Post Expansion Evaluation of the Midpalatal Suture in Children Submitted to Rapid Palatal Expansion: a CT Study

Omar Gabriel da Silva Filho* / Tulio Silva Lara** / Helena Cristina da Silva*** / Francisco Antônio Bertoz****

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The aim of this prospective study was to evaluate the midpalatal suture in children submitted to rapid palatal expansion, at the end of the retention stage, with CT scans. The sample was comprised of 17 children aged between 5 years 2 months and 10 years 5 months. The tomographic images showed that the midpalatal suture was completely ossified from the anterior nasal spine area to the posterior nasal spine area at the end of the retention phase, that is, 8 to 9 months post-expansion.

Key words: *Palatal expansion technique; tomography; orthodontics; suture.*
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INTRODUCTION

Suture opening was initially inferred by Angell[33,34] in 1860, looking at the gap formed between the central incisors. Almost 100 years later, Haas[4] reintroduced RPE with heavy anchorage in the United States, when orthopedic expansion began to be studied. Then came the first study on animals made on Duroc-Poland-China pigs to prove the possibility of opening the midpalatal suture up to 15 mm using heavy anchorage to promote the orthopedic effect suggested by Angell.[33,34] The results of this thesis were published by Haas[3] in 1961 and showed the opening of the midpalatal suture followed by bone formation.

Studies prior to Haas' publications had already suggested the possibility of midpalatal suture opening in cats[12] and dogs[35]; however, the appliances used insufficient anchorage to promote the orthopedic effect. Nevertheless, these studies revealed a midpalatal suture opening of 0.7 mm in the anterior area, with no effect on the palatal posterior area. Authors also commented that the discrete opening of the midpalatal suture was followed by the formation of new bone at the suture margins.

A histological study[10] in monkeys, supported the split of the midpalatal suture and showed the subsequent progressive bone formation. At the moment of the suture opening, the area was filled with unorganized, well-vascularized fibrous conjunctive tissue, suggestive of a mild chronic inflammatory response. After three months, the suture showed a histological aspect similar to the control group, but the adjacent bone was irregular and cellularized, not obeying the usual lamellar standard of the most distant bone in the suture area, indicating rapid bone formation. The histological aspect would suggest the remodeling of the recently repaired suture. Therefore, at three months, the suture morphology, when evaluated radiographically, remained unorganized and the area poorly mineralized when compared to the control group. Six months after the active expansion phase, the suture was well-organized and histologically normal, but the adjacent bone was irregular and did not follow the normal lamellar pattern. The sutural region only showed a similar degree of mineralization to the control group animals in the animal sacrificed at 9 months. Other studies revealed midpalatal suture ossification during the orthopedic expansion procedure phase.[12,36-43]

In 1998, Kanekawa and Shimizu[27] studied the regenerative capacity of the midpalatal suture after RPE in rats determining the influence of age with such a procedure. The formative capacity of the bone matrix in response to the stimulus caused by mechanical stretching resulting from RPE did not depend on age, whereas bone formation speed did not decrease after adolescence. This implies the need for more retention time in adult patients who undergo RPE.

Since the 1960's Haas reported on the transverse orthopedic mechanics in the maxillary dental arch, showing the histological, clinical and radiographic effects induced by the fixed expansion appliance supported by teeth and palate which provides maximum anchorage.[1-4] In spite of the time of publication, Haas studies remain as the most important papers ever written concerning the treatment of maxillary transverse deficiencies. However, we have extended the indications of the original rapid palatal expansion (RPE) protocol to the primary and mixed dentition stages (Figure1).[6] The main criteria for orthopedic expansion is the presence of maxillary constriction, regardless of the stage of occlusal development. Its permanent

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Table 1: Means (X) and standard deviations (SD) in millimeters for the pre-and post-RPE measurements. (extracted from Silva Filho *et al.*[15])

Variables	Pre-expansion		Post-expansion		Pre-expansion post-expansion
	$\overline{X}$	SD	$\overline{X}$	SD	difference
ANS	0.15	0.01	2.36	0.05	2.21
PNS	0.15	0.01	1.10	0.04	0.95

effect includes anatomical and occlusal advantages as shown in Figure 1.

