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Platelet-rich plasma's (PRP) impacts on accelerated canine movement

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Abstract

OBJECTIVE: To investigate the impact of platelet-rich plasma (PRP) on canine movement acceleration.

METHODS: Randomized clinical trial split-mouth study with a double-blind design and controlled group on 31 orthodontic patients, which had been indicated bilateral maxillary first premolar extraction. Each patient recorded clinical features, analyzed lateral cephalometric film, and evaluated the acceleration on dental models at every specific interval.

RESULT: The cumulative distance to the distal canines was larger for the PRP injection group than for the control group at three time points (4 weeks, 8 weeks, and 12 weeks), all of which were statistically significant. The PRP injection group's canine distal width increased from the first 4 weeks (ΔT1) to the highest in the middle 4 weeks (ΔT2 = 1.78 ± 0.11 mm/month), and then it gradually decreased in the last 4 weeks (ΔT3). The speed of the PRP-injected canine was faster than the control group by 1.51 times.

CONCLUSION: PRP can accelerate the speed of canine movement in orthodontics and can be applied for severe cases, for example, impacted tooth retraction, molar protraction or retraction, and other cases.

Keywords:

Accelerated tooth movement, Canine retraction, Orthodontics, Platelet-rich plasma

Introduction

The development of orthodontics recently has improved the quality of clinical and technical results by using new technologies and computer software to formulate treatment plans. Moreover, these uninterrupted changes in archwires and brackets systems have more biomechanical adaptations to shorten treatment time. The improvements of these systems, however, can reach their limitations from recent material technologies and biomechanics of surrounding tissues in accelerated tooth movements. Although osteotomy and corticotomy were proven to have positive effects in accelerating the movement of orthodontic teeth for decades, those techniques preferred considerable interventions and flap raising which could cause painful and unesthetic scars after treatments.[1-3]

In recent years, platelet-rich plasma (PRP) submucosal injection has been proposed to deliver condensed growth factors, for example, PDGF, TGF- β, and IGF-1, into connective tissues for esthetic healing and repairs which was applied in medical fields in general and oral maxillofacial specialties in specific.[4] Several articles concluded the reliable effects of PRP from 2017 and minimal intervention in accelerated orthodontic tooth movement which can shorten the length of orthodontics treatment duration.[4-6]

This study aimed to evaluate the effects of platelet-rich plasma on accelerated canine

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movement. We would like to contribute more scientific evidence for the new era of orthodontic treatment modalities.

Materials and Methods

Study participants

Inclusion criteria: Patients (≥12-year-old) who had enough two maxillary first molars, no orthodontic treatment history, had been indicated to extract first or second maxillary first premolar and had the symmetric position of maxillary canines before retraction, had normal values of blood tests, for example, bleeding time 1–4 minutes, coagulation time 5–10 minutes, platelet counts 150,000–400,000/mm^3. Patients agreed to participate in the research.

Exclusion criteria: Patients with a history of craniofacial traumas, anomalies, congenital defects, or systemic diseases related to osteogenic metabolisms, for example, diabetes mellitus, kidney diseases, and osseous diseases. Patients took anticoagulant drugs which affected bone metabolism, for example, heparin, warfarin, NSAIDs, cyclosporine, glucocorticoids, medroxyprogesterone acetate, and thyroid hormones.

Study methods

The Ethics Committee in Biological Research (Approval number: 90/HĐĐĐ) approved this study's ethics committee. A split-mouth investigation using a double-blind, randomized clinical trial design was carried out by our team. One orthodontic professional collected and analyzed all oral exams, radiographs, and model data.

The sample size has been calculated by using the formula for one proportion with p as the proportion of accelerated teeth movement with PRP injection compared to control teeth. According to Eric J.W. Liou's research, we chose $P = 0.7$[5] and the sample size was 31 participants.

Palatal lock preparation

Acrylic resins were pressed into the incisive papilla and middle area of the premaxilla procedure, and two reference stainless steel wires were used to cover the rugae palatine (0.9 mm in diameter). The mesials of the two reference wires were buried in the resins, and the laterals were sharpened and placed on the canine's mesial side. To superimpose and quantify the distances of canine movement, this palatal lock was put to match with the incisive papilla and medial palatal raphe on the following models Figure 1].

