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ORIGINAL ARTICLE

Maxillary sagittal growth evaluated on dry skulls from children and adolescents

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Abstract

Objective. The hypothesis of the present study is that the inter-relationship between the greater palatine foramen (stable structure) and the first maxillary molar, which is located in the growing and forward-moving maxilla, expresses the longitudinal growth of the maxilla. ***Materials and methods.*** The material comprised 25 human anthropological maxillae, normally developed and without tooth agenesis. The material was sub-grouped according to dental stages. Each sample was photographed in the occlusal view and two transverse reference lines were constructed, one connecting the palatine foramina and another connecting the lingual interlobal incisions in the first permanent molars. The perpendicular distance (T) between these two lines expressed the distance between the foramen and the first molar. ***Results.*** The T-distance increased markedly between the stages where the first, second and third molars had erupted. The study also showed that the greater palatine foramen was located palatally to the first molar in the stage where only the first molar had erupted, palatally to the second molar when this molar had erupted and palatally to the third molar when this molar had erupted. ***Conclusion.*** This study shows that the greater palatine foramen is located close to the most posterior located and erupted permanent molar in normally developed dentitions without agenesis. This information may be valuable for dentists when applying local anesthetics. Furthermore, the study revealed a growth pattern in the maxilla, which may reflect the etiology behind crowding in the maxillary molar region.

Key Words: *Anthropology, growth, maxilla, molar, palatal foramen*

Introduction

The sagittal maxillary growth has been evaluated by Björk and Skieller [1], who performed a cephalometric longitudinal study on individuals examined from childhood to adulthood over a period of 25 years. Metallic markers were inserted in these individuals. The markers were visible on profile radiographs and served as superposing structures for evaluation of growth. The study revealed that the maxillary growth occurs in the sutures surrounding the maxillary bone and it also revealed that the pterygomaxillary fissure, extending through the palatine canal to the greater palatine foramen, could serve as a stabile structure in cases where metal markers were not inserted. As the length of the hard palate posterior to the palatine foramen does not change significantly from early childhood to adulthood it was concluded that the sagittal growth occurs anterior to the palatine foramen. Previously, Björk and Skieller [2] have shown that the sagittal growth in the maxilla primarily occurs in the transverse palatine suture and at the tuber maxillae.

Björk and Skieller [2] furthermore showed that the direction of the maxillary growth in the lateral aspect is anterior and caudal.

The greater palatine foramen is located in the horizontal lamina of the palatine bone. In the adult cranium the location of this foramen has been described in relation to the maxillary permanent molars [3–7]. These studies were all performed on large anthropological materials of different ethnicities. Generally, the studies concluded that the foramen is located palatal to the third molar, but locations palatal to the region

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between the second and third molars are also described. Seemingly, no studies have attempted to describe the location of the foramen in relation to the permanent molars on skulls of children and adolescents where the second and/or third molars have not erupted.

On 22 skulls from children Sejrsen et al. [8] evaluated the palatal growth in the sagittal plane. They found that the growth takes place anterior to the greater palatine foramen. The growth increment in the area between the incisive foramen and the transverse palatine suture is more pronounced than the growth increment in the area between the transverse palatine suture and the greater palatine foramen. Furthermore, this study showed that the distance from the greater palatine foramen to the posterior margin of the osseous palate did not increase significantly with age [8].

A histological study on the formation of the human fetal palate has demonstrated that the transverse palatine suture has an oblique orientation with extensive bone apposition on the maxillary edge of the suture and minor apposition on the palatal edge [9]. This supports the above-mentioned results achieved on post-natal growth of the palate achieved by cephalometry. The pre-natal study by Nijo and Kjær [9] also documented that the incisal suture does not contribute to the elongation of the palate. This was further documented by radiography of pre-natal material [10].

According to the studies mentioned it is generally agreed that the longitudinal growth of the maxilla occurs in the transverse palatal suture and anterior to the greater palatine foramen. This growth pattern, which results in a forward-moving of the maxilla, is coordinated with appositional growth at the tuber maxillae, which prolongs the alveolar process and thereby gradually provides space during childhood first to the second molar and subsequently to the third molar.

