# Evaluation of the midpalatal suture during rapid palatal expansion in children: a CT study

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*The midpalatal suture of 18 children submitted to rapid palatal expansion with the Haas fixed expander and ranging in age from 5 years 2 months to 10 years 5 months was evaluated with computerized tomography. The posterior nasal spine undergoes the impact of RPE in patients in the primary and mixed dentition stages, similarly to the anterior nasal spine though to a lesser extent. The average opening of the midpalatal suture was 2.21 mm in the anterior nasal spine region and 0.95 mm in the posterior nasal spine region.*
J Clin Pediatr Dent 29(3): 231-238, 2005



## INTRODUCTION AND LITERATURE REVIEW

Maxillary constriction may be diagnosed in the primary dentition and is one of the etiological factors for malocclusion, with consequences both in the intra-arch and inter-arch relationship.[1] One of the treatment possibilities consists of transverse orthopedic mechanics with a fixed expansion device known as the Haas expander. When the expander screw is activated, both maxillary segments are separated (Figure 1), with bone gain between them.[2-4] During activation of the expansion screw, a force equivalent to the skeletal structure resistance of the face is created. Such a resistance varies with age, but may surpass 7000 grams during the activations.[5]

Studies aim to explain three-dimensionally the range of the skeletal effect of rapid palatal expansion (RPE) on the maxilla using radiographs, mainly. Studies with postero-anterior (PA) cephalometric radiographs[4,6,7-14] show the frontal behavior of the maxilla and indicate that RPE induces the pendular separation of the maxillary segments, with the dental arch widening corresponding to almost twice the amount of the basal bone widening,[7,8] as suggested in the picture of the dry skull submitted to RPE shown in Figure 1. Measurements taken from PA radiographs of children in the primary and mixed dentition stages showed an average increase of approximately 5.46 mm in the intermolar width and 2 mm in the intra-nasal width, which corresponds to 43% of the alveolar region width[11] (Figures 1 and 2). Therefore, RPE is always characterized by buccal inclination of the anchoring teeth.[2,4,15,16] In summary, RPE induces a transverse rotation of the maxillary segments in the PA view, with the larger opening located in the oral cavity and the center of rotation of the maxillary segments near the frontonasal suture.[4,9,13,17,18]

In the transverse view, maxillary occlusal radiographs have shown that the midpalatal suture does not follow a parallel pattern either.[13] Figure 1 clearly shows that the greatest separation occurs in the anterior area, decreasing toward the posterior nasal spine (PNS). This was also verified in the occlusal radiographs shown in Figure 2. However, maxillary occlusal radiographs have a limitation in the posterior area of the midpalatal suture, attributed to the overlapping of the cranial base structures (Figure 2).

Therefore, the radiographic studies have revealed that both maxillary segments are pendulously separated in the PA and occlusal views, as suggested in Figure 1. Such distancing of the maxillary segments also

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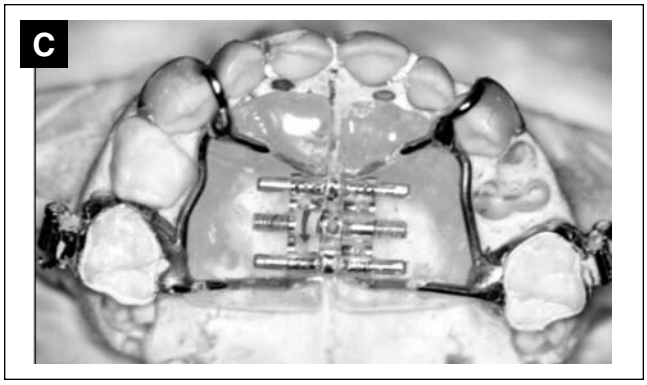
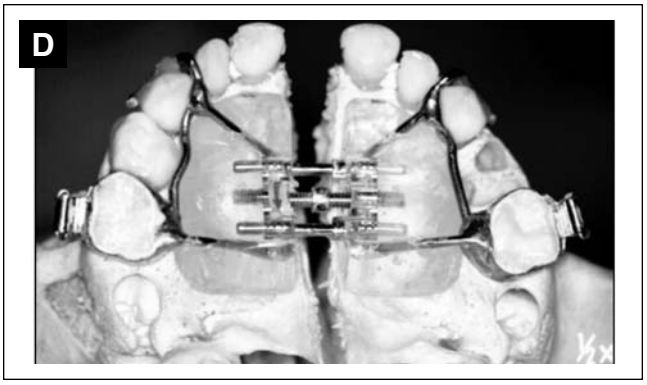
**1A** – Dry skull (Frontal view) – Fixed expansion appliance installed


