The Quad-Helix Appliance in the Primary Dentition – Orthodontic and Orthopedic Measurements.

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Changes in the midpalatal suture and the alterations in intercanine and intermolar widths with the use of the quad-helix appliance were evaluated. Study casts and occlusal radiographs from 10 patients with a mean age of 4 years and 10 months (SD 11 months) were analyzed. A statistically significant palatal suture widening was observed in all cases. The proportion of dental tipping accomplished with the treatment was greater than opening of the suture.

Keywords: primary dentition, malocclusion, preventive orthodontics.
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INTRODUCTION

Posterior crossbite is a transverse discrepancy of the dental arches. It affects primary and mixed dentition in children, with prevalence that varies from as little as 8% to as much as 80%.[1,2,3,4] The etiology of crossbite is complex, and has been related to genetic, congenital, and functional parameters.[5,6] Several different kinds of posterior crossbite have been investigated, though it is known that in approximately 90% of cases the original problem is of functional and unilateral nature, with symmetric atresia of the maxilla.[7,8]

According to Silva Filho *et al.*[9] (1989), the correction of posterior crossbite in primary and mixed dentition aims to (i) profit from the bioelastic features of the bone; (ii) redirect permanent tooth germs; (iii) promote better skeletal interactions between the apical base; (iv) correct inappropriate temporomandibular joint patterns; (v) support normal mandible closing course; and (vi) contribute to the better self-esteem of the child patient.

Approaches to treat the posterior crossbite include the use of selective abrasion of primary canines, the re-positioning of individual teeth with elastomer bands, and the expansion of the constricted maxillary arch.[10,11]

The studies published in the literature agree that the use of removable expansion appliance generates the orthodontic forces that act on tooth displacement exclusively. In this situation, the main problem before the clinician is the patient compliance necessary to this treatment approach.[2,12,12,15] Conversely, the rapid expansion of the midpalatal suture addresses the transverse correction of maxillas suffering from skeletal deficiencies. The aim is to cause maxillary expansion by opening of the palatal suture, and thus minimize orthodontic tooth movements.

The quad-helix appliance[16] was developed with a vision to generate low force magnitudes. It came as a modification to the W-arch as designed by Coffin[2] in 1889. The inclusion of four helical loops in the design led to increased appliance size, which in turn extended the range of the forces generated and improved the system's flexibility.[17,18] The main advantages offered by the quad-helix appliance are that child or parent compliance with the treatment is not strictly necessary, and that the patient enjoys greater comfort and better adaptation. Moreover, the hygienic procedures involved are simple, total treatment times are short, and the activation forces needed are smaller as compared to other orthodontic appliances. Considering the actual appliance manufacture, wires of different cross-section sizes may be used; besides, activation and reactivation procedures may be carried out at

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individually outlined intervals. Nevertheless, consensus has indeed been reached over the efficiency of the quad-helix appliance to treat functional and dentoalveolar posterior crossbite.[3,13,18,19,20,21] Still, these studies failed to consider the inherent differences between primary and mixed dentitions, or were directed to investigate mixed dentitions only. Few are the papers that focus on the use of the quad-helix appliance in primary dentition exclusively, and the alterations in the palatal suture have not yet been fully investigated.[17,22,23]

The treatment of posterior crossbites is routine in pediatric dentistry; thus, consensus over orthodontic and orthopedic changes occurring with the use of the quad-helix fixed appliance is of fundamental importance in primary dentition studies, as such changes ultimately have a bearing on palatal suture.

In the light of the scarce literature on the subject, this study was designed to report the clinical and radiographic alterations in intercanine and intermolar widths, as well as the transverse changes in the midpalatal suture during pretreatment, post- active treatment, post-retention and one month after quad helix removal.

MATERIALS AND METHOD

This study was approved by the Commission of Ethics in Research of the Federal University of Rio Grande do Sul (UFRGS), protocol number 56/05. Ten children (5 males and 5 females) presenting functional/ dentoalveolar unilateral posterior crossbite took part in this investigation. All patients consulted with the Pediatrics Dentistry Service, School of Dentistry, UFRGS and attended a caries prophylaxis program. Mean patient age was 4 years 10 months (SD 11 months).

