Maxillary Canine Transverse and Angular Changes Due to Rapid Maxillary Expansion In Early Interceptive Treatment Patients Analyzed with Cone Beam Computed Tomography

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ABSTRACT

Objective: The purpose of this retrospective study was to evaluate the changes in the maxillary skeletal width, maxillary canine angulations and transverse widths, and maxillary first molar angulations and transverse widths in early interceptive orthodontic patients with and without rapid maxillary expansion (RME).

Materials and Methods: Pretreatment and posttreatment cone-beam computed tomography (CBCT) scans of 56 early interceptive treatment patients were retrospectively evaluated. Of the 56 patients, the control group consisted of 19 patients who were treated with fixed, traditional orthodontic appliances not including rapid maxillary expansion as part of their early interceptive orthodontic treatment. The expansion group consisted of 37 patients treated with RME followed by fixed traditional orthodontic appliances as part of their early treatment protocol. Linear and angular measurements made at the level of the first molars and maxillary canines between pre-treatment and posttreatment CBCT scans were compared.

Results: Results of this study demonstrated that early interceptive orthodontic treatment including rapid maxillary expansion in patients under the age of 9 years significantly increases the width of the maxilla, the maxillary molars, the width of erupting maxillary canines, and positively improves the angulation of the erupting maxillary canines compared to patients treated with fixed appliances alone.

Conclusions: Lack of apical alveolar bone volume may be a contributing factor to maxillary canine impaction. Rapid maxillary expansion, as part of early interceptive treatment, increases maxillary width and apical bone base volume, improving the direction of the erupting maxillary canine. Early interceptive orthodontic treatment with orthodontic appliances alone, without rapid maxillary expansion results in increased buccal angulation of the maxillary canine. Rapid maxillary expansion is a practical treatment regimen for the prevention, as well as the early interceptive treatment of impacting and/or impacted maxillary canines.

KEY WORDS: Rapid maxillary expansion; RME; Mixed dentition; Cone beam computed tomography; CBCT; Transverse discrepancies

INTRODUCTION

Rapid maxillary expansion and its effects upon the dentofacial skeleton and nasal structures has been extensively studied. Rapid maxillary expansion has been proven to open the midpalatal suture,[1,2] increase the width of the maxilla,[1,3-11] lengthen the arch perimeter, [12-16,] and increase the width of the nasal cavity.[1,12,13,17-20] A study by Baccetti et al.[21] reported that patients treated early with rapid maxillary expansion, before the pubertal peak, exhibited significantly more effective long term changes in the maxilla and circummaxillary structures. Expansion occurring after the pubertal growth spurt demonstrated more dentoalveolar changes than skeletal.[21]

Few studies to date have utilized cone-beam computed tomography (CBCT) to evaluate anterior maxillary changes, specifically changes in the eruption path of the maxillary canines, associated with early rapid maxillary expansion. Impacted, impacting, and potentially impacting maxillary canines can be detected at an early age. With proper clinical and radiographic evaluation, canine impaction can be prevented with timely and appropriate interceptive orthodontic treatment.[22,23] Some suggested interceptive treatment regimens advocate the extraction of deciduous and/or permanent teeth, or increasing maxillary arch length with orthodontic appliances to encourage the eruption of the maxillary canines. Other studies have indicated that rapid maxillary expansion is a viable treatment regimen for the early treatment of impacted canines.[24,25]

The objective of this study was to examine changes in the anterior maxilla, especially the transverse and angular changes to the maxillary canines with early interceptive orthodontic treatment utilizing rapid maxillary expansion as evaluated with CBCT.

MATERIALS AND METHODS

Cone beam computed tomography scans of 56 early interceptive treatment patients from the same private orthodontic practice, treated by the same practitioner, were evaluated. All scans were evaluated retrospectively. Each patient had a 7 second EFOV, 0.3 voxel scan, performed on a Next Generation i-CAT scanner (Imaging Sciences International, Hatfield, PA) taken immediately pretreatment (T1) and at the end of the early interceptive orthodontic treatment (T2). The included patients were all in the mixed dentition and ranged in age from 6.35 - 9.96 years of age. Of the 56 patients, the control group consisted of 19 patients (8 female and 11 male) who were treated with fixed traditional orthodontic appliances, not including rapid maxillary expansion, as part of their early interceptive orthodontic treatment. The expansion group consisted of 37 patients (18 female and 19 male) treated with rapid maxillary expansion

Figure 1. Rapid Maxillary Expansion Appliance

followed by fixed traditional orthodontic appliances as part of their early treatment protocol. The rapid maxillary expander was a bonded acrylic splint expansion type of appliance (Fig. 1).

Patients in the expansion group were expanded at a rate of ¼ turn am (0.25 mm per turn) and ¼ turn pm for an average of 2 weeks. The amount of expansion varied from 5 - 7.5 mm with an average, clinically, of 6.3 mm of total expansion. The bonded expander was retained in situ in a passive state, for retention, for an average of 0.69 years, with a range of 0.5 - 0.92 years, after delivery.

