Original Research Article

CLINICAL EVALUATION OF IMMEDIATE IMPLANT STABILITY IN FRESH MANDIBULAR POSTERIOR EXTRACTION SOCKETS USING PLATELET-RICH FIBRIN COMBINED WITH DEMINERALIZED FREEZE-DRIED BONE ALLOGRAFT: A PROSPECTIVE CLINICAL STUDY

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ABSTRACT

Background: Immediate implant placement into fresh extraction sockets has become an established treatment option because it reduces treatment duration, preserves alveolar ridge dimensions, and improves patient comfort. However, achieving predictable osseointegration and minimizing peri-implant bone loss remain important clinical challenges. Platelet-rich fibrin (PRF) and demineralized freeze-dried bone allograft (DFDBA) have been widely investigated as regenerative adjuncts to promote peri-implant bone healing, enhance osseointegration, and improve implant stability. This study evaluated the clinical stability of immediate implants placed in fresh mandibular posterior extraction sockets using PRF combined with DFDBA.

Materials and Methods: This prospective clinical study included 11 patients requiring extraction of mandibular posterior teeth followed by immediate implant placement. PRF was prepared from autologous venous blood and combined with DFDBA to fill the peri-implant gap before primary wound closure. Implant stability was assessed three months after surgery using reverse torque and percussion tests. Standardized intraoral periapical radiographs were obtained immediately after implant placement and at three and six months to evaluate vertical peri-implant bone changes. Bone loss measurements at different follow-up intervals were compared using Student's t-test.

Results: Eleven immediate implants were placed, of which 10 achieved successful osseointegration, resulting in an implant survival rate of 90.9% after six months of follow-up. One implant failed before second-stage surgery because of severe traumatic extraction and poor oral hygiene. Mean vertical bone loss among successfully osseointegrated implants increased from 0.043 ± 0.096 mm immediately after implant placement to 0.260 ± 0.117 mm at three months and 0.367 ± 0.240 mm at six months. Two patients demonstrated radiographic bone gain during follow-up. A statistically significant increase in vertical bone loss was observed between the immediate postoperative period and the three-month follow-up (t=3.38), whereas no significant difference was observed between the three- and six-month evaluations (t=0.82), indicating stabilization of peri-implant bone levels after the initial healing phase.

Conclusions: Immediate implant placement in fresh mandibular posterior extraction sockets using PRF combined with DFDBA demonstrated favorable short-term clinical outcomes, with a 90.9% implant survival rate and minimal peri-implant bone loss after six months. The greatest bone remodeling occurred during the first three months, followed by stabilization of peri-implant bone levels. Although these findings suggest that PRF combined with DFDBA may support successful osseointegration and peri-implant bone preservation, larger randomized controlled studies with longer follow-up are required to confirm the long-term effectiveness of this treatment approach.
Keywords: Immediate dental implant; Platelet-rich fibrin; Demineralized freeze-dried bone allograft; Fresh extraction socket; Osseointegration; Implant stability; Vertical bone loss; Mandibular posterior teeth; Bone regeneration; Oral implantology.

INTRODUCTION

Dental implants have become a predictable and well-established treatment option for the rehabilitation of partially and completely edentulous patients because of their high long-term survival rates and favorable functional and esthetic outcomes. Conventional implant therapy generally involves extraction of the compromised tooth, followed by a healing period before implant placement. Although this staged approach has demonstrated excellent clinical success, prolonged treatment duration and post-extraction alveolar bone resorption remain significant limitations. Consequently, immediate implant placement into fresh extraction sockets has emerged as a predictable treatment approach that reduces treatment time while preserving alveolar ridge dimensions and peri-implant soft tissue contours when appropriate case selection and meticulous surgical technique are employed.[1-5]

Immediate implant placement offers several clinical advantages, including reduced surgical interventions, maintenance of alveolar ridge dimensions, preservation of peri-implant soft tissue architecture, shortened treatment time, and improved patient acceptance. However, achieving predictable outcomes depends on careful patient selection, atraumatic extraction, adequate primary implant stability, and proper management of the peri-implant gap. Failure to satisfy these biological and mechanical prerequisites may compromise osseointegration and adversely affect long-term implant success.[1-5]

Systematic reviews have demonstrated high survival rates for immediate implants placed in carefully selected extraction sockets. Nevertheless, survival rates alone do not fully reflect clinical success, as peri-implant bone remodeling, maintenance of crestal bone levels, and long-term implant stability remain critical determinants of favorable outcomes. Therefore, strategies aimed at enhancing peri-implant bone regeneration and minimizing marginal bone loss around immediately placed implants continue to be an important focus of clinical research.[3,4]

