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A CBCT Assessment of Bone Density Changes During Accelerated Orthodontic Retraction of Canine by Platelet Rich Fibrin and Ascorbic Acid Augmented Platelet Rich Fibrin

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ABSTRACT

Objective: To compare and evaluate the effects of PRF and C PRF on the density of bone at a locally injected site.

Materials and Methods: A split-mouth randomized clinical trial was applied to 20 patients (>18 years of age) who required maxillary first premolar extraction. The right and left sides were randomized into quadrants receiving C PRF and PRF. Post extraction PRF and CPRF were repeatedly injected submucosally every 15 days. A CBCT of both the quadrants was taken pre-retraction(T0), post-retraction (T1), and 3 months(T3) post retraction and the density of bone at three sites; cervical third, middle third, and apical third were obtained in Grey Values was compared at the three-time intervals.

Results: T1 (post retraction) and T2 (3 months Post Retraction) in the Cervical region of the Canine between the two groups PRF and C PRF showed that the values were higher in the C PRF group with t values of 3.963 ($p < 0.001$) and 3.692 ($p < 0.001$) respectively. Analysis of bone density in the middle third of the canine root revealed a higher T2-T1 value in the PRF group compared to the C-PRF group. The comparison of canine root apical bone density between groups at T2-T1 showed a higher difference in the C-PRF group, but it was not statistically significant ($t = 1.309$, $p = 0.198$).

Conclusion: C PRF showed higher densities in the cervical region, while PRF led to a more significant increase over time in specific regions - the middle 1/3rd of the canine root and middle premolar region. Further research with larger samples and longer follow-ups is needed to confirm these trends and understand underlying mechanisms for effective bone regeneration and density promotion.

KEYWORDS

PRF, Canine retraction (CR), Orthodontic tooth movement (OTM), Platelet Rich Fibrin (PRF), Tooth Movement (TM), Growth factor (GF)

INTRODUCTION

Orthodontic tooth movement is the product of a biological response and causes tooth movement by constant bone remodeling. Studies have shown that patients who received orthodontic treatment have a 24% reduction in the density of the bone around the teeth which can be regained to its original level following sufficient retention time[1]. Orthodontists have always attempted to increase the rate of tooth movement[2]. Recent methods prioritize using intricate natural scaffolds, which can be repopulated with a patient's own cells, ultimately creating an organ through tissue engineering that is compatible with the patient's body. Lately, numerous investigations have aimed to achieve adequate bone quality and volume. Different

types of bone grafts—autogenous, xenografts, allografts, and alloplastic—have been created to repair bone deficiencies. Research has also explored a range of substances that encourage bone growth. Among these are bone morphogenetic protein (BMP), platelet-derived growth factor (PDGF), and transforming growth factor (TGF), all of which are commonly found in platelets[3,4]. Masuki et al[5] measured concentrations of inflammatory cytokine in PRF, concentrated growth factor (CGF) and derivatives of PRF. In the case of IL-1b, similar concentrations were observed in all groups except for the PRGF group. This suggested that PRF may inhibit early stages of inflammation postoperatively and contribute to early stages of bone formation. Numerous studies have reported the effectiveness of PRF in bone regeneration.[4-7] PRF was also reported to minimize adverse effects following extractions such as severe alveolar bone resorption and gingival invaginations that might hinder orthodontic treatment stability. Vitamin C, a powerful antioxidant, plays a crucial role in the hydroxylation of procollagen, proline, and lysine. Additionally, Vitamin C stimulates collagen synthesis by increasing the expression of osteocalcin and encourages osteoblast differentiation by influencing the interaction between type I collagen and a2b1 integrin. It also enhances the expression of a2b1 integrin, a key receptor for type I and III collagen. Elbehwashy et al[7] conducted a study to evaluate the clinical and radiographic outcomes of using ascorbic acid-augmented platelet-rich fibrin in treating intra-osseous defects in patients with stage III periodontitis, discovering a notable rise in bone density compared to using platelet-rich fibrin alone. Various non-invasive methods can be used to evaluate alveolar bone density, such as X-ray absorptiometry, dual analysis, digital image analysis of microradiographs, and ultrasound. CBCT is now widely employed in orthodontic diagnosis, treatment planning, and research due to its advantages over traditional two-dimensional radiography. While there are numerous suggested uses for CBCT, scientific proof of its effectiveness in enhancing diagnosis, treatment planning, or outcomes has only begun to emerge recently for certain applications. CBCT provides valuable information on both tissue density and structure. CBCT provides 3D Images, and it is low cost with low ionizing radiation exposure in comparison to computed tomography (CT). Ibrahim et al[8] using CBCT assessed the root surface changes and bone density with two different methods of accelerated orthodontic tooth movement and observed a decrease in bone density in both groups after canine retraction. It has been proven in recent studies that the administration of PRF and Vit C influences bone density which potentially facilitates OTM. In recent times, However, in what way ascorbic acid augmented PRF administered on the site of retraction would influence bone density is questionable which was the rationale behind this study.

