Observation of maxillary sinus septa and bony bridges using dry skulls between Hellman’s dental age of IA and IIIC

By

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Summary: Maxillary sinus septa and bony bridges were observed using dry skulls in childhood, classified based on Hellman’s dental age, to clarify maxillary sinus septum formation.

Eighty-eight maxillary sinuses of 44 dry skulls and a cone-beam computed tomography (CBCT) unit were used. The locations of the septum, defined as a pointed bony structure originating from the inferior wall, and bony bridge, defined as a bony structure between the maxillary sinus wall and dental germ, were antero-posteriorly recorded, and the supero-inferior distance, distance from the bony palate, and angle to the median palatine suture were measured.

The rate of septum presence in the maxillary sinus was high (41.7%) in IIIC, and the septa were located in the deciduous molars, premolars, and molars. Also, all bony bridges were related to the median maxillary sinus wall, and the rate of the maxillary sinus showing a bony bridge was high in IIA and IIIA.

Septum presence in the maxillary sinus was observed in IIA, IIC, IIA, IIIB, and IIIC of Hellman’s dental age. Also, bony bridges were observed in IC, IIA, IIC, IIIA, IIIB, and IIIC of Hellman’s dental age.

Introduction

Septum presence in the maxillary sinus, especially in the inferior wall, complicates sinus floor elevation surgery11. The rate of septum presence in the maxillary sinus was reportedly over 30% in previous studies1–3. The etiology of the maxillary sinus septum has been hypothesized by several authors4–6. Uemura (1974)6 considered that maxillary sinus septa were formed by pressure, such as that generated by chewing. Also, Naitoh et al. (2009)3 suggested that disharmony due to the enlargement of sutures and deposition and resorption of the bone surface in the alveolar process and maxillary sinus occur, a maxillary sinus septum might be formed as a buttress to retain the volume and form of the maxillary sinus. However, the timing and mechanism of maxillary sinus septum formation have not been clarified.

The spatial resolution of cone-beam computed tomography (CBCT), which was recently developed, is high in comparison with multislice CT7, and maxillary sinus septum presence and fine mandibular anatomical structures were clearly observed using it8–12.

In the present investigation, maxillary sinus septa and bony bridges were observed using CBCT and dry skulls in childhood from infancy to school-aged children to clarify maxillary sinus septum formation. A bony bridge was observed as a bony structure between maxillary sinus wall and dental germ.

Materials and Methods

Objectives

Fourty-four dry child skulls were used in the investigation. On classifying the dental age of each skull using Hellman’s classification13, one skull belonged to IA, 6 to IC, 8 to IIA, 7 to IIC, 13 to IIIA, 3 to IIIB, and 6 to IIIC.

CBCT

CBCT employing Alphard VEGA (Asahi Roentgen
Ind., Kyoto, Japan) was performed using 88 maxillary sinuses of 44 dry child skulls. The palatal plane of each dry skull was set parallel to the floor base. The exposure volume was set at 102 mm in diameter and 60 mm in height, and the voxel size was 0.2 × 0.2 × 0.2 mm. The DICOM files of axial images were saved to a portable hard disk (HD).

Assessment of septum and bony bridge presence

CBCT images were analyzed using two DICOM viewer software packages (OsiriX Imaging Software: The OsiriX Foundation, Geneva, Switzerland, http://www.osirix-viewer.com[14], and INTAGE Realia: CYBERNET SYSTEMS Co., Tokyo, Japan). OsiriX software was used for the measurements of two-dimensional (2-D) images, and INTAGE Realia software was employed for the reconstruction of three-dimensional (3-D) images. The inferior maxillary sinus wall was observed between the most inferior site of the maxillary sinus and 10 mm superiorly. A septum was defined as a pointed bony structure originating from the inferior maxillary sinus wall (Fig. 1). A bony bridge was defined as a bony structure between the maxillary sinus wall and dental germ (Figs. 2 and 3). Also, the configuration of the bony bridge was classified into two types: pointed and rounded. Further, any septum/bony bridge less than 1 mm in height was excluded from the evaluation. One oral and maxillofacial radiologist with experience of 25 years (M.N.) and one

Fig. 1. Septum presence in a right maxillary sinus
A. Axial image
   A septum, which connected the median and frontal walls, was observed.
B. Longitudinal image
   A septum, which originated from the inferior wall, was observed in the second deciduous molar.
C. Three-dimensional image
   A septum, which originated from the inferior wall, was observed.
Black and white arrow: septum
general practitioner with experience of 15 years performing dental implant treatment (Y.S.) reconstructed and observed images in consultation.

