Original Article

Efficacy of injectable platelet-rich plasma in reducing alveolar bone resorption following rapid maxillary expansion: *A cone-beam computed tomography assessment in a randomized split-mouth controlled trial*

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ABSTRACT

Objectives: To evaluate the effectiveness of platelet-rich plasma (PRP) with its growth factors in minimizing the side effects of rapid maxillary expansion (RME) on the periodontal tissue of anchoring teeth using cone-beam computed tomography (CBCT).

Materials and Methods: A randomized, split-mouth clinical trial was conducted on 18 patients aged 12–16 years (14 ± 1.65) with a skeletal maxillary constriction who underwent RME using a Hyrax appliance. The sample was randomly divided into two groups: intervention and control sides. PRP was prepared and injected on the buccal aspect of supporting teeth in the intervention group. High-resolution CBCT imaging (H-CBCT) was carried out preoperatively (T0) and after 3 months of retention (T1) to study the buccal bone plate thickness (BBPT) and buccal bone crest level (BBCL) of anchoring teeth. Changes induced by expansion were evaluated using paired sample *t*-test ($P < .05$).

Results: Results showed that there was no significant difference in BBPT and BBCL between the two groups after RME ($P > .05$). The prevalence of dehiscence and fenestrations was increased at (T1) in both groups and the percentage was higher in the PRP group.

Conclusions: RME induced vertical and horizontal bone loss. PRP did not minimize alveolar defects after RME. (*Angle Orthod.* 2019;89:705–712.)

KEY WORDS: Platelet-rich plasma; PRP; Platelet concentrate; Autologous platelet; Rapid maxillary expansion; RME; RPE; Injection; Orthodontic; Hyrax; Buccal bone thickness; Alveolar bone loss; Alveolar bone resorption; Crest level; Fenestrations; Dehiscence.

INTRODUCTION

Background

Correction of maxillary transverse problems is essential for treatment of various types of malocclusions. Palatal expansion is the most reliable and stable procedure used, especially rapid maxillary expansion (RME).[1–3] Along with the desired effect of midpalatal suture splitting, RME is unavoidably associated with intermittent high forces that cause lateral flexion of the alveolar processes and buccal displacement of the anchor teeth outside the alveolar anatomic limits, which can damage the periodontium, cause consequent gingival recession, and finally compromise tooth longevity.[4–6] Many researchers have studied the side effects of RME on the buccal aspect of the alveolar bone, using cone-beam computed tomography (CBCT) images.[7–11]

Alveolar bone morphology can be determined before and after orthodontic treatment through CBCT scans.[2,4,7,9,12,13] CBCT is useful for many clinical dental applications, because of its lower dose of radiation, good image resolution, and lower costs compared with computed tomography (CT) scans.[6]

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Studies in dental and oral surgery often investigate materials to improve clinical outcomes and success rates. Platelet-rich plasm (PRP) has the ability to enhance tissue regeneration and accelerate wound healing by inducing stem cell differentiation through its growth factors (GFs). It is widely used in various surgical fields including maxillofacial surgery. Blood clotting is the primary requisite for initiating tissue healing and bone regeneration. PRP is a simple strategy to concentrate platelets in the natural blood clot for accelerating wound healing.[14] Platelets form a rich source of important GFs that are involved in the angiogenic cascade, which assists in soft and hard tissue healing.

Objectives

The objective of this study was to develop a treatment approach to reduce RME side effects employing resources, which are easy to use and modest in cost in the dental clinic. No study combined PRP with RME before. The hypothesis was that the use of injectable PRP on the buccal aspect of anchor teeth during RME would: (1) Reduce the loss in the buccal alveolar bone thickness, (2) Reduce the loss in the buccal alveolar bone height; and (3) Reduce the incidence of dehiscence and fenestrations.

MATERIALS AND METHODS

This study was approved by the institutional review board and ethical review committee of Damascus University (Damascus-Syria) No.2939 to conduct this study.

Study Design

This was a randomized (1:1), split-mouth clinical trial (randomized control trial) studying the effects of Injectable (PRP) on alveolar bone resorption following RME in maxillary constriction. The CONSORT (Consolidated Standards of Reporting Trials) statement was used as a guide for this study.[15] The study was conducted in the Department of Orthodontics and the laboratory of the Maxillofacial Surgery hospital at Damascus University.

