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Original article

Three-dimensional evaluation of palatal vault changes after unilateral posterior crossbite correction with quad helix or rapid maxillary expansion: A randomized controlled trial with 1-year follow-up

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Highlights

- Both appliances normalized palatal vault dimensions, 6 months post-retention.
- Rapid maxillary expansion showed slightly greater palatal changes than quad helix in the early mixed dentition.
- Rapid maxillary expansion reduced treatment time by 97 days with an equal success rate to quad helix.

Keywords
Palatal expansion technique
Rapid maxillary expansion
Quad helix
Posterior crossbite
Three-dimensional imaging

Summary

Objectives > To compare the effects of quad helix (QH) anchored on permanent molars versus rapid maxillary expansion (RME) anchored on deciduous teeth on palatal morphology in early mixed dentition patients.
Trial design > A two-arm randomized controlled trial, together with a non-randomized normal bite data for comparison.

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Early mixed dentition
Orthodontics
Orthodontic appliances

Methods > Seventy-one patients (mean age: QH = 9.3 years; RME = 9.4 years) with unilateral posterior crossbite were analysed. The QH group (*n* = 36) and RME group (*n* = 35) were evaluated at baseline (T0), post-retention (T2), and one-year post-treatment (T3). A third age- and sex-matched control group (*n* = 22; mean age = 9.1 years) served as a normative reference. Evaluated outcomes were 3D palatal measurements, as well as treatment success rate and total treatment duration.

Results > Both treatment groups showed significant increases in palatal surface area, projection plane area, and volume from T0 to T3. The RME group experienced a greater increase in palatal surface area (7.0%) compared to the QH group (4.2%) over the same period (*P* = 0.045). Palatal volume increased notably more in the RME group during active treatment (T0–T2), with an 11.2% gain versus 6.8% in the QH group (*P* = 0.046). By T3, palatal vault dimensions had normalized in both groups compared to the control group. The RME group completed treatment 97 days earlier than the QH group.

Conclusions > Treatment with either QH or RME resulted in normalized palatal vaults compared to the control group. RME had a significantly shorter treatment time but achieved similar success in correcting posterior crossbite as QH.

This trial was registered at ClinicalTrials.gov (ID NCT04458506) and Researchweb.org (project number 260581).

Introduction

Unilateral posterior crossbite is one of the most common malocclusions, affecting approximately 8% of children in the mixed dentition [1,2]. When the unilateral crossbite is caused by a narrow intermolar width and/or narrow maxilla the mandible tends to shift to the side to have more occlusal contacts; this is referred to as forced bite or functional shift. Untreated posterior crossbite with a functional shift has been correlated to skeletal and muscle asymmetry, temporomandibular disorders, and facial asymmetry [3,4]. Asymmetrical growth may also progress over time [5], which is why it is recommended that it be treated early [6]. A newly published article also stated an association between a narrow palate and sleep-disordered breathing in non-syndromic children; the causation is yes not determined [7]. The treatment goals are therefore to normalize the narrow palate, remove the functional shift, and facilitate normal growth and development.

The selection of treatment modalities for the correction of unilateral posterior crossbites varies across different countries and among practitioners [8,9]; however, the choice may also be influenced by the patient's age. Evidence suggests that for children in the early mixed dentition stage (age 7 to 11 years old), quad-helix and expansion plates are more beneficial than no treatment for correcting posterior crossbites. Additionally, the quad-helix is more effective than expansion plates for correcting posterior crossbite and increasing intermolar distance. For adolescents in permanent dentition (age 12 to 16 years old), Hyrax and Haas are similar for posterior crossbite correction and increasing the inter-molar distance [10]. However, in the early mixed dentition stage, RME can also be an option for treatment and can be anchored to either permanent or deciduous teeth. Treatment with RME on the deciduous dentition has been suggested to be beneficial to avoid side effects such as decreased buccal bone thickness [11–13]. These appliances are also described for preventing anterior crowding in non-crossbite patients [14].

Linear measurements have been widely used in orthodontics, but these measurements fail to account for the complex three-dimensional (3D) shape of the palate and may be skewed by tooth inclination and angulation [15]. Within orthodontics, the adoption of three-dimensional techniques offers significant benefits, such as assessing treatment outcomes and monitoring normal growth. For instance, the evaluation of the palatal vault has previously been conducted using 3D scanning method, before and after treatment, which has proven to be reliable [16–19]. 3D evaluation provides a more accurate and detailed analysis of the palatal vault, enabling better assessment of treatment outcomes and monitoring of post-treatment changes. The evaluation of treatment effects within randomized controlled trials (RCTs) provides critical insights into the efficacy of various treatment modalities. Such evaluations ascertain the impact achieved and determine whether specific treatments should be favoured over others. Consequently, the objective of this RCT was to compare changes of the palatal vault using QH anchored on the permanent first molars versus RME anchored to the deciduous dentition in patients in the early mixed dentition.