Initially, patient clinical history was recorded and a panoramic radiograph requested. An informed consent form was then read and signed, upon which the clinical procedures started.

Manufacture and fitting of the appliance

Elastomer bands (Dental Morelli Ltda, Brazil) were placed between the first and the second maxillary primary molars. Once bands were fitted, impressions were taken (Ava Gel alginate, Dentsply, Brazil). Appliances were manufactured with .032-in stainless steel wire, with two posterior and two anterior helices.[10,23]

Initial activation of the appliance equaled the buccolingual width of the anchoring molar (8 to 10 mm). This generated a force modulus of roughly 350-450 g[30]. Cementation was conducted using Meron glass-ionomer cement (Voco, Germany), and clinical examinations were made every four weeks. On the first visit, the appliance was removed and reactivation performed to a value similar to the initial activation value, in all patients. Upon the crossbite overcorrection of 2 to 3 mm[10,17,20,23], the appliance was removed and passively re-cemented. The appliance thus remained for 3 months for retention purposes.[2,10,19,20]

Manufacture and analysis of the orthodontic study specimens

Impressions of the upper and lower arches were taken with Ava Gel alginate (Dentsply, Brazil). Study specimens were then prepared with gypsum, for each of the 4 treatment periods: pretreatment, post- active treatment, and post-retention, as well as one month after retention was discontinued.

Specimen measurements were carried out using a digital caliper (Centech, Brazil) as follows:

- Maxillary intermolar width: the distance between the central fossa of the second primary molars.[25]
- Maxillary intercanine mean width: the distance between the cusps of primary canine teeth; in the event of cusp wear, measurements were made on the center, next to the vestibular edge[17,21]

All measurements were carried out by an examiner trained for the method. Data were used to construct a table as appropriate for the study methodology.

Occlusal radiographs — procedure and analysis

Occlusal radiographs were obtained as of 3 treatment stages: pretreatment (to assess normal midpalatal suture and tooth structures); post- active treatment (to measure changes in midpalatal suture width); and 3 months after retention (to inspect bone apposition). One trained operator under strict standardization criteria took all radiographs. All films were processed on one same day in automatic equipment. A 5.25-mm-wide radio-opaque metallic device was used to ensure reproducibility of results for the measurement software.

To measure the transversal widths, six dots were vertically marked on each pre- and post- active treatment radiograph. These dots served as marks to direct suture measurements, and were used to calculate mean values for anterior and posterior regions, as shown in Figure 1. All radiographs were scanned and adjusted for standardized bright-

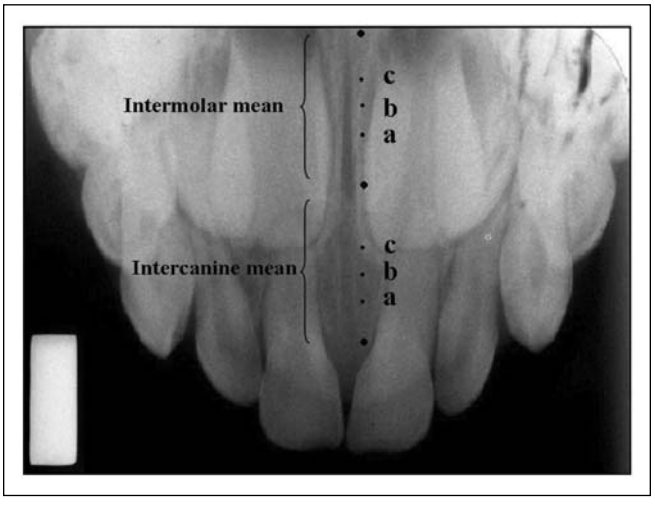

Figure 1. Dots marked to direct the measurements of midpalatal suture opening in occlusal radiographs.

ness and contrast. Radiographs were then loaded onto the Adobe Photoshop software, version 7.0. After this, the specific measurement software UTHSCSA Image Tool version 3.0 was used to carry out measurements.

All data were collected by a trained investigator, and then used to construct a table for ulterior statistical analysis.

RESULTS

Posterior crossbite was corrected in the 10 patients examined. Mean treatment time with orthodontic appliance was 60 days, and mean treatment conclusion time was 150 days.

