

Evaluation of Alveolar Socket Preservation Using Mineralized Plasmatic Matrix with or without Pontic Shield in Anterior Maxilla

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ABSTRACT

Background: This study aimed to evaluate alveolar socket preservation using mineralized plasmatic matrix (MPM) with or without pontic shield in the anterior maxilla. **Materials and Methods:** Twenty-seven non-restorable maxillary anterior teeth indicated for extraction were randomly divided into three equal groups. Group I underwent extraction only. Group II received MPM grafting. Group III received MPM with pontic shield technique. CBCT was used at baseline and after 4 months to assess ridge width, height, and bone density. Soft tissue healing was evaluated at 7, 14, and 21 days using the Landry index. **Results:** A statistically significant difference in ridge width reduction was observed at 3 mm apical to the crest ($p < 0.05$), with no significant difference at 6 mm ($p > 0.05$). Buccal bone height reduction differed significantly ($p < 0.05$), unlike palatal height reduction ($p > 0.05$). Bone density decreased significantly over time in MPM groups, with no intergroup difference at follow-up. Soft tissue healing showed no significant intergroup differences ($p > 0.05$), but MPM sites exhibited clinically favorable healing. **Conclusion:** Combining MPM with the pontic shield technique resulted in superior preservation of ridge dimensions and enhanced soft tissue healing compared to MPM alone or ungrafted sockets. **Key Words :** Socket preservation, Mineralized plasmatic matrix, Pontic shield, CBCT, Ridge dimensions

Received: 02 August 2025, **Accepted:** 06 October 2025

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ISSN: 2090-097X, September 2025, Vol. 16, No. 4

INTRODUCTION

Tooth extraction is followed by changes in the alveolar bone, causing gradual resorption of the residual ridge^[1], which may result in considerable challenges related to prosthodontics, esthetics, and function during tooth replacement^[2]. Socket preservation is a procedure that aims to reduce and compensate for the expected horizontal and vertical loss of alveolar bone following tooth extraction, while enhancing bone formation within the socket.^[1, 3] A clinical study employed CBCT to evaluate buccal bone thickness at three levels apical to the crest, and it was found that the buccal bone plate in the anterior maxilla is mostly thinner than one mm.^[4] Various techniques have been introduced to manage the adverse event of teeth extraction including immediate implant placement, socket

grafting with biomaterials, and the application of bioabsorbable membranes for ridge preservation.^[5] Immediate implant placement has been suggested as an effective strategy to take advantage of socket healing and optimize the use of existing bone. However, several studies have shown that it does not prevent alveolar bone resorption.^[3] The socket-shield technique (SST) was introduced by Hürzeler et al. ^[6] in 2010 as a type of partial extraction therapy, where the root is partially removed, preserving the buccal portion with its periodontal ligament attached to the facial bone. An implant is then positioned immediately on the palatal side of the retained shield. ^[7] Although considered a promising technique, SST has some complications. The most frequently reported issue is the coronal exposure of the socket shield across the

such as shield mobility or displacement, may also occur, potentially compromising implant stability.^[8] Following the socket shield method introduced by Hürzeler, Glocker et al.^[9] proposed an alternative technique involving delayed implant placement. Depending on the treatment plan, clinicians may postpone implant placement for a duration ranging from two to six months to allow for bone regeneration before implant placement or to keep the site without a second surgical step.^[7] So, these techniques may also be indicated in cases that include their use as part of delayed implant placement protocols, for optimizing pontic support in crown and bridge restorations, or for providing enhanced support for removable prostheses.^[9] Grafting materials and absorbable membranes have been widely utilized following tooth extraction for preserving the alveolar ridge. The use of protein therapy in regenerative approaches can reduce or even eliminate the need for barrier membranes in specific cases, simplifying grafting approaches.^[10] Furthermore, the use of platelet concentrates in combination with graft materials is increasingly advocated, as platelets are rich in growth factors that stimulate cellular proliferation and promote angiogenesis.^[11] Mineralized Plasmatic Matrix (MPM) is a type of platelet concentrate that includes a bone graft component. MPM's distinctive advantage lies in its dual action: the presence of platelets and growth factors promotes osteoinduction, while the graft particles contribute to osteoconduction, structural stability, and volume maintenance. MPM ensures bone graft particles are embedded in the fibrin network, unlike earlier autologous growth factor membranes.^[10-12] According to the forementioned data it was of interest to evaluate alveolar socket preservation using mineralized plasmatic matrix with or without pontic shield in anterior maxilla.