The activation of the screw opens the appliance and creates a force equivalent to the skeletal structure resistance of the face[9], separating the maxillary segments[10,11] and the midpalatal suture along the horizontal plane. The opening is wider in the anterior nasal spine (ANS) than in the posterior nasal spine (PNS) area.[3,12-15]

The separation of the maxillary segments also causes downward displacement of the maxilla, with possible forward advancement[14,16-19] inducing a clockwise rotation of the mandible[3,14,16-18,20-23] in the sagittal plane. However, the maxillary response in the sagittal plane is reversible and does not influence the facial growth pattern.[14,16,19,24]

We have recently evaluated the response of the midpalatal suture during RPE with the Haas fixed expander in children in the primary and mixed dentition by means of CT scans.[15] The scans at the palatal plane level (Figure 2) show that PNS respond to RPE as well. The images clearly demonstrate that the midpalatal suture also opens posteriorly, contiguous to the vigorous pterygoid segments of the sphenoid bone, which are pillars of resistance to maxillary opening. Such a detail had not yet been shown in studies with humans. In most patients the midpalatal suture opening was pyramid-shaped while in others the opening appeared to be parallel. We showed that the midpalatal suture opening at the PNS area was equivalent to 43% of the ANS area.

The results shown in Table 1 corroborate the few earlier studies that suggest involvement of the maxillary posterior extremity during RPE. One of the studies is biomechanical and uses a three-dimensional duplication of the craniofacial skeleton at 12 years of age.[25] From an occlusal point of view the study showed an almost parallel separation of the two maxillary segments.

After the end of the activation phase with the Haas expander, the appliance is maintained passively in the mouth until complete ossification of the midpalatal suture. Such a progressive ossification, evaluated in occlusal radiographs of the maxilla, can vary between three and six months. Then, the expander is removed and a removable retention plate can be used up to a year. Occlusal radiographicic follow up of the maxilla shows only part of the midpalatal suture. The overlapping with the cranial base structures and the two-dimensional nature of the images compromise the evaluation of the midpalatal suture ossification in its posterior area.[26]

CTs have many advantages over radiographs since they permit clear visualization of sections of the human body without structure overlap. We have already demonstrated what happens in the ANS and PNS areas at the end of the active phase of RPE with CT scans. In the current study we verified whether the ossification of the midpalatal suture occurs along its entire extension during the retention phase with the expansion appliance.

