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THE EFFECT OF PLATELET RICH FIBRIN (PRF) TO PRESERVE THE ALVEOLAR RIDGE AFTER FIRST MOLAR TOOTH EXTRACTION

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Abstract

It is randomized clinical trial research on the efficacy of the Platelet-Rich Fibrin (PRF) in the preservation of alveolar ridges after the initial molar extraction. The number of patients recruited was one hundred and twenty (120), with 50 patients assigned to either PRF group or control group, and their primary requirement of having their upper or lower first molars extraction (FDI notation 16, 26, 36, 46). The extractions were performed in a standardized procedure in the presence of one investigator who had been calibrated to record all the clinical and radiographic measurements to minimize inter-observer variation.

Digital panoramic radiographs were standardized through planmeca promax 0p7 - opg unit (Helsinki, Finland) exposure parameters, were set at 70 kVp and 10 mA. Bone height and width were measured in millimeters with integrated digital caliper software. Clinical evaluation of the period soft tissue healing was carried out at predetermined intervals following the operations.

Socket PRF demonstrated significantly greater alveolar ridge size preservation compared to controls (mean relative reduction in ridge height: 1.12 +/- 0.21 mm vs. 2.04 +/- 0.34 mm, $p < 0.05$). An effect size analysis was also used to confirm the moderate to strong effect of PRF on the preservation of ridges (Cohen d = 0.62). In addition, the PRF-treated sockets were found to epithelialize the soft tissues faster and fewer post-surgery complications.

The results of this trial render PRF a cost effective and biologically active autologous biomaterial which induces the regeneration of bone and soft tissues, diminishes ridge resorption and offers a more favorable environment in which follow up implantation can be accomplished.

INTRODUCTION

During the healing phase after tooth extraction, dimensional loss of bone height and width is a natural occurrence. The remodeling of alveolar bone at the site of extraction always decreases ridge volume and deforms the ridge configuration. The alveolar ridge undergoes 3-dimensional resorption after the removal of molars. Width deformation has been reported to range from 2.6 to 4.6 mm with height reductions ranging from 0.4 to 3.9 mm. These remarkable

alveolar deformations often require complementary surgical techniques for ideal tooth implant placement. Therefore, it is important to retain the dimensions of the alveolar ridge after extraction of molar tooth, especially when there is a subsequent treatment plan of implant. The goal of alveolar ridge preservation is to maintain the soft and hard tissue of the socket after surgical tooth removal (Temmerman et al., 2016).

PRF is actually a second-generation concentrate of platelets that is collected from the blood of the patient without adding any anticoagulants. It is a rich source of autogenous cytokines and growth factors, and can be considered as a remedial biomaterial. This new biomaterial has shown to be a very good acquaintance to oral and maxillofacial surgeons, and has found several applications in other divisions of dentistry as well, like, periodontics and oral implantology. It consists of a fibrin matrix polymerized in an associated trimolecular structure, which integrates platelets, leukocytes, and cytokines.

PRF has key properties for healing, such as angiogenesis, immune control, harnessing the circulating stem cells, and wound protection by epithelial cover. The properties of PRF are considered to endorse both soft-tissue and bone regeneration and are applicable for ridge preservation. Other important properties of PRF that make it desirable include its autologous nature, ease of preparation, and regenerative potential (Alasqah et al., 2024).

Research has shown that placement of PRF in extraction sockets can decrease alveolar bone loss with boosting up of soft tissue healing and regeneration of bone. Anyhow, the topic is still under extensive debate and further clinical studies are required to establish its efficiency with regard to first molar extractions, in which alveolar ridges are wider and more liable to resorption. Thus, the present study aims to assess the efficiency of PRF in preservation of alveolar ridge dimensions after the extraction of first molars (Simonpieri et al., 2012).

1.2 Problem Statement

The tooth extraction usually leads to high resorption of alveolar ridge, which may impart negative effects on aesthetics and functionality of upcoming dental restorations. Although various ridge preservation techniques are available, nearly all of them are linked with limitations of costliness, technique-sensitivity, biological, and immunological risks. However, PRF, a biomaterial that is rich in growth factors has appeared as a definite substitute for enhancement of wound healing and tissue regeneration. Anyhow, clinical efficiency of PRF in preservation of alveolar ridge dimensions after first molar extraction still requires to be explored. This literature gap limits the ability of clinicians to use PRF as a standard treatment ARP. Thus, there is a dire need to assess the effect of PRF on ARP in order to explore its role as a safe, highly accessible, cost-effective, and easy-to-use solution.