A significant increase of 0.90 mm (SD 0.44) for the intercanine and 0.63 mm (SD 0.19) for the intermolar regions was observed for midpalatal suture measurements as of the pre- and post- active treatment stages (Table 1).

The changes in intercanine and intermolar widths observed in study casts made as of pretreatment, post- active treatment, and post-retention stages were statistically tested with the analysis of variance with randomized block design, complemented by the Tukey test of multiple comparisons, at a 5% significance level. Mean intercanine widths were similar during post- active treatment and the 1-month period with no retention, but considerably longer than the values obtained for pretreatment. Mean width in the post-retention stage was significantly greater than in the other stages. As for intermolar widths, the greatest values were observed for mean widths in post-retention and post- active treatment stages, and did not differ. Yet, these mean values were significantly higher when compared to the means obtained for the pretreatment stage and for the 1-month period with no retention. Mean intermolar widths after the 1-month period with no retention were statistically greater than mean pretreatment values, and shorter than in post- active treatment as well as in post-retention measurements (Table 2).

Mean intercanine and intermolar width increases were significantly sharper for tipping (orthodontic effect) as compared to suture opening (orthopedic effect), according to the paired samples *t* test ($p<0.001$). The approximate ratio observed was 6:1 for the intercanine region and 10:1 for the intermolar region (Table 3).

Table 1. Mean intermolar and intercanine widths (mm) for pretreatment and post- active treatment. Measurements carried out in occlusal radiographs of the midpalatal suture.

Width	Period			
	Pretreatment		Post- active treatment	
	Mean	SD	Mean	SD
Intercanine	0.24 C	0.09	1.14 B	0.05
Intermolar	0.22 C	0.46	0.84 B	0.26

Means followed by different letters along one line differ significantly by the analysis of variance for randomized block designs, complemented by the Tukey test of multiple comparisons, at a 5% significance level.

Table 4. Widths attained with midpalatal suture opening and with tipping in the intercanine and intermolar regions by the Pearson Correlation Coefficient at significance level 5%.

	Pearson Correlation Coefficient	p
Intercanine	-0.051	0.888
Intermolar	0.299	0.401

Table 2. Mean intermolar and intercanine widths (mm) for the four experimental times (pretreatment, post- active treatment, post-retention, after one month with no retention). Measurements carried out in study casts of the upper arch.

Width	Period							
	Pretreatment		Post- active treatment		Post-retention		After one month with no retention	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Intercanine	27.10 C	2.08	32.41 B	2.28	35.15 A	2.47	31.89B	2.32
Intermolar	36.62 C	1.95	42.62 A	1.67	43.54 A	1.6	40.84B	1.41

Means followed by different letters along one line differ significantly by the analysis of variance for randomized block designs, complemented by the Tukey test of multiple comparisons, at a 5% significance level for measurements carried out in study casts.

Table 3. Differential mean widths (mm) for pretreatment and post- active treatment as measured in study models and occlusal radiographs. ($p<0.001$)

Width	Difference (post- active treatment/pretreatment)				
	Study Casts		Occlusal radiographs		
	Mean	SD	Mean	SD	P
Intercanine	5.30	1.98	0.90	0.44	<0.001
Intermolar	6.00	1.46	0.63	0.19	<0.001

The Pearson Correlation Coefficient (significance level 5%) did not reveal any correlation between the differences as measured for specimens and in sutures, either for intercanine or intermolar regions (Table 4).

DISCUSSION

The specialized literature describes a considerable variety of appliances whose main purpose is to treat posterior crossbite. The present study aimed to assess the tooth and midpalatal suture changes occurring in study specimens and in occlusal radiographs with the use of the quad-helix appliance in children with primary dentition.

As a matter of course, longitudinal studies run into some difficulties. Such obstacles may be encountered while carefully planning the treatment strategy as well as during the elaboration of a descriptive sample. Yet another challenge faced by the clinician concerns patient follow-up, especially those of young age, in maintaining the technical firmness of control needed to all treatment stages. However, careful and focused planning affords quality to the sample, and allows fashioning all the study's stages under uniform, standardized parameters.