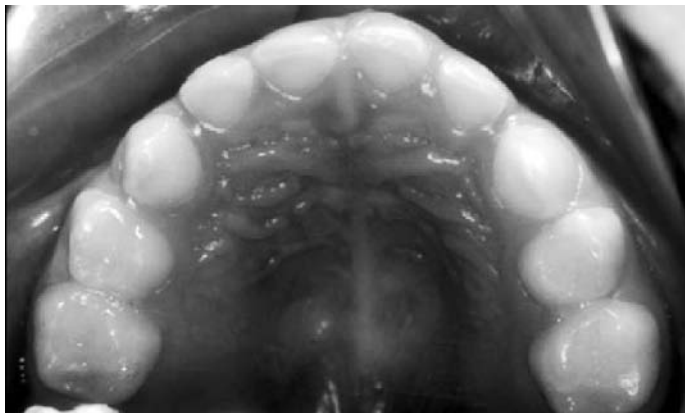

Figure 1A: Pre-treatment

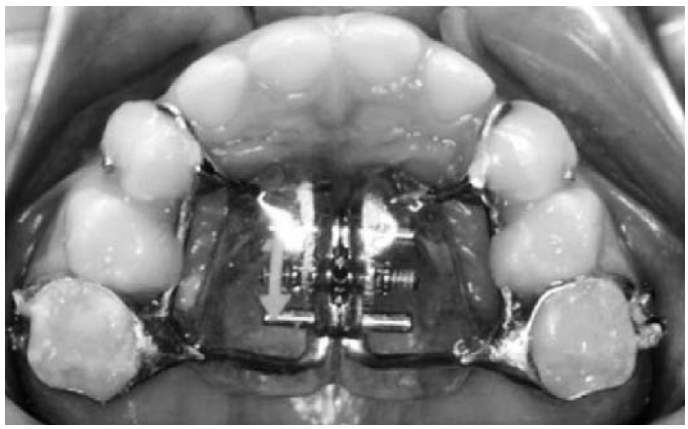

Figure 1B: Fixed expansion appliance inserted

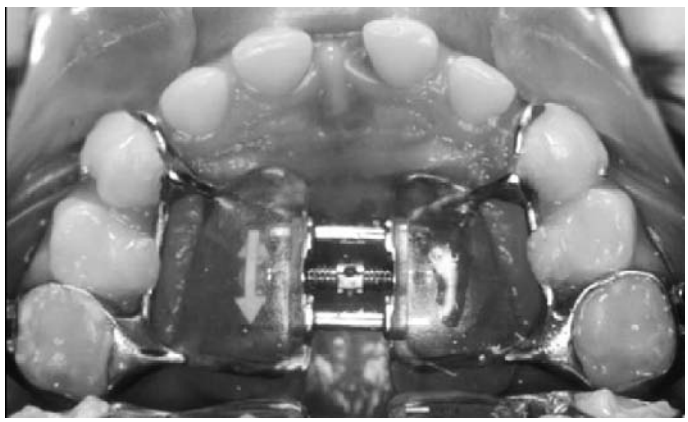

Figure 1C: Fixed expansion appliance after activation

PURPOSE

The purpose of this study was to evaluate the ossification of the midpalatal suture in children submitted to RPE after retention phase with CT scans.

MATERIAL

The sample was comprised of 17 of the 18 children who made up the first study where RPE was evaluated by means of CT scans.[15] The children, 10 males and 7 females, ranged in age from 5 years 2 months to 10 years 5 months (mean age of 8 years 2 months at the beginning of treatment). Only one patient was in the primary dentition while all others were in their mixed dentition. The Haas fixed expansion appliance (Figure 1) was used to treat the transverse maxillary deficiency. The activation protocol[16] included one complete

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Figure 1D: Retention phase

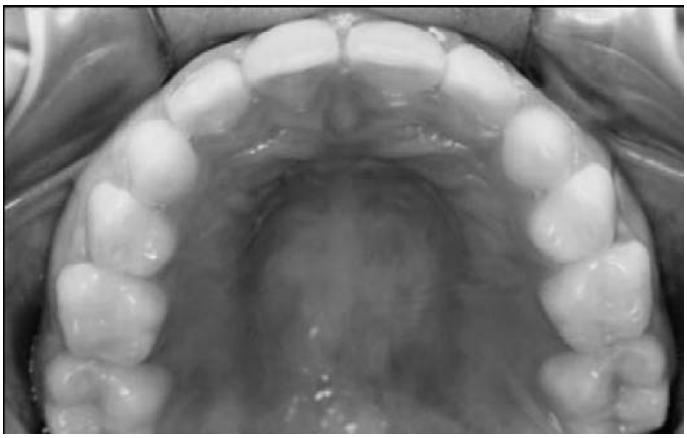

Figure 1E: After treatment RPE in the primary dentition. The Haas fixed expansion appliance, modified for the primary and mixed dentition and activated one turn per day, changed the morphology of the upper dental arch

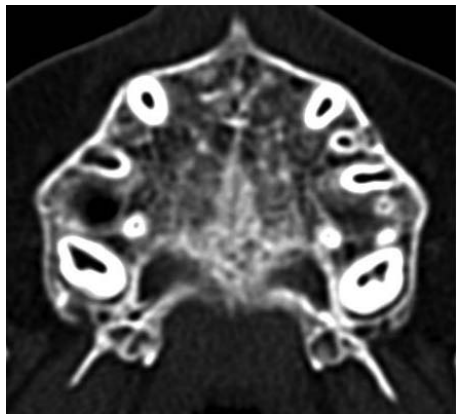

Figure 2: Patient: V.M.G. (Pre-expansion)

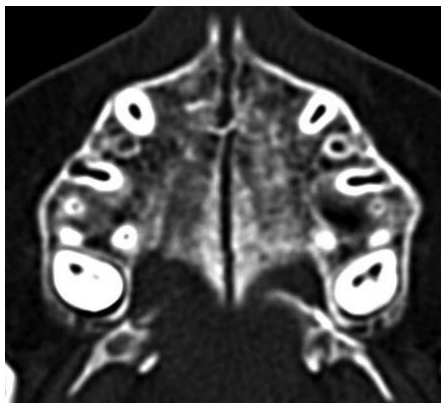

Figure 2A: Patient: V.M.G. (Post-expansion)

Figure 2: CT scan of a patient before and immediately after RPE. The image shows the opening of the midpalatal suture along its entire extension, from the ANS to the PNS.

turn of the screw per day until good morphology of the maxillary dental arch was obtained, with some over-correction.

