Original Article

Skeletal effects of posterior crossbite treatment with either quad helix or rapid maxillary expansion: a randomized controlled trial with 1-year follow-up

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ABSTRACT

Objectives: To assess skeletal and dental effects and evaluate possible side effects of maxillary expansion with two different appliances, directly after expansion and 1 year postexpansion.

Materials and Methods: Forty-two patients with unilateral posterior crossbite (mean 9.5 $\pm$ 0.9 years) were randomized to either rapid maxillary expansion (RME) banded on the deciduous second molars and bonded to the primary canines or slow expansion with quad helix (QH) on the permanent first molars. Cone-beam computed tomography records were taken at baseline, directly after correction of the posterior crossbite and at follow-up 1 year after expansion.

Results: All patients were analyzed. RME opened the midpalatal suture more anteriorly and inferiorly (mean 4.1 mm) and less posteriorly and superiorly (mean 1.0 mm). No effect on midpalatal suture could be shown in the QH group after expansion, $P < .001$. Buccal bone width had significantly decreased ($P < .001$) in the QH group compared with the RME group. Buccal fenestrations and root resorption on the left first molar had a higher prevalence directly after expansion finished in the QH group ($P = .0086$, $P = .013$) but were not significant at 1-year follow-up ($P = .11$, $P = .22$).

Conclusions: Opening of the suture with RME was more anterior and inferior, and the QH did not open the midpalatal suture at all. More buccal bone loss and fenestrations were seen on the permanent first molar in patients treated with conventional QH than RME anchored to deciduous teeth. (*Angle Orthod*. 0000;00:000–000.)

KEY WORDS: Palatal expansion technique; Crossbite; 3D imaging

INTRODUCTION

Posterior crossbite is a common malocclusion in children, with a prevalence of about 8% to 11%.[1] When correcting a posterior crossbite due to a constricted maxilla, expansion of the maxilla is the gold standard.[2] Expansion of the maxilla can be done rapidly with a fixed appliance such as a Hyrax type expander (rapid maxillary expansion; RME) or slowly with a removable expansion plate or fixed bent steel wire such as a quad helix (QH) appliance.[3,4] Compared with an expansion plate, the QH is a more successful method in terms of correcting a posterior crossbite and also has a significantly shorter treatment time.[5]

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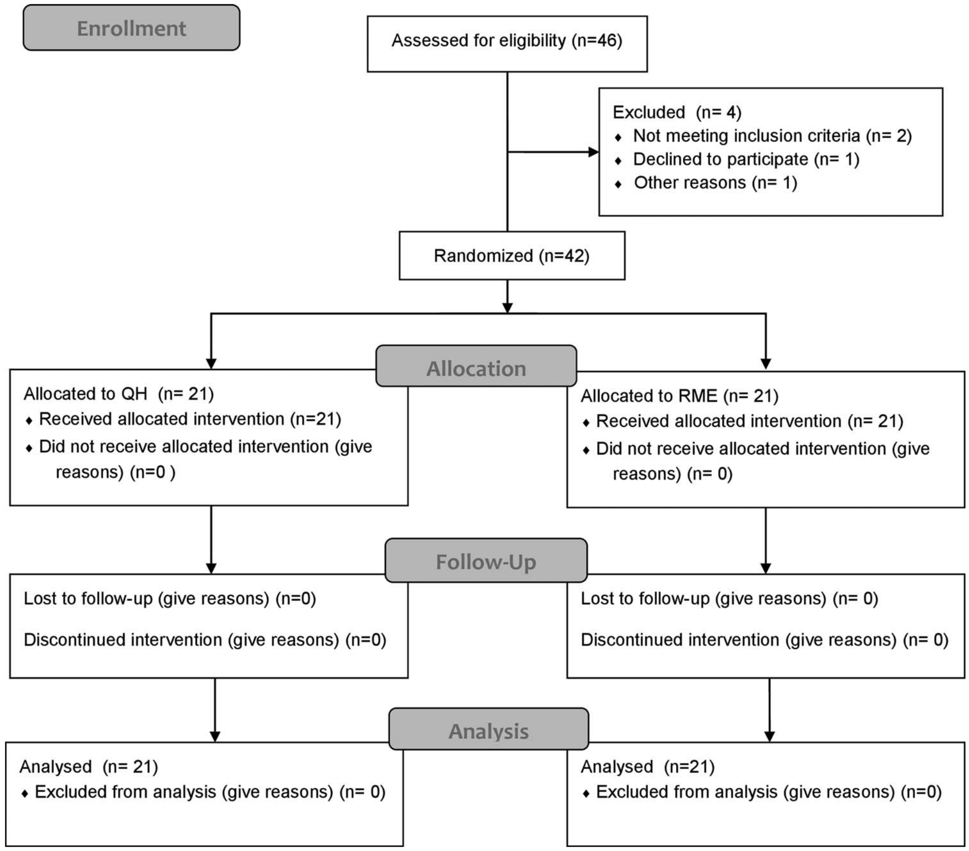

