 3D INTAL oral scanner***. The final restoration of zirconia was fabricated and cemented on the abutment.

Evaluation:

A) Clinical Evaluation:

Clinical parameters will be obtained immediate postoperative and after 6 months.

Acrylic Stents Preparation:

Surgical stents of Acrylic type were constructed up to cover 1/3rd of the adjacent tooth crown on both sides of surgical field. A relative foramen to the center zone at the bony socket was done in acrylic resin prepared stent, and hence, prepared grooves on surface aspects at mid- buccal as well mid-palatal of the stent was done. Surgical stent gave merit of accurate clinical measures replications from surgical baseline intervention as for six months post-operative at 2nd surgery stage [16].

(a) Clinical horizontal width dimensions (Bucco-palatal ridge width): Horizontal width of Bucco palatal measurement was in a correspondence to a line, two mm in an apical to the utmost coronal point at the bony socket/ alveolar residual ridge with help of Caliper of Ridge Mapping.

(b) Clinical height dimensions: Mid-buccal crestal vertical length: Corelated to the space between stable reference point at the surface of surgical polymeric stent till the utmost cephalic mid-buccally to a point at the crest on surface of the plate of buccal bone cortex by use of a probe.

Mid-palatal crestal vertical length: Was assigned to the space from a stable fixed point on surface of surgical polymeric stent till the utmost cephalic-mid palatal crestal reference point at surface of cortical palatal bone plate by use of a probe.

(c) Alveolar socket relative depth: Was assigned to a space calculated from the central foramen on surface of surgical polymeric stent to the utmost socket/ridge cephalic end by use of a marked dental probe (twenty mm) with a corresponding stopper.

B) Radiological Evaluation:

Periapical radiographs are taken constantly to perform proper diagnosis. CBCT scans were obtained immediately after tooth extraction, 6 months and 3 months after implant placement.

1. Thickness of Buccal plate of bone at 3 different levels (one mm, three mm and five mm down palatal crestal alveolar bone) so as (BBP-1, BBP-3, BBP-5) which was (at baseline only).

2. Mid-buccal (BH) and mid-palatal (LH) height aspects of the alveolus.
3. Horizontal width of the ridge measured at 3 different levels so as (at one mm, three mm, five mm) down the utmost coronal level at the crest (HW-one, HW-three, HW-five) [17].

4-After 6 months CBCT scans were obtained to determine the follow up measurements, the bony healing changes, and dental implant dimensions

Statistical analysis:

The data were analyzed using SPSS® software version 25 (SPSS Inc., Chicago, IL, USA). All data were parametric and presented as mean± standard deviation. Comparison of clinical and radiographic measurements of bone vertical height, as well radiographic measurement of bony hard tissue width between groups and sites was performed using two-way Analysis of variance succeeded by Bonferroni post hoc test for multiple comparisons. Radiographic measurements Comparison of bone width, and bone density between six months postoperatively and 3 months post implant placement was made by using a paired samples t-test. Comparison of bone density, clinical measurements of bone width, and socket depth between groups was made by use of One-way ANOVA succeeded by Bonferroni correction for multiple post hoc tests. Graphic presentation of data was made using clustered bar charts. P-values <0.05 were considered to be significant.

RESULT

Radiographic evaluation

Change in bone height after 6 months

Comparison of mean change in bone height between groups and sites is presented in table 2. For both sites (mid buccal and mid palatal), there was a significance in mean change in bone vertical height among groups. The highest change in bone height (resorption) was observed with control group, succeeded by Beta-TCP group, and finally the lowest change in bone height was noted with B-TCP+PRF group. For control and B-TCP groups only, there was a significance in mean change in bone vertical height among sites. Mid buccal showed significant higher change in bone height than mid palatal site.