One of the major biological challenges associated with immediate implant placement is the physiologic remodeling of the extraction socket following tooth removal. Significant dimensional changes of the alveolar ridge occur during the early healing period, resulting in horizontal and vertical bone loss despite immediate implant placement. These changes may compromise implant stability, esthetic outcomes, and prosthetic rehabilitation, particularly when residual gaps exist between the implant surface and the socket walls. Various socket preservation techniques and grafting procedures have therefore been recommended to minimize post-extraction bone resorption and maintain alveolar ridge dimensions.[5,11-16]

Platelet-rich fibrin (PRF) has emerged as a promising autologous biomaterial that promotes wound healing and tissue regeneration in oral and maxillofacial surgery. As a second-generation platelet concentrate, PRF is produced without the use of anticoagulants and forms a three-dimensional fibrin matrix that gradually releases numerous growth factors involved in angiogenesis, cell migration, proliferation, and osteogenesis. In addition to its biological activity, PRF contains leukocytes that may contribute to immune regulation and tissue repair, thereby creating a favorable environment for both soft tissue healing and bone regeneration.[6-8]

Several clinical investigations have evaluated the application of platelet concentrates in extraction socket preservation and implant therapy. The combination of platelet-derived biologic materials with bone grafts has demonstrated promising effects on early wound healing, bone regeneration, and osseointegration in implant therapy. Simon et al. reported favorable clinical and histological healing following ridge preservation procedures using platelet-rich fibrin matrix combined with demineralized freeze-dried bone allograft (DFDBA), highlighting the regenerative potential of platelet concentrates when combined with grafting materials.[9] Earlier work on platelet-rich plasma also emphasized the role of autologous growth factors in accelerating tissue repair and bone regeneration, providing the biological basis for the subsequent development of PRF.[10]

Demineralized freeze-dried bone allograft (DFDBA) is one of the most extensively studied allograft materials for alveolar bone regeneration because of its osteoconductive properties and potential osteoinductive capacity attributed to the presence of bone morphogenetic proteins (BMPs). When used in combination with immediate implant placement, DFDBA may reduce the peri-implant gap, enhance bone fill, and support osseointegration. Combining DFDBA with PRF may provide synergistic biological and mechanical benefits by integrating the osteoconductive properties of the graft with the sustained release of autologous growth factors from PRF.[11,12]

Although immediate implant placement has demonstrated predictable clinical outcomes, physiologic post-extraction bone remodeling cannot be completely prevented. Experimental and clinical studies have consistently shown that dimensional alterations of the alveolar ridge occur despite immediate implant placement, supporting the continued need for adjunctive regenerative procedures to preserve peri-implant bone and optimize long-term treatment outcomes.[13-16]

More recent evidence continues to support the role of regenerative biomaterials during immediate implant placement. A systematic review and meta-analysis reported favorable outcomes for immediate implants placed in molar extraction sockets when appropriate surgical protocols were followed.[17] Contemporary clinical studies have demonstrated that PRF used as a space-filling material during immediate implant placement may improve peri-implant healing and reduce marginal bone changes compared with grafting materials alone.[18,19] Furthermore, a recent systematic review and meta-analysis concluded that PRF has the potential to enhance implant stability and promote osseointegration, although additional well-designed randomized clinical trials are required to strengthen the available evidence.[20]

Despite increasing evidence regarding the regenerative potential of PRF, relatively few clinical studies have specifically evaluated its combined use with DFDBA for immediate implant placement in fresh extraction sockets of mandibular posterior teeth. The present prospective clinical study was therefore undertaken to evaluate the stability of immediate implants placed in fresh mandibular posterior extraction sockets using PRF combined with DFDBA and to assess vertical bone changes during the six-month follow-up period.

MATERIALS AND METHODS

Study design and setting

This prospective clinical study was conducted at the Department of Oral and Maxillofacial Surgery at a tertiary care teaching hospital in Kalaburagi, Karnataka, India. The study was designed to clinically evaluate the stability of immediate implants placed in fresh extraction sockets of mandibular posterior teeth using platelet-rich fibrin (PRF) and demineralized freeze-dried bone allograft (DFDBA). Patients were followed for six months after implant placement.

Patient selection

Patients aged 20 years or older who required extraction of mandibular posterior teeth because of extensive caries or vertical root fracture that rendered the tooth non-restorable were considered eligible. Only patients classified as American Society of Anesthesiologists (ASA) physical status I were included. Patients with periodontal or periapical pathology, systemic conditions contraindicating minor oral surgery, previous radiotherapy involving the head and neck region, tobacco or alcohol abuse, smoking, bruxism, or psychological disorders were excluded.