**1B** – Dry skull (Frontal view) – Post-expansion




**1C** – Dry skull (Occlusal view) – Fixed expansion appliance installed




**1D** – Dry skull (Occlusal view) – Post-expansion


**1E** – Dry skull (Posterior view) – Post-expansion. PNS rupture can be clearly observed after RPE.

**Figure 1.** Simulation of the orthopedic effect of RPE on a dry skull with the Haas fixed expander installed during the primary dentition stage.

causes the lowering of the maxilla and the upper teeth (Figure 3), inducing a clockwise rotation of the mandible,[4,6,10,13,14,19-22] with or without maxillary anterior dispalcement.[6,13,21-23] However, maxillary behavior in the sagittal plane is reversible and does not influence facial growth patterns.[6,13,23,24]

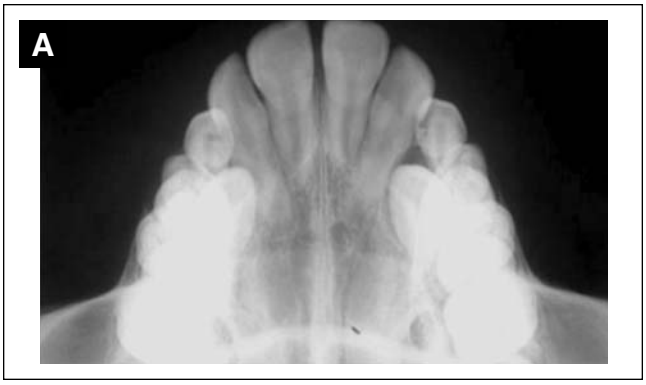
This study evaluated the behavior of the midpalatal suture immediately after RPE with the Haas fixed expander, in the primary and mixed dentition stages with computerized tomography (CT) analysis.

## MATERIALS AND METHODS

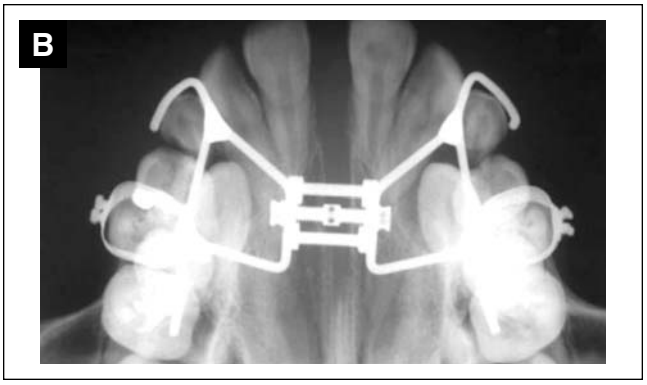
The sample was comprised of 18 children, 11 males and 7 females, ranging in age from 5 years 2 months to 10 years 5 months (mean 8 years 2 months) with transverse maxillary deficiency. Of the total sample, only one patient was in the primary dentition stage and the remaining were in the mixed dentition stage. The Haas fixed expansion appliance (Figure 4) was used to treat the upper dental arch constriction. The activation protocol[25] included one complete turn of the screw per day until obtaining good morphology of the upper dental arch, with some over correction.

CT scan was used to study the behavior of the midpalatal suture with RPE (Figures 5 and 6). CT scans clearly show sections of the human body three-dimensionally. All patients were subjected to the computerized tomographic exam prior to and immediately after RPE. A Toshiba Xvision EX helicoid CT-scanner (Toshiba Corporation Medical Systems Company, Otawara-Shi, Japan), manufactured in 1997 and operating at 120kV and 100mA was used for the tomographies. Secondary radiation was eliminated with the use of a 0.9 x 0.9 mm quadrangular collimator.

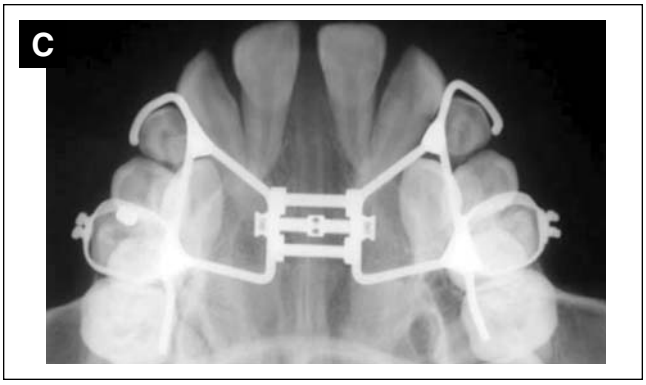
Axial CT scans with a slice thickness of 1mm were made parallel to the palatal plane, including the dentoalveolar area and the maxillary base, up to the lower third of the nasal cavity (Figure 5). Approximately 36 to 40 scans (36 to 40mm) were made for each patient.