Similarly to other studies[3,17,22,23,26], the present paper managed a 100% success rate in correcting crossbite. Mean treatment time was 59.6 days; all child patients adapted well to the appliance and complied with follow-up routines. But other studies did not show such inspirational results, as that by Follin and Milleding[27] (1994), in which over 10% of children treated with a quad-helix appliance were reported to show poor outcomes or to walk out of treatment. The selection of subjects with complete primary dentition for the present research is due to the fact that young age is an important factor in the diagnosis of pediatric dentistry disorders. In our literature reviews, we found only three papers treating primary and mixed dentition patients with different sample approaches: Lindner *et al* [22] (1986), Bell and Le Compte[17] (1981), and Matta *et al* [23] (2002). The first study mentioned investigated 29 children, on average 4-year 10-month-olds; the second resorted to a sample composed of 5 primary dentition and 5 mixed dentition children, whereas in the third paper the sample population was 5 primary and 4 mixed dentition children. As a whole, the other papers reviewed were examinations of patients with mixed or permanent dentition, or even of patients at different dentition stages conjointly.[2,3,4,13,26,19,20]

Literature also shows that treatment times may vary, stretching to the correction of crossbite, or even for as long as 9 months after the removal of retention.[13,17,20,23,24] In the present study, upper gypsum casts and occlusal radiographs were examined at 4 distinct treatment periods (pretreatment, post- active treatment, post-retention, and 1-month period with no retention). Mean changes in intercanine and intermolar widths during pretreatment were 5.31 mm (SD 1.98) and 6 mm (SD 1.46), and tally well with other literature data[3,17,13,26,20,21,24] that corroborate greater expansion around the second primary molar.

Careful examination of standardized occlusal radiographs, also carried out during the first stage of treatment, showed the opening of the midpalatal suture in all cases studied,[3,17,26] and the measurement of values both in intercanine and intermolar regions. The method is reliable, though only one study reviewed measurements carried out based on occlusal radiographs,[29] while the majority of the papers published only mentions the occurrence of suture opening. The research papers that quantitatively report suture opening resort to transverse measurements based on posterior-anterior radiographs[10,20,26] After the first treatment stage evaluations using casts, and the subsequent comparison with occlusal radiographs, the tooth movement: suture opening ratio observed was 6:1 for the intercanine and 10:1 for the intermolar region. This result disagrees with the figure found by Frank and Engel[26] (1982), in which patients with mixed dentition were evaluated using postero anterior cephalometric radiographs and casts, with a 6:1 ratio for the intermolar region.

The absence of correlation between the differential measurements for cast and for suture — both for intercanine and intermolar widths — demonstrates an individual variation, as it were, in suture opening for a given degree of tipping. This means that larger suture expansion values do not necessarily correlate positively with the occurrence of greater widths as measured in casts.[3,23]

The appliances used in the present study were manufactured with 0.32-in stainless steel and activated to between 8 and 10 mm. According to Chaconas and Caputo[30] (1982), such design affords roughly a 400-g force magnitude, and produces the expected orthopedic effect in patients with primary dentition and with incipient mixed dentition. In the present study, however, the increased transverse measurements observed for the upper arch treated with a quad-helix appliance were the result of vestibular tipping, which ultimately reflects the predominance of the orthodontic force exerted by the appliance.[14,23,26] Yet, a different result was obtained by Sandikçioglu and Hazar[21] (1997), who reported that the quad-helix appliance presented identical ratios for orthodontic and orthopedic effects.

The second stage of the treatment — the retention stage — has been the object of much discussion among researchers. The literature reports studies conducted without retention, as well as studies that adopted retention stages that varied from as little as 6 weeks to as much as 6 months.[3,17,31,2] These studies also diverged as regards the retention approach chosen. Ekstron *et al* [32] (1977), in slow expansion studies, report that well-organized mineralized tissue can already be observed within 30 days after expansion, and that in 3 months this newly-formed bone has acquired a stability status.