Figure 1. Flow diagram.

The effect on the midpalatal suture during maxillary expansion has been discussed, and almost any expansion device has been argued to open the midpalatal suture up to the age of 9 to 10 years.[6] The maturation of the midpalatal suture has been investigated in previous radiographic studies, and no child aged between 5 and 11 years had any fusion of the midpalatal suture.[7] However, that study was not assessed in conjunction with clinical experience.

Side effects of unilateral posterior crossbite correction have been described previously. Vertical and horizontal bone loss has been reported in both slow and rapid activation protocols using fixed expanders.[8,9] A consequence of bone loss is fenestration or dehiscence. Fenestration is defined as loss of the bone coverage of the root with the marginal bone level (MBL) still intact. Dehiscence appears when the distance between the cementoenamel junction and the MBL increases, leading to gingival recession.[10]

Cone-beam computed tomography (CBCT) is, at present, the most reliable imaging method when conventional 2D radiology fails to provide a correct rendering,[11] as when measuring and evaluating skeletal changes and potential dental side effects. CBCT has high sensitivity and accuracy, and doses can be kept relatively low compared with other radiographic modalities.[12,13] The principle of ALADAIP (as low as diagnostically acceptable being indication-oriented and patient-specific) is recommended.[14]

To date, specifically comparing RME and QH in the early mixed dentition (EMD), there is no evidence on which maxillary expansion method is more feasible in correcting a unilateral posterior crossbite with optimal skeletal effects and minimal side effects. The aims of this randomized controlled trial (RCT) were to compare the RME banded to the deciduous first molars and QH banded to the permanent first molars regarding the effect on the midpalatal suture, dental tipping, and adverse effects, such as fenestration and dehiscence, when correcting unilateral posterior crossbite in the EMD.

MATERIALS AND METHODS

This study was a bicenter, two-arm, parallel-group RCT performed at orthodontic departments in regions the of Örebro and Jönköping, Sweden. The regional radiation protection committee gave their approval, and the Regional Ethical Review Board in Uppsala, Sweden, which follows the guidelines of the Declaration of Helsinki, approved the study protocol (Dnr: 2018/308).

Figure 2. Quad helix on permanent first molars (left) and rapid maxillary expander on deciduous molars and deciduous canines (right).

The sample in this trial was selected from general dental practice in Örebro County and Jönköping County, Sweden. Children who were diagnosed with unilateral posterior crossbite and who met the eligibility criteria were recruited between May 2019 and January 2021. After receiving oral and written information about the trial, the included participants and their guardians signed the consent form.

The following inclusion criteria had to be fulfilled by all participants:

- Unilateral posterior crossbite
- EMD: the maxillary first permanent molars had to be erupted, and the maxillary deciduous canines and second deciduous molars had to be persisting (DS2M1)[15]
- Class I or Class II molar relationship with a maximum of 5-mm overjet

Patients with previous or ongoing orthodontic treatment, craniofacial syndromes, or orofacial clefts were considered ineligible for the study.

Randomization

All 42 participants were randomly allocated in blocks of different sizes, using the concealed allocation principle in a 1:1 ratio, to two groups: a QH group and an RME group. The randomization procedure was as follows: a computer-generated randomization list was created using SPSS software (version 22.0; SPSS, Chicago, Ill) and stored with a dental nurse who was not involved in the trial. Each time a patient gave his or her consent, the dental nurse was contacted to provide the information about which type of expander the patient would receive (Figure 1).

Intervention and Radiographic Examination

Appliance design (Figure 2) and clinical intervention were performed in accordance with a previously published study.[16] All patients had a CBCT 8 cm $\times$ 8 cm scan at baseline (before start of the treatment, T0), at finished expansion (T1), and at follow-up (T3) 1 year

Figure 3. Three image planes orthogonal to each other: axial, sagittal, and coronal.