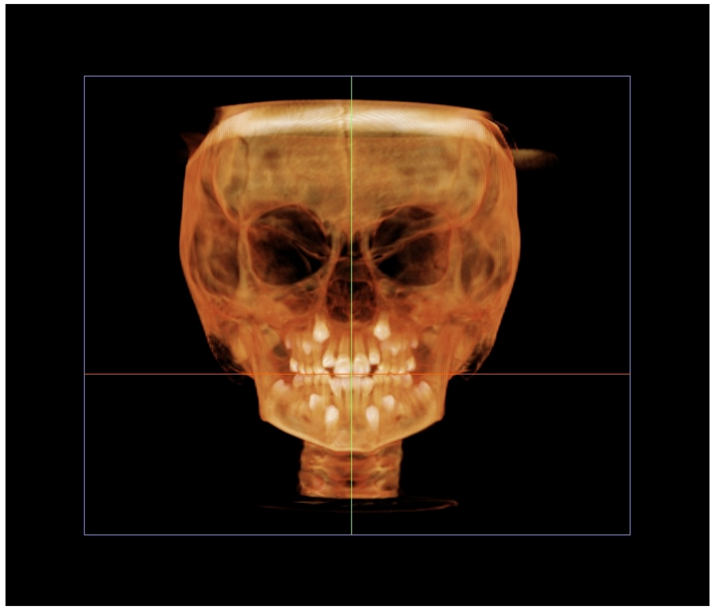

Figure 2. Orientation of the axial, coronal, and sagittal planes

All patients, control and expansion groups, were treated non-extraction. Skeletal and dental landmarks were used to examined the efficacy of rapid maxillary expansion followed by fixed orthodontic appliances versus fixed orthodontic appliances alone. Sixteen measurements were taken per patient at both the pretreatment (T1) and progress (T2) scans.

To ensure orientational consistency of the 2-dimensional coronal and axial slices at the molar region, the following reference planes were used: (1) the functional occlusal plane was defined as the axial plane, (2) the coronal plane was perpendicular to the axial plane, and (3) the sagittal plane was perpendicular to the axial and coronal planes, oriented between the midpoint of the orbits (Figs 2 & 3).

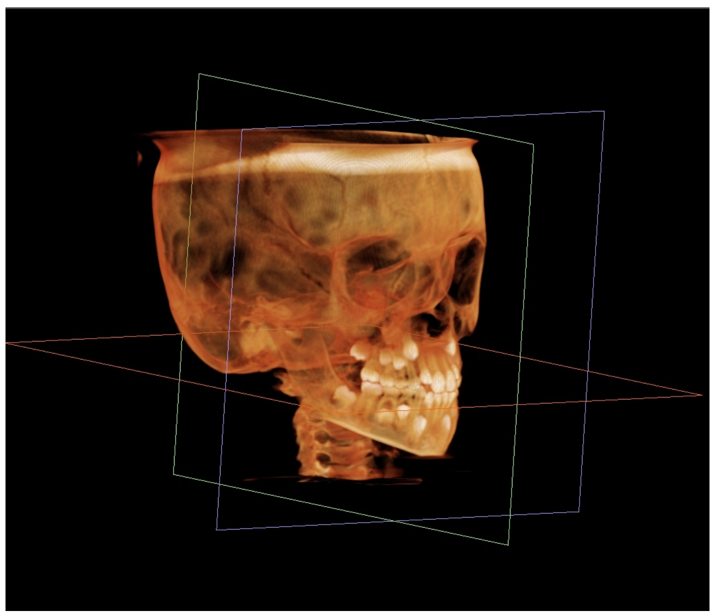

Figure 3. An oblique view of the orientation of the axial, coronal, and sagittal planes

Ten different measurements were made, six linear and four angular, on 5 mm thick CBCT coronal cross-sections through the middle of the maxillary and mandibular first molar crowns. Five mm thick slices were utilized at the level of the first molars to accurately visualize both the buccal and palatal roots of the maxillary molars. Thinner slices resulted in only a portion of the roots being visible, potentially affecting the accuracy of the measurements. Moreover, because of the anatomy of the first molars, it was necessary to evaluate adjacent coronal slices to evaluate the long axes of the palatal, mesiobuccal & distobuccal roots of the maxillary first molars, and the mesial & distal roots of the mandibular first molars.

Three different linear measurements of the nasal cavity were made in the coronal section at the widest part of the level of the inferior turbinate at: (1) the coronal level of the buccal groove of the maxillary first molar, (2) the coronal level of the permanent maxillary canine cusp tip, and (3) at the most anterior part of the pyriform rim of the maxilla in the coronal view (Fig 4). All measurements were made with 5 mm thick coronal sections.