Study procedure

After the extraction of two maxillary first molars in each patient, we managed a sliding mechanism to retract the canine on 0.016''x0.022'' stainless steel wire. Before retraction, we began to inject PRP into the oral submucosal area as follows:

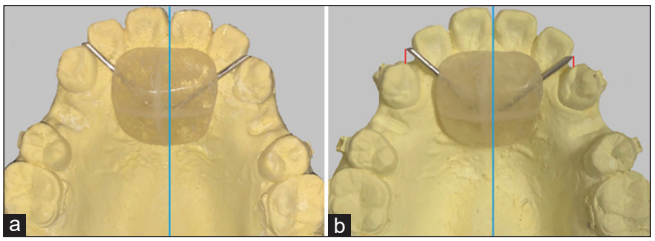

Figure 1: (a) Canine retraction phase study model and palatal lock; (b) canine movement measurement technique. The blue line represents the center of the maxilla, and the red lines run parallel to it. The accumulable distance of canines was calculated by measuring the distance between the top stainless steel wire and the junction of the red line and the canine

First of all, we managed local anesthesia by injecting lidocaine 2% with adrenaline 1:100,000 at the middle buccal, distobuccal, middle palatal, and distopalatal sites of each canine on both sides. Then, 1 ml of PRP was delivered by oral submucosal injection to either the maxillary left or right canine, and the remaining canine was injected with saline sodium chloride 0.9% as control. PRP has been prepared by centrifugations twice from 17 ml of total blood with 3 ml of Acid Citrate Dextrose (ACD) solution anticoagulants. According to patients' order numbers, patients with odd numbers were injected PRP in the right canine, sodium saline 0.9% injection in the left canine, and vice versa for patients with even numbers.

The delivery of PRP and model preparation was completed, and then we started to activate the retraction force on the maxillary canine. Therefore, the researcher recorded the accumulated distance of canine movement on both sides and compared between canine with the PRP-injected group and the control group (canine with saline injection) at three time points: 4 weeks (T1), 8 weeks (T2), and 12 weeks (T3). Moreover, we calculated the rate of canine movement at three intervals: the first 4 weeks (ΔT1), the middle 4 weeks (ΔT2), and the last 4 weeks (ΔT3). In addition, the average speed of canine movement every month has been carried out after 3 months and analyzed the difference between the two groups. All the measurements have been carried out once every four weeks for a total of 12 weeks on dental casts by using digital caliber and individual palatal keys [Figure 1].

Statistical analysis

SPSS was used to conduct the statistical analysis (version 18.0, IBM Corp, Armonk, New York, United States). When the data were normally distributed, the paired t-test was used to compare the findings at each time point and the Wilcoxon signed-rank test when

the data were not. Using Pearson's correlation, the correlation between the two groups was determined.

Results

Acceleration of canine displacement in PRP

The accumulated amount of maxillary canine distalization was significantly longer ($P < 0.001$) in the PRP injection group (after 4 weeks: 1.75 ± 0.22 mm, 8 weeks: 3.54 ± 0.23 mm, and after 12 weeks: 5.06 ± 0.23 mm) than in the control group (after 4 weeks: 1.34 ± 0.23 mm, 8 weeks: 2.36 ± 0.24 mm, and after 12 weeks: 3.37 ± 0.23 mm) [Table 1]. The PRP injection group had a noticeably higher rate of canine movement every 4 weeks (first 4 weeks: 1.75 ± 0.22 mm, middle 4 weeks: 1.78 ± 0.11 mm, and last 4 weeks: 1.52 ± 0.13 mm) than the control group with $P < 0.001$ [Table 2]. Moreover, the average speed of canine movement in a month of the PRP injection group was also significantly faster than the control group with a very strong correlation (r = 0.964, $P < 0.001$) [Table 3]. Furthermore, the average acceleration of canine movement in the PRP injection group was 1.51 times, ranging from 1.34 to 1.75 times [Figure 2].