The hypothesis of the present study is therefore that the inter-relationship between the greater palatine foramen (stable structure) and the first maxillary molar, which is located in the growing and forward-moving maxilla, expresses the longitudinal growth of the maxilla.

Accordingly, the purpose of the present study is to analyze the distance from the greater palatine foramen to the first molar in anthropological crania from children and adolescents and to evaluate whether this distance is useful as an expression of the longitudinal growth of the maxilla.

Materials and methods

Maxillae

The anthropological material comprised 25 human maxillae from a collection located at the Department of Orthodontics, Copenhagen School of Dentistry. An example is shown in Figure 1. Exact ages, skeletal maturity and gender were unknown. The maxillae represent normal development and dentitions without agenesis.

Figure 1. Photograph of an anthropological human palate and dentition. Dental stage DS4 M3.

Dental stage

For the evaluation of the approximate ages of the crania, dental stages were determined according to Helm and Seidler [11]. The age-related stages are as follows:

According to incisor, canine and premolar eruption:

- DS02 (the primary dentition has fully erupted): from 2.5 years,
- DS1 (permanent incisors erupting): 6 years,
- DS2 (permanent incisors completely erupted): 8–8.5 years,
- DS3 (permanent canines and premolars erupting): 9–9.5 years, and
- DS4 (permanent canines and premolars completely erupted): 12–12.5 years.

According to molar eruption:

- DSM0 (first molar erupting): younger than 6 years,
- DSM1 (first molar completely erupted): 6 years,
- DSM2 (second molar completely erupted): 13–13.5 years, and
- DSM3 (third molar completely erupted): Presumably older than 21 years.

Photography

Each sample was photographed with a digital camera, exposing the palate parallel to the lens of the camera.

The images were transferred from the camera to a computer and printed.

Enlargement from the prints to the actual samples

Measurements were taken of the length from the transverse suture to the posterior border of palate bone on each printout. Corresponding measurements were taken of the length from the transverse suture to the posterior border of palate bone on each sample.

The results from the measurement on each sample are divided with the measurement on the corresponding printout. This gives the size relationship for each sample and is later to be used for correction of differences in projection.

Measurements

Two transverse lines were constructed on each print:

- PF-line, connecting the posterior limitation of the bilateral greater palatine foramina, and
- ML-line, connecting the bilateral lingual interlobal incisions in the first permanent maxillary molar.

The distance between the PF- and ML-lines was measured on each print. This distance was designated T and the T-line is perpendicular to the PF- and ML-lines. If either the first permanent molar or the palatine foramen were missing unilaterally, a line from the present molar or from the present foramen was drawn perpendicular to the median palatine suture.

The two lines and the distances (in mm) between the lines are illustrated in Figure 2.

Results

Dental stages DS02M0 to DS02M1

Seven maxillae were available. The distance T was seemingly constant ($M = 2.6$ mm) in this period where the first molar is erupting and has fully erupted (Figure 3).

Dental stages DS2M2 to DS4M2

Thirteen maxillae were available. The distance T had markedly increased in this period where the second molar is erupting when compared to dental stage DS02M0 to DS02M1 (M = 13.1 mm) (Figure 3).

Dental stage DS4M3

Five maxillae were available. The distance T was largest in this group compared to the other groups (M = 19.0 mm) (Figure 3). In this group the third molar had erupted.

