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Platelet-rich fibrin versus demineralized freeze-dried bone allograft for peri-implant bone regeneration after immediate implant placement: A CBCT study

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Abstract:
Immediate implant placement can reduce treatment time, but the residual peri-implant jumping gap may influence hard-tissue healing. Therefore, it is of interest to compare the platelet-rich fibrin (PRF) with demineralized freeze-dried bone allograft (DFDBA) for management of the jumping gap after immediate implant placement in 30 sites allocated to two groups (n=15 each). CBCT measurements at implant placement and six months assessed horizontal bone thickness, vertical bone height and change in alveolar crest height. Both groups showed peri-implant bone regeneration; however, DFDBA produced significantly greater six-month horizontal bone thickness (p=0.017), vertical bone height (p=0.005) and change in alveolar crest height (p=0.001) than PRF. Thus, DFDBA provided greater preservation or gain of peri-implant hard-tissue dimensions than PRF over six months.

Keywords: Immediate implant placement, platelet-rich fibrin (PRF), demineralized freeze-dried bone allograft (DFDBA), jumping distance, crestal bone height, bone regeneration, cone-beam computed tomography (CBCT), peri-implant bone loss

Background:
Immediate implant placement can shorten treatment time and may support preservation of peri-implant tissue contours, although outcomes depend on case selection and site conditions **[1, 2].** Fresh extraction sockets are often wider than the implant, creating a peri-implant "jumping gap" whose management can influence hard-tissue remodelling. DFDBA is an allogeneic graft material with osteoconductive properties and variable osteoinductive potential related to exposed bone morphogenetic proteins **[3-6].** PRF is an autologous platelet concentrate that provides a fibrin matrix and releases growth factors during early wound healing **[7].** Recent clinical evidence has reported favourable hard-tissue outcomes with DFDBA and PRF-based regenerative approaches in immediate implant sites, although performance depends on defect dimensions, graft type and protocol **[8-10].** Therefore, it is of interest to compare PRF with DFDBA for management of the peri-implant jumping gap using CBCT-based horizontal, vertical and crestal bone measurements.

Materials and Methods:
Study design:
The present *in vivo* interventional study was conducted in the Department of Periodontics and Implantology in collaboration with the Department of Oral Medicine and Radiology, Institute of Dental Sciences, Bareilly, from April 2024 to March 2025. The study population comprised individuals requiring extraction followed by immediate implant placement. A total of 30 participants were included and the sample size was determined using G*Power software. Institutional ethical approval was obtained (IEC/259/2024/04) and the study was registered in the Clinical Trials Registry-India (CTRI/2024/11/077403).

Sample size and study population:
This interventional study included 30 participants allocated to two groups of 15 each:

In group I:
PRF was placed after implant insertion to fill the jumping gap. PRF was prepared from each participant's blood according to Choukroun's protocol **[7].**

In group II:
DFDBA was placed after implant placement to occlude the jumping distance. DFDBA was obtained from TATA Memorial Hospital, Mumbai.

Inclusion criteria:
[1] Age >18 years.
[2] Requirement for replacement of one or more teeth indicated for extraction and immediate implant placement (e.g., root stump, poor endodontic prognosis, or fractured tooth).
[3] Sufficient apical bone allowing for implant placement.
[4] Willingness to accept the treatment protocol and provide informed consent.

Exclusion criteria:
[1] Patients with systemic conditions that could compromise surgical healing or implant therapy.
[2] Absence of buccal plate or failure to maintain the integrity of socket wall during extraction.
[3] Pregnant or lactating participants.
[4] Periapical pathologies.

Procedure:
Preoperative CBCT was obtained for implant planning and baseline radiographic measurements. A complete presurgical evaluation, including intraoral examination and diagnostic casts, was performed for each participant. After local infiltration with lignocaine and epinephrine (1:100,000), atraumatic extraction was carried out and the socket was thoroughly curetted and irrigated. Osteotomy preparation was initiated with a lance drill and sequentially enlarged to the planned depth and diameter while maintaining the intended angulation. The implant was inserted with an insertion torque of approximately 30-35 Ncm until primary stability was achieved. Circumferential or horizontal defects >2 mm were augmented with DFDBA particles (Tata Memorial Hospital Tissue Bank, Mumbai, India) or PRF according to group allocation. After achieving tension-free soft-tissue closure, the site was sutured and standard postoperative instructions were provided.

