AJDS LAZHAR
Al-Azhar Journal of Dental Science
Vol. 21- No. 2- 175:182- April 2018
Record 1110-2624 | the ISSN Portal
portal.issn.org

EFFECT OF RAPID MAXILLARY EXPANSION ON THE BUCCAL ALVEOLAR BONE: CLINICAL AND RADIOGRAPHIC EVALUATION

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ABSTRACT

Aim of the study: This study was conducted to evaluate clinically as well as radiographically using cone beam computed tomography (CBCT) the effect of rapid maxillary expansion on the buccal alveolar bone. **Material and Methods:** The current study was conducted on a total sample of thirty young adult orthodontic patients (20 girls and 10 boys) presented with transverse maxillary deficiency with an age ranged from 11-15 with mean of 13.3 ±1.1Y.The patients were distributed randomly in to three equal groups according to the position of center of the expansion screw in relation to the palatal surface of the maxillary first permanent molars. The CBCT were taken before the start of the orthodontic expansion (T1), three months after the last activation immediately after removal of the expander (T2). All patients did not have brackets or wires placed in the maxillary arch until after the T2 records were taken. **Results:** Paired t-test used to statistically test the mean differences between pre-expansion and pos-expansion measurements within each group. One-way analysis of variance (ANOVA) was used to compare among the different three groups. Tukey's post-hoc test was used for pair-wise comparisons among the groups when ANOVA test was significant. The significance level was set at $P \leq 0.05$. **Conclusions:** RME may have a deleterious effect on buccal alveolar bone of the anchor teeth at least in the first stages of RME leading to its decrease in thickness and height, while the palatal bone thickness showed marked increase in all groups.

INTRODUCTION

Rapid maxillary expansion (RME) is a common orthodontic procedure used to correct posterior crossbite, increase maxillary width, and enlarge arch perimeter [1,2]. It was first described by Angell in 1860[3] and later on subjected to numerous modifications described through literatures [2,4]. RME is accomplished by opening the midpalatal and circummaxillary sutures rather than moving the teeth buccally [5,6]. Traditionally, it is carried out by using a tooth-borne appliance with a center jackscrew, attempting to spread maxillary halves apart. RME may causes considerable side effects in terms of buccal tipping of the anchorage teeth and associated dehiscence of the buccal cortical plate, root resorption, and gingival recessions [7,8].

Several authors have recommended the importance of optimizing the orthopedic effects of RME to minimize its complications, mainly the buccal inclination of the posterior teeth and associated undesired side effects on buccal bone [5,9,10].

The alveolar bone is more difficult to visualize and measure with two dimensional radiographs, because of its limited thickness and proximity to the teeth and the periodontal ligament [11]. With increasing popularity of CBCT imaging in orthodontics, it has been proposed that the proper way of using CBCT to measure the height and thickness of the alveolar bone need to be elucidated [12,13].

Although RME has been widely used in orthodontics for several decades [2-4], the influence of the different sagittal positions of the expansion screw

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on the orthodontic and orthopedic responses to RME awaits further clarification. Therefore, the current study was directed to evaluate the buccal alveolar bone after rapid maxillary expansion with different sagittal expansion screw positions.

MATERIAL AND METHODS

The current study was conducted on a total sample of thirty young adult orthodontic patients (20 girls and 10 boys) presented with transverse maxillary deficiency with an age ranged from 11-15 with mean of 13.3 ±1.1Y.

The research project was explained both verbally and in writing and the objectives of the study were discussed with the patients and parents and a consent form for patient participation in the research project was obtained before commencing the study.

Group allocation:

According to the sagittal position of the expansion screw, the patients were randomly allocated into three equal groups, using online generated randomization plan (Graph Pad) found at the website http://www.graphpad.com/quickcalcs/index.cfm.

- **Group (A):** The centre of expansion screw tangent to a line bisecting the centre of the maxillary first permanent molar (seven girls and three boys) (Figure 1a).
- **Group (B):** The centre of expansion screw tangent to a line bisecting the mesiopalatal cusp of the maxillary first permanent molar (seven girls and three boys) (Figure 1b).
- **Group (C):** The centre of expansion screw tangent to a line bisecting the distopalatal cusp of the maxillary first permanent molar (six girls and four boys) (Figure 1c).