Table 1. Description of Anatomical Landmarks[a]

Anatomical Landmark	Description
P1	Position 1, apex of permanent incisor root/
P2	Position 2, apex of permanent first molars palatal root/
P3	Position 3, spina nasalis posterior/
Midpalatal suture	Midpalatal suture width inferior (inf) and superior (sup), respectively. Distance between cortical borders of the suture at the inferior as well as superior part of Os palatinum. Measured in millimeters.
Buccal MBL	Marginal bone level at the buccal aspect of the right (dx) and left (sin) first molar, respectively. Distance from the cementoenamel junction to the marginal bone crest. Measured in millimeters.
Palatal MBL	Marginal bone level at the palatal aspect of the right (dx) and left (sin) first molar, respectively. Distance from the cementoenamel junction to the marginal bone crest. Measured in millimeters.
Buccal bone width	Alveolar bone thickness. Buccal bone measured horizontal at the height of the furcation of the mesiobuccal root of the first permanent molar. Measured in millimeters.
Palatal bone width	Alveolar bone thickness. Palatal bone measured horizontal at the height of the furcation of the palatal root of the first permanent molar. Measured in millimeters.
Angle	Dental inclination. Angle of teeth between the line passing through the palatal root apex and palatal cusp at the right (1) and left (2) first permanent molar, respectively, and the vertical line parallel to the midsagittal plane. Measured in degrees.

[a] MBL indicates marginal bone level.

after finished expansion. According to the principle of ALADAIP, the volume, voltage, and mA were optimized to minimize the radiation given to the patients but sufficient to be able to answer the questions. The CBCT unit used at both centers was the 3D Accuitomo 170 manufactured by J Morita (Osaka, Japan), field of view size 8 × 8, 90 kVp 45 mA. The effective dose was 128 μSv on a child phantom.[17]

The endpoint in both groups was when the palatal cusp of the maxillary permanent first molars was in contact with the buccal cusp of the mandibular permanent first molars (T1). The appliance was kept as retention for 6 months in both groups before removal (T2). Between time points T1 and T3, no additional orthodontic treatment was carried out on the patients.

Reformatting of the image volume was done to achieve an optimal and standardized visualization of the facial skeleton in three image planes orthogonal to each other: axial, sagittal, and coronal (Figure 3). Assessment and measurement of the different parameters used were performed according to the definitions and reference points as well as positions 1–3 stated in Table 1 and Figure 4. All measurements were performed by two experienced specialists in oral and maxillofacial radiology (Dr Miranda-Bazargani, Dr Lund) under optimal viewing conditions. All images were stored and reviewed in a picture archiving and communication system (Sectra, Linköping, Sweden). Remeasurement was performed after 3 weeks on 10 randomly selected participants to investigate intra- and interexaminer reliability.

Outcomes

The primary outcome was the midpalatal suture expansion in a coronal and axial view.

Secondary outcomes were as follows:

- MBLs, buccal and palatal, on the permanent first molars
- Bone thickness, buccal and palatal, measurement from root surface to the cortical bone buccal and palatal, respectively

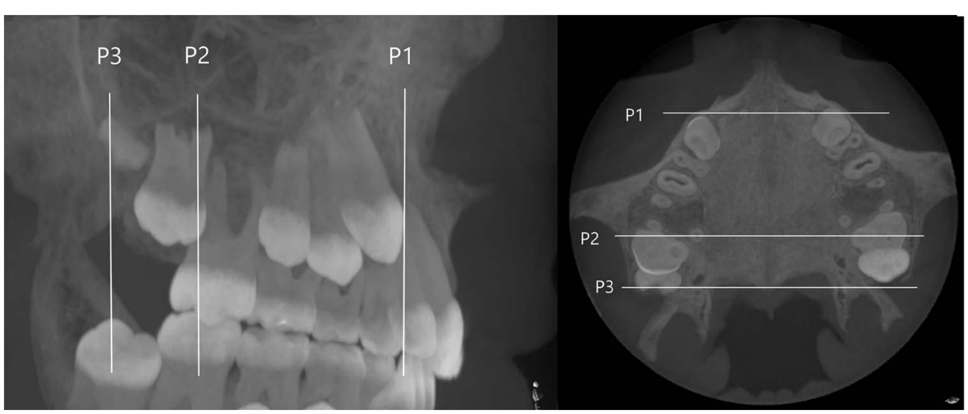

Figure 4. Sagittal and axial view of anteroposterior positions 1–3 (P1–3).