Bony Change in width after six months

Comparison of mean change in alveolar bone horizontal width among groups as well sites at six months post-tooth extraction and 3 months post-implant placement is presented in table 3. For both observations (post six months of extraction and post implant placement by 3 months), there had a significance in the mean change in alveolar bone horizontal width between groups in all places. For all sites (1mm, 3mm, and 5mm), the highest decrease in bone width was noted with the non-study group, followed by Beta-TCP group, and so the lowest decrease was noted with (Beta-TCP +Platelet Rich Fibrin) group. There was a significance in mean ridge width change between places for all groups. For all groups, the highest decrease in bone width was noticed with 1mm, succeeded by 3mm, and the minimal decrease was noticed with 5mm

Comparison of mean change in bone width between observations (post six months of extraction and post implant placement by 3 months) for control group, B-TCP and B-TCP+PRF groups is presented in fig 6, fig 7, and fig 8, respectively. For all groups and sites, the change in bone width after 6 months of extraction was significantly higher than after 3 months of implant placement.

Change in bone density after 6 months

Comparison of mean change in bone density between groups and observations (post six months of extraction and post implant placement by 3 months) is presented in table four. There was a significance in mean change in bony hard tissue density among groups, and observations. For both observations, the highest bone density was observed with (Beta-TCP plus PRF) group, succeeded by Beta-TCP group, but the minimal bone density was noted with control group. For both groups, the bone density after 3 months of implant placement was significantly higher than after 6 months of extraction.

Clinical evaluation

Change in bone height after 6 months

Comparison of mean change in bone height between groups and sites is presented in table 5. For both sites (mid buccal and mid palatal), there had a significant difference at mean bone vertical height change among groups. The highest change in bony vertical height (resorption) had noticed with control group, succeeded by B-TCP group, and the minimal change in bone height was noted with group(B-TCP+PRF). For control group only, there was a significant difference in mean change in level of bone height among sites. Mid buccal showed a significantly higher change in bone height than mid palatal site.

Bone width changes after six months

The comparison of mean bone width change among groups had presented in table 6. There was a significant difference in the mean bone width change among groups. The highest change in bone width was observed with control group, succeeded by Beta-TCP group, but the lowest change in bone width was noted with B-TCP+PRF group.

Change in Socket depth

Comparison of mean change in socket depth between groups is shown in table seven. There was a significance in mean change in socket depth between groups. The highest change in socket depth (bone deposition) was observed with (Beta-TCP plus PRF) group, succeeded by Beta-TCP group, but the lowest change in socket depth was noted with control group.

TABLE (2) Comparison of mean alveolar bone height change between groups

	Mid buccal		**Mid palatal**		**Independent samples t-test**
	X1	***SD1***	***X1***	***SD1***	
Control	1.967A	.240	1.183A	.874	.002*
B-TCP	1.380B	.229	.703B	.074	.007*
B-TCP+PRF	.310C	.296	.233C	.036	.743
One way analysis of variance P	.001*		<.001*		

X1; mean, SD1; The standard deviation, *p has a significance at 0.05. Dissimilar capital letters at the once vertical column indicate a significance among groups (Bonferroni post hoc test, p-value <5%). Similar capital letters in the same vertical column express non-significance among different groups (Bonferroni post hoc test, p*-value >.05).

TABLE (3) Comparison of change in bone width between groups and sites after 6 months of extraction and after 3 months of implant placement

		1mm	3mm	5mm	Two- way ANOVA test P value
		6 months postoperative			
Control	X1	2.39A,a	2.26A,a	1.30A,b	<.001*
	SD1	.55	.66	.11	
B-TCP	X1	1.34B,a	.75B,b	.74B,b	.001*
	SD1	.13	.10	.01	
B-TCP+PRF	X1	.93C,a	.25C,b	.22C,b	<.001*
	SD1	.08	.04	.03	
Two- way ANOVA test P value		<.001*	<.001*	<.001*	
		3 months after implant placement			
Control	X1	3.74A,a	3.23A,b	2.51A,c	<.001*
	SD1	.91	.77	.25	
B-TCP	X1	2.65B,a	2.19B,b	1.57B,c	.002*
	SD1	.39	.41	.31	
B-TCP+PRF	X1	2.23C,a	1.25C,b	1.01C,b	<.001*
	SD1	.50	.16	.21	
Two- way ANOVA test P value		<.001*	<.001*	<.001*	

X1; mean, SD1; the standard deviation, *p is of significance at 0.05 level. Dissimilar capital letters at the once vertical column indicate a significance among groups (Bonferroni post hoc test, p-value <5%). Different small letters in the same horizontal raw express significant differences among sites (Bonferroni post hoc, p-value <5%).