Materials and methods

Trial design

This RCT was a two-centre study, with a concealed allocation. The ratio was 1:1 between groups. The study protocol was approved by the Regional Ethical Review Board in Uppsala, Sweden, which follows the guidelines of the Declaration of Helsinki (Dnr: 2018/308). All participants and caregivers gave their written consent

before entering the study. This study was reported according to the CONSORT guidelines [20].

Participants, eligibility and setting

Between May 2019 and May 2021, a total of 72 patients were randomized at the Postgraduate Dental Education Center, Region Örebro County, Sweden, and the Institute for Postgraduate Dental Education, Region Jönköping County, Sweden, 36 in each centre (*figure 1*).

Inclusion criteria were: Unilateral posterior crossbite with functional shift. Early mixed dentition: the first permanent molar had to be erupted, and the maxillary second deciduous molar and canine had to be persisting. A class I or class II molar relation with a maximum of 5 mm overjet. Patients with craniofacial syndromes and/or orofacial cleft patients were excluded.

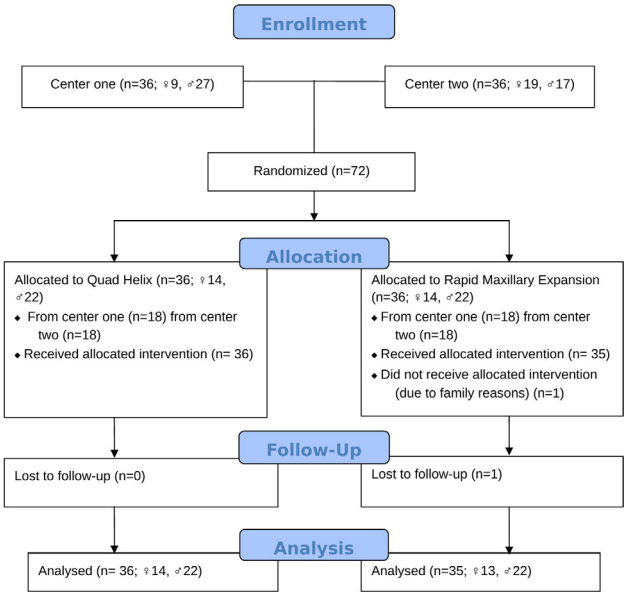

FIGURE 1

Flow diagram

Randomization

The patients were randomized, and the allocation was concealed. A computer-generated randomization list was created using SPSS software (version 25.0; IBM SPSS, Chicago, IL, USA) and stored with a research secretary. After the patient and caregivers received oral and written information about the clinical trial, and signed a consent form, the secretary was contacted to provide the information about which type of expander the patient should receive [21].

Intervention

The QH, constructed by a technician, was anchored to the first permanent molar with bands. Activation of the QH commenced one molar width before cementation and was monitored every

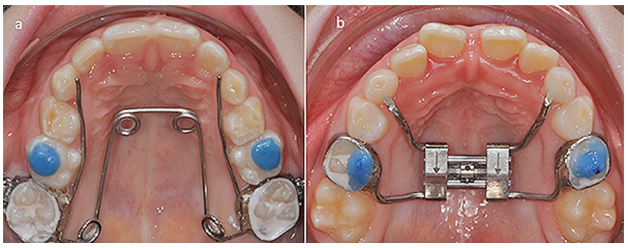

FIGURE 2

Clinical photographs of Quad-helix and RME (anchored to the primary teeth)

6–12 weeks. The RME, hyrax type (Leone Orthodontic Products, Florence, Italy) was anchored on the deciduous second molar and bonded to the deciduous canine (*figure 2*). The RME was activated a quarter turn (0.2 mm) twice a day. Finished expansion (T1) was defined as when the palatal cusp of the maxillary first permanent molar touched the buccal cusp of the mandibular first permanent molar. Models were taken at three timepoints T0, T2 and T3.

T0: baseline.

T1: finished expansion (no models).

T2: appliance removal (6 months after T1).

T3: one year after finished expansion (12 month after T1).