Patients and Methods

Ethical approval and patient consent

All cases were informed about the surgical procedure, benefits, potential complications and post-operative follow-up periods. Each patient was given a consent form to sign after receiving detailed information before starting the study. Ethical approval for the study was obtained from the Ethical Committee of the Faculty of Dentistry, Mansoura University. (Approval No. A0109023OS) Patient

Selection This randomized clinical trial included 27 non-restorable maxillary anterior sockets in patients that were selected from the Outpatient Clinic of the Department of Oral and Maxillofacial Surgery, Faculty of Dentistry, Mansoura University.

Patient Selection Criteria

Inclusion Criteria: Patients aged between 18–45 years, with non-restorable maxillary anterior teeth indicated for extraction. Intact socket following tooth extraction (type I) (13) with a labial bone thickness ≤ 1 mm, and without any soft or hard tissue defects.

Exclusion Criteria: Patients were excluded if they had systemic diseases, smokers, with active infections, pregnant, undergoing radiotherapy, or uncooperative.

Sample Size Calculation
The required sample size was calculated using G*Power software (v3.1.9.7). A total of 27 sockets (9 per group) achieved 81% power to determine a large effect size (Cohen's $f = 0.648$) at a significance level of 0.05, based on expected differences in width reduction among the groups as reported by Maraqa et al.^[11] (2023).
Randomization

Sockets were randomly divided into three equal groups using sealed opaque envelopes based on computer-generated randomization (www.randomizer.org):

- Group I (Control): Sockets left to heal spontaneously after atraumatic extraction.
- Group II (MPM): Atraumatic extraction followed by socket filling with mineralized plasmatic matrix (MPM).
- Group III (MPM with Pontic Shield): Partial extraction using the pontic shield technique followed by MPM grafting.

Preoperative Measures

Comprehensive history taking was performed, including demographic data and medical/dental history. Clinical examination involved inspection and palpation of oral tissues, and evaluation of tooth condition. Panoramic radiography was used as a screening tool to assess the general state of the teeth indicated for extraction.

Surgical Protocol

All procedures were done under local anesthesia. In Groups I and II, atraumatic extraction was performed to preserve socket integrity.

. In Group III, the pontic shield technique was carried out. Carious tooth structure was removed using a round bur. In root canal-treated teeth, the canal filling material was removed with rotary files. A long-shank surgical bur was used to section the root mesiodistally. The palatal segment was carefully elevated and extracted, while the buccal segment was prepared to the level of the socket crest and shaped into a shield using diamond and flame-shaped burs.

MPM Preparation and Application

A xenogenic bone graft was mixed with plasma derived from two 9 mL non-coated tubes of venous blood centrifuged at 2500 rpm for 12 minutes. The yellow plasma rich in platelets and fibrin was aspirated and mixed with the graft until a cohesive mass formed. This MPM was placed into the sockets of Groups II and III. Group I sockets were left to heal spontaneously. A figure-eight suture was placed to stabilize the graft or clot in all groups.

Postoperative Care

All patients were prescribed amoxicillin/clavulanic acid twice daily for three days, NSAIDs as needed, and instructed to use 0.12% chlorhexidine mouthwash every 12 hours for one week. Postoperative instructions included avoiding spitting and rinsing in the first 24 hours, applying cold packs, soft diet, and maintaining good oral hygiene. Clinical Evaluation The Landry Wound Healing Index was used to evaluate Soft tissue healing at 7, 14, and 21 days; scoring from 1 (very poor) to 5 (excellent), based on tissue color, bleeding, granulation tissue, and epithelialization. Radiographic Evaluation Cone Beam Computed Tomographic (CBCT) scans were acquired immediately postoperative (T0) and at 4-month later (T1). Scans were analyzed using OnDemand3D software with the fusion and alignment features enabled.