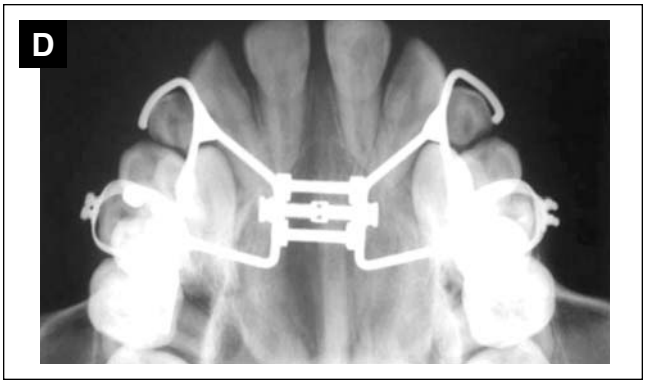

**2A** – Initial radiograph - 01/18/01



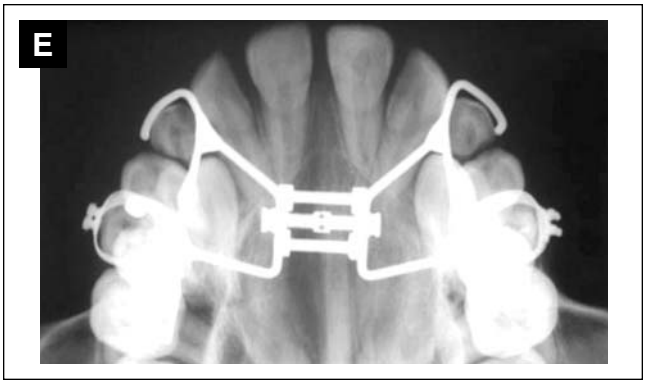

**2B** – End of active phase (end of activation) - 06/12/01



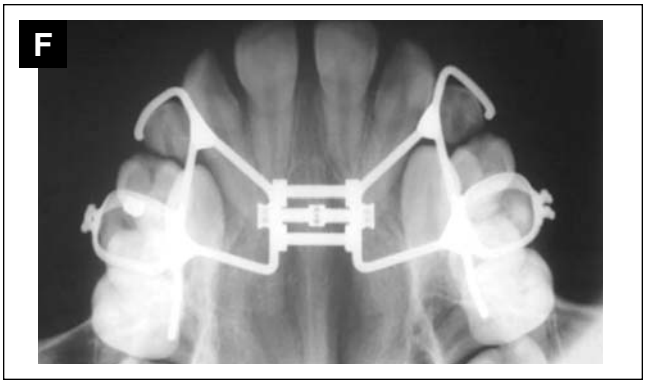

**2C** – 1 month post-expansion (retention phase) - 07/16/01



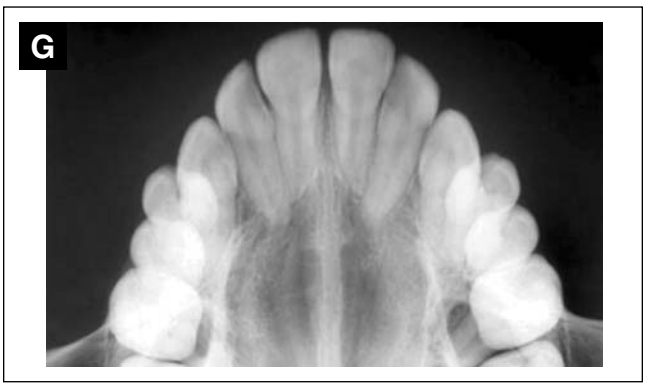

**2D** – 2 months post-expansion (retention phase) - 08/14/01




**2E** – 3 months post-expansion (retention phase) - 09/12/01




**2F** – 4 months post-expansion (retention phase) - 10/18/01




**2G** – In the permanent dentition, the expander was removed after formation of the new suture - 12/19/02

**Figure 2.** Longitudinal occlusal radiographs of the maxilla show the initial stage, the immediate effect of RPE, and the progressive ossification of the midpalatal suture during the retention phase, until the complete permanent dentition.

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 6).