Acceleration of canine displacement by gender in PRP

Cumulative distal maxillary canine distance following PRP injection in males (after 4 weeks: 1.71 ± 0.32 mm, after 8 weeks: 3.53 ± 0.30 mm, and after 12 weeks: 5.01 ± 0.33 mm). There was no statistically significant difference between the male and female genders (after 4 weeks: 1.77 ± 0.19 mm, after 8 weeks: 3.54 ± 0.21 mm, and after 12 weeks: 5.08 ± 0.19 mm) with ($P > 0.05$) [Table 4]. PRP canine distal width was equal for males and females every four weeks (first 4 weeks: 1.71 ± 0.32 mm, middle 4 weeks: 1.82 ± 0.05 mm, and final 4 weeks: 1.47 ± 0.07 mm), with no statistically significant differences observed at any of the three time points with ($P > 0.05$) [Table 5]. The male PRP group canine movement speed (1.67 mm/month) was nearly identical to the female PRP group canine movement speed (1.69 mm/month) [Table 6].

Table 1: Accumulated amount of maxillary canine distalization of the two groups at three time points

Time points	The accumulated amount of movement		*P*
	PRP injection (mm)	Control (mm)	
T1	1.75±0.22	1.34±0.23	0.001
T2	3.54±0.23	2.36±0.24	0.001
T3	5.06±0.23	3.37±0.23	0.000

(Paired samples *t*-test) T1: 4th week, T2: 8th week, T3: 12th week

Table 2: Rate of canine movement of the two groups every 4 weeks

Intervals	Rate of canine movement		*P*
	PRP injection (mm)	Control (mm)	
ΔT1	1.75±0.22	1.34±0.23	0.001*
ΔT2	1.78±0.11	1.02±0.11	0.000**
ΔT3	1.52±0.13	1.01±0.12	0.000**

(*: Paired samples *t*-test, **: Wilcoxontest) ΔT1: first 4 weeks, ΔT2: middle 4 weeks, ΔT3: last 4 weeks

Table 3: Correlation of the average speed of canine movement between the two groups after 3 months of retraction

Groups	Speed of canine movement (mm/month)		*P*
	Average	Standard deviation	
PRP injection	1.69	0.08	0.035
Control	1.12	0.07	

Pearson's correlation (*r*=0.964)

Discussion

Before the canine retraction phase, we optimally aligned and leveled the entire maxillary arch which minimized the friction force between brackets and archwire to prepare for the sliding mechanism on 0.016''x0.022'' stainless steel wire. This helped to eliminate the confounder related to mechanics.

At all times, the PRP group's cumulative distance moving further away from the canines was much greater than that of the control group [Table 1]. According to Güleç A *et al*.[7] (2017)'s histology study on the assessment of alveolar bone in guinea pigs, it was demonstrated that PRP injections lower the quantity of bone tissue surrounding the teeth due to increased osteoclast activity when compared to the control group. Thus, it was hypothesized that PRP injection has a greater expedited area impact than traditional orthodontic treatment often based on histological analysis of early and quick bone disintegration in this group of PRP.

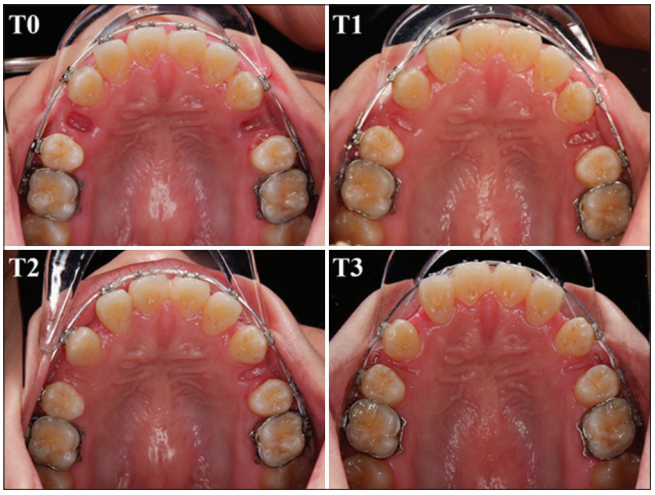

Figure 2: Photographs of intraoral maxillary occlusal views were taken at four different times: (T0) before the canine retraction phase, (T1) 4 weeks after activating canine retraction, (T2) 8 weeks after activating canine retraction, (T3) 12 weeks after activating canine retraction