For digital imprints one centre utilized intraoral scanning (Trios 3, 3Shape, Copenhagen, Denmark). The other centre took alginate imprints (Cavex Orthotrace, Cavex, Haarlem, Holland) that were digitalized with a desktop scanner (PlanScan Lab 5.0, Planmeca, Helsinki, Finland).

An age- and sex- matched control group (n = 22, mean age 9.1 years) in the early mixed dentition, with normal transverse relations, was used to compare means at follow-up (T3). Data for the control group were collected mainly from an earlier published trial [19] together with two additional normal cases (2 girls) recruited from Malmö University, to be matched by age and sex, with normal occlusion, and no or mild orthodontic treatment need (IOTN-DHC of 1 or 2).

Three-dimensional measurements of maxillary morphology were obtained using the reverse modelling software Rapidform. (INUS Technology Inc., Seoul, South Korea) Measurements and calculations for palatal surface area (PSA) (*figure 3*a), projection plane area (PPA) (*figure 3*b), and palatal volume (PV) (*figure 3*c) required defining palatal boundaries in three dimensions. Vertically, the gingival horizontal plane served as the boundary, determined by a best-fit plane through the midpoints of dentogingival junctions of all teeth from the first permanent molars. Posteriorly, a distal plane perpendicular to the gingival horizontal plane was established through two points positioned distal to the first permanent molars. Subsequently, the software computed the PSA, PPA and PV. The analysis followed the protocol by Primozic et al. [18], a well-established method in previous

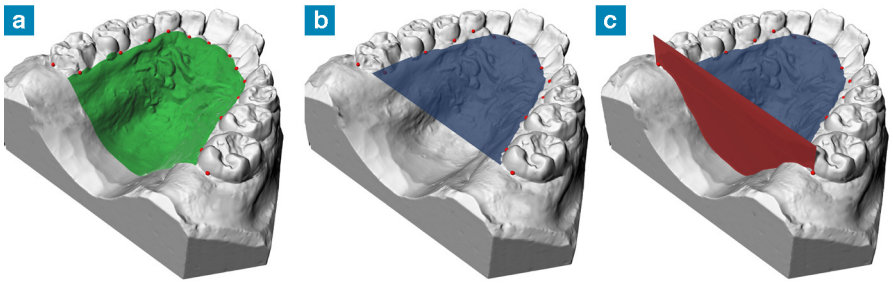

FIGURE 3

Measurements defining palatal boundaries in three dimensions: a: palatal surface area (PSA); b: projection plane area (PPA); c: palatal volume (PV)

studies [16,19]. All analyses were conducted by a single researcher (LB), who is experienced in this method and was blinded to group assignments.

Outcomes

Outcomes in this study included crossbite correction and normal transverse relations at follow-up (T3), one year after completion of expansion, as well as changes in the PSA, PPA, and PV, along with treatment time.

Blinding

Due to the study design, blinding the patients or clinical operators was not possible; the outcome accessors were blinded to group assignments.

Sample size estimation and statistical analysis

The sample size was estimated from an earlier published study [19], which estimated a minimum of 23 patients in each group with 80% power and an alpha of 0.05, assuming the same variance as Primozic et al. in their study as a basis for clinically relevant changes [18].

Changes in outcomes (at T2/T3 minus T0) between groups were evaluated with a random intercept linear mixed model. Study groups and times (T2, T3) and the interaction (group × time) were used as fixed factors, and the baseline outcome variable at T0 as covariate. The same type of analysis but with T0 as the outcome was used to compare the outcomes within the study groups. Multiple comparisons were managed with the Benjamin-Hochberg (B-H) procedure to control the false discovery rate, and adjusted *P*-values were reported. For comparisons between the QH and RME groups, *P*-values were adjusted for six tests (three outcomes tested at two timepoints). For within-group comparisons, *P*-values were adjusted for 18 tests (three outcomes tested three times within the QH and RME groups, respectively). The outcomes transformed to a $\log_{10}$ scale were used to estimate the mean percentage change between time points. Multiple imputation (MI) was used due to missing outcome data at baseline for one patient in the RME group. Ten imputations using chained equations were estimated by linear regression with treatment groups, age, sex and the outcomes as predictors. The mixed-model analysis was performed by combining the imputed data sets with MI command in STATA as primary analysis and with exclusion of the missing patient as secondary analysis. The mean differences of outcomes in the mixed models were reported with 95% confidence intervals (CIs). The outcomes at T3 for each study group were compared to those of a control group with unpaired *t*-test, and the results were visualized using boxplots. A *P*-value below 0.05 was considered statistically significant and the analyses were performed with SPSS Statistics 25 (IBM, Armonk, N.Y.) and Stata release 17 (StataCorp, College Station, TX).