Initially, the scans were morphologically evaluated and then the PNS opening was classified as either pyramid or parallel-shaped. Besides the visual diagnosis, the widths at the anterior edge of the midpalatal suture and in the PNS region were measured with the aid of a mea-

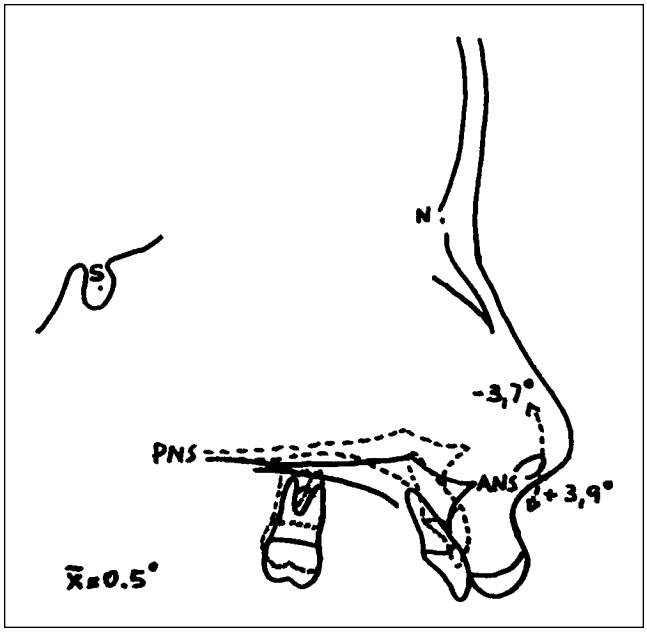



Figure 3

suring tool of the CT-scanner reading program. Means and standard deviations were calculated for the midpalatal suture opening at the anterior edge and in the PNS region, as well as the difference for each of them during the pre- and post-expansion periods (Table 1).

## RESULTS AND DISCUSSION

Maxillary behavior after RPE is better explained whenever biological and mechanical aspects are considered. Biologically, the maxilla is located at the cranium base within the craniofacial complex, articulating with nine bones: nasal, lachrymal, frontal, ethmoid, sphenoid, zygomatic, vomer, inferior nasal conchae, and palatine[26] (Figure 7). Mechanically, the expander is placed in the occlusal part of the maxilla, the teeth and the palate, which makes the force released distant from the maxillary center of resistance (Figures 1 and 4). These two factors limit the orthopedic action of the expander and impede the maxillary segments to separate on a parallel basis.

The orthopedic effect of RPE is clinically evidenced through the opening of the inter-upper central incisors diastema (Figure 4). Such effect is easily confirmed in the occlusal radiographic image of the maxilla (Figure 2). The midpalatal suture is not the only suture influenced by RPE. Indeed, all anatomical structures associated with the maxilla receive tension caused by the activation of the expansion screw[18], including histological distortion in the parietal suture and in the sphenoccipital synchondrosis,[3] but without lateral displacement in the temporal, parietal, frontal, sphenoid and occipital bones.[17]

Table 1. Means (X) and standard deviations (SD), in millimeters, for the pre- and post-RPE measurements.

| Variables | Pre-expansion | | Post-expansion | | Pre-expansion post-expansion difference |
|---|---|---|---|---|---|
| | X | DP | X | DP | |
| **ANS** | 0.15 | 0.01 | 2.36 | 0.05 | 2.21 |
| **PNS** | 0.15 | 0.01 | 1.10 | 0.04 | 0.95 |

The purpose of this study is to illustrate the actual sagittal extension of the midpalatal suture following RPE with the Haas fixed expander in children in the primary and mixed dentition stages by means of CT. The main advantage of CT in relation to the occlusal radiograph of the maxilla is that CT allows for the perfect visualization of the PNS, with neither upper bone overlapping once the scans are parallel to the palatal plane nor any interference from other anatomical structures (Figure 6). The occlusal radiograph of the maxilla clearly shows the midpalatal suture until the middle part of the palate, but the palatal posterior area is not well evidenced when the overlapping with the cranial base structures impede the visualization of the PNS.

The tomographic images at the midpalatal suture level (Figure 6) showed that PNS undergoes the impact of RPE as does ANS. The images clearly showed that the midpalatal suture also opened at its most posterior extremity, contiguous with the vigorous pterygoid segments of the sphenoid bone - considered to be pillars of resistance to maxillary disjunction. Such a detail had not yet been exposed in studies with humans. Of the total treated sample, only one patient did not show opening of the midpalatal suture at PNS. In most patients the midpalatal suture opening was pyramid-shaped, however, in some this opening looked parallel. The images suggest that the greater the expansion the