Table 2. Patient Characteristics[a]

Treatment	Frequency	%	Mean Age, y (SD, Min, Max)
QH			
Boy	14	66.7	
Girl	7	33.3	
Total	21	100.0	9.5 (SD ± 0.9, min 8.4, max 11.4)
RME			
Boy	13	61.9	
Girl	8	38.1	
Total	21	100.0	9.6 (SD ± 1.0, min 8.4, max 12.0)

[a] QH indicates quad helix; RME, rapid maxillary expansion; SD, standard deviation.

- Permanent first molar angles in relation to the midsagittal vertical line
- Fenestration, dehiscence, and root resorption of the permanent first molars

Blinding

Due to the study design, blinding was applicable only for outcome assessments.

Sample Size and Statistics

The calculated sample size for each group was based on a significance level of .05 and 90% power to detect a difference of 2 mm (SD ± 1.7) of the midpalatal suture expansion between the groups. The standard deviation was adapted from earlier studies.[18,19] The sample size calculation indicated that 17 patients would be required in each group. To compensate for dropouts, at least 20 patients were included in each group (an additional 15% per group). Descriptive data were derived and then a linear mixed-models analysis performed.

Primary and secondary continuous scaled outcome variables were evaluated as the change from baseline (T0) with a random intercept linear mixed model. Study groups (RME vs. QH), time (T1, T3), and their interactions were fixed factors. The analyses were adjusted for the baseline outcome (T0) as a covariate and study centers as a fixed factor. The estimated marginal mean differences between study groups were reported with 95% confidence intervals (CIs). Inter- and intraexaminer intraclass correlation (ICC) was performed between the two examiners.

RESULTS

Forty-two patients, with a mean age of 9.5 years (SD ± 0.9 years), were randomized to either treatment with QH or RME (Table 2). All patients were analyzed. Twenty patients were recruited from Örebro County and 22 from

Table 3. Midpalatal Suture Opening[a]

	T0	T1			T3		
	Mean (SD)	Mean (SD)	Mean Difference[b] (95% CI)	*P*	Mean (SD)	Mean Difference[b] (95% CI)	*P*
P1 (anterior)							
Midpalatal suture (sup)							
QH group	0.1 (0.2)	0.1 (0.2)	Ref.[c]		0.1 (0.1)	Ref.	
RME group	0.1 (0.3)	3.0 (1.6)	2.9 (2.4 to 3.4)	<.001	0.2 (0.7)	0.1 (−0.4 to 0.6)	.67
Midpalatal suture (inf)							
QH group	0.1 (0.2)	0.3 (0.4)	Ref.		0.1 (0.2)	Ref.	
RME group	0.6 (1.2)	4.1 (2.2)	3.1 (2.5 to 3.7)	<.001	1.1 (1.8)	0.3 (−0.3 to 0.9)	.34
P2 (first molar)							
Midpalatal suture (sup)							
QH group	0.0 (0.1)	0.1 (0.3)	Ref.		0.0 (0.0)	Ref.	
RME group	0.0 (0.0)	2.0 (0.9)	1.9 (1.6 to 2.2)	<.001	0.0 (0.0)	0.0 (−0.3 to 0.3)	.97
Midpalatal suture (inf)							
QH group	0.2 (0.3)	0.6 (0.6)	Ref.		0.2 (0.4)	Ref.	
RME group	0.2 (0.4)	2.4 (0.9)	1.7 (1.4 to 2.1)	<.001	0.3 (0.4)	0.0 (−0.3 to 0.4)	.86
P3 (posterior)							
Midpalatal suture (sup)							
QH group	0.0 (0.0)	0.0 (0.1)	Ref.		0.0 (0.0)	Ref.	
RME group	0.0 (0.1)	1.0 (0.8)	0.9 (0.6 to 1.2)	<.001	0.0 (0.2)	0.0 (−0.2 to 0.3)	.91
Midpalatal suture (inf)							
QH group	0.0 (0.0)	0.0 (0.1)	Ref.		0.0 (0.0)	Ref.	
RME group	0.0 (0.0)	1.1 (1.0)	1.1 (0.7 to 1.4)	<.001	0.0 (0.2)	0.0 (−0.3 to 0.4)	.79

[a] Measured in millimeters at three anteroposterior positions, P1–P3, and superoinferior, superior (sup) and inferior (inf). A comparison between RME and QH groups with linear mixed model. CI indicates confidence interval; QH, quad helix; RME, rapid maxillary expansion; SD, standard deviation.