TABLE (4). Comparison of mean change in bone density between groups

	6 months after extraction		3 months after implant placement		Paired samples-t test
	X1	***SD1***	***X1***	***SD1***	
Control	519.70A	96.42	937.20A	12.52	<.001*
B-TCP	647.80B	93.92	1187.00B	170.99	<.001*
B-TCP+PRF	877.75C	73.18	2457.20C	303.36	<.001*
One way analysis of variance P	<.001*		<.001*		

X1; mean, SD1; the standard deviation, *p has significance at 0.05 level. Dissimilar capital letters at the once vertical column indicate a significance among groups (Bonferroni post hoc test, p-value <5%). Similar capital letters in the same vertical column express non-significance among different groups (Bonferroni post hoc test, p*-value >5%).

TABLE (5) A Comparison of the mean bone height change among different groups

	Mid buccal		Mid palatal		Independent samples t-test
	X1	***SD1***	***X1***	***SD1***	
Control	4.167A	1.125	2.833A	.931	.002*
B-TCP	1.333B	.258	1.000B	.316	.410
B-TCP+PRF	.500C	.548	.333C	.516	.670
One way ANOVA					
P	<.001*		<.001*		

X1; mean, SD1; the standard deviation, *p has significance at 0.05 level. Dissimilar capital letters at the once vertical column indicate a significance among groups (Bonferroni post hoc test, p-value <5%). Similar capital letters in the same vertical column express non-significant differences among groups (Bonferroni post hoc, *p >0.05).

TABLE (6) A Comparison of mean bone width change among different groups

	X1	SD1
Control	1.77A	.23
B-TCP	1.44B	.08
B-TCP+PRF	.85C	.19
F	42.22	
One way ANOVA		
P	<.001*	

X1; mean, SD1; the standard deviation, *p has a significance at 0.05 level. Dissimilar capital letters at the once vertical column indicate a significance among groups (Bonferroni post hoc test, p-value <5%). Similar capital letters at the once vertical column express non-significant differences among groups (Bonferroni post hoc, *p >0.05).

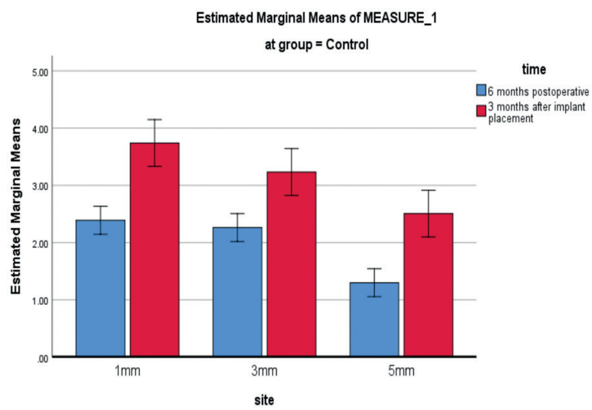

Fig (6). Comparison of mean change in bone width between observations (six months post-extraction and three months post- implant placement) for control group

TABLE (7) A Comparison of mean socket depth change among different groups

	X1	SD1
Control	7.33A	.75
B-TCP	8.83B	.68
B-TCP+PRF	10.83C	1.47
F	17.35	
One way ANOVA		
P	<.001*	

X1; mean, SD1; the standard deviation, *p has significant at 0.05. Dissimilar capital letters at the once vertical column indicate a significance among groups (Bonferroni post hoc test, p-value <5%). Similar capital letters in the same vertical column express non-significance among different groups (Bonferroni post hoc, *p -value>.05).