Participants

The sample was selected from patients who sought orthodontic treatment at Damascus University Faculty of Dentistry at the Department of Orthodontics in Damascus-Syria. Data were collected from August 2016 to January 2018.

Inclusion and Exclusion Criteria

Inclusion criteria were: patients aged 12–16 years, clinical maxillary transverse deficiency, complete emergence of first molars and first premolars, good oral hygiene (Gingival index <1, Plaque index <1) according to Silness and Loe.[16] Exclusion criteria were: patients with medical situations or drug therapy that affected orthodontic treatment and periodontal health; poor oral hygiene; patients with physical and psychological limitations; metallic restorations or endodontic treatments on supporting teeth; craniofacial anomalies; previous orthodontic treatment; those who didn't correctly follow the protocol of activation or didn't return for appointments; those whose cementation of the appliance failed; and those whose dental structures were difficult to visualize on the CBCT as a result of artifacts. After ensuring the compliance of patients with this study, 18 patients were selected to participate. The purpose and methods were explained to patients using an information sheet. In cases of agreement to participate, the patients signed an informed consent.

Randomization

Maxillary halves were allocated randomly using Microsoft Excel 2010 to either PRP (Intervention group) or NO-PRP (Control group). Therefore, there were 18 halves/group.

Intervention

All clinical manipulations were performed by the same investigator (E.A.). A Hyrax expander was cemented with bands on the maxillary first molars and first premolars using glass ionomer cement. Expansion was started after one day of cementation on the same day of PRP injection. The expansion screw was activated twice a day (0.4 mm $\times$ 2) until there was an overcorrection of 2–3 mm (Figure 1). Expansion was monitored every week to ensure the accuracy of activation. At the end of expansion, the devices were stabilized with 0.10-mm ligature wire and maintained as a passive retainer for 3 months.

PRP was obtained from 20 mL of each patient's venous blood drawn at the time of treatment and collected in vacuum tubes containing sodium citrate as an anticoagulant to prevent platelet activation prior to its use. A double centrifugation technique was performed: an initial spin (1300 rpm for 10 minutes) was done to separate red blood cells (RBCs) from plasma, which was composed mostly of white blood cells (WBC) and platelets. For production of a higher PRP concentration, the upper layer and a few RBCs were transferred to an empty sterile tube and subjected to a second spin (2000 rpm for 10 min). The upper portion of the resultant volume, which was composed mostly of PPP (platelet-poor plasma), was discarded and the remaining lower portion was homogenized to get 2.5 mL of PRP.