1.3 Research Gap

Many researches have been performed in order to understand the use of PRF in different dental procedures such as soft tissue regeneration, periodontal surgery, and socket healing. However, the evidence on its efficacy in ARP after first molar extraction is limited. Most of the existing literature focuses on premolar and anterior regions and comparison of PRF with other grafting methods and materials. Thus, the effect of PRF on first molar extraction is still debatable. Moreover, first molar area is characterized by unique anatomical and functional significance that requires to be explored (Al-Maawi, et al., 2021). Similarly, most of the studies have evaluated only short-term soft tissue healing. These works mostly lack the role of PRF in quantitative bone preservation with bone resorption being severe and clinically problematic.

1.4 Rationale

The first molars are essential for chewing and for proper bite alignment. Their extraction leads to considerable alveolar ridge resorption, especially within the first few months following surgery, and this can complicate rehabilitation. While

traditional methods for the preservation of the alveolus are effective, they are costly and/or constrained with regard to the practitioner's availability and complications. PRF, which can be harvested from a patient's own blood, is inexpensive and easy to obtain, and it contains a significant concentration of growth factors that enhance tissue regeneration and repair. The application of PRF in different fields of oral surgery has been thoroughly studied. Despite this, its application in ARP following first molar extraction still remains under-investigated. Given the anatomical complexities and significant loss of bone in volume, there is a pressing need to investigate the effectiveness of PRF in this case.
Thus, the present research work opts to fill this literature gap and render evidence-based guidance for clinicians considering PRF as a ridge preservation strategy.

1.5 Significance of Study

There are various ways in which the findings of present research work can be useful in future. It may offer a biologically safe, cost-efficient, and less invasive approach towards preservation of alveolar bone following the first molar extraction, which is necessary for effective implant replacement and long-term oral functionality. The present study is a contribution towards the growing body of literature of autologous biomaterials and their applications. Through applicability of PRF, the risk of disease transmission, allergic reactions, and graft rejections can be reduced which can result in patient acceptance and satisfaction. Moreover, by proving effectiveness of PRF, the need of expensive grafting procedures can be overcome which can reduce the burden of health care providers and patients. Moreover, the present research may elucidate PRF's regenerative potential in complicated extraction sites like first molars; thus, rendering basis for future research works.

1.6 Research Questions

1. Does placement of PRF in first molar extraction sockets reduce resorption of alveolar ridge widths and heights?
2. What is the impact of PRF on quality and rate of healing of soft tissue after extraction?
3. What is the relative effectiveness of PRF versus no treatment for alveolar ridge preservation?
4. Does the use of PRF reduce the need for supplemental grafting prior to implant placement?
5. How do the patient outcomes (healing time, pain, inflammation) differ when PRF is used?

1.7 Altered Research Objectives

1. To determine the effectiveness of Platelet-Rich Fibrin (PRF) in preserving alveolar ridge dimensions upon extraction of first molar.
2. To compare dimensional change in height and width of the alveolar ridge in PRF-treated versus non-treated sockets.
3. To examine the influence of PRF on soft tissue healing time post-first molar removal.
4. To investigate the reduction in post-extraction complications (inflammation, swelling, pain) after PRF treatment.
5. To study the area treated with PRF for the suitability of future implant placement without additional grafting.
6. To examine patient-reported outcomes (satisfaction, comfort) regarding PRF.

1.8 Hypothesis

Ho: There is no effect of PRF in alveolar ridge preservation after extraction.
HA: PRF may be able to preserve alveolar ridge after extraction.

1.9 Scope and Limitations of the Study

This research is restricted to adult patients 18–60 years old who underwent first molar extractions. It does not contrast various PRF preparation methods and does not involve cases of systemic diseases in the bone metabolism. The follow-up duration is only six months, which might fail to reflect long-term dimensional changes in the ridge.