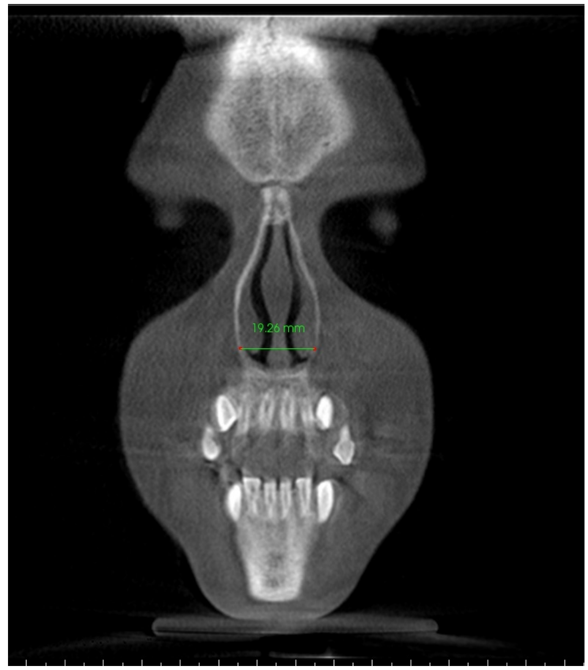

Figure 4. Linear measurement of nasal cavity at the pyriform rim.

Angular measurements of the permanent maxillary canines were made in 10 mm thick coronal sections in the coronal plane of the maxillary permanent canine cusp tip (Fig 5). Due to the variability of the angulation of the canines in the sagittal plane, 5 mm slices resulted in only partial root visibility, affecting the accuracy of the measurements. Linear measurements between the maxillary canine cusp tips were made in the orientation of the axial view in 5 mm thick sections (Fig 6). Coronal measurements of the linear distance between canine cusp tips were more variable and deemed less accurate, thus the investigator elected to make linear measurements between the maxillary canine cusp tips in the axial plane.

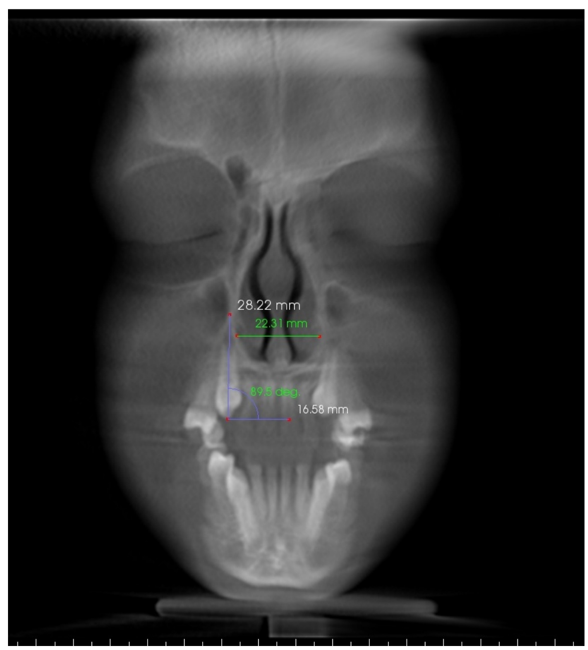

Figure 5. Linear measurement of nasal cavity and angular measurement of the canine at the cusp tip.

All sixteen measurements per scan were made with TXStudio Version 5.2.3 CBCT analysis software (Anatomage San Jose, California).

The maxillary first molar angle was defined as the intersection of two rays; one ray parallel with the axial plane, the second ray bisecting the furcation of the mesiobuccal and palatal roots, emanating from a common vertex originating from within the deepest concavity of the buccal and palatal cusps (Fig 7).

The mandibular first molar angle was defined as the intersection of two rays; one ray parallel with the axial plane, the second ray bisecting the long axis of the mesial root of the mandibular first molar, emanating from a common vertex originating from within the deepest concavity of the buccal and palatal cusps (Fig 7).

The linear maxillary and mandibular molar width measurements were made at the mid-crown level of the maxillary and mandibular first molars respectively.

The lingual linear maxillary width measurement was made at the midalveolar level of the palatal cortex, at the midpoint between the lingual alveolar crest and the horizontal bony palate. The buccal linear maxillary width measurement was made at the midalveolar level between the buccal alveolar crest and the buccal root apex of the maxillary first molar (Fig 8).

The lingual linear mandibular width measurement was made at the junction of the upper first and middle thirds of the mandibular molar mesial root.The buccal linear mandibular width measurement was also made at the junction of the upper first and middle thirds of the mandibular molar mesial root (Fig 8).