In the present study, retention time was 3 months, through which period the appliance was maintained inactivated. Mean transverse increments observed in upper casts were 2.74 mm and 0.92 mm for intercanine and intermolar measurements, respectively, and mean increase for the interca-

nine region was statistically significant. In order to explain this significance, it can be hypothesized that the occlusion of lower canines against the appliance's arch wires (used as retention tool) has generated a small force magnitude that was yet capable of producing tipping. This hypothesis is based on the evidence of the skeletal structures formed in the suture opening area, as observed by the absence of central radio-luminescence in post-retention occlusal radiographs.

Each patient's condition was evaluated in a fourth treatment stage, i.e., upon one month without retention. Minute recurrences, in this situation, cannot be ascribed to treatment failure, but to a physiologic adaptation between dental occlusion and muscle. Intercanine widths decreased 2.59 mm on average, while for intermolar widths the drop measured was 2.34 mm. Therefore, a 2- to 3-mm overexpansion was performed during active treatment, as amply mentioned in the literature.[2,3,17,19,23]

As regards the spontaneous transverse arch expansion, Lee[33] (1999) reviewed the literature and according to the majority of studies examined, such expansion figures predominate between 7 and 12 years of age. Based on this evidence, it may be plausibly suggested that the transverse expansion observed in the population examined in the present study is imputable to the appliance model adopted.

Posterior crossbite, either of functional or of dental derivation, may occur precociously due to the patient's abnormal oral habits, or due to cusp interference in canine eruption. The importance of treating posterior crossbite at an early age lies in the fact that only seldom does the disorder correct itself, and that such disorder in permanent dentition may bring about skeletal asymmetries throughout the patient's growth, as a whole.

CONCLUSIONS

The results discussed in the present paper afford the following conclusions:

The quad-helix appliance promoted the opening of the midpalatal suture in all cases studied; nevertheless, the mean increase in intercanine and intermolar widths was significantly sharper due more to tipping than to suture opening, with a 6:1 ratio for the intercanine region and 10:1 ratio for the intermolar region.

Study casts revealed that both intercanine and intermolar mean widths were statistically higher as of the end-of-treatment examination (one month after the removal of retention), when compared to the pretreatment.

The results obtained did not define a positive correlation between the differences in cast and suture measurements, either for intercanine or for intermolar regions.