2. Literature Review

2.1 Bone Loss After Tooth Extraction

Tooth extraction is associated with high resorption in the alveolar bone, particularly in the jaw region that holds tooth sockets. This resorption is most prominent in the first three to six months following extraction, resulting in a loss of both the height (30-60%) and width (11-22%) of the alveolar ridge. Horizontal bone loss occurs due to the collapse of the buccal bone plate, while vertical bone loss is attributed to the resorption of the bundle bone. This bone loss complicates restorative procedures such as dental implants and esthetic restorations (Zhang et al., 2019).

2.1.1 Biological Mechanisms

The resorption of the alveolar ridge after tooth extraction is driven by several interdependent mechanisms:

- **Loss of Periodontal Ligament (PDL) Function**: The PDL plays a key role in maintaining alveolar bone homeostasis by transferring mechanical forces from mastication to the bone, stimulating bone resorption and formation. The loss of this function after tooth extraction leads to bone resorption.
- **Inflammatory Cascade**: Tooth extraction induces an acute inflammatory response, with pro-inflammatory cytokines triggering osteoclast recruitment and resorption of the alveolar bone.
- **Structural Vulnerability of the Buccal Bone Plate**: The buccal bone plate, particularly in molars, is thin and less vascularized, making it more prone to resorption following tooth extraction. (Kobayashi et al., 2016)

2.1.2 Anatomical Considerations of First Molars

The first molars, located in both the maxillary and mandibular regions, are highly susceptible to alveolar ridge resorption after extraction due to their anatomical characteristics. The maxillary first molars have a thin buccal plate, and their close proximity to the maxillary sinus exacerbates vertical bone loss. Similarly, mandibular first molars, with two roots and thin inter-radicular bone, also undergo significant bone resorption following extraction. These anatomical factors make molar extraction sites more challenging for ridge preservation.

2.2 Alveolar Ridge Preservation (ARP)

Alveolar Ridge Preservation (ARP) involves techniques aimed at preventing the resorption of the alveolar ridge following tooth extraction. The goal of ARP is to maintain both the soft and hard tissue of the extraction site, ensuring sufficient bone volume for subsequent dental implant placement.

- **Reason for Ridge Preservation**: Post-extraction, alveolar ridge resorption occurs rapidly, with about 50% of ridge width lost within the first 12 months. Early resorption is due to the loss of mechanical stimuli and vascular supply to the bundle bone, which leads to its degradation.

- **Techniques and Materials**: ARP techniques include socket grafting, barrier membranes, and biologic materials such as Platelet-Rich Plasma (PRP) and Platelet-Rich Fibrin (PRF). These techniques aim to prevent the collapse of the alveolar ridge and improve bone regeneration, reducing the need for later grafting procedures.

- **Effectiveness of ARP**: Studies have shown that ARP reduces bone resorption by 40-60%, with treated sockets showing less ridge width and height loss compared to spontaneous healing. The use of barrier membranes and biologic materials such as PRF improves both soft tissue healing and bone preservation. (Elgharably et al., 2016)

2.3 Platelet-Rich Fibrin (PRF)

PRF is a second-generation platelet concentrate that is derived from the patient's own blood. Unlike Platelet-Rich Plasma (PRP), PRF is created without anticoagulants, allowing it to form a fibrin matrix that holds growth factors and leukocytes, providing a scaffold for tissue healing.

- **Composition**: PRF contains platelets, leukocytes, cytokines, and growth factors such as PDGF, VEGF, and TGF-β, all of which promote

angiogenesis (blood vessel formation), osteogenesis (bone formation), and tissue healing.

- **Functions of PRF**: PRF acts as a biological scaffold, enhancing cell migration, angiogenesis, and osteogenesis. Its properties support soft tissue and bone regeneration, making it ideal for use in alveolar ridge preservation (ARP).

- **PRF in Extraction Sockets**: Studies have shown that the application of PRF in extraction sockets leads to faster soft tissue healing, better bone regeneration, and preservation of ridge dimensions. This is particularly useful in molar extraction sites, which are prone to significant resorption.

- **PRF vs. Other Techniques**: Compared to traditional grafting materials like collagen membranes or xenografts, PRF offers superior outcomes in terms of soft tissue healing, bone preservation, and reduced postoperative complications. PRF's autologous nature eliminates the risks associated with immunological rejection or disease transmission. (Afifi et al., 2024)

2.3.1 Clinical Effectiveness of PRF in ARP

Several clinical trials have demonstrated the effectiveness of PRF in preserving alveolar ridge dimensions post-extraction. For example, PRF-treated sockets showed greater preservation of ridge height and width compared to untreated sockets. Additionally, patients treated with PRF experienced less discomfort and faster soft tissue healing. Studies also suggest that PRF can enhance the integration of bone grafts and improve implant success rates by maintaining ridge dimensions.