MATERIAL AND METHODS

20 patients undertaking treatment at the Department of Orthodontics and Dentofacial Orthopaedics in KM Shah Dental College and Hospital were enrolled and allocated (Figure 1). The study was approved by the university ethics Committee (SVEIC/ON/DENT/RP/MAY/23/50). This study included CBCTs of adults (> 18 years), having an indication of maxillary 1st premolar extraction treated with 0.022 MBT Prescription fixed orthodontic treatment.[9,10] Individuals with bleeding disorders, prior orthodontic treatment, systemic conditions, congenital syndromes, facial asymmetry, missed 15-day follow-ups, and developmental or craniofacial abnormalities were excluded from the study. The site of allocation for the administration of PRF and C PRF was done by categorizing into groups 1(PRF) and 2(C PRF). Group 1: PRF aided CR and Group 2: C PRF. The split-mouth design was obtained by dividing each half of the maxillary arch into the right and left sides with equal distributions of the two side allocations which were generated using the Microsoft Excel Randomization Tool. The patient was blinded as to which quadrant received PRF or C PRF. Injection sites received 1 ml on each buccal, palatal, and distal side around the canine at

an interval of every 15 days repeatedly till complete extraction space closure for both PRF and C PRF respectively (Figure 2b,2c,2d).

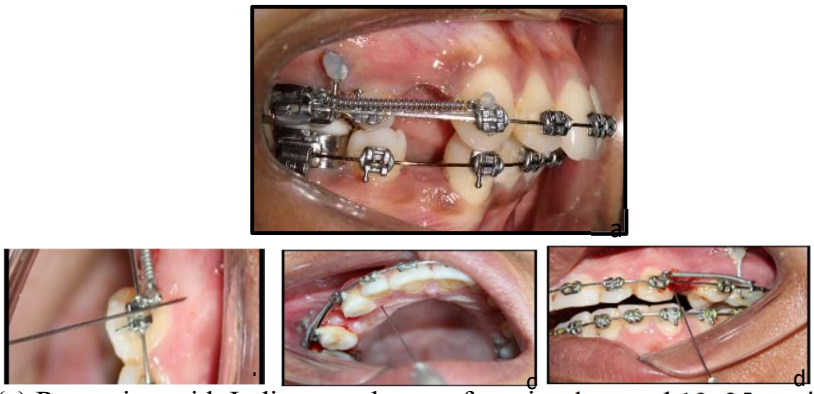


Figure 2: (a) Retraction with Indirect anchorage from implant and 19x25ss wire. (b) Sites of administration of injections: (b)Buccally, (c) Palatally, (d) – Distally to canine being retracted.

Post-extraction, PRF and C-PRF injections were administered, with patients recalled every 15 days for follow-up injections based on quadrant assignment. One week before the retraction of the canine, sectional Cone Beam Computed Tomography (CBCT) was taken including canine to the second premolar with the patient positioned with the head upright so that the intersection lines were straight horizontal and vertical through the center of the interested region. A constructed frontal plane on the distal aspect of the canine and premolar was used as a guide to check the density of bone at 3 points along the length of the roots of the canine and premolar - the cervical, middle, and apical 1/3rd of root[5](Figure 3). Bone density in Grey Values was evaluated at these 3 sites at 3 time periods – T0: Pre retraction; T1: Post retraction and T2: 3 months post retraction. Group A was allotted to CBCTs of quadrants that were administered PRF and Group B to C PRF.