Registration

This trial was registered at ClinicalTrials.gov (ID NCT04458506) and Researchweb.org (project number 260581).

Results

Thirty-six patients were treated with QH and 35 with RME. One patient dropped out before receiving intervention due to family reasons. Included 3D scans used as controls with a normal bite were 22 (*table I*).

Table I
Patient characteristics

	QH (n = 36)	RME (n = 35)	Controls (n = 22)	P-value[1]
Age, mean (SD) Minimum–maximum	9.3 (0.8) (8.4–11.4)	9.4 (0.9) (8.3–12.1)	9.1 (0.9) (7.7–10.7)	
Girls, n (%)	14 (38.9)	13 (37.1)	8 (36.4)	
Boys, n (%)	22 (61.1)	22 (62.9)	14 (63.6)	
Total treatment time (days)	310.86 (65.30)	214.17 (22.88)	–	< 0.001
Expansion phase (T0–T1)	119.75 (59.28)	22.74 (19.96)	–	< 0.001
Retention phase (T1–T2)	191.11 (16.94)	191.43 (12.58)	–	0.929
Follow-up (T2–T3)	193.67 (26.18)	195.37 (22.73)	–	0.771
Success rate[2]	31/36 = 86.1%	31/35 = 88.6%		

SD: standard deviation.
[1]Statistical analysis, Pearson Chi^2 test was applied on categorical data, comparing means with independent sample t-test. Statistical significance $P < 0.05$.
[2]Defined as normal transverse relation at follow-up one year after expansion phase.

Success rate

Success at follow-up (T3) was defined as normal transverse relations on the first permanent molars. According to an intention-to-treat approach, 31 out of 36 were described as successes at T3, in both groups. Provided that the randomized patient who did not receive any treatment is classified as a failure (RME group). In the analysis, this patient was excluded because no models were available at both T2 and T3 time points.

A total of 71 participants received treatment, with 31 of 35 patients (88.6%) in the RME group and 31 of 36 in the QH group (86.1%) being defined as successful at T3. The non-success differed between groups. In the QH group, three patients had persisting overcorrection with scissor bite on the permanent molars at T3, and two had relapsed to edge-to-edge relation (5.5%). One patient in the RME group had a persisting crossbite at T2 due to early loss of deciduous molars, and two had just reached edge-to-edge alignment. At T3, one additional RME patient had an edge-to-edge relationship due to relapse (2.9%), and the one patient with early loss of deciduous molars in the RME group had not self-corrected at T3; no scissor bite was observed in the RME group.

Palatal surface area

When removing the appliance, at T2, the QH group had increased the PSA with a 107 mm^2 (8.5%) while the RME group increased with 136 mm^2 (11%) both groups had the same PSA at T2 (QH: 1365 mm^2, vs. RME: 1359 mm^2) the increase in both groups were statistically significant ($P < 0.001$). At T3, both groups ended on the same levels, QH: 1311 mm^2, vs. RME: 1310 mm^2. The decrease in amount between T2 and T3 was also nearly the same in both groups. The total increase of PSA between T0 and T3 was 53 mm^2 (4.2%) in the QH group ($P < 0.001$) and 86 mm^2 (7%) in the RME group ($P < 0.001$). The difference between QH and RME group, were statistically significant in favour to the RME group, which had a bigger total increase of PSA (T0-T3) compared to the QH group ($P = 0.045$) (*tables II and III*, *figure 4*a).

TABLE II

Comparing the outcomes within and between QH and RME groups with a linear mixed model