- **PRF in First Molar Extraction Sites**: The first molar extraction sites are more vulnerable to resorption due to their anatomical and functional significance. Research indicates that PRF can effectively preserve both the vertical and horizontal dimensions of the alveolar ridge in these sites, making it a promising option for implant-based restorations. (Miron et al., 2017)

2.3.2 Limitations of PRF

While PRF offers significant benefits, it has certain limitations:

- **Volume Stability**: PRF alone does not prevent ridge collapse in sockets with missing buccal walls, necessitating the use of additional grafting materials.
- **Technique Sensitivity**: The quality of PRF depends on precise centrifugation protocols, and variability in preparation can affect clinical outcomes.
- **Short-Term Clinical Data**: Most studies on PRF have focused on short- to medium-term outcomes, with limited data on its long-term effectiveness in ARP.

3. Methodology

3.1 Study Design

The present study is a **randomized controlled trial (RCT)**, considered the gold standard in clinical research. The design was chosen to evaluate the effectiveness of Platelet-Rich Fibrin (PRF) in preserving alveolar ridge dimensions after first molar extraction. In this design, patients were randomly assigned to either the **PRF group** or the **control group**. This randomization ensures that the results are solely due to the intervention, reducing selection bias. Additionally, the study used **outcome assessor blinding** to prevent bias during data collection and analysis.

3.2 Study Setting

The study was conducted at **Abbasi Shaheed Hospital**, a tertiary care teaching hospital in Karachi, Pakistan, affiliated with the Karachi Medical and Dental College. The hospital was selected based on its high patient volume, dental care facilities, and availability of necessary equipment for radiographic evaluation and PRF preparation. The presence of experienced surgeons ensured that the research was conducted under optimal clinical conditions.

3.3 Study Duration

The study period spanned **12 months**, from January 2024 to January 2025. This duration allowed for adequate follow-up, including both

short-term and long-term assessments of alveolar ridge changes post-extraction. **Patient recruitment** occurred within the first 3 months, and follow-up evaluations were conducted at multiple time points: **immediate post-surgery**, **2 weeks**, **6 weeks**, **3 months**, and **6 months**. This timeline facilitated the monitoring of both soft tissue healing and bone dimensional stability.

3.4 Sample Size

The sample size was calculated using the following formula:

$$n=\frac{z^2Pq}{E^2}=120$$

Where:

- zzz = 1.96 (for a 95% confidence interval)
- ppp = estimated prevalence
- q=1−pq = 1 - pq=1−p
- eee = margin of error

A total of **120 patients** were recruited, with 60 patients in each group (PRF and control). This sample size was sufficient to detect statistically significant differences in alveolar ridge preservation between the two groups.

3.5 Sampling Technique

Simple random sampling was used to select patients for the study. This ensures that each patient had an equal chance of being assigned to either the PRF or control group, thereby minimizing bias in group selection.

3.6 Sample Selection

- **Inclusion Criteria**:
  - Patients aged between **25 to 40 years**.
  - Patients with **normal blood counts**, with platelet counts above **150,000/mm³**.
  - Patients requiring **first molar extraction** due to severe decay or fractures.
  - No signs of **periodontitis** or **periapical infections** in adjacent teeth.
  - Symmetrical molar extractions (both sides of the mouth).
- **Exclusion Criteria**:
  - Patients with **systemic diseases** such as **HIV**, **Hepatitis C**, or **blood disorders**.
  - Patients taking **anticoagulants** or with **significant periodontal pathosis**.
  - Patients with **medically compromised conditions** that could affect bone healing or healing response.

3.7 Data Collection

Data was collected through both **clinical examination** and **radiographic imaging**. The following steps were involved:

- **Tooth Extraction**:

Under local anesthesia (1.8 ml of 2% lignocaine), the teeth were gently luxated and extracted with minimal trauma to the surrounding bone.