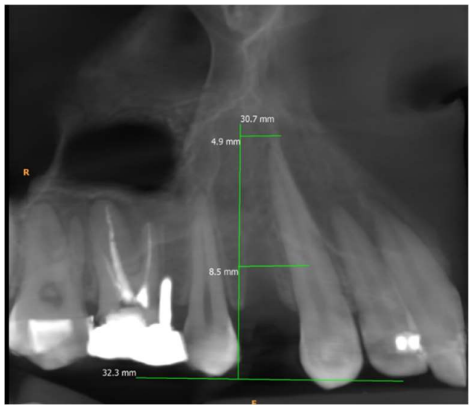


Figure 3a – Pre retraction

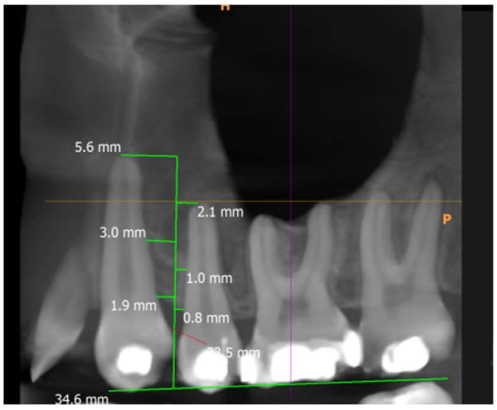


Figure 3b – 3 months post retraction

SPSS software (IBM Version 26) was used for statistical analysis. Sample size to detect significant differences in OTM was computed with the assumption of a power of 0.8 with a permissible (α) error of 5% and, a beta error of 20%. The level of significance was fixed at p=0.05 and any value less than or equal to 0.05 was considered to be statistically significant. Comparative evaluation of both groups PRF and C PRF, Inter and Intragroup analysis, Linear

distance moved, and rotation created at each time interval was done using paired t-tests, and independent t-tests.