	T0	T2	T3	T2 vs. T0		T3 vs. T2		T3 vs. T0	
	Mean (SD)	Mean (SD)	Mean (SD)	Mean difference (95% CI)	B-H adjusted *P*-values[2]	Mean difference (95% CI)	B-H adjusted *P*-values[2]	Mean difference (95% CI)	B-H adjusted *P*-values[2]
QH group, *n* = 36									
Palatal surface area	1258 (124)	1365 (136)	1311 (129)	107 (84 to 131)	< 0.001	−54 (−70 to −38)	< 0.001	53 (33 to 73)	< 0.001
Projection surface area	907 (84)	1020 (96)	965 (91)	113 (94 to 132)	< 0.001	−55 (−73 to −37)	< 0.001	58 (39 to 76)	< 0.001
Palatal surface volume	5380 (867)	5771 (1066)	5844 (986)	392 (245 to 538)	< 0.001	73 (−55 to 200)	0.28	464 (315 to 613)	< 0.001
RME group, *n* = 35									
Palatal surface area	1223 (98)[1]	1359 (112)	1310 (100)	135 (114 to 155)	< 0.001	−49 (−64 to −33)	< 0.001	86 (66 to 106)	< 0.001
Projection surface area	879 (87)[1]	1017 (102)	963 (93)	137 (115 to 160)	< 0.001	−54 (−72 to −35)	< 0.001	84 (61 to 107)	< 0.001
Palatal surface volume	5171 (754)[1]	5766 (872)	5749 (847)	589 (444 to 735)	< 0.001	−18 (−114 to 79)	0.72	572 (419 to 725)	< 0.001
QH vs. RME group				Change T2 to T0 adjusted for T0				Change T3 to T0 adjusted for T0	
Palatal surface area				25 (−5 to 56)	0.21			29 (1 to 57)	0.14
Projection surface area				22 (−10 to 54)	0.26			21 (−12 to 53)	0.26
Palatal surface volume				213 (8 to 418)	0.14			105 (−110 to 319)	0.34

[1] *n* = 34 in RME group, multiple imputation used for one patient with missing outcome data at baseline.
[2] Multiple comparisons were addressed using the Benjamin-Hochberg (B-H) procedure to control the false discovery rate. For comparisons between QH vs. RME groups, *P*-values were adjusted for six tests and for comparisons within groups, *P*-values were adjusted for 18 tests.

TABLE III

Comparing the outcomes mean percentage difference between T0, T2 and T3 with linear mixed model

	T0	T2	T3	T2 vs. T0	T3 vs. T2	T3 vs. T0
	Mean	Mean	Mean	Mean percentage differences (95% CI)	Mean percentage differences (95% CI)	Mean percentage differences (95% CI)
QH group, *n* = 36						
Palatal surface area	1258	1365	1311	8.5 (6.6 to 10.5)	−4.0 (−5.1 to −2.8)	4.2 (2.6 to 5.8)
Projection surface area	907	1020	965	12.4 (10.3 to 14.6)	−5.4 (−7.1 to −3.7)	6.4 (4.3 to 8.4)
Palatal surface volume	5380	5771	5844	6.8 (4.2 to 9.6)	1.6 (−0.6 to 3.9)	8.5 (5.8 to 11.4)
RME group, *n* = 35						
Palatal surface area	1223[1]	1359	1310	11.0 (9.3 to 12.7)	−3.5 (−4.6 to −2.4)	7.0 (5.3 to 8.8)
Projection surface area	879[1]	1017	963	15.6 (13.1 to 18.1)	−5.2 (−6.9 to −3.6)	9.6 (7.0 to 12.1)
Palatal surface volume	5171[1]	5766	5749	11.2 (8.3 to 14.2)	−0.2 (−2.0 to 1.6)	11.0 (8.0 to 14.1)

[1] *n* = 34 in RME group, multiple imputation used for one patient with missing outcome data at baseline.

