This study aimed to evaluate the bone dimensional changes associated with extraction sockets preserved with calcium phosphosilicate (CPS) morsels and platelet-rich fibrin (PRF) at 6 months posthealing. Thirty fresh extraction sockets were randomly allocated to one of the following groups and grafted using PRF: Control (n = 10), CPS morsels (Test I; n = 10), or CPS+PRF (Test II; n = 10). All sites were sealed with PRF as a socket seal. CBCT scans were taken at 1 week postsurgery and at 6 months posthealing. The intergroup comparison showed a statistically significant difference in mean horizontal bone dimensional changes, and no such significance was observed for vertical bone changes. Bone density measured using Hounsfield units (HU) fell within the range of 350 to 850 HU (D3 bone quality) at 6 months posthealing for all three groups. Within the limitations of this study, socket preservation using CPS morsels with and without PRF demonstrated more favorable conditions for future implant placement.

Tooth extraction and the subsequent healing of the alveolus can result in both horizontal and vertical dimensional changes with more pronounced buccal bony wall resorption than the lingual/palatal bony walls.\(^1\)\(^-\)\(^3\) In their systematic review, Ten Heggeler et al\(^4\) stated that the reductions in alveolar ridge width and height range from 2.6 to 4.6 mm and from 0.4 to 3.9 mm, respectively. Moreover, the dimensional change in the alveolar width was directly correlated to the site and thickness of the buccal bone. Araújo and Lindhe demonstrated in an animal model that after extraction, the coronal part of the buccal bony plate (comprised solely of bundle bone) is lost due to initial osteoclastic activity.\(^5\) Therefore, understanding the basics of socket healing will facilitate successful esthetic and functional prosthetic reconstruction by enabling optimal implant positioning.\(^6\) Socket preservation helps minimize the dimensional changes occurring within the socket, thus reducing the need for further grafting procedures at implant placement. Based on their systematic review, Avila-Ortiz et al concluded that the mean difference in buccolingual width and midbuccal height loss following socket preservation were 1.89 mm and 2.07 mm, respectively.\(^7\)

Bioactive glass is a silica-based surface reactive alloplastic graft

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**Comparative Evaluation of Bone Dimensional Changes in Extraction Sockets Preserved With Calcium Phosphosilicate Bone Substitutes With and Without Platelet-Rich Fibrin: A Randomized Controlled Clinical Trial**

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material that forms a direct bond with bone.8,9 Once in contact with bone, initial dissolution of the outer particle layer is followed by formation of a carbonated hydroxyapatite layer induced by the occurrence of elevated calcium ion levels and soluble silica, causing adsorption of proteins onto the surface, which can stimulate osteogenic cells within the area with subsequent bone matrix formation.10 Platelet-rich fibrin (PRF) stimulates osteoblastic proliferation and neo-angiogenesis and favors wound healing. Evidence in the literature is sparse in relation to use of bioactive calcium phosphosilicate (CPS) morsels as a socket preservation material. Therefore, the present study’s hypothesis is that the use of CPS would be a viable alternative for maintaining horizontal and vertical postextraction socket dimensions.

Keeping in mind the enhanced wound-healing potential of PRF as well as the osteostimulative and osteoprotective properties of bioactive glass, the usefulness of their combined application in maintaining socket dimensions needs to be further verified. Thus, the present study aims to quantify and compare the bone dimensional changes associated with extraction sockets in nonmolar sites grafted with CPS bone substitutes mixed with and without PRF.

Materials and Methods

Experiment Design and Randomization

The present randomized controlled clinical trial was approved by the Institutional Review Board of SRM Dental College, Ramapuram (SRMDC/IRB/2017/MDS/No.505). Thirty sites (one site per patient) with healthy adjacent teeth indicated for atraumatic extraction followed by socket preservation were recruited from the outpatient population of the Department of Periodontics from the same institute. The participants were randomized based on sequentially numbered opaque sealed envelopes that were picked up at the time of surgery, allocating participants into one of three groups: In the control group, PRF was used to preserve the sockets (n = 10); in Test I, CPS morsels (Bioactive Synthetic Bone Graft Morsels, Novabone Products) were used (n = 10); in Test II, CPS morsels were mixed with particulated PRF (n = 10). Following socket preservation, all three groups received PRF as a socket seal. The buccolingual and apicocoronal bone dimensions and bone density changes were evaluated following socket preservation with CPS with and without PRF at 6 months posthealing. All surgical procedures were performed by a single experienced operator. (P.S.G.P.)

Clinical and Surgical Procedures

Clinical parameters

Probing pocket depth, clinical attachment level, FMPS, and FMBS were recorded at six sites per tooth (distobuccal, buccal, mesiobuccal, mesiolingual, lingual, and distolingual) using a manual periodontal probe (UNC-15) by a single calibrated examiner (T.M.I.).

Surgical procedures

Under local anesthesia with 2% lidocaine, a mucoperiosteal flap was elevated, careful luxation of the indicated teeth was performed using periotomes, and the tooth was extracted atraumatically without causing any damage to the socket walls. Granulation tissue was completely curetted from the socket. Following the grafting procedures and based on the study design, the flaps were stabilized
using resorbable sutures. However, no measures were made to achieve primary closure, and the PRF placed as a socket seal was left exposed in all three groups.