Table 4: Accumulated amount of maxillary canine distalization of the two groups at three time points

Time points	The accumulated amount of movement		*P*
	Male	Female	
T1	1.71±0.32	1.77±0.19	0.618
T2	3.53±0.30	3.54±0.21	0.952
T3	5.01±0.33	5.08±0.19	0.557

(Independent samples *t*-test) T1: 4th week, T2: 8th week, T3: 12th week

Table 5: Rate of canine movement of the two groups every 4 weeks

Time points	The accumulated amount of movement		*P*
	Male	Female	
T1	1.71±0.32	1.77±0.19	0.618*
T2	3.53±0.30	3.54±0.21	0.219**
T3	5.01±0.33	5.08±0.19	0.151**

(*: Independent samples *t*-test, **: Mann–Whitney *U*-test) T1: 4th week, T2: 8th week, T3: 12th week

Table 6: Correlation rate of PRP canine distal movement (mm/month) by gender after 12 weeks

Groups	Speed of canine movement (mm/month)		*P*
	Male	Female	
PRP injection	1.67±0.11	1.69±0.06	0.557

(Independent samples *t*-test)

Platelets were typically made up about 6% of peripheral blood, whereas PRP has 94% of extremely big platelets. Platelets were one of the elements that trigger the healing of both soft tissue and hard tissue wounds, according to the study. Contains in platelets growth factors had a crucial role in regulating cellular functions such as cell division, chemotaxis, differentiation, and metabolism.[8] After 4 weeks, we measured the cumulative distance accumulation of the distal maxillary canine teeth, and Table 2 shows that the values were 1.75 ± 0.22 mm and 1.34 ± 0.23 mm, respectively, in the PRP-injected group and the control group ($P < 0.01$). The injection of PRP similarly produced statistically significant improvements in canine movement during the first month of El-Timamy's study (2020).[9] At 12 weeks, the PRP-injected group showed a greater total canine movement distance than the control group (5.06 ± 0.23 mm vs. 3.37 ± 0.23 mm). The results were similar to Ali's research (2020) after 108 days following the termination of the canine distal process.[10] After 4 months of follow-up, an Egyptian author named Seddik[6] (2020) also noted comparable outcomes. We moved the canines with 150 g of force, similar to the method used in another study.[6,9,10] According to Vinod Krishnan's study, 150–200 g was the ideal force to shift the canine away from the orthopedic core of a patient. At this force, the tooth moves at its fastest possible rate. Below this point, little force did not cause tooth movement. Although the force exceeds at this point, the rate of tooth movement will finally slow to zero in one week.[11] However, it was challenging to compare particular data between studies since orthodontics differs significantly between studies in terms of the system brackets employed, archwire guiding canine slippage, space closing mechanism, anchorage, etc.[12]

According to Table 2, we observed the group's canines where PRP injection moved quicker than the control group, maximum at the middle 4 weeks by 1.75 times (ΔT2 PRP injection/control = 1.78/1.02) and progressively reduced to 1.5 times in the final 4 weeks (ΔT3 PRP injection/control = 1.52/1.01). The canine distal speed of the PRP group would decrease 3 months after the initial day of injection, according to the findings of our study, which were comparable to those of El-Timamy *et al*. (2020).[9] This may have been a part of a mechanical response mechanism, whereby the release of growth factors experiences negative feedback when linked with elevated blood and/or tissue concentrations, just the same as hormones receive negative feedback.[13] As a result, a chance increase in the growth factor concentration at the PRP injection site may have an impact on how these factors were produced during tooth movement. Table 3 reveals that the long-distance canines' average acceleration was 1.51 times (1.34–1.75 times). The study results matched those of Güleç *et al*.[7] when the results were 1.4–1.7 times. Similar results of 1.55 times in the higher function were also reported by Seddik *et al*. (2020).[6] The result of the research by Karakasli K, and Erdur EA Karakasli and Erdur[1] (2021) was 2 times greater; the difference might be due to the lower density of incisor alveolar bone compared to our study carried out in the surrounding bone and distal bone of the canine which would allow incisors to move faster. According to Seddik HA's Heba A. Seddik's[6] (2020) study, it concluded that injecting PRP the risk of root resorption was not significantly different compared to the control group. It might be explained that the distal alveolar bone of the canine when retraction was thicker than the buccal alveolar bone of the incisors during alignment and leveling. Furthermore, at the compression sites while distalizing the anterior teeth, the alveolar bone volume was preserved and no significant resorption.[14] Finally, PRP can be an effective method for accelerating orthodontic movement with minimal invasion, safety, and alveolar bone preservation, and PRP did not elevate the risk of root resorption.[6]