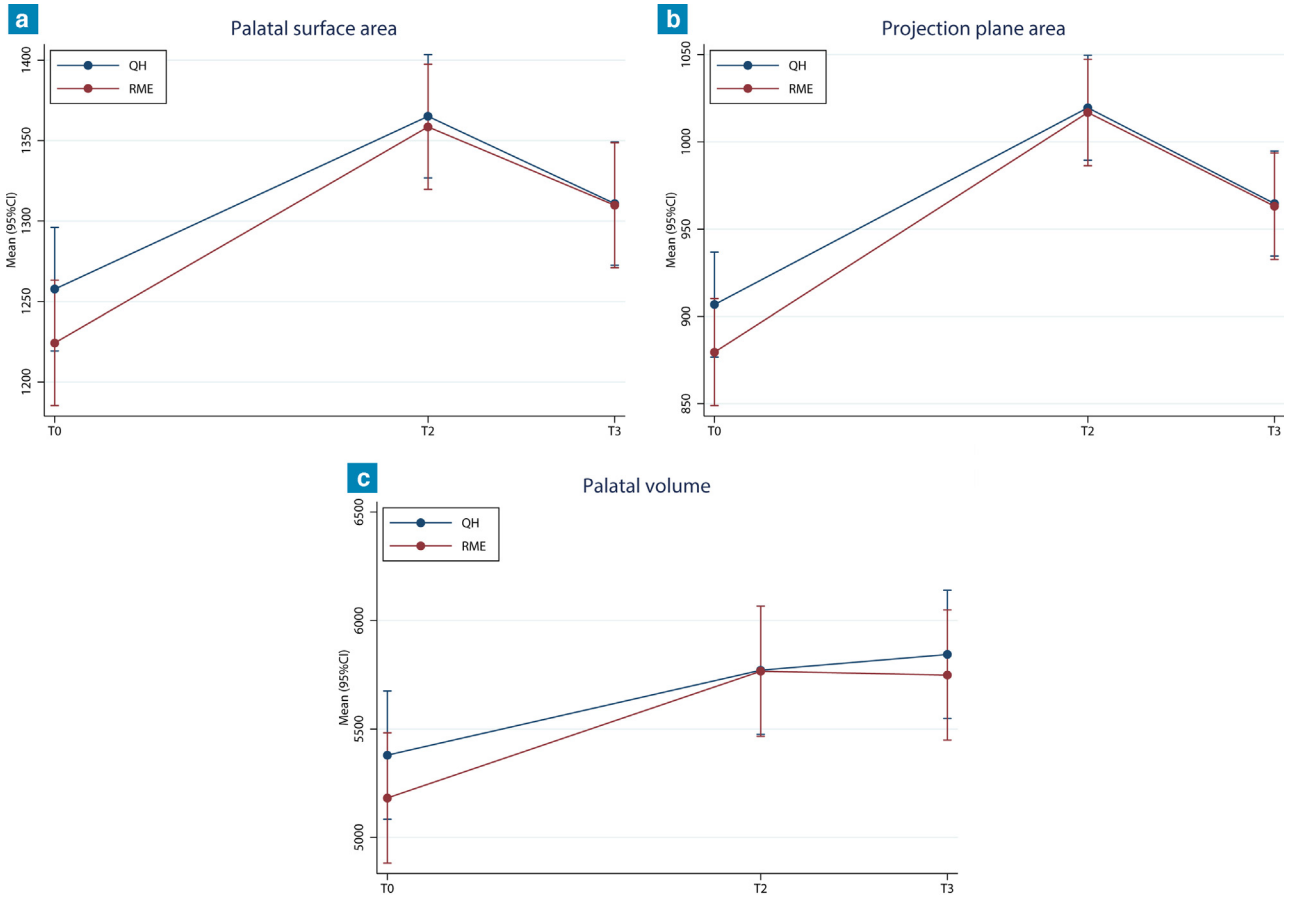

FIGURE 4

Boxplot comparing treatments at follow-up: a: palatal surface area (PSA); b: projection plane area (PPA); c: palatal volume (PV)

Projection plane area

Significant differences in both groups were seen between T0 and T2 ($P < 0.001$) as well as total increase in PPA (T0–T3) ($P < 0.001$). At follow-up, a total increase of 58 mm^2 (6.4%) was measured in the QH group and 84 mm^2 (9.6%) in the RME group. No statistically significant difference was seen between groups T0–T3 regarding PPA ($P = 0.21$) (*tables II and III*, *figure 4*b).

Palatal volume

The PV in the QH group were at baseline 5380 mm^3 and in the RME group 5171 mm^3. At T2 the volume in the QH group had increased to 5771 mm^3 (6.8%) and the RME group had increased to the same level, 5766 mm^3 (11.2%). The changes between T0-T2 adjusted for baseline showed a significant difference of increased PV (T0–T2) between groups, favouring the RME group ($P = 0.042$). Changes T0–T3 showed no difference between groups ($P = 0.34$) (*tables II and III*, *figure 4*c).

Intraclass correlation (ICC) were performed remeasuring 30 randomly chosen cases at least 6 weeks after first measurement. The ICC of the assessor (L.B) was excellent on all measurements (PSA: 0.995, PPA: 0.987, PV: 0.995).

Control group

In comparison with a control group at T3 there were no significant difference between the normal transverse relation group and the patients treated with either QH or RME regarding PSA, PPA, PV (*table IV*, *figure 5*a–c).