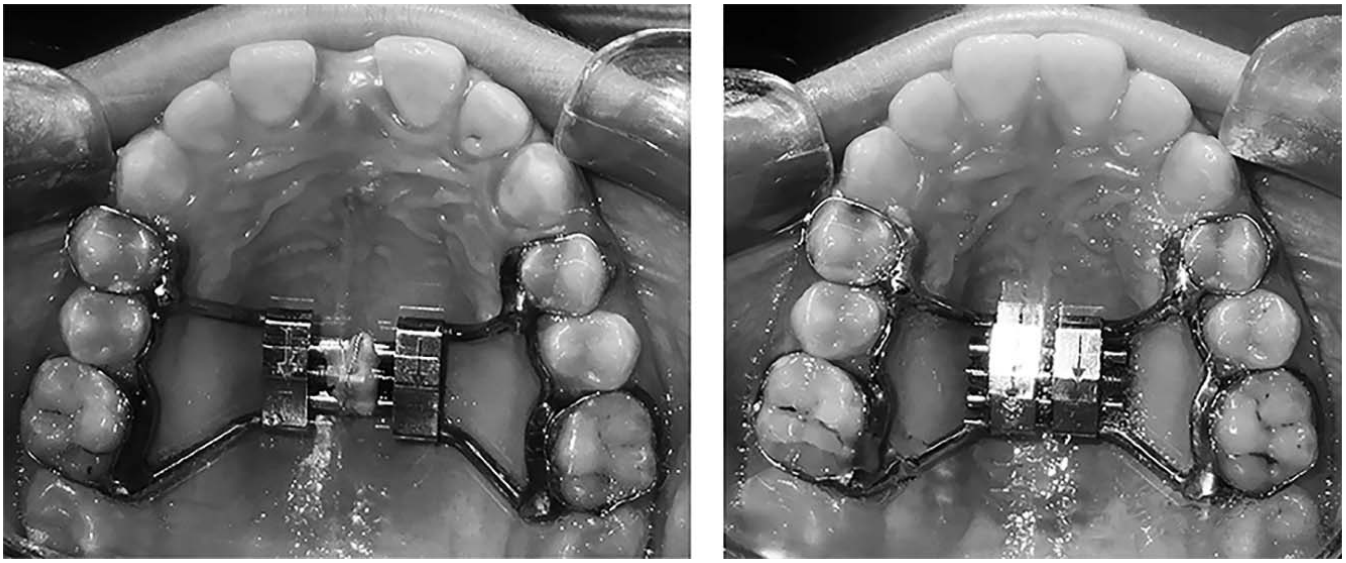

Figure 1. (A) Hyrax appliance before activation. (B) Hyrax appliance at the end of expansion.

The buccal mucosa of the supporting teeth was anesthetized and PRP was injected along the roots of those teeth in the intervention group. After the end of activation, PRP injection was repeated in the same way.

H-CBCTs were taken preoperatively (T0) and after 3 months of retention (T1), when the expander was removed. All measures were analyzed between T0 and T1 by one investigator who was blinded to the CBCT time points and the patient's name. All scans were done by a single trained radiographer at the same scanner-console (Scanora 3D; SOREDEX®, USA). Comparisons between CBCTs were possible due to the standardization made in all studied planes.

Tomographic analysis was performed similarly to that proposed by Brunetto.[4] The patient's Frankfort plane was parallel to the horizontal ground plane within the CBCT device. The sagittal, axial, and coronal planes were detected at each anchor tooth. Initially the image was viewed in a multiplanar reconstruction mode, which contained three sections in three different windows, each section having two axes: X and Y, and each axis related to a scrolling of the tomographic cut in a specific plane of space.

For the first molar on either side: The long axis (Y) in the sagittal plane was made parallel to the long axis of the mesiobuccal root. The X-axis was made tangent to the trifurcation. This process was also performed for the first molar on the other side. In the axial plane; the X-axis was positioned according to the buccolingual axis of the oval section of the mesiobuccal root and applied.

Finally, in the coronal plane; the buccal surface of the root was made parallel to the tomographic vertical plane. The cementoenamel junction (CEJ) and the buccal alveolar crest were identified. Finally, readjustments were made if any change occurred.

The loss in buccal bone crest level (BBCL) was measured vertically from the CEJ to the alveolar crest. The buccal bone plate thickness (BBPT) was measured in two axial planes: the furcation plane and 3 mm above that plane, between buccal surfaces of the root and alveolar bone.

The same technique was followed to orient CBCT sections for the first premolar with its buccal root. The CEJ was set as a reference to identify two axial planes above it (3 mm and 6 mm) for BBPT because it was difficult to identify the furcation region of the first premolar.

The incidence of buccal dehiscence and fenestrations of the anchor teeth was reported. Dehiscence was defined as an increase in the distance between the CEJ and alveolar crest of more than 2 mm based on the normal value of alveolar height. Fenestrations were considered as alveolar bone discontinuation, which exposed a small region of the root and the defect didn't involve the alveolar crest.[6,11] If the image showed no cortical bone around the root in at least three sequential views, the defect was recorded as a dehiscence or a fenestration.[6,7]

All measurements were carried out in a dark room using an ASUS TP550LD screen (ASUSTek Computer Inc, China), then recorded and compared between T0 and T1.