STATISTICAL ANALYSIS

All 112 scans were evaluated by the same examiner. Twenty scans were randomly chosen

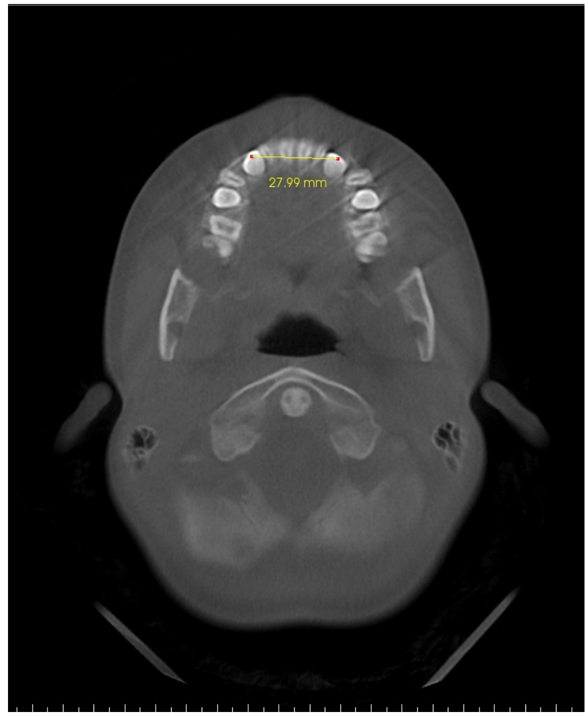

Figure 6. Linear measurement of maxillary canines in the axial plane.

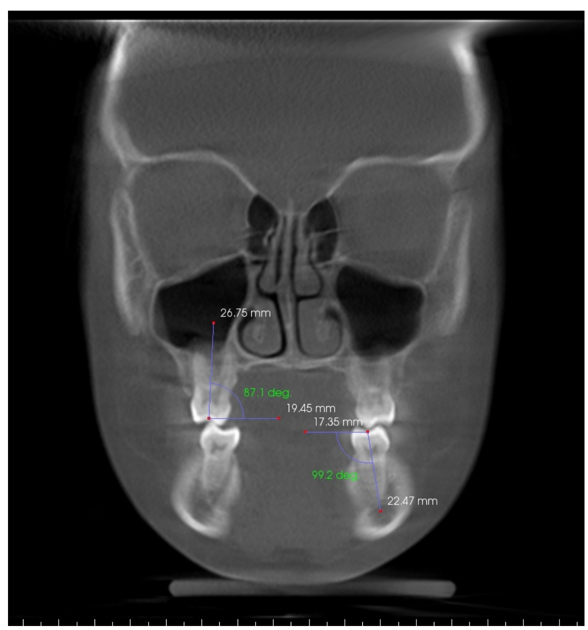

Figure 7. Angular measurements of maxillary and mandibular first molars.

for remeasurement and measurement errors were insignificant. Standard descriptive statistics, including means, standard deviations and variances were calculated for each measurement. Differences in means, standard of error of the difference and two-tailed t-tests were performed for each measurement between T1 and T2. P values less than 0.05 were determined to be statistically significant.

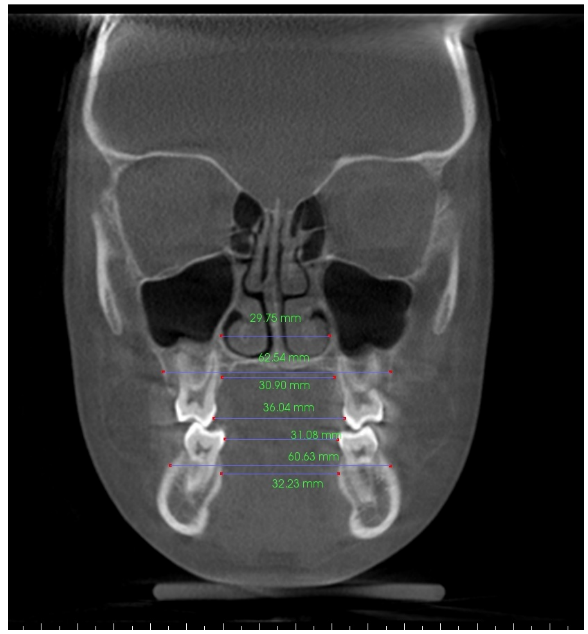

Figure 8. Buccal and Lingual Linear measurements of the first molars, maxilla and mandible.

RESULTS

The control group had one patient with an anterior crossbite, one patient with two missing permanent teeth and three patients with impacted teeth. The expansion group had two patients with posterior crossbites, two patients with anterior crossbites, one patient with both an anterior and a posterior crossbite, one with an impacted tooth, one with a missing tooth, and one with an extra tooth.

The average age of the control group was 8.73, with a range of 6.35 - 9.96 years of age. The expander group's average age was 8.39, with a range of 6.98 - 9.90 years of age. (Table I)

Table I. Scan Ages at T1 and T2.