A) Alveolar Ridge Width
In cross-sectional CBCT views, a reference point was placed at the midpoint between the buccal and palatal crests (BC–PC) at T0. From this point, two lines perpendicular to each other were generated: a horizontal line (BC–PC) connecting the buccal and the palatal crests and a vertical line (BIS) bisecting the socket. These were drawn and automatically reproduced at T1 using the software's fusion feature to ensure

consistent measurement. Ridge width was measured bucco-palatally at 3 mm and 6 mm apical to the crest.^[3] The change was calculated by subtracting T1 from T0 values.

Alveolar Ridge Height

In the cross-sectional view, a reference point was placed at the socket apex at T0. From this point, two lines perpendicular to each other were generated: a horizontal line (A-line) and a perpendicular vertical line (BIS) were drawn and automatically reproduced at T1. The vertical distance from the A-line to the buccal crest (BC) and palatal crest (PC) was measured to assess the height of the buccal and palatal socket walls. The difference between T0 and T1 values indicated the bone height change on both aspects.

Relative bone density

The 3D ROI tool available within the fusion mode of OnDemand3D software was used to measure bone density values at both T0 and T1 phases. This tool enables precise localization and quantification of the region of interest (ROI) in three dimensions, allowing for consistent and reproducible density comparisons over time.

Statistical Analysis

Data were analyzed using SPSS software, version 26 (PASW Statistics for Windows, Version 26. Chicago: SPSS Inc.). Quantitative data were described as mean and standard deviation or median and range. Qualitative data were described as numbers and percentages. Data were explored for normality using the Shapiro-Wilk test. The significance level was set at $p < 0.05$. For qualitative data:

Chi-square test was used to compare proportions between groups, as appropriate. For quantitative data:

- Intergroup comparisons:
- Regarding normally distributed data, one-way ANOVA test was used, followed by Tukey post hoc test for pairwise comparisons.
- Regarding non-normally distributed data, Kruskal–Wallis test was used, followed by U test for pairwise comparisons.

Intragroup comparisons:

- For normally distributed paired data, paired t-test was utilized.
- For non-normally distributed paired data, Wilcoxon test was utilized.

Results

This study was conducted on twenty-seven non-restorable maxillary anterior teeth indicated for extraction. They were equally and randomly distributed into three groups: Group I served as a control with no additional socket preservation technique, Group II was managed using the Mineralized Plasmatic Matrix (MPM) technique, and Group III was treated using the Pontic Shield combined with MPM technique. All procedures were carried out under local anesthesia without any recorded intraoperative complications. Patients underwent clinical and radiographical assessments at different time intervals during the follow-up periods.

Clinical evaluation:

The Landry Wound Healing Index was used to evaluate Soft tissue healing at 7, 14, and 21 days postoperatively. The results are presented in Table (1). The intergroup difference wasn't statistically significant at any time point ($P > 0.05$). However, the distribution of healing scores showed a clear clinical pattern favoring the MPM-treated groups. At day 7: In the control group, 44.4% of cases scored 2, 44.4% scored 3, and only 11.1% scored 4. In contrast, the MPM group showed 77.8% of cases scoring 3, while the MPM with pontic shield group had an even better distribution, with 44.4% of cases reaching score 4. the intergroup difference wasn't significant ($\chi^2 = 7.2$, $p = 0.126$). At day 14: Improvement continued in all groups, with 88.9% of patients in both the MPM and MPM with pontic shield groups scoring 4, compared to only 55.6% in the control group. However, the intergroup difference remained non-significant ($\chi^2 = 3.857$, $p = 0.145$). At day 21: The highest level of healing (score 5, excellent healing) was achieved by 88.9% of patients in both the MPM and MPM with pontic shield groups, while only 55.6% of the control group reached this level. The remaining 44.4% in the control group were

still at score 4. The intergroup difference, however, remained statistically non-significant ($\chi^2 = 3.857$, $p = 0.145$). Intragroup comparisons revealed statistically significant healing progression over time in all groups; however, the MPM-treated groups demonstrated earlier and more stable healing, with most of the improvement occurring between day 7 and 14, and no further significant changes observed between day 14 and 21, suggesting earlier wound stabilization.