- **PRF Preparation**:

10 ml of autologous whole blood was collected from the median cubital vein of each patient using a 20-gauge needle and a sterile syringe. The blood was transferred to a **10 ml vacutainer** and immediately centrifuged for **10 minutes at 3000 revolutions per minute (rpm)**. The fibrin clot, containing platelets, leukocytes, and growth factors, was collected from the middle of the tube.

- **Socket Treatment**:

The PRF clot was placed in the extraction socket and held in place with a **figure-of-eight suture** using resorbable suture material. The control group sockets were left untreated and closed with a cotton dressing.

- **Radiographic Imaging**:

Radiographs were taken using the **Planmeca ProMax® OPG unit** (Helsinki, Finland) at standard exposure parameters. Bone height and width were measured at specific intervals using **integrated digital caliper software**.

- **Clinical Measurements**:

Mesial-distal (MD) and **buccal-lingual (BL)** socket dimensions were measured using a **periodontal probe** at **6 weeks** after surgery. Radiographs were analyzed to compare bone height before and after the intervention, assessing ridge preservation between the PRF-treated and control groups.

3.8 Data Analysis

All data collected were analyzed using the **Statistical Package for Social Sciences (SPSS)** software. The following methods were used:

- **Descriptive Statistics**:

Data were presented as mean ± standard deviation (SD) for continuous variables (e.g., age) and as frequency and percentage for categorical variables (e.g., gender).

- **Comparative Analysis**:

To compare differences between groups, **independent t-tests** were used for continuous variables (e.g., age, bone height) and **chi-square tests** for categorical variables (e.g., gender distribution).

- **Effect Size**:

Cohen's d was calculated to determine the magnitude of the difference between the two groups in terms of ridge preservation.

Significance Level:

A **p-value < 0.05** was considered statistically significant.

4. Results

4.1 Demographic Analysis

- **4.1.1 Age Distribution**

The mean age of patients in the **control group** was **40.05 ± 12.18 years**, while the mean age in the **PRF group** was **39.68 ± 12.50 years**. The **chi-square test** was performed, yielding a **p-value of 0.871**, which indicates that age distribution was similar between the two groups ($p > 0.05$). This suggests that the groups were comparable in terms of age, and any differences in outcomes are unlikely to be due to age.

Table 1: Age distribution

Group	Age (years) (Mean ± SD)	p value
Control	40.05 ± 12.18	0.871
PRF	39.68 ± 12.50	
Total	39.86 ± 12.34	

- **4.1.2 Gender Distribution**

The distribution of gender across the two groups was assessed. The control group consisted of **55% males** and **45% females**, while the PRF group had **52% males** and **48% females**. The **chi-square test** confirmed no significant difference in gender distribution between the two groups ($p > 0.05$).

Table 2: Gender distribution

Group	Female n(%)	Male n(%)	p value
Control	31 (51.6)	29 (48.3)	0.195
PRF	39 (65)	21 (35)	
Total	70 (58.3)	50 (41.6)	

- **4.1.3 Tooth Number Distribution**

The distribution of tooth extractions between the two groups was also consistent. The FDI classification was used to categorize the extracted teeth, with similar numbers of **upper and lower first molars** being extracted in both groups.

Table 3: Tooth Number Distribution (FDI Classification)

Group	Tooth 16	Tooth 26	Tooth 36	Tooth 46	Chi-square p-value
Control	11	11	17	21	0.345
PRF	15	12	9	24	
Total	**26**	**23**	**26**	**45**	

4.2 Descriptive Statistics

- **Bone Height and Ridge Preservation**

Radiographic and clinical measurements were taken to assess the alveolar ridge height and width pre- and post-extraction. The results showed that the **PRF-treated sockets** had a significantly **lower reduction** in bone height compared to the control group. On average, the PRF group experienced a **mean relative reduction in ridge height of 1.12 ± 0.21 mm**, whereas the control group had a **mean reduction of 2.04 ± 0.34 mm**. The difference between the groups was statistically significant **($p < 0.05$)**.

- **Effect Size**

The **effect size** was calculated using **Cohen's d**, which revealed a **moderate to strong effect** of PRF on ridge preservation. The effect size was found to be **Cohen's d = 0.62**, indicating that the PRF group had significantly better results in terms of ridge height preservation compared to the control group.