Results:
At six months, mean horizontal bone thickness was 1.2667 ± 0.4378 mm in Group 1 and 2.0000 ± 1.0351 mm in Group 2, with a significant between-group difference (p=0.017; **Table 1).** Mean vertical bone height was 1.1000 ± 0.9297 mm in Group 1 and 2.1333 ± 0.9348 mm in Group 2 (p=0.005; **Table 2).** Mean change in alveolar crest height was -0.4333 ± 0.5706 mm in Group 1 and 0.6000 ± 0.8904 mm in Group 2 (p=0.001; **Table 3).** Within-group baseline to six month comparisons for horizontal and vertical bone measurements were statistically significant (all p<0.005; **Table 4**). Overall, the six-month radiographic findings favoured Group 2 for the evaluated hard-tissue dimensions. **Table 1** at six months, the DFDBA group showed a mean horizontal bone thickness of 2.0000 ± 1.0351 mm versus 1.2667 ± 0.4378 mm for PRF (n = 15 per group). The observed difference was 0.7333 mm, with substantial variation in the DFDBA group; the manuscript reports p = 0.017. This is an endpoint comparison and must not be interpreted as bone gain without reference to the baseline measurements. **Table 2** mean six-month vertical bone height was 2.1333 ± 0.9348 mm with DFDBA and 1.1000 ± 0.9297 mm with PRF. The between-group difference was approximately 1.03 mm (reported p = 0.005). These values summarize measurements at a single follow-up and should be interpreted with the method used to define the vertical CBCT landmark. **Table 3** the reported alveolar-crest-height change was −0.4333 ± 0.5706 mm in Group 1 and +0.6000 ± 0.8904 mm in Group 2, a separation of approximately 1.03 mm (reported p = 0.001). The direction of change must be interpreted according to the radiographic reference convention, which should be explicitly confirmed from the measurement protocol. **Table 4** for PRF, horizontal thickness changed from 1.3333 to 1.2667 mm and vertical height from 1.5333 to 1.1000 mm. For DFDBA, corresponding values increased from 1.3667 to 2.0000 mm and from 1.5000 to 2.1333 mm. Although the source table reports all paired p values <0.005, paired significance cannot be recovered from baseline and follow-up means/SDs alone; specimen-level paired measurements are required before accepting that omnibus claim.

Table 1: Horizontal bone thickness (mm) at 6 months between groups

Parameter	Group	N	Mean	SD	SEM
Horizontal bone thickness at 6 months	Group 1	15	1.2667	0.43780	0.11304
Horizontal bone thickness at 6 months	Group 2	15	2.0000	1.03510	0.26726
P value	0.017 (significant)				

Table 2: Vertical bone height (mm) at 6 months between groups

Parameter	Group	N	Mean	SD	SEM
Vertical bone height at 6 months	Group 1	15	1.1000	0.92967	0.24004
Vertical bone height at 6 months	Group 2	15	2.1333	0.93478	0.24136
P value	0.005 (significant)				

Table 3: Change in alveolar crest height (mm) at 6 months between groups

Parameter	Group	N	Mean	SD	SEM
Change in alveolar crest height at 6 months	Group 1	15	-0.4333	0.57061	0.14733
Change in alveolar crest height at 6 months	Group 2	15	0.6000	0.89043	0.22991
P value	0.001 (significant)				

Table 4: Intra-group comparison of bone parameters at baseline and 6 months

Parameter	Time	Mean	N	SD	SEM
Horizontal bone thickness - Group 1	Baseline	1.3333	15	0.46930	0.12117
Horizontal bone thickness - Group 1	6 months	1.2667	15	0.43780	0.11304
Horizontal bone thickness - Group 2	Baseline	1.3667	15	0.43164	0.11145
Horizontal bone thickness - Group 2	6 months	2.0000	15	1.03510	0.26726
Vertical bone height - Group 1	Baseline	1.5333	15	0.41043	0.10597
Vertical bone height - Group 1	6 months	1.1000	15	0.92967	0.24004
Vertical bone height - Group 2	Baseline	1.5000	15	0.42258	0.10911
Vertical bone height - Group 2	6 months	2.1333	15	0.93478	0.24136
P value	All paired comparisons p<0.005 (significant)				