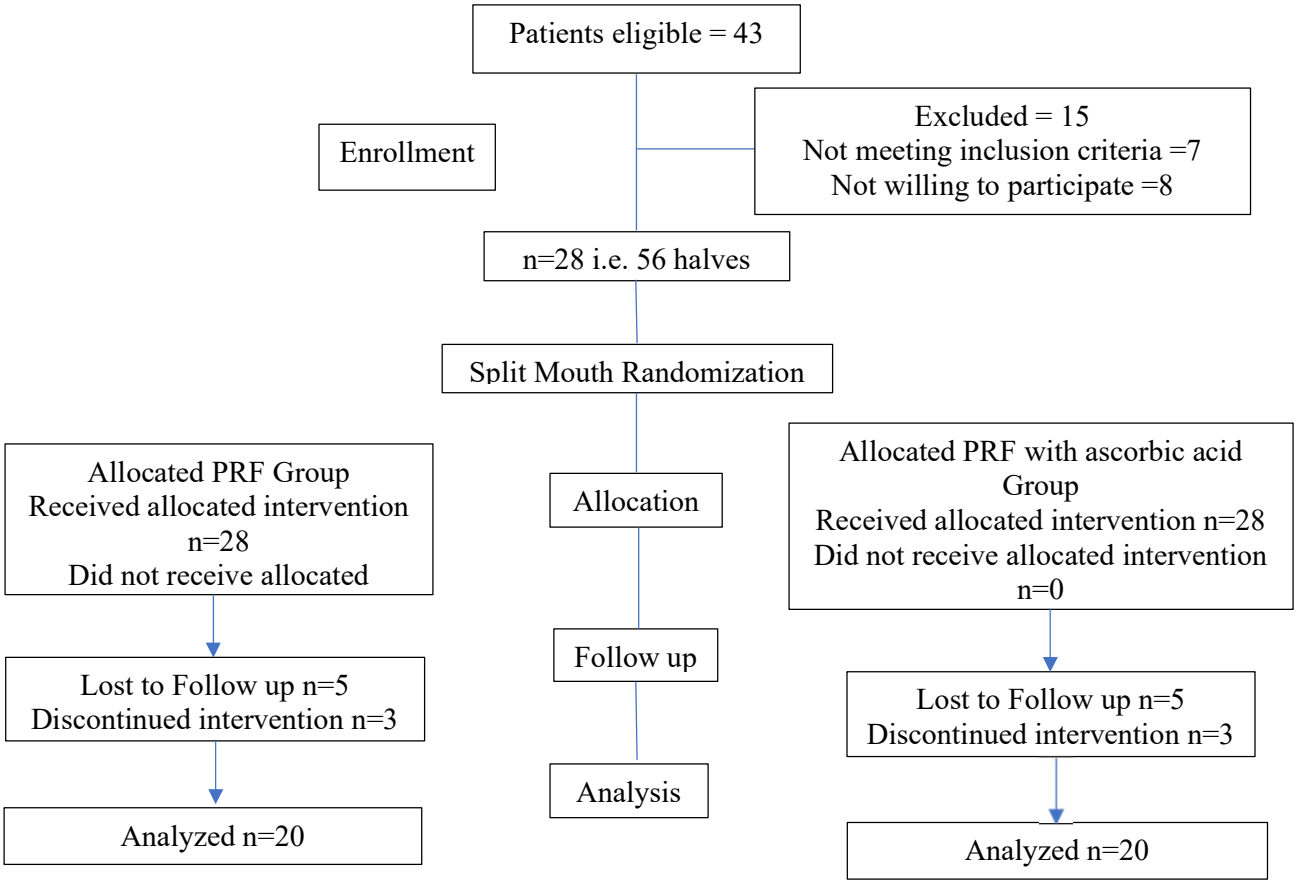


Figure 1: Consort flow Chart

RESULTS

Comparison of bone densities at T1 (post retraction) and T2 (3 months Post Retraction) in the Cervical region of Canine between the two groups PRF and C PRF showed that the values were higher in the C PRF group with t values of 3.963 ($p < 0.001$) and 3.692 ($p<0.001$) respectively. The mean bone densities at T1 in the cervical region of canine increased in both PRF and C-PRF. However, there was a greater increase seen with C-PRF administered area with bone density increasing from 253.2±87.48 at T0 to 459.15±152.42 at T1. A similar pattern was observed in the middle 1/3 of the root with C-PRF showing a greater increase in density from 276.85±90.46 at T0 to 510.3±92.52 at T1. In the apical 1/3rd of the root of canine, a drastic increase in density of bone was not appreciable with both PRF and CPRF however it was still more wrt C-PRF increasing from 275.75±112.8 at t0 to 309.7±55.97 at T1. The T2-T1 difference in cervical canine is higher in the PRF group, but this difference is not statistically significant ($t = -1$, $p = 0.327$)(Table 1). Analysis of bone density in the middle third of the canine root revealed a higher T2-T1 value in the PRF group compared to the C-PRF group. This difference is statistically significant ($t = -4.039$, $p < 0.001$)(Table 2). Bone density in the apical third of the canine root was compared between the two groups at T2-T1. The C-PRF group had a higher T2-T1 difference, but this result is statistically non-significant ($t = 1.309$, $p = 0.198$) (Table 3).

Comparison of the T2-T1 difference in Cervical Premolar between the two groups shows that the T2-T1 difference in Cervical Premolar was higher in the C PRF group with a t-value of 1.138 and was statistically non-significant with a p-value of 0.263(Table 4). The T2-T1 difference in the middle premolar was higher in the PRF group, with a t-value of -2.389, indicating statistical significance (p = 0.022). The T2-T1 difference in the apical premolar was higher in the PRF group, but this finding is not statistically significant (t = -0.766, p = 0.448) (Tables 5 and 6).