Preoperative assessment

All patients underwent comprehensive clinical examination and routine laboratory investigations, including complete blood count, bleeding time, clotting time, HIV, and hepatitis B surface antigen testing. Oral prophylaxis was performed before surgery, and patients were instructed to use chlorhexidine mouthwash twice daily for three days before the procedure. Prophylactic amoxicillin (2 g) was administered one hour before surgery. Radiographic evaluation included assessment of the inferior alveolar nerve, root morphology, socket dimensions, cortical bone height, and the presence of apical pathology. Diagnostic casts were prepared for all patients, and implant dimensions were selected according to the available bone and extraction socket morphology.

Surgical procedure

All procedures were performed under local anesthesia using lignocaine with adrenaline (1:80,000). Atraumatic tooth extraction was carried out using flap elevation and root sectioning when required to preserve the buccal, lingual, and interseptal bone. Following thorough socket debridement and irrigation, implant osteotomy was prepared using sequential drilling under copious saline irrigation. Implants were inserted at least 2 mm apical to the alveolar crest with an insertion speed of 20–30 rpm to achieve primary stability.

Preparation and placement of PRF and DFDBA

Immediately before implant placement, 10 mL of venous blood was collected into sterile tubes without anticoagulant and centrifuged at 3000 rpm for 10 minutes to obtain PRF. The fibrin clot was separated, cut into small fragments, and mixed with DFDBA. The PRF-DFDBA mixture was packed into the gap between the implant surface and the extraction socket wall before flap closure. Primary wound closure was achieved using interrupted 3-0 silk or polyglactin sutures without tension.

Postoperative care and follow-up

Postoperative medications included amoxicillin-clavulanic acid (625 mg twice daily), diclofenac sodium for 5–7 days, and chlorhexidine mouthwash twice daily for two weeks. Patients were advised to consume a liquid or semisolid diet for the first three postoperative days and were recalled after one week for suture removal.

At three months, implant stability was evaluated using reverse torque testing (20 Ncm) and percussion testing. Following confirmation of osseointegration, gingival formers were placed, and definitive prosthetic rehabilitation was completed using single crowns cemented with glass ionomer cement. Standardized intraoral periapical radiographs (IOPA) were obtained immediately after implant placement, at three months, and at six months using the paralleling technique.

Outcome measures

The primary outcome measure was implant stability after osseointegration at three months. Secondary outcome measures included vertical peri-implant bone loss or gain measured immediately after implant placement and at three- and six-month follow-up. Radiographic measurements were performed on standardized IOPA radiographs using CorelDRAW software by assessing the mesial and distal aspects of each implant.

Statistical analysis

Vertical bone loss measurements obtained at different follow-up intervals were compared using Student's *t*-test. Statistical significance was determined at a p-value of less than 0.05.

RESULTS

A total of 11 patients underwent immediate implant placement following extraction of mandibular posterior teeth. The baseline demographic characteristics and implant dimensions are summarized in Table 1. The study population comprised eight females (72.7%) and three males (27.3%). Seven patients (63.6%) were aged 20–30 years, while four (36.4%) were aged 30–40 years. Implant diameters ranged from 3.4 to 4.3 mm, and implant lengths ranged from 11.5 to 14 mm.

Table 1: Baseline demographic and implant characteristics (n = 11)

Characteristic	Value
Total patients	11
Female	8 (72.7%)
Male	3 (27.3%)
Age 20–30 years	7 (63.6%)
Age 30–40 years	4 (36.4%)
Implant diameter	3.4–4.3 mm
Implant length	11.5–14 mm

Implant stability

Clinical outcomes are presented in Table 2. Immediate implant placement was successfully performed in all 11 patients. Atraumatic extraction was achieved in eight patients (72.7%), minimal traumatic extraction in two patients (18.2%), and severe traumatic extraction in one patient (9.1%). At the three-month follow-up, 10 of the 11 implants demonstrated successful osseointegration, corresponding to an implant survival rate of 90.9%. One implant (9.1%) failed before second-stage surgery because of severe traumatic extraction and poor oral hygiene. Radiographic examination of the failed implant demonstrated peri-implant radiolucency, and reverse torque and percussion tests were negative. All successfully osseointegrated implants were asymptomatic, immobile, and exhibited no detectable peri-implant bone defects on clinical examination.