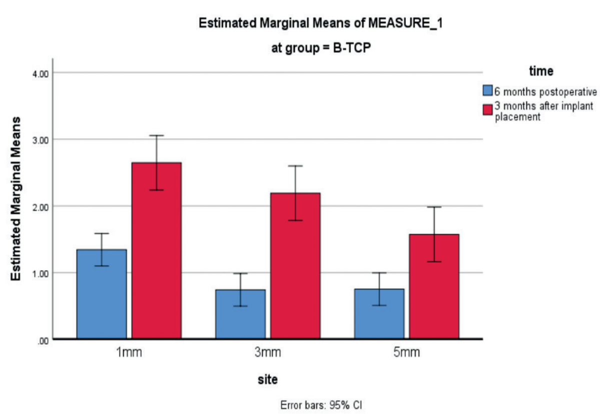

Fig (7). Comparison of mean change in bone width between observations (six months post-extraction and three months post- implant placement) for B-TCP group

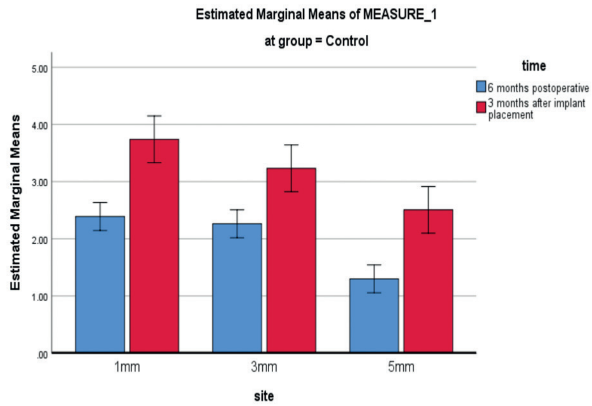

Fig (8). Comparison of mean change in bone width between observations (six months post-extraction and three months post- implant placement) for B-TCP+PRF group

DISCUSSION

The current study assessed the role of using autologous leucocytes platelets rich fibrin in addition to beta-tricalcium phosphate (β-TCP), or use of B-TCP alone in maxillary premolar extraction socket preservation for future implant placement, as well it's effect in post implant placement follow up period. This was done by using both clinical and radiographic methods. These procedures were compared with a control group that received traditional, unassisted socket repair. The comparisons were in terms of preserving alveolar bone vertical height, horizontal width and bony tissue density increase over a six-month healing period and after 3 months of implant placement. and null hypothesis of this research was rejected as there was a significant difference in results between the three different management groups. Mainly regarding clinical and radiographic outcomes obtained from the study results in the form of bone height and width change, bone density change, and all other clinical data as highly positive results were noticed with **(B-TCP+PRF) group, followed by (B-TCP) group, and the least positive results were seen with control group**.

The study's findings showed that the non-study, (β-TCP), as well (β-TCP + L-PRF) groups differed significantly in the preservation of alveolar ridge width at all examined levels (1 mm, 3 mm, and 5 mm from the crest). The β-TCP + Leucocyte Platelet Rich Fibrin group showed the minimal amount of bone decrease, while the non-study group showed the largest decrease in ridge width, followed by β-TCP alone. This order of efficacy is consistent with other research that supported the use of platelet concentrates and osteoconductive grafts together to preserve the bony ridge **(18,19).**

According to a previous study assessing periapical bone defects, β-TCP + L-PRF caused significantly greater bone fill and smaller defects than either material used alone, indicating a higher capacity for regeneration when these materials are combined **(20).** In a similar vein, CBCT-based investigation found that, especially in younger patients, sockets grafted with β-TCP + PRF maintained significantly greater labio-palatal width and higher residual graft volume after six months [(21)], these results are in a line with this study results.

Data of this research supports the idea that L-PRF increases the osteoconductive qualities of β-TCP by promoting angiogenesis, prolonged growth factor release, and faster bone remodeling. A consistent pattern of ridge width reduction across several vertical levels was also found in our investigation; the largest resorption occurred at 1 mm from the crest, followed by 3 mm and 5 mm, which was Due to its exposure to mechanical and biological resorptive stimuli. the coronal section of the alveolar ridge showed the most significant dimensional alterations in post-extraction remodeling, which was reflected in this gradient. Furthermore, the bulk of bone resorption occurred during the first healing phase, with a significantly greater reduction in width at the 6-months mark, when compared to three months after implant insertion. Results of the present research was in a line with the body of research showing that the first three to six months after extraction are the most crucial time for alveolar ridge rebuilding, and that was when preventative preservation measures are most effective [1]. The promise of β-TCP + L-PRF as a clinically viable substitute for conventional grafting techniques is highlighted by its improved performance in maintaining both vertical and horizontal ridge dimensions through obtained clinical and radiographic outcomes.