Four-banded Hyrax expanders* 9mm screw length (Figure 1) were used and supported bilaterally by first premolars and first molars. The appliance was activated 2 quarter turns at the time of delivery (0.25 mm per each) then it was activated quarter turn at the morning and another one at the evening [6,14,15-17] by the patient or parents for 15 days, thus reaching the total amount of expansion of 8 mm in all subjects [17-23]**.** The patients were seen on third, sixth and tenth days for verification and confirmation of activation process of the appliance. The screw was tied off with a ligature wire, and then covered by a small piece of composite material** and kept in Place within the mouth for three months after the last activation of Hyrax expander. No ad-

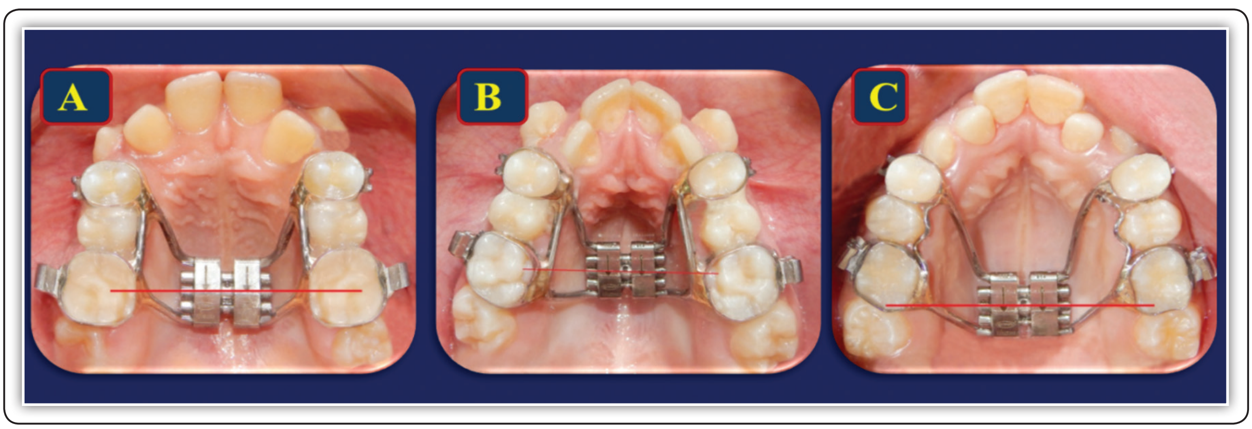

Fig. (1): Different sagittal position of the expansion screw (A) centered (B) Mesial and (C) distal position.

Leone 9mm expansion screw, Italy.
3M z150, Germany.

ditional orthodontic treatment was initiated in both jaws until after the retention phase has finished.

The CBCT were taken before the start of the orthodontic expansion (T1), three months after the last activation immediately after removal of the expander (T2), (Figure 2). They were transferred to a personal computer as a DICOM (digital imaging and communications in medicine), data files and were reconstructed at 0.3 mm increments then analyzed by using In vivo (Anatomage) imaging software (version 5.1; USA).

The patients were positioned by adjusting the Frankfort horizontal plane parallel to the floor, laser beams were used as a guide for orientation of the head according to FH plane. The following measurements were assessed for linear alveolar bone measurements according to previous studies.[14-16,18,20,21,23]

Linear measurements:

1- Transverse measurements:

- Buccal bone thickness at root level (BBTr)
- Buccal bone thickness at most alveolar convexity (BBTc)
- Buccal bone thickness mid-way (BBTm)
- Palatal bone thickness at root level (PBTr)
- Palatal bone thickness at most alveolar convexity (PBTc)
- Palatal bone thickness mid-way (PBTm)
- Total bone thickness at root level (TBTr)
- Total bone thickness at most alveolar convexity (TBTc)
- Total bone thickness mid-way (TBTm)

2- Vertical measurements:

- Buccal marginal bone level (BMBL)
- Buccal bone thickness level (BBTL)