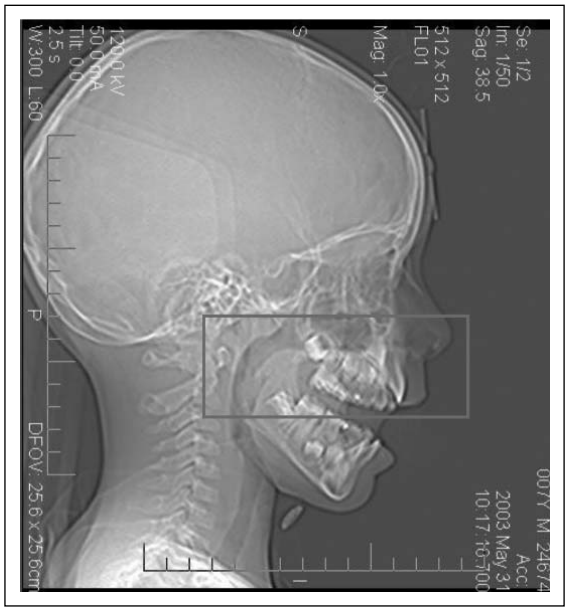



Figure 3

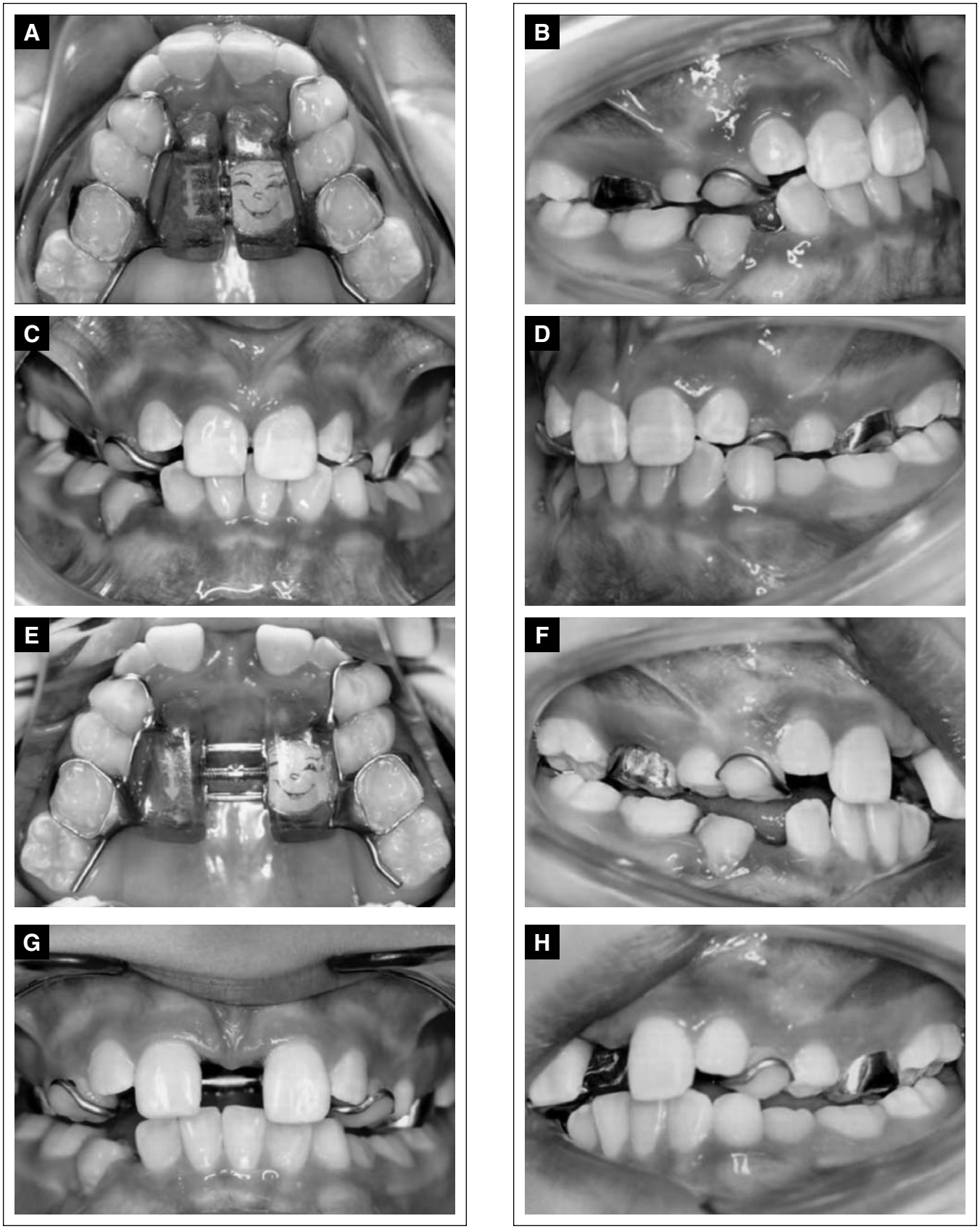



**Figure 4A-4H** - The Haas fixed expander was used to correct the upper dental arch constriction. The intraoral photographs show the pre- and post-expansion stages in a patient from the sample group.
**4A -** Occlusal view - Fixed expansion appliance installed; **4B -** Lateral view (right side) - Fixed expansion appliance installed; **4C -** Frontal view - Fixed expansion appliance installed; **4D -** Lateral view (left side) - Fixed expansion appliance installed; **4E -** Occlusal view - Post-expansion; **4F -** Lateral view (right side) - Post-expansion; **4G -** Frontal view - Post-expansion; **4H -** Lateral view (left side) - Post-expansion