Table (1): Comparison of Landry Healing Index scores between studied groups at 7, 14 and 21 days:

Time assessment	The Landry wound healing index	Control group (n=9)	MPM group (n=9)	MPM with pontic shield group (n=9)	Test of significance
7 days	Score 2	4 (44.4)	1 (11.1)	1 (11.1)	$\chi^2=7.2$ $p=0.126$
	Score 3	4 (44.4)	7 (77.8)	4 (44.4)	
	Score 4	1 (11.1)	1 (11.1)	4 (44.4)	
14 days	Score 3	4 (44.4)	1 (11.1)	1 (11.1)	$\chi^2=3.857$ $p=0.145$
	Score 4	5 (55.6)	8 (88.9)	8 (88.9)	
21 days	Score 4	4 (44.4)	1 (11.1)	1 (11.1)	$\chi^2=3.857$ $p=0.145$
	Score 5	5 (55.6)	8 (88.9)	8 (88.9)	
Pairwise comparison	P1=0.005*	P1=0.005*	P1=0.025*		
	P2=0.003*	P2=0.317	P2=1		
	P3=0.004*	P3=0.007*	P3=0.025*		

χ^2 =Chi-Square test, *statistically significant, data expressed as number (%). P1: difference between 7 versus 14 days, P2: difference between 14 versus 21 days, P3: difference between 7 versus 21 days

Radiographic Evaluation

CBCT scans were acquired immediately postoperatively (T0) and at 4-month later (T1). Scans were analyzed using OnDemand3D software with the fusion and alignment features enabled

Alveolar Ridge Width:

Intergroup comparison of bone width reduction between baseline and follow-up among the studied groups. The results are presented in Table (2). At 3 mm: A statistically significant

Bone width reduction	Control group (n=9)	MPM group (n=9)	MPM with pontic shield group (n=9)	Test of significance
At 3mm	1.88 (0.78-4.0)	2.06 (1.09-3.08)	0.78 (0-1.41)	kw= 8.58 P= 0.014*
At 6mm	1.48 (0.68-2.64)	1.10 (0.65-2.28)	0.66 (0-1.23)	kw= 5.56 P= 0.062
Wilcoxon signed rank test	z=1.99 p=0.046*	z=1.99 p=0.046*	z=0.944 p=0.345	

Kw: Kruskal Wallis test, z: Wilcoxon signed rank test, *statistically significant, data expressed as median(range) of bone width loss in mm Alveolar ridge height:

Intergroup comparison of bone height reduction between the studied groups at the buccal and palatal walls. The results are presented in Table (3).

At the buccal wall:

A significant difference was detected between the studied groups ($p = 0.025$). The median of bone height reduction was 1.75 (0.96-2.47) mm, 0.715 (0.64-2.08) mm and 0.415 (0.08-1.06) mm, respectively for the control group, MPM group and MPM with pontic shield group.

At the palatal wall:

The intergroup difference wasn't statistically significant ($p = 0.587$). The median of bone height reduction was 1.1 (0.2-2.12) mm, 0.755 (0.44-2.87) mm and 0.655 (0.02-1.43) mm, respectively for the control group, MPM group and MPM with pontic shield group. Intragroup comparison of bone height reduction between the buccal and palatal walls: The intragroup difference between buccal and palatal bone height loss wasn't statistically significant within any group ($p = 0.173$, 0.723 and 0.345) for the control, MPM and MPM with pontic shield groups, respectively. Table (3): Intergroup comparison of bone height reduction (baseline to a 4-month follow-up period)

Bone height reduction	Control group (n=9)	MPM group (n=9)	MPM with pontic shield group (n=9)	Test of significance
Buccal wall	1.75 (0.96-2.47)	0.715 (0.64-2.08)	0.415 (0.08-1.06)	kw= 7.35 P= 0.025*