Measurement	Scan Age T1 Mean, Range (years)	Scan Age T2 Mean, Range (years)	Average Time Between Scans Mean, Range (years)
Patients treated without RME	8.73, 6.35 - 9.96	11.40, 8.87 - 12.95	2.68, .96 - 4.58
Patients treated with RME	8.39, 6.98 - 9.90	10.62, 9.36 - 11.91	2.24, 1.63 - 3.19

Ten of the 19 patients in the control group had Angle Class II or End-on molar relationships; the remaining nine patients had Class I malocclusions. Twenty-three of the 37 patients in the expansion group had Angle Class II or End-on molar relationships with the remaining 14 presenting with Class I malocclusions.

There were no statistical differences in the 16 areas of evaluation between the control and expander groups at pretreatment T1. The lack of differences between groups confirmed an unbiased assignment between the control and expander groups. As anticipated, there were individual variations between T1 and T2 within and between the two groups.

The mean values and their standard deviations resulting from the control group of fixed appliances alone are shown in Tables II & III.

Table II. Anterior Maxillary Changes - Control Group

n = 19

Measurement	Scan Time T1 Mean ± SD	Scan Time T2 Mean ± SD	*t*	*P*
Maxillary Canine Width at Cusp Tip (mm)	29.70 ± 2.54	35.16 ± 2.58	-7.207	0.000*
Maxillary Right Canine Angle (º)	95.09 ± 5.33	82.63 ± 8.63	5.354	0.000*
Maxillary Left Canine Angle (º)	95.54 ± 3.54	81.36 ± 7.87	7.159	0.000*
Nasal Width at Canine Cusp Tip (mm)	21.64 ± 1.20	22.50 ± 1.44	-2.002	0.061
Nasal Width Pyriform Rim (mm)	21.28 ± 1.31	20.80 ± 1.91	0.893	0.383

Table III. Posterior Maxillary Changes - Control Group

n = 19

Measurement	Scan Time T1 Mean ± SD	Scan Time T2 Mean ± SD	*t*	*P*
Maxillary Right Molar Angle (º)	82.79 ± 3.63	81.22 ± 3.67	1.324	0.202
Maxillary Left Molar Angle (º)	80.59 ± 3.64	81.33 ± 3.47	-0.639	0.531
Mandibular Right Molar Angle (º)	105.81 ± 5.48	102.84 ± 4.41	1.839	0.082
Mandibular Left Molar Angle (º)	103.31 ± 4.16	101.50 ± 4.61	1.268	0.221
Maxillary Molar Width (mm)	33.12 ± 2.78	33.95 ± 2.07	-1.044	0.310
Maxillary Lingual Width (mm)	27.43 ± 2.23	28.51 ± 1.66	-1.683	0.110
Maxillary Buccal Width (mm)	58.71 ± 3.43	60.43 ± 3.21	-1.599	0.127
Mandibular Molar Width (mm)	32.13 ± 1.82	31.80 ± 1.82	0.558	0.584
Mandibular Lingual Width (mm)	31.58 ± 2.28	31.15 ± 2.76	0.522	0.608
Mandibular Buccal Width (mm)	62.81 ± 4.00	62.09 ± 3.76	0.569	0.576
Nasal Width at Molar (mm)	26.32 ± 2.09	27.55 ± 1.87	-1.910	0.072

Within the control group, changes in maxillary canine width, and canine angulation were significant ($P < .05$). The canine width at the cusp tip of the control group improved by an average of 5.99 mm. Canines that were initially erupting palatally became significantly more flared to the buccal during phase I treatment. Right and left maxillary canine angulations changed by 12.46º and 14.17º respectively. The remaining changes between the pretreatment (T1) and progress (T2) scans were statistically insignificant.

In regards to the expansion group; statistically significant changes were evident from T1 to T2 in canine width, canine angulation, maxillary molar angulation, maxillary lingual and buccal widths, mandibular molar angulation and all three nasal widths. Individual changes in linear and angular measurements between T1 and T2 within the expansion group are shown in Tables IV & V.

The expansion group showed an average of 5.18 mm width increase at the canine cusp tip. Maxillary right and left canine angulations improved to become more uprighted by 7.59º and 6.47º, from 95.41º and 93.50º, to 87.82º and 87.04º respectively. Nasal width increased by an average of 1.67 mm from 21.26 mm to 22.95 mm at the level of the maxillary canine cusp tip.

Nasal width increased significantly by 2.23 mm and 1.00 mm at the level of the maxillary 1st molar and at the pyriform rim respectively. The maxilla significantly increased in width by 2.75 mm and the maxillary first molar width also increased significantly by an average of 2.55 mm. Right and left maxillary first molars uprighted significantly in the expansion group from 81.44º and 79.42º to 84.25º and 83.35º respectively. Changes in the mandibular molar and mandibular skeletal widths were negligible.