REFERENCES

1. Keski-Nisula K, Lehto R, Lusa V, Keski-Nisula L, Varrela J. Occurrence of malocclusion and need of orthodontic treatment in early mixed dentition. Am J Orthod Dentofacial Orthop, 124: 631–8. 2003.
2. Ranta R. Treatment of unilateral posterior crossbite: comparison of the quad-helix and removable plate. J Dent Child, 55: 102–04. 1988.
3. Adimari MRW, Júnior AA, Jimenez EEO, Caleffe LG. Terapêutica da mordida cruzada posterior em dentadura mista através de dois métodos: quadri-hélice e expansor. Revista Paulista de Odontologia, 5: 12–20, 1994
4. Silva Filho OG, et al. Uma concepção realista do quadrihélice na ortodontia interceptativa. Ortodontia, 24: 32–40. 1991.
5. Silva Filho OG, Júnior FMF, Aiello CA, Zopone N. Correção da mordida cruzada posterior na dentição decídua. Ortodontia, 32: 60–9, 1999.
6. Berlocher WC, Mueller BH, Tinanoff N. The effects of maxillary palatal expansion on the primary dental arch circumference. Pediatr Dent, 2: 27–30. 1980.
7. Bishara SE, Staley RN. Maxillary expansion: clinical implications. Am J Orthod, 91: 3–14. 1987.
8. Heese KL, Artun J, Joondeph DR, Kennedy DB. Changes in condilar position and occlusion associated with maxillary expansion for correction of functional unilateral posterior crossbite. Amer J Orthodont Dentofac Orthop, 111: 410–18, 1997.
9. Myers DR, Barente JT, Bell RA, Williamson EH. Condylar position in children with functional posterior crossbite correction. Pediatr Dent, 2: 190–4, 1980.
10. Silva Filho OG, Valladares Neto J, Almeida RR. Early correction of posterior crossbite: biomechanical characteristics of the appliances**.** J Pedod, 13: 195–221, 1989.
11. Harrison JE, Ashby D. Orthodontic treatment for posterior crossbites. (Cochrane Review). In: The Cochrane Library, Issue 2, 2005. Oxford: Update Software.
12. Thailander B, Wahlund S, Lennartsson B. The effect of early interceptive treatment in children with posterior crossbite. Eur J Orthod, 6: 25–34, 1984.
13. Erdinç AE, Ugur T, Erbay E. A comparison of different treatment techniques for posterior crossbite in the mixed dentition. Am J Orthod Dentof Orthop, 116: 287–300, 1999.
14. Silva AA, Valle S. Biomecânica do quadrihélice e suas variações. J Bras Ort Ortop Facial, 5: 57–65, 2000.
15. Hass, AJ. The treatment of maxillary deficiency by opening the midpalatal suture. Angle Orthodont, 35: 200–17, 1965.
16. Ricketts RM. Features of the bioprogressive therapy. Rocky Mountain Orthodontics, 14, 1973.
17. Bell RA, Le Compte EJ. The effects of maxillary expansion using a quad-helix appliance during the deciduous and mixed dentitions. Am J Orthod, 19: 152–61, 1981.
18. Chaconas SJ, Levy JAA. Orthopedic and orthodontic applications of the quad-helix appliance. Am J Orthod, 72: 422–28, 1977.
19. Henry RJ. Slow maxillary expansion: a review of quad-helix therapy during the transitional dentition. J of Dent For Child, 60: 408–13, 1993.
20. Pinheiro PMM. Avaliação dos efeitos dento-esqueléticos ocorridos após o tratamento da mordida cruzada posterior, com o uso do aparelho expansor fixo tipo quadrihélice. Dissertação (Mestrado em Ortodontia) – Faculdade de Odontologia, Universidade Estadual Paulista. 133p, Araçatuba, 2003.
21. Sandikçioglu M, Hazar S. Skeletal and dental changes after maxillary expansion in the mixed dentition. Am J Orthod Dentof Orthop, 111: 321–27, 1997.
22. Lindner A, Henrikson CO, Odenrick L, Modeér T. Maxillary expansion of unilateral cross-bite in preschool children. Scand J Dent Res, 94: 411–18, 1986.
23. Matta ENR, Machado RBL, Silva PA. Quadrihélice – Aspectos cefalométricos e ortopédicos da sua utilização na mordida cruzada posterior funcional. Rev Clin Ort Dental Press, 1: 73–80, 2002.
24. Silva Filho OG, Oliveira EA, Capelozza Filho L. Avaliação das alterações dentárias e esqueléticas ocorridas na dentadura mista após o uso do expansor fixo tipo quadrihélice. Ortodontia, 18: 23–35, 1985.
25. Pereira CB, Alvin MCM. Manual para Estudos Craniométricos e Cranioscópicos. Santa Maria: Imprensa Universitária da UFSM, 1979: 88.
26. Frank SW, Engel GA. The effects of maxillary quad-helix appliance expansion on cephalometric measurements in growing orthodontic patients. Am J Orthod, 81: 378–89, 1982.

27. Follin ME, Milleding A. Quad-helix treatment in general practice. Swed Dent J, 18: 43–48, 1994.
28. Silva Filho OG et al. Alterações cefalométricas ocorridas na dentadura mista após o uso de um expansor fixo tipo quadrihélice. Ortodontia, 19: 22–33, 1986.
29. Horst LHM, Brücker MR. Análise radiográfica de imagens digitalizadas da abertura da sutura palatina mediana na expansão rápida da maxila em pacientes de 6 a 14 anos. Revista Odonto Ciência, 18: 31–8, 2003.
30. Chaconas SJ, Caputo AA. Observation of orthopedic force distribution utilizing maxillary orthodontic appliances. J Dent Res, 54: 45, 1975
31. Harberson VA, Myers DR. Midpalatal suture opening during functional posterior cross-bite correction. Am J Orthod, 74: 310–13. 1978/
32. Ekstron C, Henrikson C, Jensen R. Mineralization in the midpalatal suture after orthodontic expansion. Am J Orthod, 71: 449–55, 1977.
33. Lee RT. Arch width and form: A Review. Am J Orthod Dentofacial Orthop, 115: 305–13, 1999.