[b] Primary outcomes were evaluated as the change from baseline (T0) with a random intercept linear mixed model. Study groups, center, time (T1, T3), and their interactions were fixed factors and the baseline outcome (T0) as a covariate, and the model's estimated marginal mean differences between study groups were reported with 95% CIs.

[c] Ref. Quad helix group is used as the reference value.

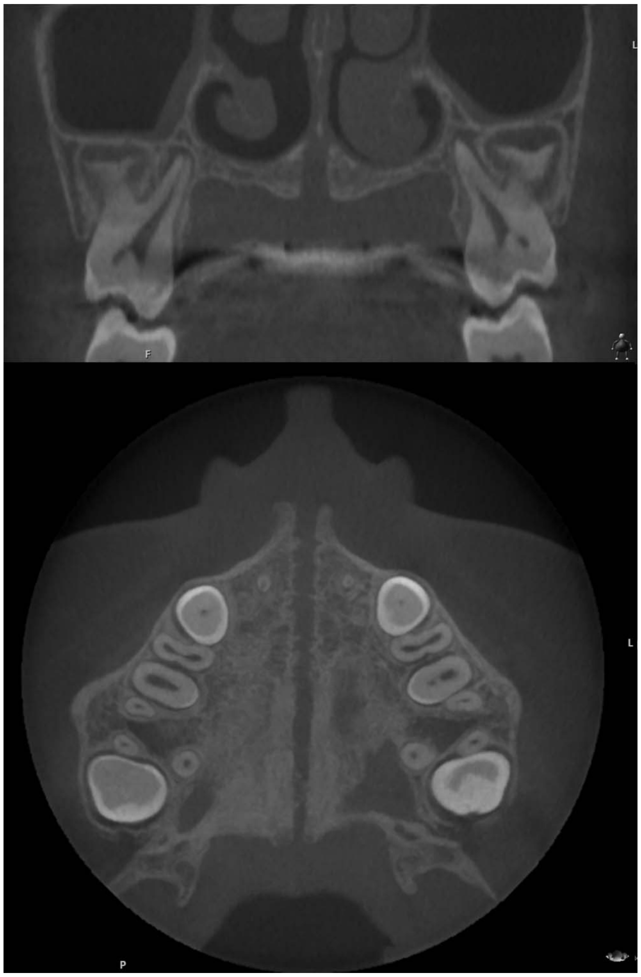

Figure 5. In a coronal view, the opening of the midpalatal suture directly after rapid maxillary expansion (upper). In an axial view, the opening of the midpalatal suture directly after rapid maxillary expansion (lower).

Jönköping County. The examiners of the CBCT scans (Dr Miranda-Bazargani, Dr Lund) had excellent ($>$.9) correlation on the primary outcome. The lowest values found were found in intraexaminer measuring angles ($>$0.7), which is considered moderate ICC.[20]

Primary Outcome

The primary outcomes are shown in Table 3 and Figure 5. In the QH group, no opening of the midpalatal suture was shown after expansion or at follow-up compared with baseline. The opening of the midpalatal suture, in a coronal view, in the RME group was confirmed to be slightly triangular. The midpalatal suture opened 4.1 mm inferiorly compared with 3.0 mm superiorly. In an axial view, the midpalatal suture opened more anteriorly, 4.1 mm at position 1, 2.4 mm at position 2, and 1.1 mm at position 3. At all three positions, as well as the superior and inferior part of the midpalatal suture, there was a statistically significant difference between groups ($P < .001$), At follow-up, the difference between groups was no longer statistically significant due to new bone formation at the suture in the RME group.

Secondary Outcomes

Table 4, Table 5, and Figure 6 present the secondary outcomes. Buccal MBL in the QH group lengthened significantly compared with the RME group between T0 and T1, which indicated decreased bone volume buccally on both the right ($P = .0055$) and the left side ($P = .0013$). Between T0 and T3, the significance was present only at the right side ($P = .035$), not the left ($P = .16$). Palatal MBL between groups had no significant difference at any time point.