The study showed that the distance from the ML-line, connecting the two first permanent maxillary molars, to the PF-line, connecting the

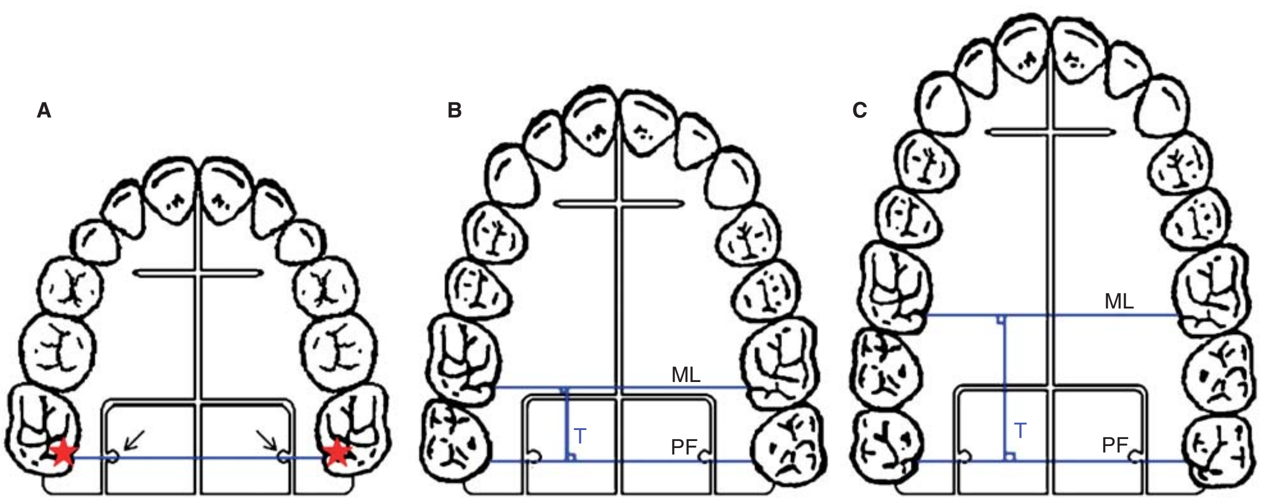

Figure 2. Schematic drawings of the hard palate from three anthropological human skulls, representing three different dental stages. (A) Dental stage DS02 M0: The primary dentition has fully erupted (DS 02) and the first molar is in its initial eruption phase (DS M0). The transversal line between the two greater palatine foramina (arrows) corresponds to the line between the lingual interlobal incisions (stars) of the first permanent molars. The greater palatine foramen is located palatally to the first molars. (B) Dental stage DS4M2: The permanent canines and premolars have fully erupted (DS4) and so has the second molar (M2). The greater palatine foramen is located palatally to the second molars. The PF-line connects the posterior limitation of the bilateral greater palatine foramina. The ML-line connects the bilateral lingual interlobal incisions in the first permanent maxillary molar. T indicates the distance between the two lines. (C) Dental stage DS4M3: The permanent canines and premolars have fully erupted (DS4) and so has the third molar (M3). The greater palatine foramen is located palatally to the third molars. The PF-line connects the posterior limitation of the bilateral greater palatine foramina. The ML-line connects the bilateral lingual interlobal incisions in the first permanent maxillary molar. T indicates the distance between the two lines. The figure shows that the distance from the ML-line, connecting the two first permanent maxillary molars, to the PF-line, connecting the two greater foramina, is shortest when the first molar is under eruption, larger in the stage when the second molar has erupted and largest when the third molar has erupted.