Sample Size Calculation

G*Power 3.1.3 (Heinrich-Heine-Universität, Düsseldorf, Germany) software was used according to the results of a similar previous study.[2] Effect size was calculated depending on the mean and standard

Table 1. Sample Descriptive Statistics

		Sex		Age, Years			
	n	Male	Female	Min.	Max.	Mean	SD
PRP group	9	8	10	11.1	16.5	14.067	1.6556
Control group	9	8	10	11.1	16.5	14.067	1.6556
Total sample (patients)	18	8	10	11.1	16.5	14.067	1.6556

deviation of the BBPT changes in the Hyrax group for the first molar before and after expansion. Paired *t*-test was used. The statistical power was 95% with a significance level of 0.05. This calculation revealed that a sample size of 18 was more than enough.

Statistical Analysis

All statistical analyses were performed using the Statistical Package for the Social Sciences (IBM SPSS Inc. version.25, Chicago, Ill) and a P value of $<.05$ was considered statistically significant. Kolmogorov-Smirnov and Shapiro-Wilk tests were done to determine the normality of the data distribution. Paired *t*-test was applied to evaluate the differences between T0 and T1 for both groups.

Error of the Method

A total of 25% of the measurements were randomly selected and repeated after a month of the first measurement by the same examiner (E.A.). Systematic and random errors were calculated by comparing the first and second measurements using paired *t*-tests. No statistically significant differences ($P > .05$) were found between the first and second measurements for any variable. The range of random errors was 0.01 to 0.2 mm. Intraclass correlation coefficient (ICC) was performed to assess the reliability of the measurements in the same image and by the same investigator; the coefficient of reliability was above 0.956, indicating that the reliability of all measurements was acceptable.

RESULTS

Illustration of the CONSORT flow diagram of patients is shown in Figure 2. Eighteen patients were enrolled in this study. No dropouts occurred. Complete follow-up was done for all patients and appropriate analysis was achieved. Descriptive statistics of the sample regarding sex and age are shown in Table 1.

Tables 2 and 3 show that BBPT of supporting teeth was significantly decreased after RME between T0 and T1 ($P < .05$) in each group separately in all studied planes. Tables 4 and 5 indicate that BBCL of the mesial root of the first molars was not significantly changed by RME between T0 and T1 ($P > .05$) in both groups. However, the buccal root of the first premolar showed a statistically significant change ($P < .05$).

No significant differences ($P > .05$) were found between the two groups regarding all variables of the buccal bone thickness and height of the anchor teeth (Tables 6 and 7).

The prevalence of alveolar defects between T0 and T1 is presented in Tables 8 and 9. In general, the prevalence of dehiscence was greater in the intervention group for all supporting teeth. Similarly, the prevalence of fenestrations was greater in the intervention group for the first molar region but it decreased at the first premolar. The percentage of these defects increased after RME in all studied teeth within each group.

DISCUSSION

This study aimed to evaluate the effectiveness of PRP in reducing alveolar defects after RME. Continuous monitoring of treatment progress every week and the retention phase every 2 weeks was done to ensure precise evaluation. There was no previous study in the literature involving the use of PRP with RME and studying its effects on the alveolar bone.

Previous studies assessing changes in BBPT of posterior teeth after RME were performed in the permanent or late mixed dentition. Garib et al. reported a significant decrease in BBPT of supporting teeth that ranged from 0.6 to 0.9 mm, 3 months after expansion.[11] Rungcharasseng et al. also showed a significant decrease in BBPT of the supporting teeth, with an average of 1.1–1.2 mm, 3 months after expansion.[17] These findings were in agreement with the present study, which revealed a statistically significant reduction in buccal bone plate thickness, 3 months after expansion, in the first molars and first premolars with

Table 2. Buccal Bone Plate Thickness (BBPT) Expansion Changes (Paired *t*-test) in the Intervention (PRP) Group

Variables	n	T0, Mean ± SD	T1, Mean ± SD	T0–T1, Changes (Mean)	T0–T1, SD	*t*	*P*
First molar–trifurcation plane	18	1.3561 ± 0.75211	0.7333 ± 0.66332	−0.6228	0.44084	5.994	.000*
First molar–3 mm above trifurcation	18	1.4017 ± 0.61543	0.4833 ± 0.43386	−0.9183	0.5231	7.448	.000*
First premolar–3 mm above CEJ	18	1.05 ± 0.24734	0.6411 ± 0.42996	−0.5889	0.45457	5.496	.000*
First premolar–6 mm above CEJ	18	0.8494 ± 0.49248	0.2806 ± 0.37146	−0.5689	0.31889	7.570	.000*

* Statistically significant at $P < .05$.