Results of the current study demonstrated a clear hierarchy in bone density outcomes, with the β-TCP + L-PRF group yielding the highest bone density, followed by β-TCP alone, while the control group expressed the lowest density at six months post-surgery. Additionally, the significant increase in alveolar bone density observed at three months post-implant placement compared to a six months post-extraction suggested that implant placement may further stimulate bone remodeling and maturation.

Findings of this research are consistent with previous studies, including those **by Hamuda et al. (2023)** [20], who reported enhanced bone density and reduced defect dimensions when combining β-TCP with PRF, and **Nguyen et al. (2024)** [21], who noted improved outcomes in alveolar bone grafts with this combination, particularly in younger patients. While β-TCP alone had been shown to support bone formation, as demonstrated by **Brkovic et al.,** the addition of L-PRF appears to accelerate and enhance the regenerative process [22]. Notably, a previous systematic review highlighted the unpredictable effects of PRF alone on bone repair, reinforcing the importance of combining it with a scaffold like β-TCP for consistent results, which was in line with clinical and radiographic findings of this study. [23]**.**

Present study findings reinforced the growing consensus that combining β-tricalcium phosphate (β-TCP) with leukocyte-platelet-rich fibrin (L-PRF) offers superior preservation of alveolar bone height compared to β-TCP alone or natural healing. The results demonstrated a clear pattern: the greatest bone resorption occurred in the control group, particularly at the mid-buccal site, which was anatomically more vulnerable due to thinner cortical bone. The β-TCP group showed moderate resorption, confirming its osteoconductive role in maintaining ridge dimensions. In contrast, the β-TCP + L-PRF group exhibited the least resorption, suggesting a synergistic effect that enhanced bone preservation. This site-specific difference (greater mid-buccal vs. mid-palatal resorption in control group) aligned with established patterns of post-extraction remodeling, further validating our observations.

The current study results are consistent with multiple other researches, though some variations exist depending on clinical context. As **Brkovic et al.** stated that βeta-TCP combined with fibrils of collagen effectively preserved horizontal ridge dimensions without barrier membranes, but this study results showed that adding L-PRF reduced vertical bone loss in addition to minimizing bone ridge width loss. Similarly, **Hamuda et al. (2023)** [20] found that β-TCP + PRF significantly reduced bone defect height and width in periapical lesions compared to either material alone. **Nguyen et al. (2024)** [21] observed improved graft thickness and residual calcified volume with β-TCP + PRF in alveolar bone grafts, particularly in younger patients, reinforcing the age-dependent efficacy of this combination. However, **Das et al.** [24] noted that PRF alone led to more buccolingual width reduction than β-TCP with collagen, suggesting that PRF's regenerative benefits are maximized when paired with a scaffold, that was consistent with the current study outcomes.

Interestingly, results of this study was in agreement with results of **Faima Banu et al.** [25] as compared PRF alone versus PRF combined with hydroxyapatite/β-TCP in infra-bony defects and found that the combination group had superior bone fill and attachment gain, although both groups improved over time. Conversely and in contrast to results gained from this study, **Refaat et al.** [26] compared injectable PRF with collagen versus β-TCP in sinus lifts and found that β-TCP provided greater vertical bone gain, while PRF with collagen was more economical yet still clinically effective. This indicated that β-TCP may outperform PRF in certain volumetric applications, depending on the anatomical site and surgical requirements. Additionally, **Lu et al.** [27] highlighted that β-TCP's performance can vary based on scaffold porosity, design, and host factors, with some studies even reporting delayed healing when β-TCP is used alone.

The current study supported the use of β-TCP + L-PRF as a composite graft for socket preservation, particularly in esthetic zones like maxillary premolars, where minimizing vertical bone loss is critical. This combination not only reduced the need for additional augmentation at implant placement but may also enhance soft tissue healing due to L-PRF's growth factor release. With regards to that, specific factors related to the patient, such as, for instance patient age, general systemic health, and morphology defects should guide treatment selection.