Through the study, we observed in Table 4 that there was no statistically significant difference between the cumulative distance of the distal maxillary canines in males and females after PRP injection ($P > 0.05$). Similarly, Table 5 shows that when PRP was injected, the canine distal width was greater in males than in women, although this difference was not statistically

significant. According to Table 4's results, we determined that PRP had a similar accelerating impact on canine distal to maximum posteriorly at 8 weeks (T2) and progressively decline after 12 weeks in both the male and female groups (T3). Additionally, there was no statistically significant difference in the mean canine distal speed between the sexes in the group that received PRP injections ($P > 0.05$). In orthodontic treatment, the expression of OPG, RANKL, and IL-17A indicates inflammation, bone resorption, bone deposition, and tooth movement. RANKL and IL-17A increase significantly in males and do not relate to the time of treatment. However, in young women, the high expression of estrogen has suppressed the RANKL and IL-17A release which would inhibit the differentiation of osteoclasts and result in slow tooth movement. Moreover, after ovulation, the teeth can move faster due to the decrease in estrogen secretion (Kanal 2015).[15] To prove this hypothesis and eliminate the bias in gender, we compared males to females in the speed of orthodontic tooth movement and there is no significant difference. This might come from the growth factors secretions in PRP that helps to overcome the difference in hormone expression between the two genders. Furthermore, the expression of OPG would be declined significantly after PRP injection after a week and a month. It presented a decrease in osteoblast activity and the alteration of osteogenesis which was affected by PRP. The suppression of OPG leads to the increase of RANKL, which will stimulate osteoclastogenesis and accelerate tooth movement (Saraa L. Angle, 2022).[16]

Conclusions

The cumulative distance to the distal canines was larger for the PRP injection group than for the control group at three time points (4 weeks, 8 weeks, and 12 weeks), all of which were statistically significant. The PRP injection group's canine distal width increased from the first 4 weeks (ΔT1) to the highest in the middle 4 weeks (ΔT2 = 1.78 ± 0.11 mm/month) and then it gradually decreased in the last 4 weeks (ΔT3). After 8 weeks, PRP had to be repeated since the canine width of the PRP injection group had increased from the first 4 weeks and maximized in the next 4 weeks. The average speed of canine movement in the PRP injection group (1.69 mm per month) was significantly faster than the control group (1.12 mm per month) with a very strong correlation (r = 0.964). The acceleration of PRP injection canine was 1.51 times on average.

Main points

In orthodontics, PRP can accelerate the movement of the canine and be used in extreme situations. PRP has to be repeated after 8 weeks since the canine distal width of the PRP injection group increased from the first 4 weeks to the highest in the middle 4 weeks. There was a considerable correlation (r = 0.964) between the average monthly movement speed of the canine in the PRP injection group (1.69 mm) and the control group's (1.12 mm) movement.

The limitations

Between the two groups of PRP injection and the control during the tooth movement, CTCB has not been employed to evaluate the root condition and alveolar bone density. The effect of PRP's faster tooth movement on tooth root resorption when moving in orthodontics has not been examined in this study. According to Heba A. Seddik's[6] (2020) study, it concluded that injecting PRP the risk of root resorption was not significantly different compared to the control group; therefore, PRP can be an effective method for accelerating orthodontic movement with minimal invasion, safety, and alveolar bone volume preservation and PRP did not elevate the risk of root resorption.

Author contributions

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Nil.

Conflicts of interest

There are no conflicts of interest.

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