Buccal bone width decreased in the QH group. The buccal bone width was, on average, 1.9 to 2.0 mm in both groups before treatment. At finished expansion (T1), the bone had decreased to 0.5–0.6 mm in the QH group. In the RME group, the buccal bone width maintained 1.5–1.7 mm at T1. This difference was statistically significant ($P < .001$).

The palatal bone width at T0 was 1.2–1.5 mm. In the RME group, the palatal bone width decreased at T1 compared with baseline but had increased in both groups at follow-up (T0–T3) but significantly more so in the QH group.

The frequency of buccal fenestration of the first permanent molar was statistically significant in the QH group compared with the RME group (T0–T1; $P = .0086$) on both the left and the right side. One year later, the difference was no longer significant. Palatal fenestration was present at baseline in both groups. After finished expansion, palatal fenestration was registered only in the RME group, but there was no significant difference between groups. No palatal fenestration was present in any group at follow-up (T3).

Root resorption was measured in four degrees of severity.[21] No resorption, grade 0, or slight resorption, grade 1, defined as up to half of the dentin thickness to the pulp, was found more on the left first molar in the QH group ($P = .013$) between T0 and T1 but was not significant at follow-up ($P = .22$). Moderate, grade 2, or severe, grade 3, resorption was not found in any of the patients.

DISCUSSION

Most previously published studies assessed the immediate effects of different expansion devices and very seldom evaluated the long-term effects and stability of the treatments. The finding of this longitudinal RCT showed that the midpalatal suture did not open in the QH group as earlier suggested.[6] In an axial view, the suture in the RME group opened most

Table 4. Comparing Secondary Outcomes at Position 2 Between the RME and QH Groups With a Linear Mixed Model[a]

	T0	T1			T3		
	Mean (SD)	Mean (SD)	Mean Difference[b] (95% CI)	*P*	Mean (SD)	Mean Difference[b] (95% CI)	*P*
Buccal MBL_{dx}							
QH group	0.8 (0.2)	1.3 (0.6)	Ref.[c]		1.1 (0.4)	Ref.	
RME group	1.1 (0.5)	0.9 (0.4)	−0.4 (−0.8 to −0.1)	.0055	0.9 (0.3)	−0.3 (−0.6 to −0.02)	.035
Buccal MBL_{sin}							
QH group	0.9 (0.3)	1.5 (1.0)	Ref.		1.1 (0.6)	Ref.	
RME group	0.8 (0.4)	0.8 (0.4)	−0.6 (−1.0 to −0.3)	.0013	0.8 (0.4)	−0.3 (−0.7 to 0.1)	.16
Palatal MBL_{dx}							
QH group	1.1 (0.5)	1.1 (0.5)	Ref.		1.2 (0.5)	Ref.	
RME group	0.9 (0.4)	1.2 (0.5)	0.1 (−0.2 to 0.4)	.58	1.0 (0.5)	−0.1 (−0.4 to 0.2)	.42
Palatal MBL_{sin}							
QH group	1.0 (0.2)	1.3 (0.6)	Ref.		1.3 (0.5)	Ref.	
RME group	0.9 (0.4)	1.2 (0.4)	−0.1 (−0.4 to 0.2)	.58	1.1 (0.4)	−0.1 (−0.4 to 0.1)	.32
Buccal bone $width_{dx}$							
QH group	1.9 (0.8)	0.5 (0.5)	Ref.		0.9 (0.5)	Ref.	
RME group	1.9 (0.8)	1.5 (0.6)	1.0 (0.8 to 1.3)	<.001	1.4 (0.6)	0.6 (0.3 to 0.8)	<.001
Buccal bone $width_{sin}$							
QH group	2.0 (0.6)	0.6 (0.6)	Ref.		0.9 (0.5)	Ref.	
RME group	1.9 (0.8)	1.7 (0.6)	1.1 (0.9 to 1.4)	<.001	1.5 (0.6)	0.6 (0.3 to 0.8)	<.001
Palatal bone $width_{dx}$							
QH group	1.5 (0.7)	2.8 (1.0)	Ref.		2.2 (0.9)	Ref.	
RME group	1.5 (0.7)	1.4 (0.7)	−1.4 (−1.8 to −1.0)	<.001	1.6 (0.8)	−0.6 (−1.0 to −0.2)	.0021
Palatal bone $width_{sin}$							
QH group	1.2 (0.6)	2.7 (0.9)	Ref.		2.1 (0.9)	Ref.	
RME group	1.2 (0.7)	1.4 (0.5)	−1.3 (−1.7 to −0.9)	<.001	1.6 (0.8)	−0.5 (−0.9 to −0.1)	.011
Angle 1_{dx}, °							
QH group	14.4 (4.9)	18.3 (4.8)	Ref.		14.0 (4.1)	Ref.	
RME group	11.9 (5.1)	15.5 (4.6)	−1.4 (−3.6 to 0.9)	.23	14.4 (5.5)	2.0 (−0.2 to 4.2)	.079
Angle 2_{sin}, °							
QH group	14.8 (5.2)	21.1 (7.7)	Ref.		16.5 (6.2)	Ref.	
RME group	14.6 (6.5)	17.2 (5.6)	−3.9 (−6.4 to −1.4)	.0031	15.3 (5.2)	−0.9 (−3.4 to 1.6)	.46