The present findings supported the synergistic benefits of combining β-TCP with L-PRF in socket preservation, particularly in maintaining vertical and horizontal ridge dimensions. The non-study group demonstrated the maximum decrease in bone width, consistent with the well-documented post-extraction resorptive process, while β-TCP alone provided moderate preservation, in line with its established osteoconductive properties. Most notably, the β-TCP + L-PRF group exhibited the least bone width loss, suggesting that L-PRF enhanced β-TCP's scaffold function, that in agreement with current study results.

These results aligned with previous studies [20, 21], also a multicenter trial demonstrated that rhBMP-2 combined with β-TCP significantly reduced horizontal resorption compared to β-TCP alone, reinforcing the concept that biological adjuvants (such as PRF or BMPs) optimized β-TCP's regenerative potential [28]. However, some studies presented nuanced findings. β-TCP's efficacy can vary based on scaffold design and host factors, with some cases even showed delayed healing when β-TCP was used without biological enhancers [27]. Additionally, a trial compared β-TCP composites with xenogeneic substitutes found no significant difference in ridge width preservation, suggested that material selection may be less critical than surgical technique or patient-specific factors in certain clinical scenarios [29],that was in line with findings of this research.

The clinical and radiographic findings of this study demonstrated that the combination of β-tricalcium phosphate (β-TCP) with leukocyte-platelet rich fibrin (L-PRF) offered superior socket preservation outcomes compared to either material alone or natural healing. The most significance decrease at clinical socket depth change was seen at (β-TCP + Leucocyte-PRF) group, demonstrated enhanced bone fill capacity, while β-TCP alone showed moderate improvement and the control group exhibited the expected pattern of natural healing with minimal bone deposition.

The present research findings aligned with previous research that also highlighted important nuances in socket preservation strategies as **Reddy et al.** similarly reported improved socket depth reduction and ridge preservation when combining β-TCP with PRF membranes [30]. However, comparative studies revealed interesting trade-offs in regenerative approaches. **Das et al.** [24] found that while PRF alone promoted greater early socket fill than β-TCP with collagen, the latter demonstrated better maintenance of ridge width. The conflict indicates that PRF could be effective in stimulating rapid bone growth, whereas β-TCP provides crucial structural support for dimensional stability, similarly as results gained from this study.

Mendoza-Azpur et al., observed that PRF-enhanced surgical sites, and showed greater mineralized tissue formation but experienced more buccolingual shrinkage compared to β-TCP-treated sockets, that was in contrast to results of this study that may be due to data gathering maneuver and/or the used surgical technique. [31].

The β-TCP + L-PRF combination at this research appeared to offer the dual advantage of accelerated socket fill and improved dimensional maintenance, addressed two critical aspects of successful socket preservation. This synergistic effect may reduce healing time, minimize the need for secondary grafting procedures, and create more favorable conditions for implant placement and improve implant stability. The results supported the use of this composite approach particularly in clinical situations where both rapid bone formation and structural preservation are desired, such as in esthetically demanding areas or when immediate implant placement is not feasible.

The idea that L-PRF acts as a powerful biological enhancer in conjunction with an osteoconductive scaffold is strongly supported by results of this study [32]. There was substantial evidence in the literature supporting L-PRF's capacity for regeneration. In a line with the current study, **Peck et al.** [33] successfully preserved alveolar ridges using L-PRF as the only grafting material, demonstrating its inherent ability to promote the growth of new bone and preserve ridge shape.

According to a systematic review by **Al-Maawi et al**., [34] PRF was especially useful for lowering postoperative pain, speeding up soft tissue healing, and minimizing dimensional bone loss during the early healing phase (2–3 months). Significantly higher socket fill was seen in sites treated with PRF. which supports the results of this study.

The 6-month results for PRF and β-TCP combination in the current investigation are consistent with the findings that showed the combination of a stable β-TCP scaffold aids in preserving and prolonging these initial advantages. The current outcomes are in agreement with **Al-Maawi et al.** [34] as highlighted at six months, as the effect of PRF alone in preventing bone loss could not be statistically significant. In contrast, the β-TCP+L-PRF combination showed highly significant advantages at 6 months in the current trial.