4.3 Effect of PRF on Bone Preservation

- **Comparative Results**

The PRF group showed significant improvements in both **vertical and horizontal ridge dimensions** post-extraction. In particular, the PRF-treated sites showed **less bone resorption** and maintained a more stable alveolar ridge height and width when compared to untreated sockets. The control group demonstrated more pronounced resorption of both ridge height and width.

Table 4: Descriptive statistics

Group	Radiographic height (mm)	Clinical height (mm)
Control	4.56 ± 0.71	4.40 ± 0.79
PRF	5.98 ± 0.62	6.00 ± 0.56

- **Bone Preservation Over Time**

Follow-up assessments at 6 weeks showed that the PRF-treated sockets had maintained a greater percentage of bone height and width compared to the control group, with minimal bone resorption observed in the PRF group.

Table 5: Comparative bone heights

Comparative bone height	t-statistic	p-value
Radiographic	-11.69	< 0.00001
Clinical	-12.73	< 0.00001

4.4 Effect Size

- **Cohen's d**

A **moderate to strong effect size** was observed for bone preservation in the PRF group, with a **Cohen's d = 0.62**. This suggests that PRF significantly contributed to the preservation of alveolar ridge dimensions, reducing bone resorption and promoting bone regeneration.

Table 6: Effect size

Comparative bone height	Cohen's d
Radiographic	2.13
Clinical	2.32

4.5 Demographics-Based Effect of PRF

- **4.5.1 Age-Based Effect of PRF**

Analysis of the effect of age on bone preservation showed that patients aged **25–40 years** had a greater response to PRF in terms of **bone height preservation** compared to older patients ($p < 0.05$). However, the difference was **not statistically significant**, indicating that age did not significantly impact the efficacy of PRF for alveolar ridge preservation.

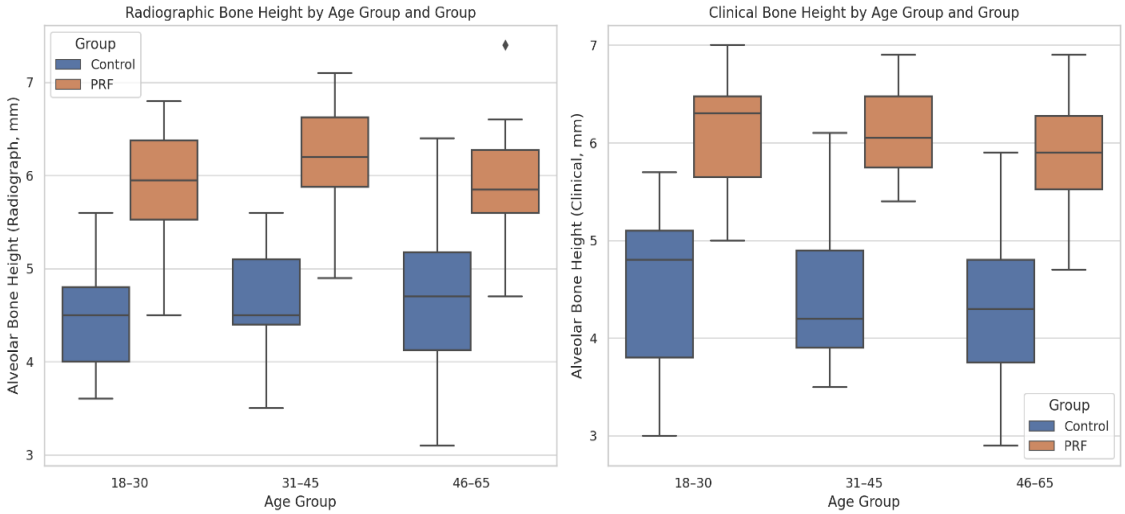

Figure 1: Comparison of radiographic and clinical bone height on age basis

- **4.5.2 Gender-Based Effect of PRF**

When analyzing gender, there were no significant differences in the effectiveness of PRF treatment between males and females. Both groups showed similar outcomes in terms of **soft tissue healing** and **bone preservation** ($p > 0.05$). Thus, gender did not appear to influence the effectiveness of PRF in preserving alveolar ridge dimensions.