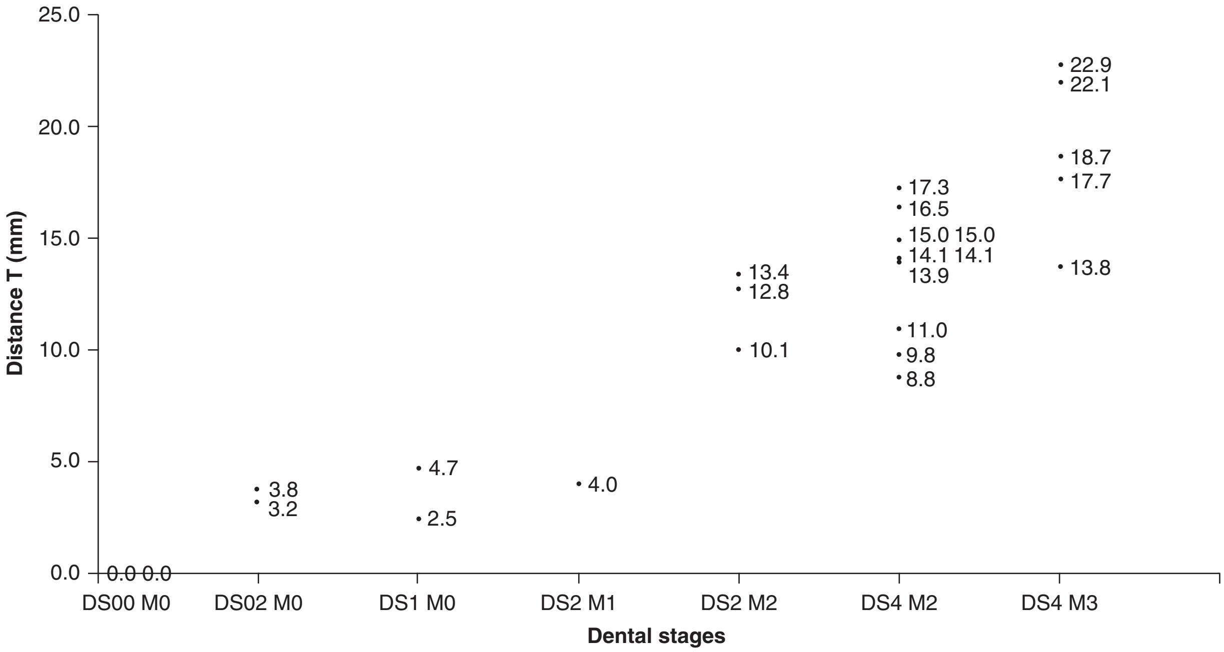

Figure 3. Graphic presentation of the distance T (indicated in Figure 2) at different dental stages. The figure shows that the value of distance T gradually increases with increasing dental maturity. DS02 (the primary dentition has fully erupted): from 2.5 years; DS1 (permanent incisors erupting): 6 years; DS2 (permanent incisors completely erupted): 8–8.5 years; DS3 (permanent canines and premolars erupting): 9–9.5 years; and DS4 (permanent canines and premolars completely erupted): 12–12.5 years. According to molar eruption: DSM0 (first molar erupting): younger than 6 years; DSM1 (first molar completely erupted): 6 years; DSM2 (second molar completely erupted): 13–13.5 years; and DSM3 (third molar completely erupted): Presumably older than 21 years.

two greater foramina, increased markedly from the stage where the first molars were under eruption or had fully erupted to the stage where the second molar has erupted. The study also showed that the greater palatine foramen was located palatally to the first molar in dental stage M0 and M1, palatally to the second molar in dental stage M2 and palatally to the third molar in dental stage M3 (Figure 4).