[a] CI indicates confidence interval; MBL, marginal bone level; QH, quad helix; RME, rapid maxillary expansion; SD, standard deviation.

[b] Outcomes were evaluated as the change from baseline (T0) with a random intercept linear mixed model. Study groups, center, time (T1, T3), and their interactions were fixed factors and the baseline outcome (T0) as a covariate, and the model's estimated marginal mean differences between study groups were reported with 95% CIs.

[c] Ref.: Quad helix group is used as the reference value.

anteriorly, consistent with earlier studies,[22–24] and in a coronal view, the suture opened most inferiorly. This is likely due to the resistance of the more rigid circummaxillary sutures[25] and might also be due the fact that the RME in this trial was anchored to the deciduous teeth. Deciduous teeth have theoretically somewhat lower anchorage value because of their short roots and are not as stable as the permanent first molars are. The increased angulation of the molars in this study is explained by alveolar bending as well as dental tipping.[19]

A sound conclusion was not made as to whether slow or rapid maxillary expansion has the least periodontal side effects.[26] In this RCT, QH showed more bone loss than rapid expansion did, which extends the knowledge of earlier studies.[9,27] In the present study, the QH was anchored on the first permanent molars, and the RME was anchored on the second deciduous molars and deciduous canines, which, to some extent, explains the favorable outcome for the first permanent molars in the RME group. The endpoint of the first permanent molars, however, was the same in both groups. Previous studies have favored using primary teeth as anchorage for maxillary expansion due to the preservation of buccal bone on the permanent first molars as well as more stable expansion in the anterior area.[28,29] In this study, bite blocks were used on the deciduous second molars in both groups during the expansion phase for disarticulation and elimination of occlusal interferences and the bite force. Bite blocks have been proven to be well accepted by patients.[16]

QH is preferred by general practitioners for correcting unilateral posterior crossbites.[30] With the current knowledge, it is recommended to raise awareness of buccal fenestrations that were found in as many as one-third of all first molars treated with QH, a side effect worth considering when choosing appliances. At follow-up, however, the presence of fenestrations had decreased to one-fifth. This could be explained by uprighting and/or relapse of the molars after removal of the appliance.

Table 5. Fenestrations and Root Resorption on the First Permanent Molars (16, 26): Comparison Between RME (n = 21) and QH Groups (n = 21)[a]