Discussion:
The present study compared PRF and DFDBA for management of the peri-implant jumping gap after immediate implant placement and used CBCT to quantify horizontal bone thickness, vertical bone height and alveolar crest-height change over six months. Both materials supported healing, but the DFDBA

group showed significantly greater values for the evaluated hard-tissue dimensions at the six-month assessment. These findings should be interpreted as a comparative result within the present sample rather than as evidence that one material will be preferable in every immediate-implant situation, because defect morphology, implant position, soft-tissue phenotype, surgical technique and healing conditions can modify peri-implant remodeling **[2, 5 and 6].** Immediate implant placement creates a characteristic interface between the implant surface and the extraction socket wall. When this horizontal gap is small, spontaneous bone fill can occur, whereas larger gaps and deficient socket walls may require regenerative support to preserve space and limit soft-tissue ingress **[6, 11].** The present study included defects that required management of the jumping space and therefore provides information relevant to this clinically important setting. The greater six-month hard-tissue dimensions observed with DFDBA are biologically plausible because allogeneic mineralized matrices can provide an osteoconductive scaffold, while demineralization may expose bone-morphogenetic proteins and other matrix-associated signals that contribute to osteoinductive activity **[3, 4 and 9].** In addition, recent randomized evidence has reported improved resolution of the jump space and preservation of crestal bone when DFDBA is used during immediate implant placement **[10].** PRF offers a different regenerative mechanism. It is autologous, forms a fibrin matrix and can release platelet-derived mediators during early wound healing **[7, 12 and 13].** Recent clinical evidence indicates that PRF can improve peri-implant bone density and other healing parameters after immediate implant placement, although the magnitude and persistence of the effect vary among studies **[14].** A recent systematic review likewise concluded that PRF can support hard- and soft-tissue regeneration in immediate implant sites, while comparative outcomes against bone substitutes remain heterogeneous **[15].** These observations are consistent with the present finding that PRF supported healing but produced smaller changes than DFDBA for several six-month CBCT measurements. The difference may reflect the ability of a particulate graft to maintain defect volume for a longer period, whereas PRF is primarily a biologically active fibrin matrix and is resorbed more rapidly. The use of CBCT allowed three-dimensional assessment of peri-implant bone dimensions and reduced the limitations of two-dimensional projection imaging. Nevertheless, radiographic measurements are influenced by voxel size, patient positioning, image reconstruction, landmark selection and examiner reproducibility. The present results should therefore be interpreted together with the study design and sample size rather than from p values alone. Reporting effect sizes and confidence intervals in future studies would provide a clearer estimate of the precision and clinical importance of between-group differences. The six-month follow-up captures early remodelling but does not establish long-term marginal-bone stability, implant survival, peri-implant soft-tissue outcomes, or prosthetic performance. Future randomized studies should use standardized defect dimensions, prespecified CBCT landmarks, calibrated examiners and longer follow-up. Comparisons should also include patient-reported outcomes, implant stability, soft-tissue phenotype and complication rates. Within these limitations, the present study adds CBCT-based comparative evidence that both PRF and DFDBA can be used to manage the jumping gap, with DFDBA showing greater preservation or gain of the measured hard-tissue dimensions over six months. Additional comparative evidence indicates that grafting protocols and outcome definitions must be considered carefully. Azangookhiavi *et al.* compared PRF with freeze-dried bone allograft after ridge preservation, which is related to but distinct from direct peri-implant jumping-gap treatment **[16].** Bhombe *et al.* described a combined PRF matrix–DFDBA approach, so their single-arm design cannot establish which component was responsible for the healing outcome **[17].** Haripriya *et al.* contrasted titanium-prepared PRF with DFDBA for intrabony periodontal defects rather than immediate-implant gaps **[18].** Verma *et al.* investigated DFDBA with T-PRF and vitamin D3 in intrabony defects; these findings provide biological context but not direct support for a superiority claim in implant sockets **[19].** Dare and Bajaj published an A-PRF/DFDBA study protocol, not completed comparative efficacy results **[20].** Sharma *et al.* reported a combined DFDBA plus PRF-membrane protocol for immediate placement into debrided infected sockets, also without separating the two agents **[21].**

Conclusion:

Both PRF and DFDBA supported peri-implant hard-tissue healing after immediate implant placement. DFDBA produced greater six-month horizontal bone thickness, vertical bone height and alveolar crest-height change than PRF. Larger randomized trials with longer follow-up are required to determine the consistency and clinical significance of these differences across immediate-implant indications.

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