CT scans were used to study the behavior of the midpalatal suture with RPE (Figures 2-4) as they clearly show sections of the human body three-dimensionally. All patients underwent the CT examination three times: prior expansion, immediately after expansion and after retention with the expander appliance. A Toshiba Xvision EX helicoid CT-scanner (Toshiba Corporation Medical Systems Company, Otawara-Shi, Japan). Secondary radiation was eliminated with the use of a 0.9 x 0.9 mm quadrangular collimator.

Axial CT scans with a 1 mm thickness were taken parallel to the palatal plane, including the dento-alveolar area and the maxillary base, up to the lower third of the nasal cavity (Figure 4). Approximately 36 to 40 scans (36 to 40 mm) were made for each patient. Data were sent to a Workstation (Silicon Graphics, Toshiba Corporation Medical Systems Company, Otawara-Shi, Japan), where the reconstruction of the axial scans parallel to the palatal plane at the midpalatal suture level were made by the Alatoview software (Toshiba Corporation Medical Systems Company) (Figure 4).

We evaluated the CT cuts morphologically. We all agreed that these cuts showed the midpalatal suture behavior after an 8 to 9-month retention phase with the fixed expander appliance. Besides the visual diagnosis, the distance between the anterior part of the midpalatal suture and PNS was also measured with the software. Means and standard deviations were calculated for ANS and PNS areas as well as the difference for each during the pre-expansion and post-retention periods. Student's 't' test was applied in order to verify if there was any statistically significant difference for the measured values in the ANS and PNS regions at the pre-expansion and post-retention stages (Table 2).

RESULTS AND DISCUSSION

The qualitative evaluation of the post-retention CT scans demonstrated normality along the midpalatal suture (Figure 4). The new suture shown in the scans at the post-retention phase is similar to the pre-treatment scans of the 17 children. The behavior of the midpalatal suture during the active and passive phases of RPE can be seen in Figure 4. Regarding the quantitative evaluation, the post-retention CT scans showed that only the ANS area showed a small gap between the suture margins (0.13 mm). However, this opening is not statistically significant when compared to the pre-treatment distance (0.15 mm) (Table 2). The results clearly show the behavior of the midpalatal suture with RPE compared to the images obtained in occlusal radiographs of the maxilla. The suture was completely ossified after the approximately 8 to 9-month retention period.

During the active phase of RPE the midpalatal suture opens as the screw is activated but it re-organizes in a few months during the passive phase with connective tissue repair and formation of new bone.[27] Routinely, the midpalatal suture opening as well as its subsequent ossification is controlled with occlusal radiographs of the maxilla, which clearly identify the separation of the maxillary seg-

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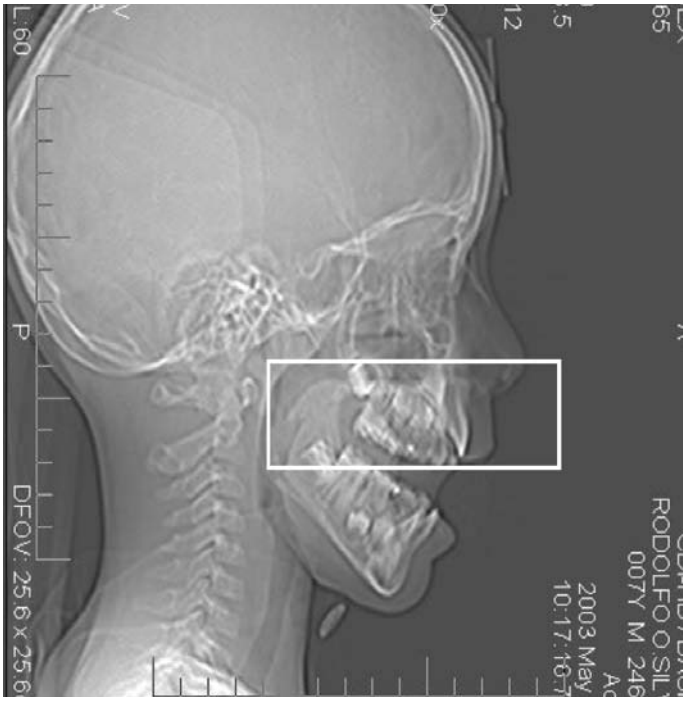