Palatal wall	1.1 (0.2-2.12)	0.755 (0.44-2.87)	0.655 (0.02-1.43)	kw= 1.06 P= 0.587
Wilcoxon signed rank test	z=1.36 p=0.173	z=0.314 p=0.753	z=0.943 p=0.345	

Kw: Kruskal Wallis test, z: Wilcoxon signed rank test, *statistically significant, data expressed as median(range) of bone height loss in mm

Relative bone density:

Intergroup comparison of relative bone density between the studied groups at baseline and 4-month follow-up period. The results are presented in Table (4). At baseline: A significant difference was detected between the studied groups ($p = 0.001$). At a 4-month follow-up period: The intergroup difference wasn't statistically significant ($p = 0.441$). Bone density change between the studied groups: A statistically significant difference was detected between the studied groups ($p = 0.001$). Intragroup comparison of relative bone density: A significant intragroup difference was seen in the control group ($p = 0.001$) and in both MPM groups ($p = 0.01$). The control group revealed an increase in bone density from 102.83 ± 14.08 to 445.33 ± 95.96 , while the MPM group and the MPM with pontic shield group demonstrated reductions from 711.5 ± 160.62 to 474.33 ± 56.01 , and from 710 ± 124.4 to 504.83 ± 44.59 , respectively. Despite these reductions, both MPM groups maintained higher bone density values at the 4-month follow-up compared to the control group. Table (4): comparison of the relative bone density among studied groups at baseline and a 4-month follow up period

Bone density	Control group (n=9)	MPM group (n=9)	MPM with pontic shield group (n=9)	Test of significance
Baseline	102.83 ± 14.08	711.5 ± 160.62	710 ± 124.4	F=53.46 P=0.001*
Follow up	445.33 ± 95.96	474.33 ± 56.01	496.83 ± 38.8	F=.0.866 p=0.441
Paired t test	t=8.92 p=0.001*	t=3.76 p=0.01*	t=3.56 p=0.01*	
Bone Density Change	342.50 ± 99.95	-237.17 ± 154.68	-213.17 ± 146.53	F=34.95 P=0.001*
% of change	333.02%	-33.33%	-30.03%	

F: One Way ANOVA test, t: Paired t test, *statistically significant, data expressed as mean $\pm$ SD

Discussion

The anterior maxilla is highly susceptible to dimensional bone loss following tooth extraction

mainly due to the delicate and thin labial bone plate, which frequently measures less than one mm in thickness.^[14] The labial plate, composed primarily of bundle bone, is highly susceptible to remodeling and rapid resorption in the early post-extraction phase. this rapid resorptive process compromises both esthetic outcomes and future prosthetic planning.^[15] Various procedures have been introduced to counteract the alveolar ridge resorption process. These include socket preservation procedures with bone grafts and membranes, immediate implant placement, and partial extraction therapies which include the SST.^[16] Building upon the socket-shield concept, Glocker et al.^[9] (2014) introduced the pontic shield technique, a modified approach in which the labial portion of the root is preserved in the extraction socket without subsequent implant placement. The aim was to support the soft tissue and maintain ridge architecture in pontic sites. Autologous biologic materials have emerged as valuable adjuncts in regenerative dentistry. In addition, MPM is a relatively novel preparation that combines platelet-derived growth factors with particulate bone grafts within a fibrin scaffold.^[17] So this study aimed to evaluate the efficacy of MPM, with or without the pontic shield technique, in enhancing socket healing following maxillary anterior tooth extraction. In the present study, the Landry wound healing index was used to evaluate soft tissue healing at 7, 14, and 21 days. The intergroup difference wasn't statistically significant at any time point. However, intragroup comparisons revealed a statistically significant improvement in healing scores over time within each group. The MPM and MPM with pontic shield groups demonstrated more rapid progression toward complete healing, with most cases achieving a score of 5 by day 21, while the control group exhibited a slightly slower healing pattern. These findings closely resemble those reported by Ustaoglu et al.^[18] (2020), who revealed no significant intergroup differences in soft tissue healing, as evaluated at 7 and 14 days using the Landry healing index, when comparing different platelet-rich concentrates to ungrafted sites. However, both platelet-rich groups showed superior and more rapid soft tissue healing compared to the control group. In contrast, the findings reported by sharma et al.^[19] (2021) demonstrated significant improvements in soft tissue healing, as evaluated at 7 and 14 days using