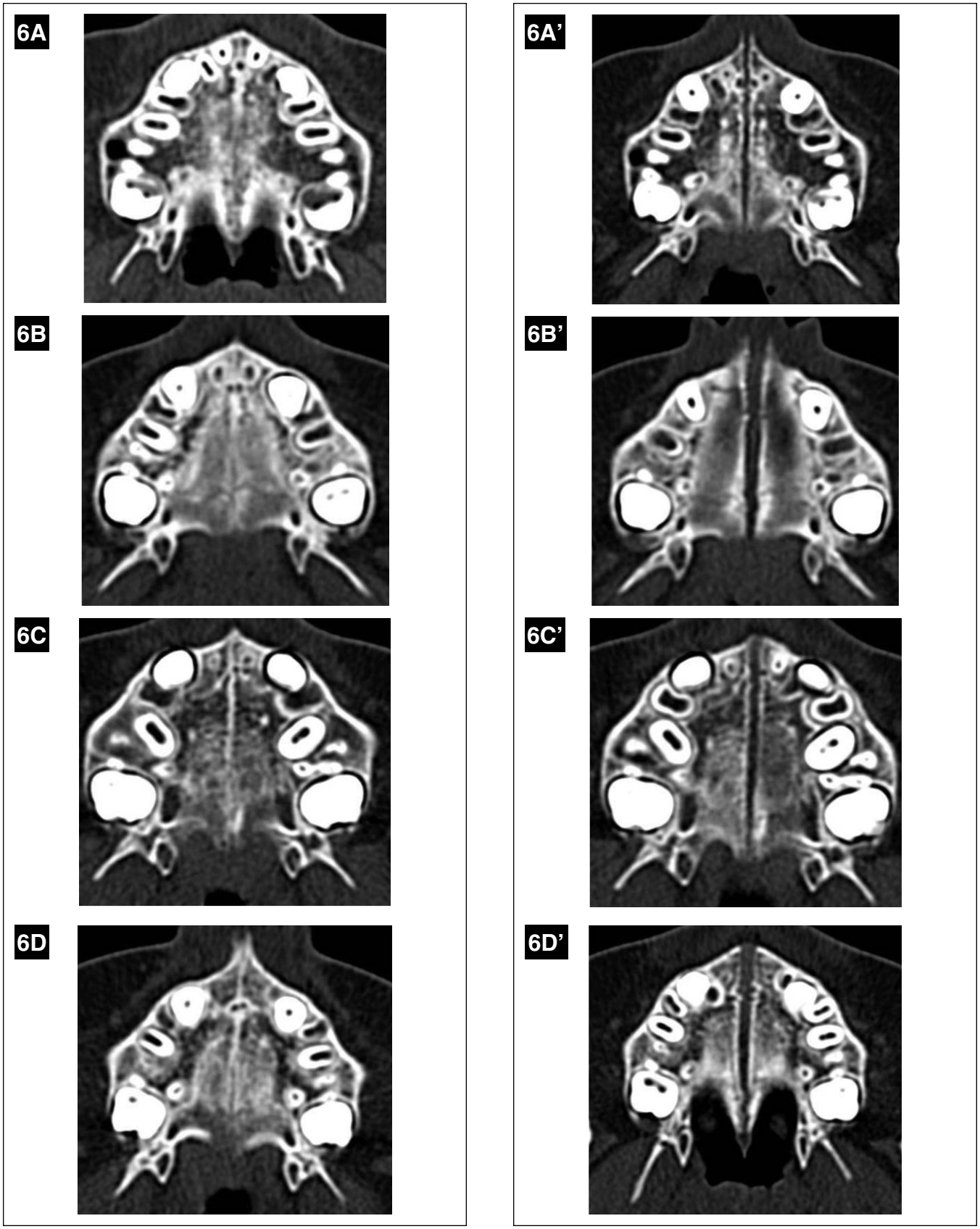
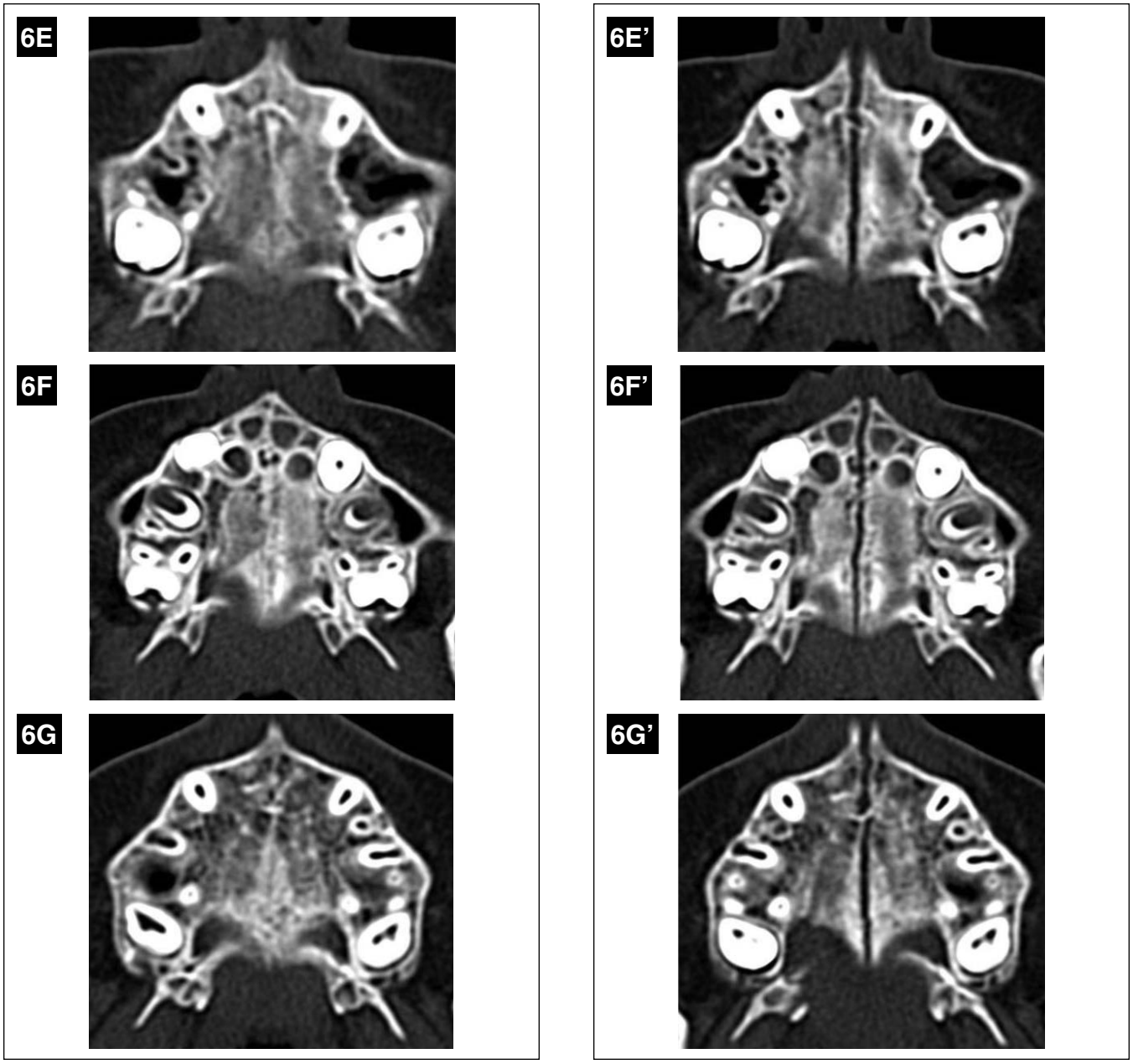



**Figure 6A-6D**. Midpalatal suture image diagnosed in the pre- and post-expansion CT scans (axial scan at the palatal vault level) of 7 of the patients randomly selected from the total sample.

