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Lack of significant volumetric alteration after rapid maxillary expansion supports the use of frontal sinuses for human identification purposes

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ABSTRACT

Aim: The present study aimed to assess the volume of the frontal sinuses before and after rapid maxillary expansion (RME).

Material and methods: The sample consisted of 12 subjects (8 females and 4 males) with maxillary deficiency aged between 10 and 15 years old. In order to treat the skeletal deficiency, RME was performed using Hyrax system. Cone Beam Computed Tomography (CBCT) scans were obtained from each subject before (T1) and 120 days after (T2) the RME. A table digitizer G-Pen F350 (Genius, Taipei, Taiwan) was used to select the area of the frontal sinuses in CBCT slices. The volume of the sinuses was quantified in T1 and T2. T-test for paired samples was used to compare the differences between the volume of the frontal sinuses before and after RME

Results: The mean volume of the frontal sinuses before and after the RME was 3.03 mm^3 (ranging from 2.20 mm^3 to 4.40 mm^3) and 3.21 mm^3 (ranging from 2.55 mm^3 to 4.52 mm^3), respectively. Differences in volume between T1 and T2 were not statistically significant ($p > .05$). The present study indicates that the frontal sinuses do not modify considerably in volume after RME.

Conclusion: From the forensic scope, this outcome supports the usefulness of the frontal sinuses for ante-mortem and post-mortem comparisons in human identification cases.

1. Introduction

The frontal sinuses consist of cavities in the frontal bone. In general, these sinuses develop around the second year of age and become visible radiographically three years later [1]. Nearly the second decade of life, the frontal sinuses grow with a more complex morphology and reach complete development [1]. The scientific literature considers the pattern of frontal sinus morphology highly distinctive among subjects [2]. For that reason, these sinuses are investigated for human identification purposes [2].

In the forensic routine human identification is founded on comparisons between ante-mortem (AM) and post-mortem (PM) data [3]. The comparisons usually include fingerprint, dental or DNA data. In 1921, radiographs of the frontal sinuses were compared for the first time for human identification [3]. Currently, they are assessed to strength the similarities between AM and PM data and consequently to support the identification process with more evidence [4]. Matching frontal sinuses AM and PM depends mainly on the medical images available and the morphology of the sinuses. While in one hand computed tomography became a powerful tool available in the forensic practice [5], on the other hand the morphology of the sinuses remained uncertain in individuals that undergo orthopedic procedures in the face.

The rapid maxillary expansion (RME) figures among the most invasive non-surgical procedures in the face. Especially in Dentistry, RME is performed to expand the maxilla through the separation of the median palatal suture [6]. The skeletal effects of this procedure involve not only sutures in the maxilla and palatal bones but also in the nasal, zygomatic and frontal bones [7]. Subjects treated with RME have the airways enlarged and breathing improved [8].

Based on the skeletal effects of the RME and on the importance of the frontal sinus for comparative human identifications, the present research aimed to assess the volume of the frontal sinuses before and after RME. Up to the present date no similar study was found in the scientific literature.

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2. Material and methods

The initial sample consisted of 424 subjects aged between 10 and 15 years old treated at a dental clinic in Brazil. These subjects underwent sampling based on the following inclusion criteria: maxillary deficiency, posterior crossbite, no systemic disease and no medical history of facial trauma. The exclusion criteria consisted of deciduous molars in the mandibular arch, missing maxillary permanent first molars, metallic restorations in the maxillary permanent first molars; periodontitis; previous orthodontic treatment; surgery in the frontal sinuses; evident facial asymmetry and malnutrition. After applying the eligibility criteria, the final sample consisted of 12 Caucasian subjects (8 females and 4 males, mean age: 12.4 years ± 1.4 years).

The subjects underwent RME using Hyrax system with 4 orthodontic bands (attached in the first premolars and first molars). The orthodontic/orthopedic system was installed and activated with a complete turn. During the treatment, the device was activated daily in the morning and in the evening (¼ turn each). The treatment was conducted until the palatal cusps of the maxillary first molars touch the vestibular cusps of the mandibular first molars. Once the treatment was concluded, the device was kept stable for 120 days as an orthodontic retained. During this period the subjects was monitored monthly. Opening of the palatal suture was confirmed clinically with the midline diastema in the maxilla. After retaining for 120, the orthodontic system was removed.