Table 2: Clinical outcomes following immediate implant placement

Variable	Value
Total implants placed	11
Successful osseointegration	10 (90.9%)
Implant failure	1 (9.1%)
Implant survival rate	90.9%
Atraumatic extraction	8 (72.7%)
Minimal traumatic extraction	2 (18.2%)
Severe traumatic extraction	1 (9.1%)
Bone loss among successfully osseointegrated implants	8 (80.0%)
Bone gain among successfully osseointegrated implants	2 (20.0%)

Footnote: *Percentages for bone loss and bone gain were calculated using the 10 successfully osseointegrated implants as the denominator.*

Vertical peri-implant bone changes

Radiographic evaluation of the 10 successfully osseointegrated implants demonstrated progressive peri-implant bone remodeling during the follow-up period (Table 3). Mean vertical bone loss increased from 0.043 ± 0.096 mm immediately after implant placement to 0.260 ± 0.117 mm at three months and 0.367 ± 0.240 mm at six months. Overall vertical bone loss ranged from 0.12 to 0.59 mm after six months of follow-up.

Table 3: Vertical peri-implant bone changes among successfully osseointegrated implants (n = 10)

Follow-up interval	Mean ± SD (mm)	Range (mm)
Immediate postoperative	0.043 ± 0.096	0.00–0.28
Three months	0.260 ± 0.117	0.10–0.55
Six months	0.367 ± 0.240	0.12–0.95

SD: Standard deviation.

Bone gain was observed in two patients (20%). Vertical bone gain ranged from 0.10 to 0.20 mm at three months and from 0.12 to 0.21 mm at six months.

The distribution of overall vertical bone changes is summarized in **Table 4.** Among the 10 successfully osseointegrated implants, eight (80%) demonstrated varying degrees of vertical bone loss, whereas two (20%) demonstrated vertical bone gain during the follow-up period.

Table 4: Distribution of overall vertical bone changes after six months (n = 10)

Overall vertical bone change	Patients, n (%)
Bone loss 0.40–0.60 mm	1 (10%)
Bone loss 0.20–0.40 mm	4 (40%)
Bone loss 0.00–0.20 mm	3 (30%)
Vertical bone gain (up to 0.20 mm)	2 (20%)

Comparison of vertical bone changes

Comparison of vertical bone loss using Student's *t*-test is shown in Table 5. A statistically significant increase in vertical bone loss was observed between the immediate postoperative period and the three-month follow-up (t=3.38). In contrast, no statistically significant difference was observed between the three- and six-month follow-up periods (t=0.82), indicating stabilization of peri-implant bone levels after the initial healing phase.

Table 5: Comparison of vertical bone changes using Student's *t*-test

Comparison	t-value	Interpretation
Immediate vs. 3 months	3.38	Significant
3 months vs. 6 months	0.82	Not significant

DISCUSSION

Immediate implant placement has become an increasingly predictable treatment approach for replacing missing teeth because it reduces treatment time, minimizes the number of surgical procedures, and helps preserve alveolar ridge dimensions and peri-implant soft tissue architecture.[1-5] Nevertheless, successful outcomes depend on achieving primary implant stability, minimizing peri-implant bone remodeling, and establishing rapid osseointegration. The present prospective clinical study evaluated the clinical performance of immediate implants placed in fresh mandibular posterior extraction sockets using a combination of platelet-rich fibrin (PRF) and demineralized freeze-dried bone allograft (DFDBA). The principal findings were a 90.9% implant survival rate after six months, minimal peri-implant vertical bone loss, radiographic bone gain in two patients, and stabilization of peri-implant bone levels after the initial three-month healing period.

The implant survival rate observed in the present study is consistent with previous systematic reviews reporting high survival rates for immediately placed implants in carefully selected extraction sockets.[3,4] Hammerle et al. reported that predictable outcomes following immediate implant placement depend on atraumatic extraction, adequate primary implant stability, and careful case selection.[1] Similarly, Chen and Buser concluded that immediate implants can provide favorable clinical and esthetic outcomes when biological principles are respected.[2]

Although the present study included a relatively small number of patients, the observed survival rate supports these recommendations and demonstrates that immediate implant placement in mandibular posterior extraction sockets can achieve predictable short-term outcomes.

One implant failed before second-stage surgery because of severe traumatic extraction and poor oral hygiene. These findings emphasize the importance of preserving socket integrity during extraction and maintaining adequate postoperative plaque control. Immediate implant placement is highly technique-sensitive, and traumatic extraction may compromise the residual bone walls, reduce primary stability, and adversely affect osseointegration.[2,5]

Therefore, careful patient selection, atraumatic surgical technique, and meticulous postoperative maintenance remain essential for successful treatment outcomes.