Table 1: Density Changes at different time intervals at cervical 1/3rd region of canine root

	C PRF(n=20)	PRF(n=21)	t	P VALUE
	Mean ± sd	Mean ± sd		
T1-T0 difference Cervical Canine	205.95±77.42	73.52±59.35	6.165	<0.001*
T2-T0 difference Cervical Canine	176.9±92.79	67.19±28.53	5.064	<0.001*
T2-T1 difference Cervical Canine	-29.05±94.11	-6.33±39.27	-1	0.327

Table 2: Density Changes at different time intervals at middle 1/3rd region of canine root

	C PRF(n=20)	PRF(n=21)	t	P VALUE
	Mean ± sd	Mean ± sd		
T1-T0 difference Middle Canine	233.45±75.04	56.38±45.65	9.074	<0.001*
T2-T0 difference Middle Canine	133.95±86.67	27.62±74.82	4.211	<0.001*
T2-T1 difference Middle Canine	-99.5±60.36	-28.76±51.64	-4.039	<0.001*

Table 3: Density Changes at different time intervals at apical 1/3rd region of canine root

	C PRF(n=20)	PRF(n=21)	t	P VALUE
	Mean ± sd	Mean ± sd		
T1-T0 difference Apical Canine	33.95±155.83	26.95±62.67	0.187	0.853
T2-T0 difference Apical Canine	-21.45±133.83	-57.9±49.58	1.146	0.263
T2-T1 difference Apical Canine	-55.4±57.4	-84.86±83.61	1.309	0.198

Table 4: Density Changes at different time intervals at cervical 1/3rd region of premolar root

	C PRF(n=20)	PRF(n=21)	t	P VALUE
	Mean ± sd	Mean ± sd		
T1-T0 difference Cervical Premolar	54.05±41.61	21.62±26.41	2.963	0.006
T2-T0 difference Cervical Premolar	45.45±53.58	2.76±27.21	3.192	0.003
T2-T1 difference Cervical Premolar	-8.6±20.93	-18.86±35.31	1.138	0.263

Table 5: Density Changes at different time intervals at middle 1/3rd region of premolar root

	C PRF(n=20)	PRF(n=21)	t	P VALUE
	Mean ± sd	Mean ± sd		
T1-T0 difference Middle Premolar	70±40.62	14.29±37.17	4.585	<0.001
T2-T0 difference Middle Premolar	37.5±24.72	4±39.41	3.277	0.002
T2-T1 difference Middle Premolar	-32.5±30.94	-10.29±28.59	-2.389	0.022

Table 6: Density Changes at different time intervals at apical 1/3rd region of premolar root

	C PRF(n=20)	PRF(n=21)	t	P VALUE
	Mean ± sd	Mean ± sd		
T1-T0 difference Apical Premolar	-7.55±20.05	-12.19±74.11	0.277	0.785
T2-T0 difference Apical Premolar	-38.55±36.09	-35.33±43.43	-0.257	0.798