Table IV. Anterior Maxillary Changes - Expansion Group

n = 37

Measurement	Scan Time T1 Mean ± SD	Scan Time T2 Mean ± SD	*t*	*P*
Maxillary Canine Width at Cusp Tip (mm)	29.08 ± 2.32	34.26 ± 2.89	-8.492	0.000*
Maxillary Right Canine Angle (º)	95.41 ± 6.85	87.82 ± 4.94	5.470	0.000*
Maxillary Left Canine Angle (º)	93.50 ± 6.45	87.04 ± 6.90	4.167	0.000*
Nasal Width at Canine Cusp Tip (mm)	21.26 ± 1.11	22.95 ± 1.43	-5.705	0.000*
Nasal Width Pyriform Rim (mm)	20.90 ± 1.51	21.90 ± 1.58	-2.794	0.000*

Table V. Posterior Maxillary Changes - Expansion Group

n = 37

Measurement	Scan Time T1 Mean ± SD	Scan Time T2 Mean ± SD	*t*	*P*
Maxillary Right Molar Angle (º)	81.44 ± 3.35	84.25 ± 2.75	-3.943	0.000*
Maxillary Left Molar Angle (º)	79.42 ± 3.72	83.35 ± 2.66	-5.233	0.000*
Mandibular Right Molar Angle (º)	107.81 ± 5.95	103.26 ± 4.43	3.726	0.000*
Mandibular Left Molar Angle (º)	106.25 ± 4.54	102.14 ± 4.35	3.980	0.000*
Maxillary Molar Width (mm)	32.69 ± 1.90	35.24 ± 1.66	-6.141	0.000*
Maxillary Lingual Width (mm)	26.80 ± 1.95	29.55 ± 1.84	-6.239	0.000*
Maxillary Buccal Width (mm)	57.55 ± 2.29	60.15 ± 2.63	-4.536	0.000*
Mandibular Molar Width (mm)	31.89 ± 1.94	32.54 ± 1.86	-1.476	0.149
Mandibular Lingual Width (mm)	31.61 ± 2.08	32.14 ± 1.86	-1.142	0.261
Mandibular Buccal Width (mm)	63.45 ± 3.94	63.15 ± 3.51	0.345	0.732
Nasal Width at Molar (mm)	26.36 ± 1.81	28.59 ± 2.07	-4.946	0.000*

The mean values and their standard deviations between the control and expansion groups are shown in Tables VI & VII. The changes in canine angulation between the control and expansion groups were found to be significant. Canines in the expansion group were erupting significantly more upright (right maxillary canine angulation 87.82º, left maxillary canine angulation 87.04º) than the non-expansion group (right maxillary canine angulation 82.63º, left maxillary canine angulation 81.36º). In the expansion group, nasal width at the level of the maxillary canine cusp tip was wider than the non expansion group by 0.46 mm but the difference was not statistically significant. Maxillary canine cusp tip width was wider with the control group, 35.16 mm vs 34.26 mm for the expansion group. This difference was the result of the significant and undesirable buccal flaring of the erupting maxillary canines in the fixed orthodontic appliance only group, resulting in the wider crown width.

Additionally, the maxillary molars were significantly more angulated towards the buccal in the control group when compared to the expansion group. The maxillary right and left molar angulations were 81.22º and 81.33º respectively in the non-expansion group. Comparatively, the maxillary molar angulations were 84.25º for the right and 83.35º for the left molars in the expansion group.

Intra-maxillary molar width and the maxillary skeletal width were significantly wider in the expansion group versus the non-expansion group. In the expansion group, the maxillary molar increased to 35.24 mm on average compared to the non-expansion group's average of 33.95 mm. The skeletal lingual width of the expansion group was 29.57 mm compared to 28.51 mm of the control group. Skeletal width measured at the buccal aspect of the expansion group was 60.15 mm compared to the control groups buccal width of 60.43 mm. This difference was statistically insignificant. The width of nasal cavity at the anterior pyriform rim was 21.90 mm for the expansion group and was significantly wider than the 20.80 mm for the control group.

Increase in nasal width at the maxillary molar for the expansion group was significant only at the level of a one tailed t test when compared to the control group. The remaining measurements for mandibular molar angle, mandibular molar width, mandibular skeletal lingual and buccal widths, were statistically insignificant.