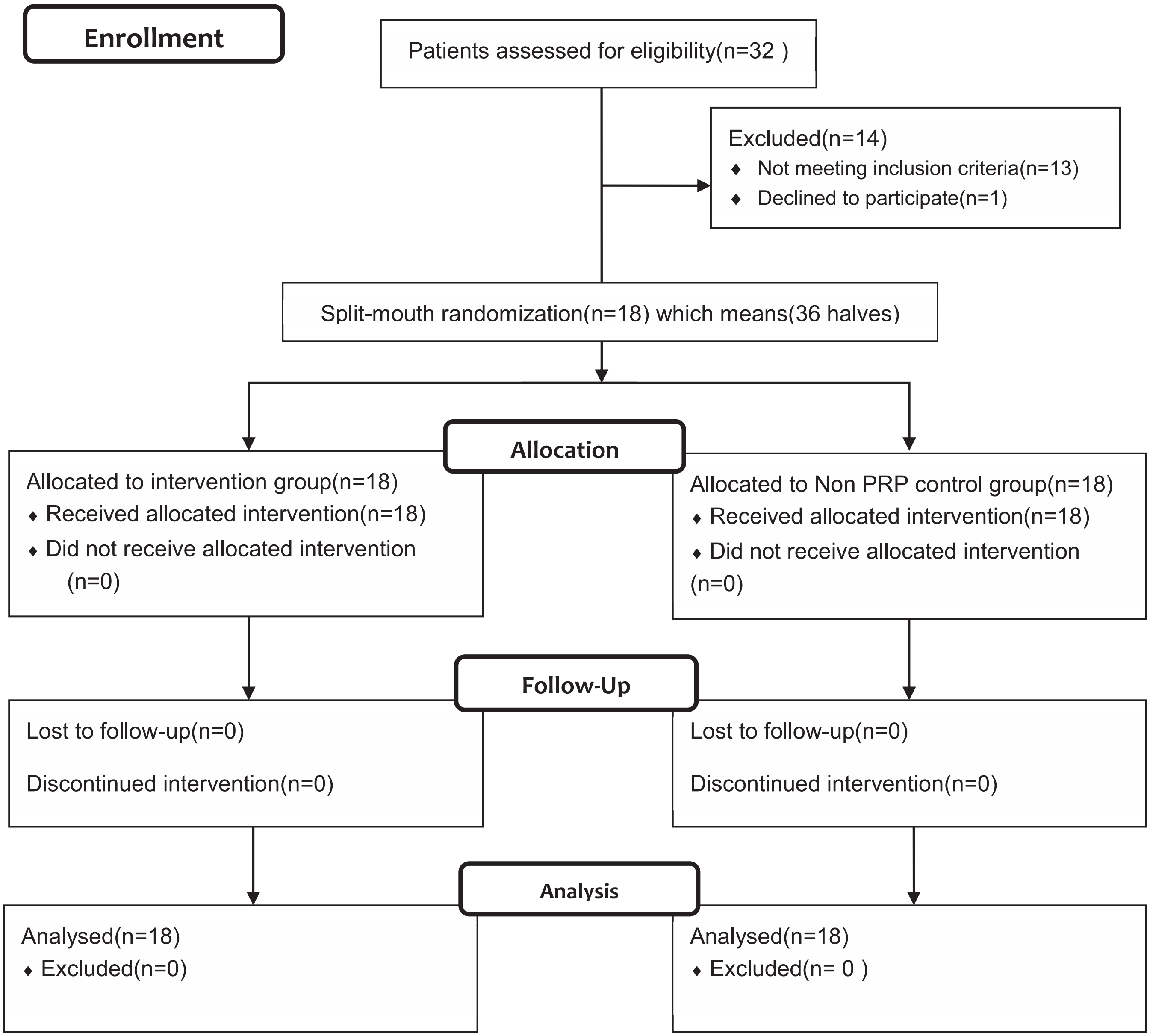

Figure 2. CONSORT flow diagram.