Figure 3: Scanogram of one patient with the maxillary area emphasized in the CT exam.

ments and their subsequent gradual ossification in the anterior area of the palate. The margins of the old suture, separated with RPE,

Variables	Pre-expansion		Post-expansion		Post-retention		Pre-expansion post-retention difference	"p" value
	$\overline{X}$	SD	$\overline{X}$	SD	$\overline{X}$	SD		
ANS	0.15	0.01	2.36	0.05	0.28	0.02	+0.13	0.2318 ns
PNS	0.15	0.01	1.10	0.04	0	0	-0.15	0.0315 ns

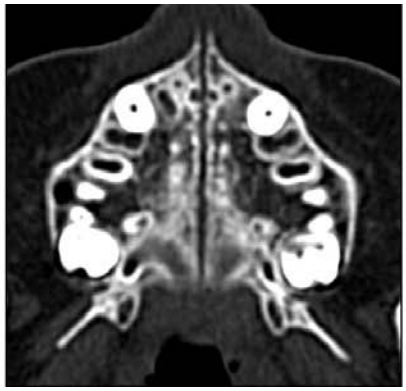
ns = statistically insignificant, at a significance level of 5%.

Table 2: Means (X) and standard deviations (SD), in millimeters, for the distance between the palatine laminae in the ANS and PNS regions, at the pre-treatment, post-expansion and post-retention stages with the expander appliance

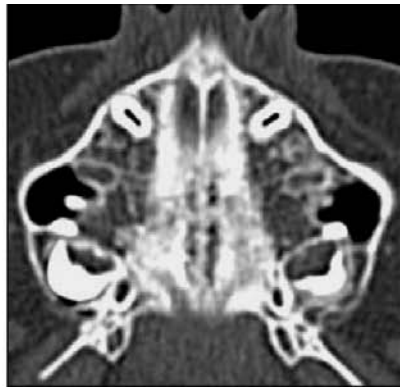
begin to disappear simultaneously with the appearance of the newly formed suture. In our opinion, from a long-term stability standpoint the appliance should be removed only after total bone formation of the midpalatal suture is achieved.[28-32] In a 5-year post-treatment follow-up study with 17 patients treated with RPE in the permanent dentition, we observed a reduction in the transverse distances measured on dental casts (Table 3).[30] However, we concluded that the relapse did not cause any consequence to the intra-arch and inter-arch relationship in the treated occlusions. Although several factors are involved in relapse, we suggested that total suture ossification can help improve post-expansion stability.[28]

The only histological study in humans that analyzed the behavior of the midpalatal suture was carried out on children ranging in age from 8 to 13 years.[39] During the third and fourth weeks after expan-

4A - Patient: A.D.B.F. (Pre-expansion)

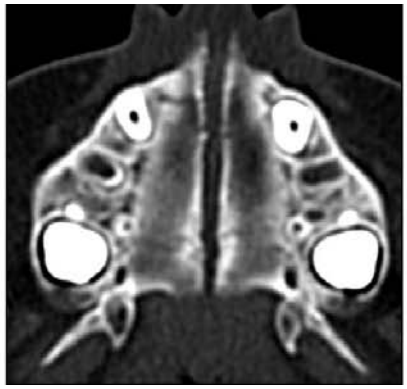


4A' - Patient: A.D.B.F. (Post-expansion)



4A"- Patient: A.D.B.F. (Post-retention phase)

4B - Patient: D.T.S. (Pre-expansion)



4B' - Patient: D.T.S. (Post-expansion)

4B"- Patient: D.T.S. (Post-retention phase)