Table IV

Comparing the outcomes at T3 between controls and patient groups

	T3	QH vs. controls		RME vs. controls	
	Mean (SD)	Mean differences (95% CI)	*P*-value	Mean differences (95% CI)	*P*-value
Controls, *n* = 22					
Palatal surface area	1295 (124)				
Projection surface area	940 (68)				
Palatal surface volume	5754 (1131)				
QH group, *n* = 36					
Palatal surface area	1311 (129)	16 (−53 to 85)	0.65		
Projection surface area	965 (91)	24 (−21 to 69)	0.28		
Palatal surface volume	5844 (986)	89 (−476 to 655)	0.75		
RME group, *n* = 35					
Palatal surface area	1310 (100)			14 (−45 to 75)	0.63
Projection surface area	963 (93)			23 (−23 to 69)	0.33
Palatal surface volume	5749 (847)			−6 (−575 to 564)	0.98

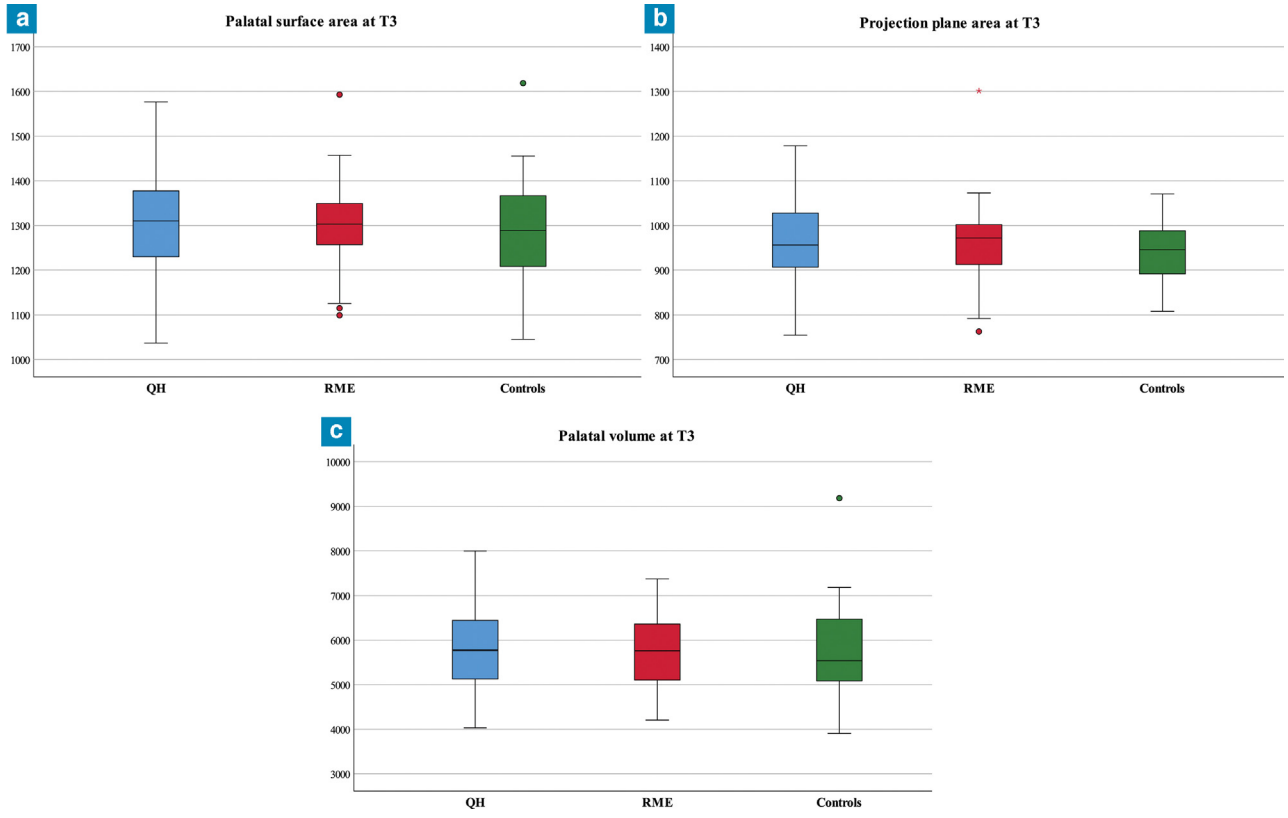

FIGURE 5

Boxplot comparing treatments to a control group with normal occlusion at T3: a: palatal surface area (PSA); b: projection plane area (PPA); c: palatal volume (PV)

Treatment time

Total treatment time was significantly shorter ($P < 0.001$) in the RME group, at 214 days compared to 311 days in the QH group. Both groups included 6 months of retention, with a mean of 191 days in both groups (T1–T2).

Discussion

This study provides new insights into the changes of the palatal vault, comparing traditional QH with RME anchored in the primary dentition, as well as treatment time and success rates.

The success rates were equal between groups at T3, as well as the amount of relapse of the posterior crossbites. The relapse rates were 2.9% in the RME and 5.5% in the QH group, which coincides with the lower levels reported in earlier studies evaluating stability with QH or RME, which found relapse rates of 5–15% after 1–5 years [16,22–24].