In agreement with results of this research, numerous investigations into the usage combination of PRF and β-TCP had shown data that generally supports a synergistic interaction [20, 25, 35]. This trend was strongly supported by the results of the current study for PRF and β-TCP combination, which showed the best results in terms of bone density and dimensional preservation. The idea of synergy was supported by a case report by **Jayalakshmi et al**. [36] that detailed rapid bone regeneration and predictable healing obtained when PRF and β-TCP were used together to treat periapical cysts.

In a study by **Barone and colleagues** [37] showed favorable results in both implant survival and marginal bone stability after alveolar ridge preservation. This study results supported the change in bone width at six months post- extraction had significantly higher than three months post-implant placement at all groups, and the minimal width change was in PRF and β-TCP group.

In accordance to results of a study by **Sunil Kumar et al.** [38] the analysis expressed a significance increase in the alveolar bone density after implant placement in line with the outcomes of this research that expressed bone density at three months post- implant placement was significantly higher than after 6 months of extraction. As well as with **Elkhidiry, et al.**[39] outcomes showed a progress in post-surgery bone density scores at 3 different bony levels surrounding dental prosthetic implants, which was supposing that alveolar bone had compressed at the surround of dental prosthetic implants post- placement, so it was great for stability of the implant, mainly at sites of minimal bone density, as in upper jaw posterior region, that was similar to results of this study. as well **Reddy GVK et al .**[(40)] results showed an improvement in post-surgical bone density measurements at 3 levels surrounding dental implants, that was in line with findings of this research.[(41)].

Von Wowern and Gotfredsen showed in two studies that hard tissue mineral content surrounding implant decreased significantly less than either skeletal bone mineral content or mandibular bone mineral content, supposing as a prosthetic dental implant obtained a fixating effect on bone surrounding implant [(42,43)]**.** While in the present study results showed that bony tissue density increased in both group B and C after 3 months of implant placement.

in a study either to stop or postpone bony ridge loss at the time immediately following initial bone loss (six–eight weeks) by Denissen ***et al.*** [(44,45))]**, provided** scarce data on that period since tooth loss, also the extraction cause or post-extraction alveolar bony socket shape. So, they concluded that hard bony tissue diminished was arrested by dental prosthetic implants had not continued by the data, in contrast to that the current study expressed that ridge width decrease was diminished in the size horizontally after 3 months of implantation at 3 horizontal levels compared to 6 months after tooth extraction. The highest decrease in bone width was noticed with the non-study group, succeeded by (Beta-TCP)group, and so the minimal decrease was seen with (B-TCP+PRF) group.

Watzek *et al.*[(46)] studied 3 groups of patient's bony ridge reductions in cases of immediate, delayed, as well late placement of dental implants. Concluded that bone loss surrounding implant was the highest in an immediate group (with mean of 1mm), little in delayed-implant group (about 0.8mm), and least resorption was in the late-implant group (about 0.5mm). Identical outcomes were also deducted by **Mensdorff-Pouilly** [(47)]**.** Data of both studies suggested that alveolar bone modeling after extraction was not influenced by dental implant presence, so refuting proposition that dental implants placement could preserve alveolar bone. While results of present research stipulated that changes in bone width six months post- extraction were significantly higher than three months post-implant placement and significant maintenance of alveolar ridge volume after implant placement was achieved.

CONCLUSION

Within limitations of the present study, which include small sample size rather than short time follow up period. The outcomes of this study showed a distinct hierarchy efficacy among the three treatment groups. For the comparison of using β-TCP alone, and the combination of β-TCP and L-PRF, results showed statistical significance in both clinical and radiological findings at different follow up times in the form of relevant superior results in fostering higher bone density and limiting bone resorption in both vertical and horizontal dimensions. The most positive results were with **(B-TCP+PRF) group, followed by (B-TCP) group, and the least positive results were seen with control group**. In turn, both therapeutic groups outperformed the control group, which had the greatest dimensional loss. Implant placement could preserve ridge volume and increase bone density, as well CBCT was a reliable technique to determine bone height, thickness changes, as well as bone density.

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