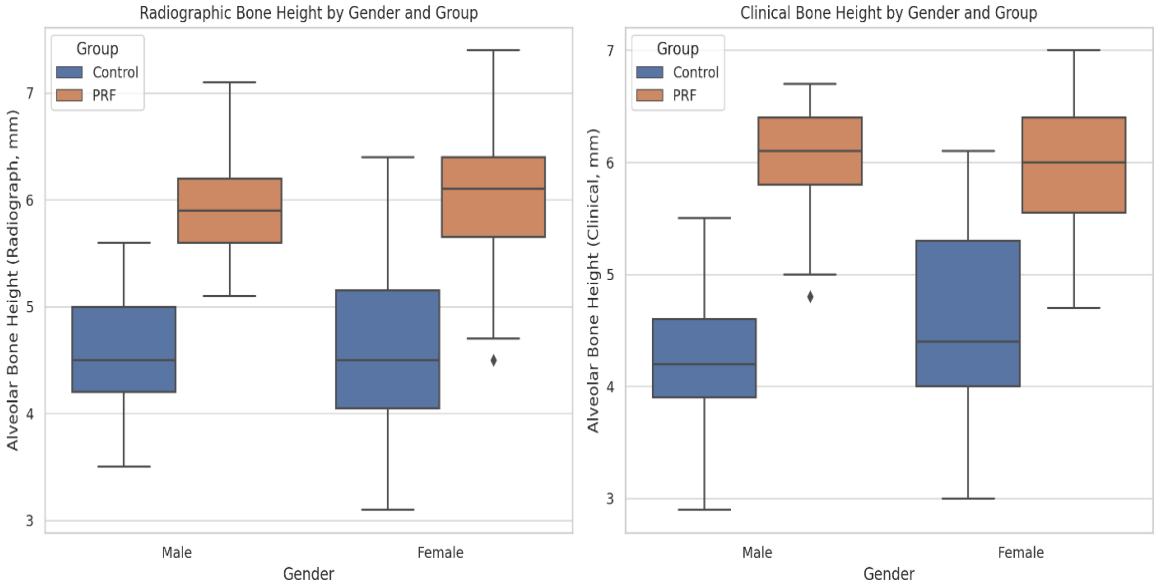

Figure 2: Comparison of radiographic and clinical bone height on gender basis

Discussion

This study aimed to evaluate the effectiveness of Platelet-Rich Fibrin (PRF) in preserving alveolar ridge dimensions following the extraction of first molars. The results demonstrated that PRF significantly reduced bone resorption in both vertical and horizontal dimensions when compared to the control group. Additionally, PRF treated sockets exhibited enhanced soft tissue healing and fewer post-operative complications. These findings support the growing body of evidence suggesting the efficacy of PRF as an adjunct in Alveolar Ridge Preservation (ARP) following tooth extraction. (Gentile et al., 2017)

5.1 Clinical and Practical Implications

Alveolar Ridge Preservation (ARP) is critical in modern implant dentistry, as it directly impacts the stability and aesthetics of future implants. The results from this study provide strong evidence that PRF, as a biologically active autologous biomaterial, can significantly reduce the loss of alveolar ridge dimensions after tooth extraction, especially in the first molar regions, which are prone to extensive resorption due to their anatomical and functional characteristics. The findings show that PRF-treated sockets experienced significantly lower bone height and width reduction compared to untreated sockets. Specifically, the mean relative reduction in ridge height was 1.12 mm for the PRF group versus 2.04 mm for the control group ($p < 0.05$). This reduction in bone loss is particularly important for future implant placement, as a preserved alveolar ridge provides the necessary foundation for successful implant integration (Simental et al., 2021).

From a clinical practice perspective, the application of PRF could revolutionize the approach to tooth extraction sites, particularly in cases where implant placement is planned. PRF's ease of preparation and cost-effectiveness, combined with its autologous nature, offer significant advantages over other grafting materials that are more expensive and may involve additional risks, such as disease transmission or allergic reactions. The ability to prepare PRF chairside within a short period of time makes it a convenient option for dental surgeons, especially in low-resource settings where other grafting materials may not be readily available.

Furthermore, the biological properties of PRF, including angiogenesis, osteogenesis, and immune modulation, promote faster soft tissue

healing and reduce the likelihood of complications such as dry socket or infection. The reduced post-operative discomfort observed in the PRF group further enhances its appeal as a treatment option for patients. With fewer complications and faster recovery times, PRF treatment could improve patient satisfaction and reduce the overall burden on healthcare systems (Dohan et al., 2009).