In this study, the retention period was 6 months and equal between groups [25]. Other studies employ different retention protocols, which can vary between treatment modalities. One research team performing RME on primary teeth with a Haas-type expander retained their appliance for up to 12 months [14], while others suggest a shorter need for retention in QH treatments, such as 3 months full-time use and 3 months part-time use [22]. The need and time for retention are subjects yet to be researched.

All participants who were treated in this study were included in the analysis, even those who did not have normal transverse relations at T3. This, however, can affect the total volume and areas. Overexpansion, such as scissor bite, was only observed in the QH group, which can be discussed. Although these treatments were all performed by orthodontists, it may be due to less control over the initial amount of expansion (one molar width) produced by the appliance compared to RME. The amount of expansion was not standardized in the QH group. However, the treatment endpoints were indeed defined.

The PSA, PPA, and PV all increased significantly in both groups between T0 and T2, as well as between T0 and T3. Both treatments normalized the narrow maxilla compared to controls with normal occlusion at T3. Although the groups were randomized with concealed allocation, a slight difference was observed at baseline between the groups. The outcome of this difference reveals a significant mean difference in change between

groups, where the PV increased more in the RME group between T0 and T2 (P = 0.042), as did the PSA, which also increased significantly more in the RME group between T0 and T3 (P = 0.045). However, the endpoints at T2 and T3 were nearly identical in both groups for PSA and PPA.

An earlier published randomized controlled trial treating posterior crossbite with RME on permanent molars, with or without skeletal anchorage, had similar material and methods [16], and baseline values between 4944–5250 mm^3 for PV, similar to our study but slightly smaller, this can be due to their inclusion of bilateral as well as unilateral crossbites. The homogeneity enables us to compare our results with those reported by Malmvind et al. RME anchored on the first permanent molars resulted in increased of the PV by almost 1000 mm^3 [16], while the PV increased just close to 600 mm^3 in RME anchored on deciduous teeth and not even 400 mm^3 in the QH group in our study. The reason for this can be discussed; at a skeletal level, the RME on deciduous teeth opens the midpalatal suture slightly triangular, more anteriorly than posteriorly, in this age group [26]. A triangular opening of the midpalatal suture has also been seen in an older population (13.8 $\pm$ 1.7 years) [27]. A more parallel opening of the suture has been seen when anchoring the RME on permanent molars in younger patients (9.3 $\pm$ 1.3 years) [28]. This additional skeletal effect might increase the palatal volume compared to RME anchored on the deciduous teeth and QH.

When evaluating expansion treatments, intermolar and intercanine measurements are often used. However, when doing linear measurements, we lean on two single points; if one deciduous canine exfoliates after treatment, the intercanine distance would be missing data. When evaluating the PPA, there are more points for best-fitting areas, and therefore less sensitive to exfoliation of single deciduous teeth. The PPA gives us a perception of the inner arch perimeter and the intermolar width. An increase in the arch perimeter provides more room for the permanent teeth [29].

Both appliances followed the same pattern of decrease of PSA and PPA between T2 and T3. The PV between T2 and T3 did not decrease significantly in either group. The QH group even tended to increase; this pattern coincides with earlier studies [16] and may feasibly indicate continued growth.

Comparing these two treatments with data from non-ionizing 3D volumes does not assess the skeletal effects and side effects. An earlier published study found that patients treated with QH lost more buccal bone compared to RME on the deciduous molars [13], a finding supported by other studies that concluded evident buccal bone loss accompanied by slow expansion [26,30].

Nevertheless, both RME and QH contributed to normalizing the palatal vault compared to a control, and the relapse rate was low. Treatment time, however, was almost 100 days longer in the QH group; this also needs to be considered when determining what appliance to use in these patients.

Conclusions and clinical implications

Both RME on deciduous teeth and QH on permanent first molars normalize the palatal vault compared to a control group. Both RME and QH achieved equal success rates one year after expansion. The palatal surface area and volume increased more with RME but ultimately reached the same levels as QH at 6 months post-retention. However, RME treatment was, on average, 97 days shorter than QH, suggesting that RME anchored to deciduous teeth might be a preferable choice of appliance during early mixed dentition.

Harms : No harm was observed in any patient.

Limitations : The sample size was an estimate from earlier studies and can be seen as a limitation; however, a significant difference was observed between groups regarding PV and PSA.

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Rune Lindsten: conceptualization; investigation; resources; supervision; writing – review and editing.
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Maja Ovsenik: methodology: writing – review and editing.
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