T2-T1 difference Apical Premolar	-31±26.59	-23.14±37.82	-0.766	0.448

DISCUSSION

Several methods are used to reduce the time required for orthodontic treatment by increasing the rate of orthodontic tooth movement. Many Studies concluded that after active orthodontic treatment for maxillary arch the bone density around the teeth of the anterior maxilla decreased by about 24%.[11,12] It has been postulated that the Injection of PRP could increase the rate of orthodontic tooth movement. This may be due to their effect on bone mineral density and the occurrence of transient osteopenia.[13] Numerous authors have suggested utilizing pharmacologic therapy, biomaterial, and the chewing force in an attempt to provide another mechanism to enhance the stability of teeth after orthodontic treatment.[9,11,12] The results of the study comparing bone densities at different regions of the canine cervical and premolar regions between PRF (Platelet-Rich Fibrin) and C PRF (Advanced-Platelet-Rich Fibrin) groups offer valuable insights into the efficacy of these treatments in promoting bone regeneration and density. The newly formed bone that results from tissue reaction and changes after orthodontic treatment has little mineral content which affects the density of alveolar bone surrounding the tooth and impair it is structural integrity.[11] Ibrahim et al concluded that the difference between the pre and post-mean values of bone density was statistically significant on the control side and the experiential side when accelerating agents were used. In this study, the comparison of bone densities at T1 (post retraction) and T2 (3 months Post Retraction) in the cervical region of the canine indicates a significant difference between the two groups. The C PRF group exhibited higher bone densities at both T1 and T2 compared to the PRF group, with statistically significant differences ($p < 0.001$) (Chart 1). This suggests that the C PRF treatment might be more effective in promoting bone density in the cervical region of the canine. These findings may stem from the impact of RAP, characterized by heightened bone metabolism and temporary reduction in bone mineral density, which typically returns to normal levels over time. The activation of an inflammatory response before the application of orthodontic force marks a crucial step in many accelerated techniques for movement. However, when analyzing the T2-T1 difference in bone density in the cervical region, the PRF group showed a higher difference, albeit statistically non-significant ($p = 0.327$). This could imply that while the absolute bone density might be higher in the C PRF group, the PRF group might experience a more significant increase in bone density over the three months, although further investigation is warranted to confirm this trend. Moving on to the middle 1/3rd of the canine root, the PRF group exhibited significantly higher bone density at T2-T1 compared to the C PRF group ($p < 0.001$). This suggests that PRF treatment might be more effective in promoting bone density in this particular region. Similarly, in the apical region of the canine root, although the C PRF group showed a higher T2-T1 difference in bone density, the difference was statistically non-significant ($p = 0.198$). This indicates that neither treatment significantly outperformed the other in promoting bone density in this region. When comparing the T2-T1 difference in bone density in the premolar regions, it was found that the C PRF group exhibited a higher difference in the cervical premolar region, although statistically non-significant ($p = 0.263$). On the other hand, the PRF group showed a significantly higher T2-T1 difference in bone density in the middle premolar region ($p = 0.022$). The T2-T1 difference in bone density in the apical premolar region did not show any significant difference between the two groups ($p = 0.448$). Overall, these results suggest that while C PRF treatment may lead to higher absolute bone densities in certain regions, PRF treatment might result in more significant increases in bone density over time, particularly in specific regions such as the middle 1/3rd of the canine root and the middle premolar region. Al Fakhry et al[14] concluded that t I-PRF has the potential to enhance the stability of teeth after orthodontic tooth movement and could

have the ability to reduce relapse, probably by increasing the alveolar bone density, thus while both may have the capacity to reduce orthodontic relapse and provide stability post-treatment no studies exist to advocate the same. Further Studies can be done to study post-treatment relapse tendencies on injecting PRF or C PRF during finishing phases of orthodontic treatment. Further studies with larger sample sizes and longer follow-up periods are needed to confirm these findings and elucidate the underlying mechanisms behind the observed differences.

Chart 1: Bone Density Changes between C PRF and PRF at cervical 1/3rd region of canine

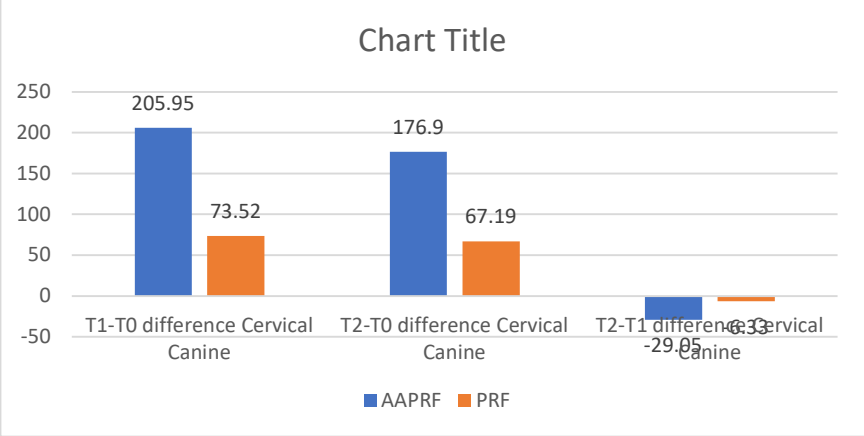


Chart 2: Bone Density Changes between C PRF and PRF at Middle l 1/3rd region of canine