Table VI. Anterior Maxillary Changes - Control Group vs Expansion Group

	Control Group ***n = 19***	**Expansion Group** ***n = 37***		
Measurement	**Scan Time T2 Mean ± SD**	**Scan Time T2 Mean ± SD**	***t***	***P***
Maxillary Canine Width at Cusp Tip (mm)	35.16 ± 2.58	34.26 ± 2.89	-1.189	0.250
Maxillary Right Canine Angle (º)	82.63 ± 8.63	87.82 ± 4.94	2.425	0.026*
Maxillary Left Canine Angle (º)	81.36 ± 7.87	87.04 ± 6.90	2.660	0.016*
Nasal Width at Canine Cusp Tip (mm)	22.50 ± 1.44	22.95 ± 1.43	1.130	0.274
Nasal Width Pyriform Rim (mm)	20.80 ± 1.91	21.90 ± 1.58	2.154	0.045*

Table VII. Posterior Maxillary Changes - Control Group vs Expansion Group

	Control Group *n = 19*	*Expansion Group n = 37*		
Measurement	**Scan Time T2 Mean ± SD**	**Scan Time T2 Mean ± SD**	***t***	***P***
Maxillary Right Molar Angle (º)	81.22 ± 3.67	84.25 ± 2.75	3.163	0.005*
Maxillary Left Molar Angle (º)	81.33 ± 3.47	83.35 ± 2.66	2.234	0.038*
Mandibular Right Molar Angle (º)	102.84 ± 4.41	103.26 ± 4.43	0.341	0.737
Mandibular Left Molar Angle (º)	101.50 ± 4.61	102.14 ± 4.35	0.500	0.623
Maxillary Molar Width (mm)	33.95 ± 2.07	35.24 ± 1.66	2.348	0.030*
Maxillary Lingual Width (mm)	28.51 ± 1.66	29.57 ± 1.79	2.222	0.039*
Maxillary Buccal Width (mm)	60.43 ± 3.21	60.15 ± 2.63	-0.326	0.748
Mandibular Molar Width (mm)	31.80 ± 1.82	32.54 ± 1.86	1.442	0.167
Mandibular Lingual Width (mm)	31.15 ± 2.76	32.14 ± 1.86	1.404	0.177
Mandibular Buccal Width (mm)	62.09 ± 3.76	63.15 ± 3.51	1.019	0.322
Nasal Width at Molar (mm)	27.55 ± 1.87	28.59 ± 2.07	1.911	0.072

DISCUSSION

The maxillary canine has the longest period of development with the most tortuous course of travel from its origin to full eruption of all maxillary teeth.[26] Its calcification commences at 4 to 5 months of age, which is approximately the same age as the initiation of calcification of the maxillary central incisor and first molar.[27,28] Eruption of the upper canine doesn't occur until 11-12 years of age, much later than the eruption of the first molar (6 years of age) and the central incisor (7-8 years of age),[27,28] and is one of the last teeth to erupt into the maxillary dental arch.

It has been hypothesized that the permanent maxillary canine is more susceptible to ectopic eruption and impaction because of its development high up in the most concentrated portion of the alveolus and its relatively late age of eruption.[26] In a study by Coulter and Richardson[29] they found that the maxillary canine travels nearly 22 mm from its position at age 5 years to its final position at age 15 years.

Maxillary canine impaction is a common occurrence and is second only to third molars for having the highest rate of impaction.[30] The frequency of maxillary canine impaction ranges between 0.8% and 3.29%.[31-36] and reported to be up to 20 times more commonly impacted than its mandibular counterpart.[37]

Unilateral impaction of the maxillary canine is significantly more frequent than bilateral impaction by a ratio of 5:1.[38] Additional studies have estimated that 8% of all patients with maxillary impacted canines are bilateral.[24,39,40] Buccal impaction of the maxillary canine only occurs 15% of the time compared to the more frequent occurrences of 85% for palatal impactions.[40-45]

Studies by Jacoby,[46] Peck et al,[47] and Zilberman et al[48] have shown that palatally impacted canines often occur with adequate arch length. Another study by Al-Nimri et al[49] suggested that the excess palatal width may contribute to the frequency of palatal canine impaction.

In stark contrast, McConnell et al[24] found that subjects with canine impactions demonstrated a profound transverse maxillary anterior arch deficiency. Schindel and Duffy[23] also reported that patients with transverse discrepancies were more likely to have impacted canines than patients without transverse discrepancies.

Regardless of the cause, because of the frequency and the potential destructiveness of impacting canines, well managed early interceptive treatment regimens are considered appropriate to reduce and prevent the impaction of displaced canines. Current interceptive treatment regimens include increasing maxillary arch length or perimeter with orthodontic treatment with or without the extraction of the deciduous canines in the late mixed dentition.[44,50-52]

Studies by Schinel & Duffey[23] and Baccetti et al[25] have reported that rapid maxillary expansion is an effective treatment option for the early treatment of impacted canines. Baccetti et al[25] found that patients treated with RME had a successful eruption rate of 65.7% of palatally displaced canines (PDC), almost 5 times greater than that of the untreated controls (13.6%). The results of these studies suggest that perimeter arch length may not be a good indicator of the volume of apical alveolar bone necessary for canine eruption. Lack of apical alveolar bone volume may be a contributing factor to maxillary canine impaction. Maxillary expansion, as part of early interceptive orthodontic treatment, increases maxillary skeletal width and apical bone base volume, improving the direction of canine eruption.