Table 3. Buccal Bone Plate Thickness (BBPT) Expansion Changes (Paired *t*-test) in the Control (No PRP) Group

Variables	n	T0, Mean ± SD	T1, Mean ± SD	T0–T1, Changes (Mean)	T0–T1, SD	*t*	*P*
First molar–trifurcation plane	18	1.2739 ± 0.48371	0.5656 ± 0.48404	−0.7083	0.33033	9.097	.000*
First molar–3 mm above trifurcation	18	1.5056 ± 0.8561	0.7444 ± 0.82478	−0.7611	0.45392	7.114	.000*
First premolar–3 mm above CEJ	18	1.0917 ± 0.43698	0.4028 ± 0.30121	−0.6889	0.32429	9.013	.000*
First premolar–6 mm above CEJ	18	1.0444 ± 0.39627	0.2944 ± 0.37334	−0.75	0.7605	9.861	.000*

* Statistically significant at $P < .05$.

Table 4. Buccal Alveolar Bone Crest Level (BACL) Expansion Changes (Paired *t*-test) in the Intervention (PRP) Group

Variables	n	T0, Mean ± SD	T1, Mean ± SD	T0–T1, Changes (Mean)	T0–T1, SD	*t*	*P*
First molar–mesial root	18	1.1844 ± 0.7125	2.0639 ± 1.36142	−0.87944	1.22379	−3.049	.007
First premolar	18	1.4889 ± 0.44177	2.7611 ± 1.46021	−1.27222	1.56921	−3.440	.003*

* Statistically significant at $P < .05$.

Table 5. Buccal Alveolar Bone Crest Level (BACL) Expansion Changes (Paired *t*-test) in the Control (No PRP) Group

Variables	n	T0, Mean ± SD	T1, Mean ± SD	T0–T1, Changes (Mean)	T0–T1, SD	*t*	*P*
First molar–mesial root	18	1.0378 ± 0.80753	1.8278 ± 1.04025	−.79	1.2566	−2.667	.16
First premolar	18	1.6778 ± 0.68217	2.7328 ± 1.44692	−1.055	1.29164	−3.465	.03*

* Statistically significant at $P < .05$.

an average of 0.8 mm and 0.6 mm, respectively, for the intervention group and 0.7 mm for the control group (Tables 2 and 3).

Ballanti et al assessed a sample of young patients and reported a significant decrease in BBPT of supporting first molars immediately after expansion.[3] The mean decrease was less than 0.5 mm.

Regarding changes in BBPT of supporting teeth between the two groups (Table 6), there was no similar study that included an intervention with RME. The results showed that overall thickness change was 0.85 ± 0.35 for the first molar at the trifurcation plane, −0.16 ± 0.75 for the first molar at 3 mm above the trifurcation, 1 ± 0.45 for the first premolar at 3 mm above the CEJ plane and 0.18 ± 0.3 for the first premolar at 6 mm above CEJ. The remaining buccal alveolar bone thickness was at a critical level in both groups. Therefore, there was no statistically significant difference between the two groups, meaning that the application of PRP did not reduce the loss in BBPT.

No significant increase in the mean BBCL was detected in either group for the first molar after RME between T0 and T1. However, there were significant differences for the first premolars. These findings related to the first premolar were in agreement with previous studies.[2,3,11] Garib et al. found a significant reduction in BBCL, with a mean loss of 7 mm for the first premolars and 3.5 mm at the mesial aspect of the first molars.[11] Rungcharassaeng et al. observed significant vertical bone loss on the buccal aspect of all supporting teeth after RME in the permanent dentition.[17] The mean change in the BBCL of the first premolars and the first molars was 4.4 mm and 2.9 mm, respectively. These results slightly differed from the current study as the first molars showed a loss of 0.9 ± 1.2 and 0.8 ± 1.25 for the intervention and control group, respectively, without any significant differences. The first premolars demonstrated a loss of 1.3 ± 1.6 and 1 ± 1.3 in the intervention and control groups, respectively, and these changes were statistically significant (Tables 5 and 6). This might be explained as the buccal alveolar bone of the first premolars had less resistance to expansion forces than the first molars. Therefore, RME performed in the permanent dentition seems to reduce the integrity of buccal bone plate because of the high forces applied.