Cone-Beam Computed Tomography (CBCT) scans were obtained from each patient before (T1) and after (T2, when the system was removed) RME (n = 24). ICat Vision™ (Imaging Sciences International, Hatfield, PA, USA) device was used with 120kVP, 37mAs, time of acquisition of 14.7 s, 0.2 voxel size and slice thickness of 0.5 mm. The CBCT scans were imported as DICOM files in OsiriX® v.5.5.2 32-bit (Pixmeo, Geneva, Switzerland) software package. Sella-nasion distance was used as reference to set the position of the image and establish the area of interest in sagittal slices (Fig. 1). With the area of interest established in three dimensions, a 2D/3D segmentation tool provided by the software was used. To quantify the volume of the sinuses, the minimum threshold was set in −1.000 and the maximum in −400 (Fig. 2). It is important to note that because the subjects sampled were younger than 20 years of age (the frontal sinuses are still developing), normal growth rates expected during the 120 days after RME were consulted in the scientific literature [9] (Table 1) and reduced from the final volume of the frontal sinuses. All the measurements taken in the software were performed twice with an interval of 20 days. Intra-examiner agreement was calculated. Finally, the morphology of the frontal sinuses of each individual was classified according to Guerram et al. [10].

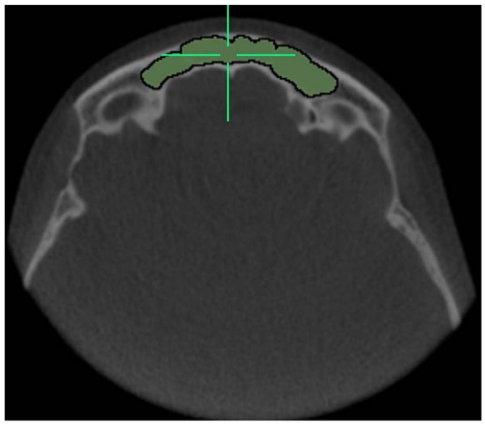

Fig. 2. Axial slice showing the frontal sinuses highlighted and selected for the quantification of volume.

Table 1
Frontal sinus growth according to Yun et al. [9].

Age	Mean volume	Annual growth	Growth in 4 months
10	1.98	–	–
11	2.36	19.2	6.4
12	3.28	39.0	13.0
13	4.61	40.5	13.5
14	5.48	18.9	6.3
15	5.73	4.6	1.5

Age expressed in years, mean volume expressed in mm^3, Annual and 4-month growth expressed in percentage (%).

To assess intra-examiner agreement, paired t-test was used. To determine the casual error intra-examiner Dahlberg's methods was adopted. The outcomes were expressed in tables as means and standard deviations of the sinus volume. Kolmogorov-Smirnov test was used to investigate sample normality. T-test for paired samples was used to compare the sinuses before and after RME. Statistica 13.0 (StatSoft Inc., Tulsa, USA) software package was used for all the statistical procedures considering a significance level of 5%.

3. Results

The systematic and casual errors intra-examiner are reported in

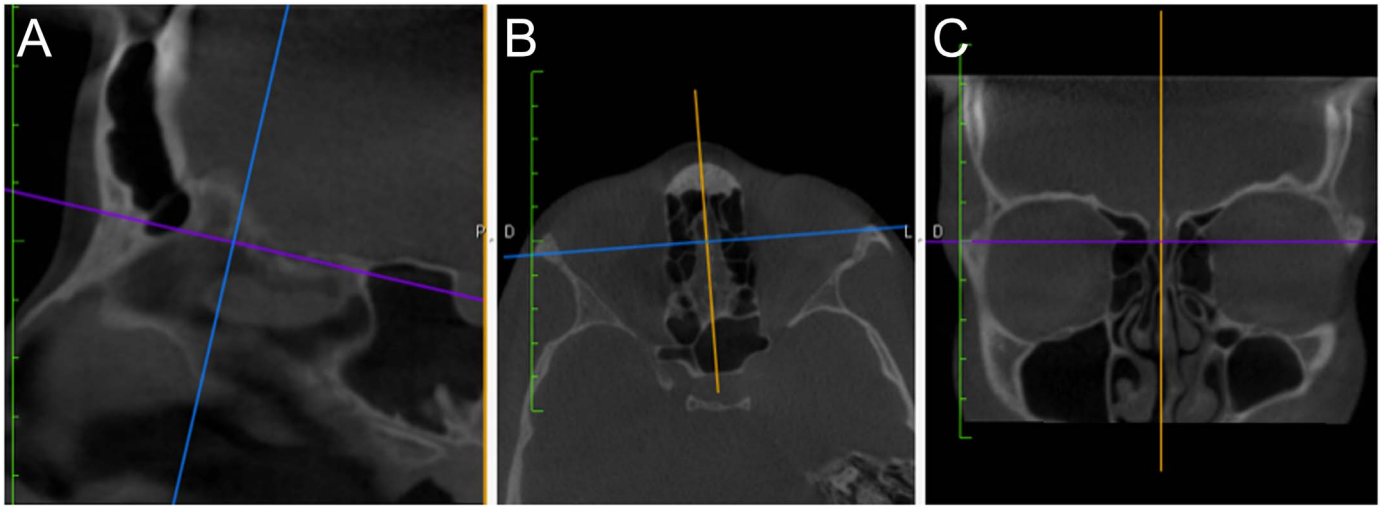

Fig. 1. Areas of interest set with the image positioned in the sagittal (A), axial (B) and coronal (C) views based on the Sella-Nasion line.