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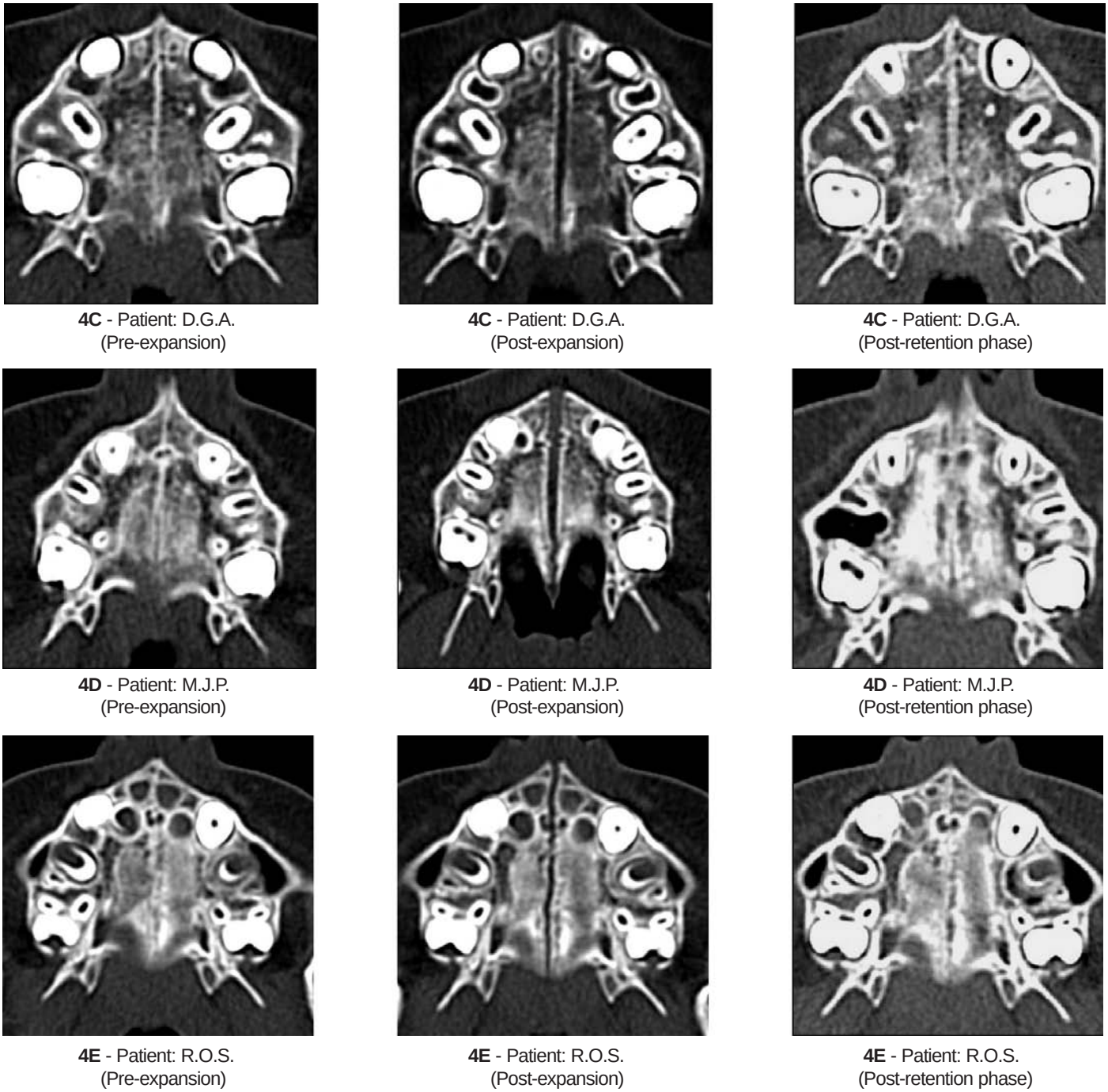

4C - Patient: D.G.A. (Pre-expansion)

4C - Patient: D.G.A. (Post-expansion)

4C - Patient: D.G.A. (Post-retention phase)

4D - Patient: M.J.P. (Pre-expansion)

4D - Patient: M.J.P. (Post-expansion)

4D - Patient: M.J.P. (Post-retention phase)

4E - Patient: R.O.S. (Pre-expansion)

4E - Patient: R.O.S. (Post-expansion)

4E - Patient: R.O.S. (Post-retention phase)

Figure 4: Midpalatal suture image in the pre-, post-expansion and post-retention CT scans (axial scan at the palatal vault level) of 5 of the patients randomly selected from the total sample.

sion, together with the widening of the suture, the tissue showed evidence of inflammation with intense osteoblastic activity along the surface and bone processes. After 5 and 6 months, ossification progressed, exhibiting bone islands along the suture. One year after expansion, the completely calcified suture showed the formation of bone bridges in the suture margins.