**6A** - Patient: A.D.B.F. (Pre-expansion) **6A'** - Patient: A.D.B.F. (Post-expansion) **6B** - Patient: D.T.S. (Pre-expansion) **6B'** - Patient: D.T.S. (Post-expansion) **6C** - Patient: D.G.A. (Pre-expansion) **6C'** - Patient: D.G.A. (Post-expansion) **6D** - Patient: M.J.P. (Pre-expansion) **6D;** - Patient: M.J.P. (Post-expansion)




**Figures 6E-6G**

**6E: -** Patient: M.B.P. (Pre-expansion) **6E'** - Patient: M.B.P. (Post-expansion) **6F** - Patient: R.O.S. (Pre-expansion) **6F'** - Patient: R.O.S. (IPost-expansion) **6G** - Patient: V.M.G. (Pre-expansion) **6G'** - Patient: V.M.G. (Post-expansion)

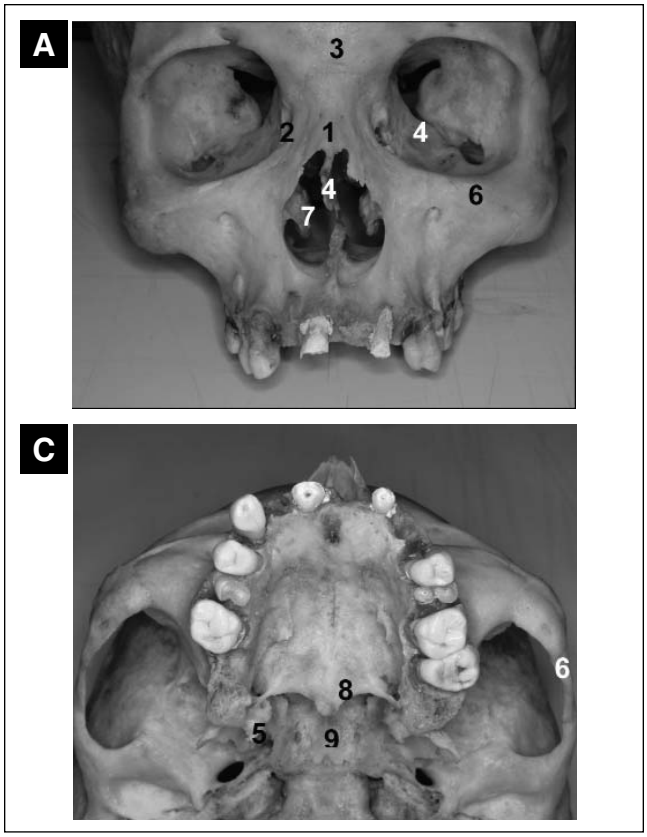
larger the triangular opening of the midpalatal suture, as shown in the tomographs in Figure 6.

The orthopedic effect on the midpalatal suture was quantified through measurements of ANS and PNS areas, made with the tomograph imaging reading program. Means and standard deviations for the pre- and post-RPE measurements are shown in Table 1. Data showed that the midpalatal suture opening at the PNS area is equivalent to 43% of the ANS area.

The result shown in Table 1 corroborates 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. It revealed, from an occlusal point of view, an almost parallel separation of the two maxillary segments.[17]

## CONCLUSION

The tomographic scans at the palatal plane level in children in the primary and mixed dentition stages submitted to RPE with the Haas fixed expander reveal an opening of the midpalatal suture at its most posterior limit - the PNS, though to a lesser extent than at the ANS.



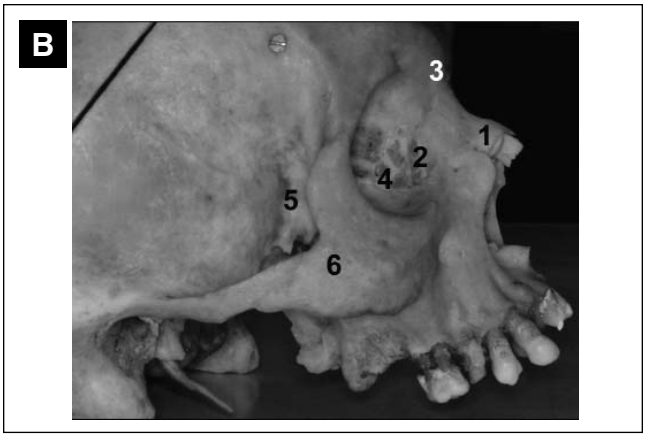




**Figure 7.** Dry skull illustrating the bones that articulate with the maxilla (1 - Nasal; 2 - Lachrymal; 3 - Frontal; 4 - Ethmoid; 5 - Sphenoid; 6 - Zygomatic; 7 - Inferior Nasal Conchae; 8 - Palatine; 9 - Vomer).

**7A** - Dry skull (Frontal view) **7B** - Dry skull (Lateral view) **7C** - Dry skull (Occlusal view)

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