the Landry healing index following socket preservation using platelet-rich fibrin (PRF) compared to ungrafted control sites. Although the intergroup difference wasn't significant in our study, both MPM-treated sites still exhibited a faster and more favorable healing than the control, supporting the clinical value of biologically enhanced grafts. In the present study, alveolar ridge width was radiographically assessed at three mm and six mm apical to the crest. A significant difference in horizontal bone reduction was detected between the studied groups at the three mm level, while the intergroup difference wasn't significant at six mm. These findings were in agreement with the results of de Oliveira et al.^[20] (2021), who evaluate alveolar bone changes following the socket shield technique without immediate implant placement. The study reported a statistically significant preservation of ridge width at 3mm level in the socket shield group compared to the extraction-only group, whereas no significant difference was noted at 5 mm. This pattern closely seems the current findings. In partial contrast, the findings of Badawy.^[21] (2025) demonstrated a significant difference in ridge width reduction between socket shield and control groups at both three mm and five mm apical to the crest. However, in our study, a significant difference was detected only at the three mm level, while the intergroup difference wasn't significant at six mm ($p = 0.062$), although the results still pointed toward better ridge preservation in the pontic shield group. The proximity of this value to the significance threshold supports the presence of a favorable biological pattern. In the present study, vertical bone height was assessed radiographically at both the buccal and palatal aspects of the socket. The analysis of bone height reduction revealed a significant difference between the studied groups at the buccal aspect, while insignificant difference was observed at the palatal side. Similar results were reported by Badawy.^[21] (2025), who evaluated alveolar bone height changes following tooth extraction using the modified SST without immediate implant placement. It demonstrated a significant difference in buccal bone height reduction between groups, while no significant difference was found at the palatal aspect. A comparable result was also recorded by Jadhav et al.^[22] (2024), who found significant less buccal

bone height reduction following the pontic shield technique compared to full extraction in anterior maxillary sites. In contrast, the findings of de Oliveira et al.^[20] (2021), revealed insignificant difference in vertical bone height reduction between the test and control groups at both the buccal and palatal aspects. This contrast may be attributed to the addition of a biologically active scaffold (MPM) in the present study, which likely enhanced soft and hard tissue regeneration plus contributing to superior vertical preservation not achieved through socket shield alone. In this study, relative bone density was evaluated via CBCT grayscale values at baseline and after 4 months. Both MPM groups initially had higher densities due to the graft's mineral content, followed by a significant reduction over time, indicating remodeling. Conversely, the control group showed increased density with healing. Although the change in density differed significantly between groups, follow-up values did not show statistical differences. Still, MPM-treated sites retained higher mean densities, possibly due to residual graft material or denser new bone formation. Also, these findings were in agreement with the results of Elkordy.^[23] (2021), who evaluated the effect of MPM in comparison to PRF for socket preservation. In both studies, the MPM group displayed a significant reduction in bone density over time, which was attributed to graft remodeling. Moreover, the MPM-treated sites maintained higher mean density values at follow-up, which may reflect the lasting radiographic presence of the graft or increased density of newly formed bone. On the other hand, the study conducted by Maraqa et al.^[11] (2023) reported findings that diverge from our results in two key aspects. First, they observed a significant difference in bone density between the MPM and control groups at follow-up. Second, bone density in their MPM group increased from baseline to follow-up. These differences may be attributed to variations in healing duration, graft material handling, or radiographic analysis methods, which could have affected the pattern of bone density changes.

Conclusion

Combining MPM with the pontic shield technique resulted in superior preservation of ridge dimensions and enhanced soft tissue healing compared to MPM alone or ungrafted sockets.

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