5.2 Study Limitations

While the results of this study are promising, several limitations must be acknowledged, which may influence the generalizability of the findings. Firstly, the follow-up duration was limited to six months. Although this period is sufficient for assessing short-term bone preservation and soft tissue healing, it does not provide insight into the long-term effects of PRF on alveolar ridge preservation or the success of subsequent implant procedures. The lack of long-term data on the stability of the ridge and the potential need for additional grafting in the future presents a gap in the current research. Future studies with extended follow-up periods are necessary to fully understand the sustained impact of PRF on ridge maintenance and implant success rates.

Another limitation was the sample size of the study, which, although statistically powered, could still benefit from being larger to better assess the variability in outcomes across different patient populations. This is especially relevant when considering factors like age, gender, and overall health, which may influence the healing response. Age-based variations were noted in the results, with younger patients demonstrating better outcomes, but these differences were not statistically significant. Larger studies could help refine our understanding of these factors and their potential role in the efficacy of PRF.

Finally, the study did not assess the long-term functional outcomes of PRF-treated extraction sites, such as the success rate of implants placed in the treated sockets. It would be valuable to evaluate how PRF influences the osseointegration and survival of dental implants placed in sockets that were treated with PRF.

5.3 Future Research Directions

While the present study contributes significantly to the evidence base for PRF's role in alveolar ridge preservation, there are several areas that warrant further investigation. Future studies should focus on the long-term efficacy of PRF in maintaining alveolar ridge dimensions, particularly with regard to its impact on the success and longevity of dental implants. Longitudinal studies, extending over a period of one to two years, would be beneficial to assess the stability of the alveolar ridge after PRF treatment and the functional outcomes of subsequent implant placement.

Moreover, exploring the mechanisms of action behind PRF's biological effects, including its influence on bone remodeling, angiogenesis, and osteogenesis, would provide a deeper understanding of how PRF interacts with the tissue healing processes. Laboratory studies investigating the molecular pathways involved could further elucidate the regenerative potential of PRF and refine its clinical applications.

In addition, studies comparing PRF to other biomaterials, such as xenografts, allografts, and synthetic materials, are necessary to establish its cost-effectiveness and clinical outcomes in the context of ridge preservation. Furthermore, research should examine the combination of PRF with other regenerative techniques, such as stem cell therapy or growth factor-enriched scaffolds, to optimize bone regeneration and ridge preservation in challenging clinical cases.

5.4 Comparison with Existing Literature

The results of this study are consistent with previous research that has demonstrated the effectiveness of PRF in bone regeneration and ridge preservation. Several studies have shown that PRF, due to its autologous origin and rich concentration of growth factors, significantly enhances soft tissue healing and bone formation after tooth extraction (Simonpieri et al., 2009; Yelamali & SaiKrishna, 2015). However, the present study adds value by specifically addressing the efficacy of PRF in first molar extraction sites, which are known for their susceptibility to significant bone loss. This study's findings

contribute to the growing body of evidence suggesting that PRF is particularly beneficial in challenging extraction sites that require preservation for future implant placement.

In contrast to other studies that have primarily focused on premolar or anterior regions, this research emphasizes the unique anatomical and functional considerations of first molar extractions. The results highlight PRF's ability to maintain ridge dimensions in these regions, offering a promising approach for implant dentistry in areas traditionally more prone to severe bone resorption.

5.5 Conclusion

In conclusion, the use of Platelet-Rich Fibrin (PRF) in alveolar ridge preservation following first molar extraction has been shown to be highly effective in preserving both bone height and width compared to untreated extraction sites. PRF significantly improved soft tissue healing, reduced post-operative complications, and provided a biologically active scaffold for tissue regeneration. The results suggest that PRF could become a standard treatment modality in regenerative dentistry, particularly in cases where implant placement is planned.

While the findings are promising, further research with longer follow-up periods and larger sample sizes is needed to fully assess the long-term impact of PRF on ridge preservation and implant success. Additionally, standardization of PRF preparation protocols and exploration of its use in combination with other regenerative techniques could further enhance its clinical applications. Ultimately, PRF's cost-effectiveness, ease of use, and biological compatibility position it as a valuable tool in modern oral surgery and implantology, with the potential to improve patient outcomes and reduce the need for more invasive and costly surgical procedures.

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