Radiographic evaluation demonstrated only minimal vertical peri-implant bone loss during the six-month follow-up period. Most of the bone remodeling occurred during the first three months after implant placement, whereas no significant increase in bone loss was observed between the third and sixth months. This pattern is consistent with the normal biological sequence of extraction socket healing and early osseointegration, during which initial bone remodeling is followed by progressive maturation and stabilization of peri-implant bone.[13,14]

Previous studies have demonstrated that physiologic ridge remodeling cannot be completely prevented after tooth extraction, even when implants are placed immediately.[13-16] However, the limited amount of bone loss observed in the present study suggests that the combined use of PRF and DFDBA may help preserve peri-implant bone during early healing.

The favorable radiographic outcomes observed in this study may be explained by the complementary biological properties of PRF and DFDBA. PRF provides a three-dimensional fibrin matrix containing platelets, leukocytes, and multiple growth factors that are gradually released during healing, thereby promoting angiogenesis, cellular proliferation, and tissue regeneration.[6-8] In contrast, DFDBA functions as an osteoconductive scaffold with potential osteoinductive properties attributed to the presence of bone morphogenetic proteins, thereby supporting new bone formation around the implant surface.[11,12] The combination of these two regenerative materials may create a favorable environment for early bone regeneration by combining the biological activity of PRF with the structural support provided by DFDBA.

The regenerative potential of platelet concentrates has been reported in several previous investigations. Simon et al. demonstrated improved clinical and histological healing when platelet-rich fibrin matrix was combined with DFDBA for ridge preservation procedures, suggesting that platelet-derived biologic materials may enhance early bone regeneration when used with bone grafts.[9] Earlier evidence regarding platelet-rich plasma similarly demonstrated the beneficial effects of autologous growth factors on tissue repair and bone healing, thereby providing the biological basis for the subsequent development and clinical application of PRF.[10]

Recent evidence has further strengthened the role of PRF during immediate implant placement. Fang et al. reported favorable healing following immediate implant placement with PRF in extraction sockets affected by periapical infection, supporting the regenerative potential of PRF even in challenging clinical situations.[18] Likewise, Elbrashy et al. demonstrated that PRF used as a space-filling material during immediate implant placement produced clinical outcomes comparable to those achieved with deproteinized bovine bone in maxillary premolar extraction sockets.[19] Furthermore, the systematic review and meta-analysis by Guan et al. concluded that PRF may enhance implant stability and osseointegration, although additional high-quality randomized clinical trials remain necessary to establish definitive clinical recommendations.[20] The findings of the present study are in agreement with these reports and provide additional clinical evidence supporting the use of PRF combined with DFDBA during immediate implant placement.

The present study has several clinical implications. Filling the peri-implant gap with a combination of PRF and DFDBA appears to be a practical regenerative approach that may facilitate early wound healing, support osseointegration, and limit early peri-implant bone remodeling. The autologous nature of PRF, together with the osteoconductive properties of DFDBA, supports the use of this combination as a regenerative adjunct during immediate implant placement, particularly in extraction sockets where residual gaps are present.

Nevertheless, the present study should be interpreted in light of its limitations. The sample size was small, the follow-up period was limited to six months, and there was no comparison group treated with immediate implants alone or with alternative grafting materials. Implant stability was assessed using clinical methods rather than resonance frequency analysis, and radiographic evaluation was based on standardized intraoral periapical radiographs rather than three-dimensional imaging. These limitations restrict the generalizability of the findings. Future randomized controlled trials with larger sample sizes, longer follow-up periods, and advanced radiographic assessment are required to validate the long-term effectiveness of PRF combined with DFDBA in immediate implant therapy.

CONCLUSION

Within the limitations of this prospective clinical study, immediate implant placement in fresh extraction sockets of mandibular posterior teeth using platelet-rich fibrin (PRF) combined with demineralized freeze-dried bone allograft (DFDBA) demonstrated favorable short-term clinical outcomes. Successful osseointegration was achieved in 10 of the 11 implants, corresponding to an implant survival rate of 90.9% after six months of follow-up. Most implants exhibited minimal vertical peri-implant bone loss, while two cases demonstrated radiographic bone gain. The greatest bone remodeling occurred during the first three months after implant placement, with no significant additional bone loss observed between the third and sixth months, suggesting stabilization of peri-implant bone levels following initial healing.

The findings suggest that the combination of PRF and DFDBA may provide a favorable biological environment for osseointegration and peri-implant bone preservation in immediately placed implants when atraumatic extraction and meticulous surgical technique are employed. However, the relatively small sample size and short follow-up period limit the generalizability of these findings. Further randomized controlled trials with larger sample sizes and longer follow-up are required to confirm the long-term clinical effectiveness of this treatment approach.

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