	RME Group (n = 21)	QH Group (n = 21)	P[b]
Buccal fenestration (16 mb)			
T0	0 (0%)	0 (0%)	NA
T1	0 (0%)	7 (33%)	.0086
T3	0 (0%)	4 (19%)	.11
Buccal fenestration (26 mb)			
T0	0 (0%)	0 (0%)	NA
T1	0 (0%)	7 (33%)	.0086
T3	0 (0%)	4 (19%)	.11
Palatal fenestration (16 p)			
T0	1 (5%)	1 (5%)	>.99
T1	4 (19%)	0 (0%)	.11
T3	0 (0%)	0 (0%)	NA
Palatal fenestration (26 p)			
T0	0 (0%)	2 (10%)	.49
T1	3 (14%)	0 (0%)	.23
T3	0 (0%)	0 (0%)	NA
Root resorption[c] (16)			
T0 any grade	0 (0%)	0 (0%)	NA
T1 any grade	1 (5%)	6 (29%)	.093
mb	0	0	
db	0	2	
pal	1	4	
T3 any grade	3 (14%)	2 (10%)	>.99
mb	0	0	
db	0	0	
pal	3	2	
Location of resorption (16)			
T0 any grade	0 (0%)	0 (0%)	NA
T1 any grade	1 (5%)	6 (29%)	.093
Apical	1	2	
Middle	0	2	
Cervical	0	2	
T3 any grade	3 (14%)	2 (10%)	>.99
Apical	3	1	
Middle	0	1	
Cervical	0	0	
Grade 1, slight resorption (16)			
T0	0 (0%)	0 (0%)	NA
T1	1 (5%)	6 (29%)	.093
T3	3 (14%)	2 (10%)	>0.99
Root resorption[c] (26)			
T0 any grade	0 (0%)	0 (0%)	NA
T1 any grade	1 (8%)	8 (57%)	.013
mb	0	0	
db	0	2	
pal	1	4	
T3 any grade	0 (0%)	3 (21%)	.12
mb	0	0	
db	0	0	
Pal	3	2	
Location of resorption (26)			
T0 any grade	0 (0%)	0 (0%)	NA
T1 any grade	1 (8%)	8 (57%)	.013
Apical	1	6	
Middle	0	2	
Cervical	0	0	
T3 any grade	0 (0%)	3 (21%)	.22
Apical	0	2	
Middle	0	1	
Cervical	0	0	

Table 5. Continued

	RME Group (n = 21)	QH Group (n = 21)	P^b
Grade 1, slight resorption (26)			
T0	0 (0%)	0 (0%)	NA
T1	1 (8%)	8 (57%)	.0088
T3	0 (0%)	3 (21%)	.12

[a] NA indicates not applicable; QH, quad helix; RME, rapid maxillary expansion.
[b] Statistical method was Fischer exact test.
[c] Root resorption was measured in four degrees of severity: no resorption (grade 0), slight resorption (grade 1), moderate resorption (grade 2), and severe resorption (grade 3).

CONCLUSIONS

- QH did not open the midpalatal suture in the EMD.
- The opening of the midpalatal suture with the RME was more anterior and inferior.
- More buccal bone loss and fenestration were seen on the permanent first molar in patients treated with QH anchored to the first permanent molars than RME on deciduous teeth.

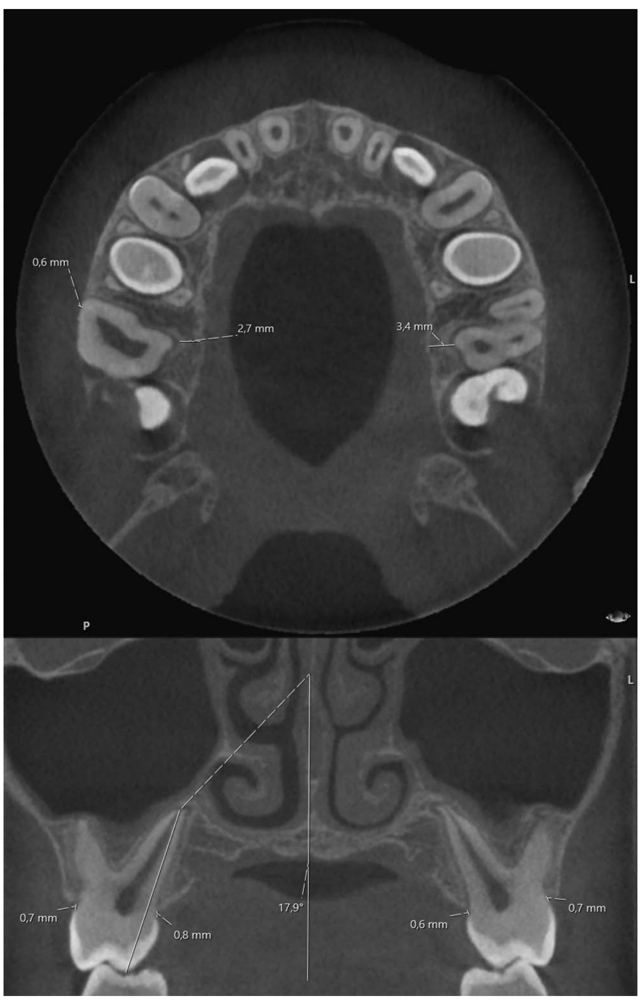

Figure 6. Buccal and palatal bone width at follow-up in the quad helix group (upper). Buccal and palatal marginal bone level and first permanent molar angulation (lower).

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