There was no previous study that included an intervention to reduce the side effects of RME regarding BBCL. The current results showed that the overall BBCL loss was 0.9 ± 1.5 for the first molar and 0.21 ± 1.73 for the first premolar (Table 7). There was no statistically significant difference between the intervention and control groups, meaning that PRP did not have any positive effects.

There was a mean increase of 13.2% in dehiscences in the intervention group and 9.7% in the control group. The increases in percentage of fenestrations were 11.8% and 10.4% in the intervention and control groups, respectively. These results agreed with previous studies,[6,7,10] which also showed increases in these alveolar defects, but previous studies observed higher increases of up to 55%.

Table 6. Buccal Bone Plate Thickness (BBPT) Differences Between Intervention (PRP) and Control (NON PRP) Groups (Paired *t*-test)

Variables	n	T0-T1, Mean ± SD	*t*	*P*
First molar–Trifurcation Plane	36	0.8556 ± 0.35052	1.036	.315
First molar–3 mm above Trifurcation	36	−0.15722 ± 0.74931	−0.890	.386
First premolar–3 mm above CEJ	36	0.1 ± 0.45338	1.026	.319
First premolar–6 mm above CEJ	36	0.18111 ± 0.30986	2.480	.24

Study Limitation

No blinding was applied to either the operator or patients regarding the side of the intervention in this study; no placebo was used, and this may have led to some risk of bias. However, the risk of bias was reduced by randomizing the side allocations for groups. Also, patient blinding would not affect treatment results because no patient self-assessed outcomes were studied.

It was not possible to obtain exactly the same values of platelet counts in all patients because of the

Table 7. Buccal Alveolar Bone Crest Level (BACL) Differences Between Intervention (PRP) and Control (NO-PRP) Groups (Paired *t*-test)

Variables	n	T0–T1, Mean ± SD	*t*	*P*
First molar–mesial root	36	−0.08944 ± 1.48487	−2.56	.801
First premolar	36	.21722 ± 1.72834	−0.533	.601

Table 8. Incidence of Fenestrations

	Intervention Group, n (%)			Control Group, n (%)		
	T0	T1	Difference	T0	T1	Difference
First molar–mesial root	0 (0)	7 (9.72)	7 (9.72)	0 (0)	4 (5.55)	4 (5.55)
First premolar	1 (1.38)	11 (15.27)	10 (13.89)	2 (2.77)	13 (18.05)	11 (15.28)

Table 9. Incidence of Dehiscences

	Intervention Group, n (%)			Control Group, n (%)		
	T0	T1	Difference	T0	T1	Difference
First molar–mesial root	1 (1.38)	7 (9.72)	6 (8.34)	0 (0)	4 (5.55)	4 (5.55)
First premolar	0 (0)	13 (18.05)	13 (18.05)	3 (4.16)	13 (18.05)	10 (13.89)

difference in the WBC for each one. However, the effect of this was reduced by using a two-step centrifugation technique to get a higher PRP concentration. It is also difficult to control patient oral hygiene that may affect periodontal tissues.

This study was limited to post-retention changes after RME without assessing long-term changes and subsequent healing. The thought was that RME performed at early ages may avoid collateral side effects. Lastly, the results of this study were based on a relatively small sample size because there was no previous similar RCT before.

Despite these limitations, using precise criteria, careful techniques, and defined methods helped to improve reliability of the data obtained. Treatment of all patients was done by the same author with the same devices and protocol, and H-CBCT was used for detailed assessment in 3D.

CONCLUSIONS

- RME performed in the permanent dentition produces undesirable effects on supporting teeth mainly in alveolar defects.
- PRP did not produce any healing effects compared with the control group. The prevalence of alveolar defects was higher in the PRP group.

ACKNOWLEDGMENTS

This study was approved by the Institutional Review Board and Ethical Committee of Damascus University (Damascus-Syria) No.2939. The first Protocol of this RCT was registered in the Clinical Trial Database (NCT03028038) (www.Clinicaltrials.gov). There is no funding to be declared.