Reorganization of the midpalatal suture is generally controlled with occlusal radiographs of the maxilla (Figure 5). Restructuring of the midpalatal suture in the occlusal radiograph image is an indication that the expander can be removed. The bone repair process begins immediately after the active phase of RPE[4,10,12,44], even though full ossification of the midpalatal suture identified in the total occlusal radiograph image of the maxilla takes about 5 months which is the span during which the appliance remains in the mouth. Children in this research underwent their last CT immediately after removal of the fixed expansion appliance, in an average period of 8 to 9 months. The CT scans evaluated immediately after removal of the expander revealed integrity of the entire midpalatal suture. CT scans complemented the identification of the images that were not identified in the radiographic image, as observed in the pre-expansion, post-expansion and post-retention scans shown in Figure 4. The scans in Figure 4 prove that the ossification of the midpalatal

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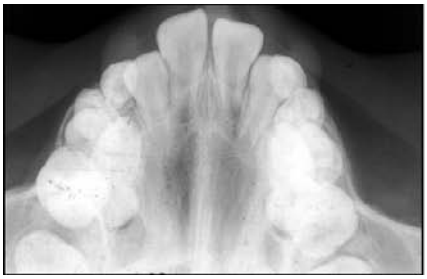
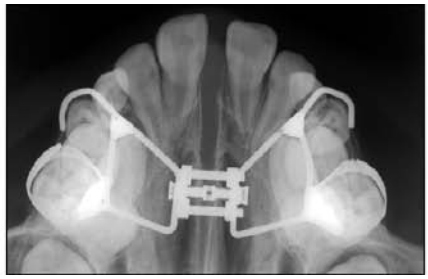
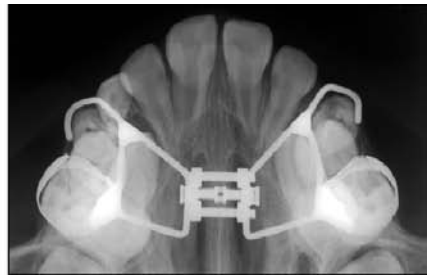


5A - Pre-treatment (21/12/00)



5B - Post-expansion (19/09/01)



5C- Post-retention phase (19/12/01)

Figure 5: Longitudinal occlusal radiographs of the maxilla showing the behavior of the midpalatal suture: (A) pre-treatment; (B) post-expansion (end of active phase); and (C) post-retention phase with the expander.

Teeth	Post-treatment		Post-retention (5 years)		Retention and treatment difference	"t" test
	$\overline{X}$	SD	$\overline{X}$	SD	$\overline{X}$	
3-3	35.51 mm	1.65 mm	34.86 mm	1.74 mm	-0.64 mm	0.0019*
4-4	43.37 mm	1.91 mm	42.46 mm	2.20 mm	-0.91 mm	0.0295*
5-5	48.96 mm	2.09 mm	47.73 mm	3.0 mm	-1.32 mm	0.0205*
6-6	53.07 mm	2.94 mm	52.53 mm	2.93 mm	-0.54 mm	0.0684 ns
7-7	58.74 mm	3.60 mm	59.04 mm	3.73 mm	0.30 mm	0.9741 ns

* significant at the 5% level of confidence ns = not significant

Table 3: Average and standard deviation values for transversal measurements obtained from dental casts of the upper dental arch (extracted from Silva Filho et al.[30])

suture occurs along its entire extension, from the ANS to the PNS.

CONCLUSION

CT scans taken at the palatal plane in children submitted to RPE with the Haas fixed expander revealed that the midpalatal suture was completely ossified after an average retention period of 8 to 9 months.

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