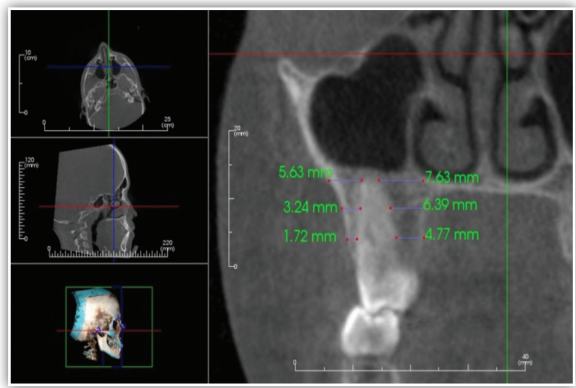

Fig. (2): Buccal and palatal bone thicknesses measurements of maxillary permanent first molar.

RESULTS

All measurements were performed twice at two weeks interval by the same examiner to determine the intra-examiner error of method.

Paired t-tests were used to test the effect of treatment on the CBCT variables within each group showed highly significant increases $P \leq .05$ for the effect of expansion on palatal bone thickness (PBT) at the three levels in all groups. Most of the buccal bone thickness (BBT), total bone thickness (TBT) at M1 and P1 in most of the three levels, showed highly significant decreases $P \leq .05$ in all groups.

On the other hand the right buccal bone thickness at the apical root level (BBTr RT) at M1 in group A, right and left buccal bone thickness at the apical root level (BBTr RT and LT) at M1 in group B and C, buccal bone thickness level (BBTL) in all groups, right and left palatal bone thickness at the apical root level (PBTr RT and LT) at M1 in group A and B, right palatal bone thickness at the apical root level (PBTr RT) at M1 in group C and finally left total bone thickness at the apical root level (TBTr LT) at M1 in group B showed no significant changes $P > .05$.

One-way analysis of variance (ANOVA) was done to test the mean differences of treatment effect on each variable measured among groups. The significance level was set at $P \leq 0.05$ (Table 1).

TABLE (1): Descriptive statistics and test of significance (ANOVA) for comparison the mean difference of CBCT buccal bone linear, palatal bone linear and total bone linear measurements among the three groups.

Variable (mm)		Group A		Group B		Group C		ANOVA		
		MD	SD	MD	SD	MD	SD	DF	F	Sig
BBTr RT	M1	.130	.2217	-.13	.5121	-.23	.670	27	1.363	.273NS
	P1	-.44	.245	-.21	.2024	-.590	.351	27	4.892	.215NS
BBTr LT	M1	.15	.206	.09	.280	-.24	.678	27	2.273	.122NS
	P1	-.32	.244	-.42	.1686	-.69	.532	27	2.960	.069NS
BBTc RT	M1	-.92	.3359	-1.08	.2440	-1.24	.287	27	3.010	.066NS
	P1	-.88	.1932	-.74	.0966	-.76	.177	27	2.199	.130NS
BBTc LT	M1	-1.0	.2260	-1.10	.1563	-1.19	.284	27	1.731	.196NS
	P1	-.740	.1646	-.730	.1337	-.71	.128	27	.114	.893NS
BBTmRT	M1	-.86	.3098	-.87	.2311	-1	.323	27	.721	.495NS
	P1	-.71	.2995	-.660	.1955	-.66	.309	27	.112	.895NS
BBTm LT	M1	-.77	.3334	-.84	.1646	-1.07	.432	27	2.273	.122NS
	P1	-.69	.2378	-.63	.1337	-.76	.309	27	.745	.484NS
BMBLRT	M1	-.689	.414	-.87	.377	-1.0	.595	27	1.154	.330NS
	P1	-.73	.3497	-.729	.286	-.739	.259	27	.004	.996NS
BMBLLT	M1	-.75	.343	-.91	.246	-.92	.505	27	.628	.541NS
	P1	-.76	.3921	-.84	.2503	-.829	.149	27	.239	.789NS
BBTL RT	M1	0.29	.18	0.45	.334	0.12	.691	27	.45	.357NS
	P1	0.25	.85	0.42	.245	0.09	.584	27	1.42	.396NS
BBTL LT	M1	0.26	.24	0.37	.346	0.21	0.354	27	.58	.659NS
	P1	0.16	.75	0.27	.941	0.11	0.842	27	.42	.829NS
PBTr RT	M1	.02	.2973	.27	.8069	.17	.388	27	.533	.593NS
	P1	.99	.6402	.90	.4396	.89	.570	27	.098	.907NS
PBTr LT	M1	.16	.6058	.18	.434	.27	.330	27	.155	.857NS
	P1	.79	.341	.870	.4785	.80	.405	27	.112	.895NS
PBTc RT	M1	1.06	.5211	1.07	.305	1.13	.374	27	.085	.919NS
	P1	1.11	.4931	1.24	.3405	1.08	.605	27	.299	.744NS
PBTc LT	M1	1.02	.3084	.97	.343	1.36	.497	27	2.936	.070NS
	P1	1.21	.4175	1.2	.4988	.85	.356	27	2.291	.121NS
PBTmRT	M1	.850	.5482	.94	.254	.86	.298	27	.161	.853NS
	P1	1.03	.7643	.97	.4498	.95	.462	27	.052	.949NS
PBTmLT	M1	.83	.5945	.76	.1712	.97	.600	27	.462	.635NS
	P1	1.06	.5834	1.05	.4503	.85	.263	27	.687	.512NS