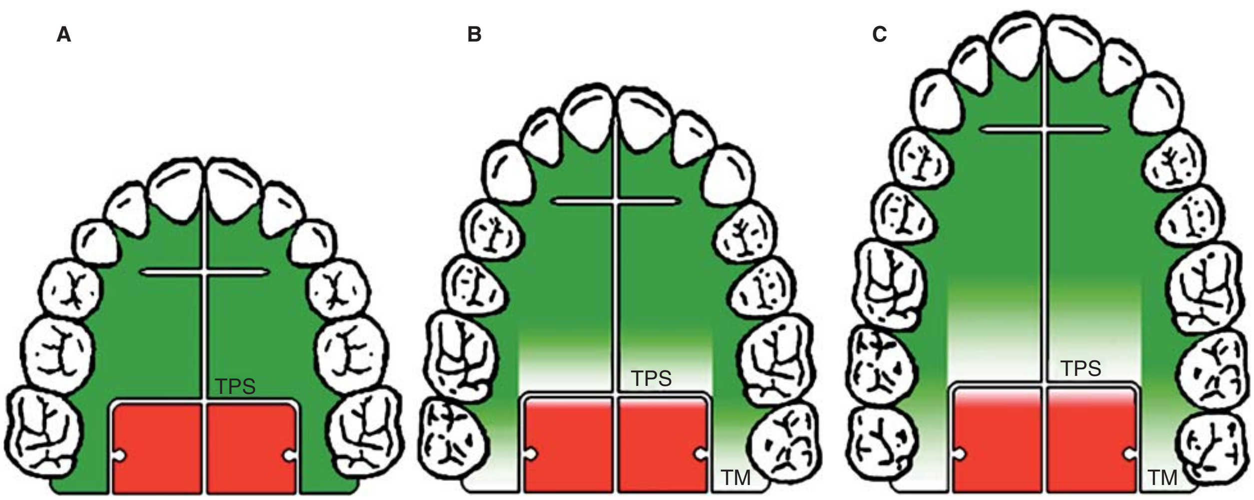

Figure 4. Schematic drawings of the hard palate from three anthropological human skulls, representing three different dental stages. The horizontal part of the palatine bone is indicated with red. The maxilla is indicated with green. Maxillary sagittal growth areas are indicated by gradually decreasing color. The weakest coloring occurs in areas with newly formed bone. Transversal growth zones are not indicated. The palatal foramen and the lingual interlobal incision on the first permanent molars are marked in Figure 2. The transpalatal suture is marked by TPS and the tuber maxillae by TM. (A) Dental stage DS02 M0: The primary dentition has fully erupted (DS 02) and the first molar is in its initial eruption phase (DS M0). (B) Dental stage DS4M2: The permanent canines and premolars have fully erupted (DS4) and so has the second molar (M2). (C) DS4M3: The permanent canines and premolars have fully erupted (DS4) and so has the third molar (M3). The figure demonstrates that the transverse palatine suture (TPS) grows differentiated with considerably more osseous growth on the maxillary edge of the suture compared to the palatine edge of the suture. The figure also indicates that appositional growth takes place in the tuber maxillae region (TM). The figure illustrates that the space needed for the second and third permanent molars comes partly from the osseous apposition on the tuber maxillae. It also illustrates that this growth is coordinated with a forward movement of the alveolar process and growth in the transpalatal suture (TPS).

Discussion

The present study confirms previous studies on the location of the greater palatinal foramen in relation to the third molars in adults [3–7]. As a new finding the study demonstrates the inter-relationship between the greater palatine foramen and the molars during childhood. The study supports cephalometric findings on the sagittal growth pattern of the maxilla [1]. The present study does not consider the transverse growth of the maxilla during childhood and adolescence. It is known from studies by Solow and Iseri [12] that the sagittal growth of the midpalatal suture has a fan-like pattern with more posterior than anterior growth [12]. This growth pattern will influence the T-distance slightly, but the influence is difficult to evaluate cross-sectionally.

Another factor which may influence the T-distance is the possible anterior migration of the first molar during shedding of primary teeth. The size differences between the primary molars/canines and the permanent teeth in these regions are minor [13]. It is not possible to consider this in the present study.

A further problem in the evaluation of the results is the small size of the material, which does not allow for statistical calculation because the sub-groups according to dental stages will be too small. Still, the study is considered valuable as there is a striking difference between the three main molar groups: first molar erupted, second molar erupted and third molar erupted.

The study showed that the greater palatine foramen was located palatally to the first molar in dental stage M0 and M1, palatally to the second molar in dental stage M2 and palatally to the third molar in dental stage M3. Thus, the greater palatine foramen is located close to the most posterior located and erupted permanent molar in normally developed dentitions without agenesis. This information may be valuable for dentists when applying local anesthetics.

The present study also leads to the question of the etiology behind crowding of permanent molars and lack of space for the third molar. Are these abnormalities a result of deviant growth in the transverse maxillary suture or lack of apposition at the tuber maxillae or both?

Accordingly, the present study documents the value of examining anthropological material in order to improve our understanding of clinical problems in dentistry. The anatomical background for optimal effect of anesthesia is one factor elucidated in this study. Another question raised concerns the etiology of crowding in the molar region.

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