**Intrasurgical measurements**
Before tooth extraction, buccal soft tissue thickness was evaluated exactly 3 mm apically from the crest of the facial gingiva margin using a no. 20 reamer (25 mm, Mani) and categorized as thin or thick: Measurements < 1.5 mm were categorized as thin, and measurements ≥ 2.0 mm were categorized as thick. Following tooth extraction, intrasurgical buccal bone thickness was measured using a surgical bone caliper (Imperial Instruments Industries) followed by socket preservation. One week after socket preservation, CBCT scans were taken to evaluate the baseline values of buccal bone thickness, horizontal alveolar width, vertical alveolar height, and bone density. Figure 1 shows an example case of a Test II patient who received both CPS and PRF.

**Postsurgical instructions and infection control**
Patients received systemic antibiotics and analgesics for 5 days. They were instructed to refrain from brushing at the surgical area for 1 week to avoid mechanical disturbance to the surgical site. Patients were instructed to rinse twice daily gently with 0.12% chlorhexidine di-gluconate for the first 2 weeks.

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**Fig 1** (a) Preoperative clinical view of root stumps indicated for extraction. (b) Clinical view of the intact buccal bone immediately postextraction. (c) The socket was grafted with CPS morsels and (d) covered with PRF as a socket seal. (e) The flap was sutured with 4-0 vicryl using the horizontal internal mattress suturing technique. (f) CBCT scans show the bone dimensions at baseline and (g) 6 months posthealing.
Reevaluation post socket healing
After a healing period of 6 months, CBCT scans were taken prior to implant placement, and the horizontal alveolar width, vertical alveolar height, and bone density were re-evaluated.

Statistical Analysis
All statistical analysis was performed using SPSS (version 17, IBM) for Microsoft Windows. Clinical and radiographic variables were expressed in mean ± SD. Normality tests revealed that the variables were normally distributed, and thus parametric tests were performed. For intergroup comparison, one-way analysis of variance was done, followed by post hoc Tukey test. For intragroup comparisons at different time points, paired t test was performed. P ≤ .05 was considered to be statistically significant.

Results
The descriptive variables of the recruited subjects at baseline showed no statistically significant differences (P > .05) between the groups (Table 1). The mean horizontal alveolar width measured from CBCT scans at baseline and at 6 months in all three groups is shown in Table 2. All three groups showed horizontal bone loss from baseline, and the intragroup comparison showed statistically significant bone loss from baseline to 6 months (P ≤ .05) in all groups, indicating that neither CPS nor PRF completely prevented postextraction bone loss. The amount of horizontal width resorption observed at 6 months posthealing was minimal in Test I compared to the other groups, and the intergroup mean difference was statistically significant.

Table 3 shows the vertical alveolar height measurements at baseline and at 6 months posthealing. Statistically significant mean bone loss was observed from baseline to 6 months in all three groups (P ≤ .05). The amount of vertical height resorption observed at 6 months posthealing was almost comparable in all three groups with no statistically significant difference (P > .05); however, Test I showed...
minimal mean vertical bone loss compared to the other two groups.

Table 4 shows the bone density values, measured using Hounsfield units (HU), between the three groups from baseline to 6 months. The data obtained showed a statistically significant difference when compared between the three groups at 6 months posthealing, but still all the HU values fell within the range of 350 to 850 HU, considered as D3 quality bone (Misch classification of bone density).

Discussion

Socket preservation has the capacity to modulate alveolar ridge changes that occur following tooth extraction, and thus the quest still persists for an ideal material to prevent such
volumetric changes. Clot stabilization and early angiogenesis are both crucial in influencing favorable wound healing.\textsuperscript{12,13} The properties of PRF with the clot-stabilizing effect of CPS in preserving the socket dimensions following extraction were analyzed in the present study.

The findings of the present clinical trial demonstrated that the use of CPS with PRF as a socket seal preserves the socket dimensions more predictably, allowing the development of a future implant site. It was observed that the sockets grafted with CPS showed minimal horizontal and vertical bone dimensional changes radiographically compared to PRF alone (Test I) and CPS+PRF (Test II). This could possibly be attributed to the early stimulation of bone formation in the interface between viable native bone and bioactive glass with a hydroxyapatite composition similar to that of bone.\textsuperscript{14,15} Furthermore, the above findings could also be attributed to the properties of PRF as a socket seal, which could have accelerated socket wound healing after tooth extraction.\textsuperscript{16} The radiographic findings in the present study are in agreement with Cavdar et al.\textsuperscript{17} Conversely, several clinical trials have shown otherwise with greater horizontal bone loss than vertical.\textsuperscript{18–21}

The present findings showed no added advantage when both the graft and PRF were mixed and used for socket preservation. Such a finding was contrary to the present hypothesis. Based on the statements by Kotsakis et al\textsuperscript{22} and Fickl et al,\textsuperscript{23} no attempts were made in the present study to achieve primary soft tissue closure with periosteal releasing incisions or flap advancement. Instead, PRF was used as socket seal on top of the grafting material and sutured to promote wound healing by secondary intention.

Only a few studies to date have investigated HU values to interpret the quality of bone formed following placement of biomaterials within the socket.\textsuperscript{17,24–26} The bone density observed at 6 months after socket healing was in the range of 350 to 850 HU and considered as D3 quality bone, which was similar to Cavdar et al’s study.\textsuperscript{17}

Despite the promising findings obtained in the present study, a small sample size of 10 sites in each group is a possible limitation. A second limitation is the absence of a histomorphometric analysis, which could have evidently illustrated the percentage of new bone formation and residual bone graft particles.

**Conclusions**

In the present study, CPS used with or without PRF had a more positive influence in reducing the changes in buccolingual width and apicoconal height 6 months after socket preservation. In addition, D3 bone quality was observed in all the three groups, among which the CPS group (Test I) showed better bone quality. The bone density achieved was similar to that available naturally in the maxillary premolar sites, enabling the clinician to better plan for future successful implant placement.

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**References**