REFERENCES

1. Gunyuz Toklu M, Germec-Cakan D, Tozlu M. Periodontal, dentoalveolar, and skeletal effects of tooth-borne and tooth-bone-borne expansion appliances. *Am J Orthod Dentofacial Orthop*. 2015;148(1):97–109.
2. Kayalar E, Schauseil M, Kuvat SV, Emekli U, Firatli S. Comparison of tooth-borne and hybrid devices in surgically assisted rapid maxillary expansion: A randomized clinical cone-beam computed tomography study. *J Craniomaxillofac Surg*. 2016;44(3):285–293.
3. Ballanti F, Lione R, Fanucci E, Franchi L, Baccetti T, Cozza P. Immediate and post-retention effects of rapid maxillary expansion investigated by computed tomography in growing patients. *Angle Orthod*. 2009;79(1):24–29.
4. Brunetto M, Andriani Jda S, Ribiero GL, Locks A, Correa M, Correa LR. Three-dimensional assessment of buccal alveolar bone after rapid and slow maxillary expansion: a clinical trial study. *Am J Orthod Dentofacial Orthop*. 2013;143(5):633–644.
5. Garib DG, Henriques JF, Janson G, de Freitas MR, Fernandes AY. Periodontal effects of rapid maxillary expansion with tooth-tissue-borne and tooth-borne expanders: a computed tomography evaluation. *Am J Orthod Dentofacial Orthop*. 2006;129(6):749–758.
6. Evangelista K, Vasconcelos Kde F, Bumann A, Hirsch E, Nitka M, Silva MA. Dehiscence and fenestration in patients with Class I and Class II Division 1 malocclusion assessed with cone-beam computed tomography. *Am J Orthod Dentofac Orthop*. 2010;138(2):133.e1–7.
7. Akin M, Baka ZM, Ileri Z, Basciftci FA. Alveolar bone changes after asymmetric rapid maxillary expansion. *Angle Orthod*. 2015;85(5):799–805.
8. Geramy A, Shahroudi AS. Fixed versus removable appliance for palatal expansion; a 3d analysis using the finite element method. *J Dent (Tehran)*. 2014;11(1):75–84.
9. Pangrazio-Kulbersh V, Jezdimir B, de Deus Haughey M, Kulbersh R, Wine P, Kaczynski R. CBCT assessment of alveolar buccal bone level after RME. *Angle Orthod*. 2013;83(1):110–116.
10. Baysal A, Uysal T, Veli I, Ozer T, Karadede I, Hekimoglu S. Evaluation of alveolar bone loss following rapid maxillary expansion using cone-beam computed tomography. *Korean J Orthod*. 2013;43(2):83–95.
11. Garib DG, Yatabe MS, Ozawa TO, Filho OGS. Alveolar bone morphology under the perspective of the computed tomography: defining the biological limits of tooth movement. *Dental Press J Orthod*. 2010;15(5):192–205.
12. Kapila SD, Nervina JM. CBCT in orthodontics: assessment of treatment outcomes and indications for its use. *Dentomaxillofac Radiol*. 2015;44(1):20140282.

13. Akyalcin S, Schaefer JS, English JD, Stephens CR, Winkelmann S. A cone-beam computed tomography evaluation of buccal bone thickness following maxillary expansion. *Imaging Sci Dent*. 2013;43(2):85–90.
14. Kaur G, Sharma A, Grover D. Platelet rich plasma a boon for periodontal regeneration: a review. IJSS;2014;1(4):18.
15. Schulz KF, Altman DG, Moher D. CONSORT 2010 statement: updated guidelines for reporting parallel group randomised trials. *BMC Med*. 2010;8(1):18.
16. Silness J, Loe H. Periodontal disease in pregnancy. II. Correlation between oral hygiene and periodontal condition. *Acta Odontol Scand*. 1964;22:121–135.
17. Rungcharassaeng K, Caruso JM, Kan JY, Kim J, Taylor G. Factors affecting buccal bone changes of maxillary posterior teeth after rapid maxillary expansion. *Am J Orthod Dentofacial Orthop*. 2007;132(4):428.e1–8.