TBTr RT	**M1**	-.56	.3306	-.76	.4501	-.47	.319	27	1.595	.221
	P1	-.14	.0966	-.39	.228	-.31	.196	27	4.879	.116
TBTr LT	**M1**	-.47	.1702	-.20	.4521	-.70	.596	27	3.190	.057
	P1	-.14	.1646	-.250	.1840	-.34	.231	27	2.622	.091
TBTc RT	**M1**	-.5	.2943	-.520	.2250	-.68	.466	27	.823	.450
	P1	-.29	.1370	-.32	.1475	-.33	.133	27	.222	.802
TBTc LT	**M1**	-.42	.1316	-.57	.3433	-.63	.560	27	.762	.476
	P1	-.29	.1911	-.240	.1429	-.3	.163	27	.371	.694
TBTmRT	**M1**	-.45	.1840	-.41	.1595	-.69	.634	27	1.487	.244
	P1	-.22	.1032	-.340	.1837	-.31	.110	27	2.069	.146
TBTm LT	**M1**	-.47	.1337	-.37	.1888	-.72	.315	27	6.368	.235
	P1	-.25	.1080	-.280	.1751	-.32	.269	27	.321	.728

MD = Mean difference, SD= standard deviation, SE = Standard Error, NS= non-significant, Significant at P = Probability P ≤ 0.05, DF= degree of freedom No= 30.

DISCUSSION

Rapid maxillary expansion is very common treatment strategy in patients with constricted maxilla and posterior crossbite [1-6] .

Unfortunately, studies investigating the effects of expansion screw sagittal positions on the maxillary arch after rapid maxillary expansion were limited to comparing the conventional Hyrax with fan shape palatal expander [24,25], which exhibited very large span between the two positions. Therefore, the purpose of this study was to evaluate clinically as well as radiographically the effect of rapid maxillary expansion on the buccal alveolar bone with different short span sagittal positions of the expansion screw limited to the palatal surface of maxillary permanent first molar.

CBCT show a significant advantage because all defects including buccal and lingual defects could be detected and quantified [26] .

Rapid maxillary expansion procedures have been shown to be related to the loss of buccal alveolar bone height and thickness of the anchorage teeth. The same changes represented by variations in observed bony responses to heavy forces on the buccal and palatal sides may be different as evidenced by inconsistent bone thickness changes on the buccal and palatal sides. Variations of inter dental angle (IDA), BBTr and PBTr still support different types of movement of anchor teeth. Also, the more the teeth were tipped buccaly, it is not mandatory that more bone thickness reduction at the apico-palatal area exist, because the nature of biomechanical response of the constrained body especially in bucco-palatal direction of posterior teeth may face resistant than anterior teeth due to the power of surrounding muscles especially masseter. Put in consideration the effect of different degrees of tip and torque movements with the applied force may lead to a better understanding of how alveolar bone reacts to the applied forces in different areas [23,27,28].

Capps et al, [29] advocated that the buccal bodily tooth movement is capable of producing buccal bone apposition, but there are potential limitations [29].