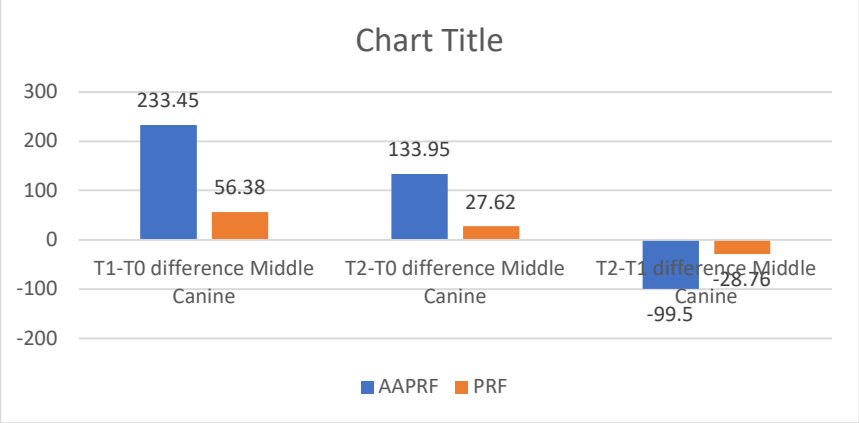
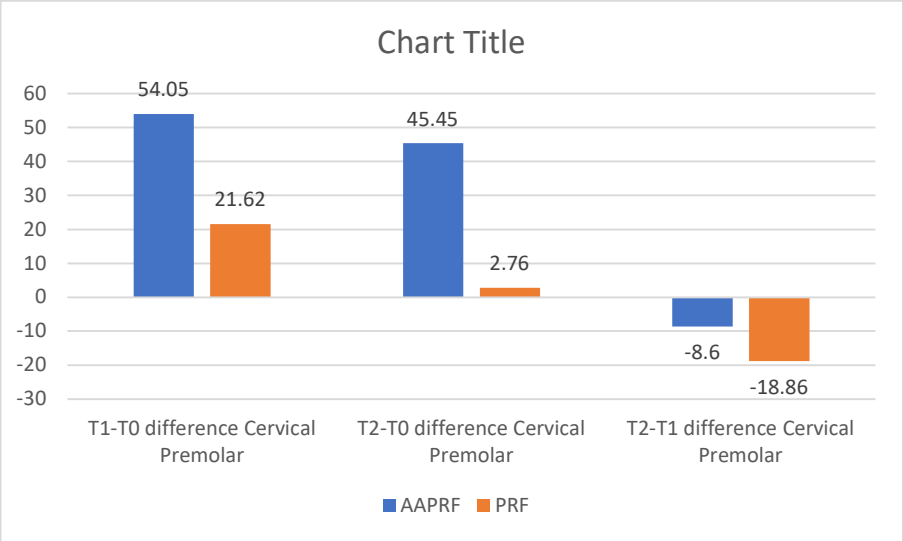


Chart 3: Bone Density Changes between C PRF and PRF at Apical l 1/3rd region of canine



CONCLUSION

The comparative analysis between PRF and C PRF treatments in promoting bone density in canine cervical and premolar regions provides valuable insights into their efficacy. While C PRF demonstrates higher absolute bone densities in certain areas, particularly in the cervical region, PRF exhibits the potential in facilitating more significant increases in bone density over time, notably in specific regions like the middle 1/3rd of the canine root and the middle premolar region. However, these observations warrant further investigation to validate the trends observed. Larger sample sizes and extended follow-up periods are necessary to better understand the mechanisms underlying these differences and to establish the most effective treatment approach for promoting bone regeneration and density which can also facilitate post orthodontic treatment stability for reduced relapse.

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