This study found that canine width significantly increased in both the control group and the expansion group. Canine angulation also changed significantly in both groups to a more buccal angulation. Treatment regimens for both groups were successful at increasing the perimeter arch length.

However, the rapid maxillary expansion group had anterior maxillary changes that increased the transverse width at the skeletal level, allowing the canine width to increase while allowing a more vertical eruption path. The control group, though canine width increased, experienced a canine eruption path that was a reflection of a significantly more buccal orientation. Even though the canine width in the control group was greater than that of the expansion group, the buccal angulation significantly affected the width at canine cusp tip, altering the perception of the actual width achieved as a result of dentoalveolar change. The same could be said about the molar width changes between groups. This increase in the arch perimeter in the RME group is most likely due to a change in skeletal width of the maxilla, with less dentoalveolar change than in the non-RME control group.

Rapid maxillary expansion increased the skeletal base providing additional bone, improving the canine eruption path. Baccetti et al[25] found that the pretreatment transverse dimension of the maxilla in their study was constricted at the dentoalveolar level. They[25] speculated that the improvement of the anatomic intraosseous position of canine and its chances for eruption were due to increases in arch width secondary to rapid maxillary expansion. Therefore, the necessity for expansion in their patients was based, partly, upon palatally displaced canines and constricted maxillary dental arches.

This clinical study demonstrated that rapid maxillary expansion improved canine width and eruption angulation in the early mixed dentition. Early diagnosis and orthodontic therapy with RME can help reduce the incidence of canine impaction.[25]

CONCLUSIONS

- Perimeter arch length may not be a good indicator of the apical alveolar bone volume necessary for canine eruption. Early interceptive treatment including rapid maxillary expansion in patients under the age of 9 years significantly increases the width of erupting maxillary canines and positively improves maxillary canine eruption angulation compared to patients treated with fixed appliances alone. Maxillary expansion, as part of early interceptive treatment, increases maxillary width and apical bone base volume, improving the direction of canine eruption.

- Rapid maxillary expansion significantly increases maxillary molar and skeletal width compared to patients treated with fixed appliances alone.

- Early interceptive patients treated with fixed appliances alone had significantly more buccal tipping of the maxillary first molars than patients treated with RME and fixed appliances.

- Rapid maxillary expansion significantly increases nasal width compared to patients treated with fixed appliances alone.

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NULL HYPOTHESIS - Maxillary expansion doesn't affect canine width or angulation

ADDENDUM

Table VIII. Anterior Maxillary Changes - Random 20

	n = 20			
Measurement	**Measurement 1 Mean ± SD**	**Measurement 2 Mean ± SD**	***t***	***P***
Maxillary Canine Width at Cusp Tip (mm)	29.64 ± 2.47	29.52 ± 2.44	0.152	0.881
Maxillary Right Canine Angle (º)	94.96 ± 7.19	93.52 ± 6.00	0.688	0.500
Maxillary Left Canine Angle (º)	93.09 ± 7.19	92.46 ± 7.17	0.277	0.784
Nasal Width at Canine Cusp Tip (mm)	21.19 ± 1.11	21.17 ± 1.52	0.058	0.954
Nasal Width Pyriform Rim (mm)	20.94 ± 1.63	21.04 ± 1.47	-0.191	0.851

Table IX. Posterior Maxillary Changes - Random 20

	n = 20			
Measurement	**Measurement 1 Mean ± SD**	**Measurement 2 Mean ± SD**	***t***	***P***
Maxillary Right Molar Angle (º)	81.44 ± 3.32	81.94 ± 3.07	-0.494	0.627
Maxillary Left Molar Angle (º)	80.66 ± 3.71	80.54 ± 3.48	0.106	0.917
Mandibular Right Molar Angle (º)	108.22 ± 5.00	107.41 ± 5.47	0.492	0.628
Mandibular Left Molar Angle (º)	106.55 ± 4.10	106.11 ± 4.25	0.329	0.745
Maxillary Molar Width (mm)	32.30 ± 1.77	32.36 ± 1.99	-0.104	0.918
Maxillary Lingual Width (mm)	26.42 ± 1.65	26.58 ± 1.90	-0.287	0.777
Maxillary Buccal Width (mm)	57.14 ± 2.50	57.47 ± 2.30	-0.432	0.671
Mandibular Molar Width (mm)	31.68 ± 1.90	31.91 ± 1.85	-0.382	0.706
Mandibular Lingual Width (mm)	31.30 ± 2.05	31.23 ± 1.92	0.104	0.918
Mandibular Buccal Width (mm)	63.57 ± 3.57	63.57 ± 3.44	-0.005	0.996
Nasal Width at Molar (mm)	20.94 ± 1.63	21.04 ± 1.47	-0.191	0.851