Measurements BBTm (middle) and BBTc (crestal) are located near the occlusal side of the alveolar bone crest than BBTr (apical) therefore; these are more directly influenced by changes in the vertical alveolar bone. On the other hand, BBTr is located in an apical area that most likely experienced little influence from vertical alveolar bone changes as a result of treatment. Hence, the mean variation of BBTr was associated with the measurement of inclination of the root regions of the maxillary right and left first permanent molars. Little decreased at the apical side was observed this may be due to probable bodily movement of the anchorage unit after three months of retention resulted from the eventual uprighting of the anchor teeth in response to forces supplied either by the buccal musculature, occlusal interdigitation, or residual energy stored in the appliance [8,23,35,36].

In all groups, the buccal bone thicknesses of the right and left first molars (M1) at crestal area BBTc, the right and left first premolars (P1) at cervical or crestal area were decreased, whereas the palatal bone thickness at the cervical and middle level of the root increased after RME. There was no difference between groups because the hyrax expanders were anchored to the first molars. The increase in palatal bone thickness and the decrease in buccal bone thickness of the banded first molars and premolar after expansion were in accordance with previous studies [23,27,28,30,31,33,34].

Corbridge et al, [32] showed that post treatment buccal bone thickness was reduced and they correlated the patients who showed the greatest increases in IMW also showed the greatest increases in lingual bone thickness and the greatest decreases in buccal bone thickness. The mean decrease in the buccal bone thickness was the same as the mean increase in lingual bone thickness. Tooth movements through the alveolar ridge tend to be greater than the orthopedic effects in his slow maxillary expansion protocol with quad helix.

On the other point of view the study of Brunetto et al, [23] and Baysal et al, [27] were in contrast to the result of the present study, this may be due to different protocol of expansion with short period of evaluation at T2.

In the present study vertical bone level was lowered in M1 and P1 immediately after three months of the last activation of RME screw. These changes may be attributed to the tipping of the maxillary posterior teeth, and this tipping movement may lead to resorption of the crestal alveolar bone. This finding was in accordance with previous studies [27,28,30,37]. This also was in agreement with Rungcharassaeng et al, [31] who found that both buccal bone height and thickness decrease significantly after RME. These results are also in accordance with Castro et al, [38] who found that the distance from the cemento-enamel junction to the alveolar bone crest changed after orthodontic treatment; the distance was greater than 2 mm in 11% of the surfaces before treatment and in 19% after treatment [38].

Pangrazio-kulbersh et al. [28] found a statistically significant loss of vertical buccal bone occurred in the banded group when measured after expansion at M1Rt with a vertical buccal bone loss of 0.63 mm and P1Lt with a vertical buccal bone loss of 0.37.

As regard to the buccal bone thickness level (BBTL) there was no significant changes within or among the groups, this was in accordance to previous studies of Rungcharassaeng et al, [31] and Pangrazio-kulbersh et al. [28]

Vertical bone reduction can be attributed to the horizontal bone reduction and vice versa, and that the greater the initial bone loss, the greater is the bone rebound. The thicker the BBT at the base line, the greater horizontal bone reduction could be expected. On the other hand RME induced bone dehiscence on the anchorage teeth's buccal aspect, especially in subjects with thinner buccal bone plates. Garib et al,[30], Rungcharassaeng et al, [31] and Baysal et al, [27] found that the first premolars had a larger reduction in the BMBL when compared with the first molars, even though they were submitted to similar forces, the great difference between these teeth is the anatomical area in which they are located. The first molars are located at a maxillary region that widens upwards. On the other hand, the first premolars are located in an area that becomes narrower upwards. In this area, when there is bodily buccal movement, the root can perforate the alveolar bone much more easily, so risk of fenestration is higher in P1 than M1 this was in accordance with pervious study [27,30,31] .

In this study there was no difference in buccal bone thickness change following RME among the three groups, since the changes were not significant (P >.05). Moreover, previous studies that completed the comprehensive fixed orthodontic treatment demonstrated that after the completion of orthodontic treatment with fixed appliances, buccal bone width is almost regained due to subsequent uprighting of the molar and premolar roots. This may be due to the different activation protocol which was 1 quarter turn per day while in the present study it was 1 half turn of the screw per day [27].

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