The location of the septum was antero-posteriorly recorded using an erupted dental formula. Also, the location of the bony bridge was antero-posteriorly recorded using an embedded dental formula. Subsequently, the height of each septum/bony bridge was measured in accordance with the method of Velasquez-Plata et al.\textsuperscript{15} In septum/bony bridge measurement, a reformatted image along a direction parallel to the mesio-distal axis of the dental arch was obtained, and the distance between the base and top of the septum/bony bridge was measured using an medio-lateral middle image of the septum/bony bridge. Moreover, the distance between the base of the septum/bony bridge and bony palate was supero-inferiorly measured using a previous described method\textsuperscript{16}. The angle between the direction of the septum/bony bridge and median palatine suture was measured on axial images using a previously reported method\textsuperscript{3}. One of the authors (M.N.) performed each measurement five times, and repeated them in the same way after approximately one month. The measurements were averaged.

**Statistical analysis**

The differences among stages of Hellman’s dental age regarding the presence of septa/bony bridges were evaluated using Chi-square statistics. The differences in

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![Fig. 2. Bony bridge presence in a right maxillary sinus](image-url)  
A. Axial image  
A bony bridge was observed between the median wall and first molar.  
B. Longitudinal image  
A bony bridge, which was classified into the pointed type, was observed in the first molar.  
C. Three-dimensional image  
A bony bridge was observed between the median wall and first molar.  
Narrow black and white arrow: bony bridge, white arrowhead: maxillary sinus, thick gray arrow: first molar
height, distances from the bony palate, and angles to the median palatine suture were evaluated using the Mann-Whitney U test. Differences were considered significant at P-values of less than .01.

**Results**

**Septa**

Septum presence in the maxillary sinus was observed in IIA, IIC, IIIA, IIIB, and IIIC of Hellman’s dental age, and the rate was high (41.7%) in IIIC (Table 1). Septal sites were observed in the deciduous molars, premolars, and molars (Fig. 4). The mean height, distance between the base and top, and angle to the median palatine suture of the septum are shown in Table 2.

**Bony bridge**

Bony bridge presence in maxillary sinus was observed in IC, IIA, IIC, IIIA, IIIB, and IIIC of Hellman’s dental age, and the rate of its presence was high in IIA and IIIA (Table 1). Bony bridges were located in the second deciduous molars, second premolar, and first, second and third molars (Fig. 5). The median maxillary sinus wall associated with all bony bridges. In IIC of Hellman’s dental age, bony bridges were located in the second deciduous molars (Fig. 3).
Observation of maxillary sinus septa and bony bridges using dry skulls between Hellman’s dental age of IA and IIIC

and first molars, and between IIIA and IIIC, bony bridges were located in the second and third molars. Also, 16 of 33 bony bridges (48.5%) belonged to the pointed type. The mean height, distance between the base and top, and angle to the median palatine suture of the bony bridge are shown in Table 3.

**Statistical analysis**

The differences between the stages of Hellman’s dental age regarding the presence of septa and bony bridges were non-significant. The difference between deciduous molars and premolar (mean: 59.9 degrees; s.d.: 12.4) and molars (mean: 84.8 degrees; s.d.: 26.7) regarding the angle of the septa to the median palatine suture was significant. Also, the differences between pointed and rounded types of bony bridge regarding the height, distance from the bony palate, and angle to the median palatine suture were non-significant.

**Discussion**

When the alveolar bone height was insufficient for the insertion of a dental implant in the posterior region,
the sinus floor elevation technique was applied. Also, modified techniques, such as the double window technique, were proposed in maxillary sinus lift procedures involving the septa. The diagnosis of septum presence was important in the presurgical imaging of sinus floor elevation techniques.

The occurrence and location of maxillary sinus septa have been evaluated using panoramic radiography, CT and CBCT. Significant differences in the septum angle were noted between the anterior maxillary sinus and transverse palatine suture regions. The direction of the septum might be influenced by the growth of maxillae and palatine bones. The growth of maxillae was complicated. It was suggested that a maxillary sinus septum might be formed as a buttress to retain the volume and form of the maxillary sinus, when disharmony due to enlargement of sutures, and deposition and resorption of the bone surface in the alveolar process and maxillary sinus occurs. However, the timing and mechanism of maxillary sinus septum formation have not been clarified. The maxillary sinus septa and bony bridges between the maxillary sinus wall and dental germ were observed using CBCT and dry skulls in childhood from infancy to school age to clarify maxillary sinus septum formation in the present investigation.

Maxillary sinus septum presence was observed in IIA, IIC, IIIA, IIIB, and IIIC of Hellman’s dental age. Also, maxillary sinus bony bridge presence was observed in IC, IIA, IIC, IIIA, IIIB, and IIIC, and the formation of bony bridges was earlier than that of septa. Septum/bony bridge presence among stages was non-significant. Since skulls showing IA and IIIB of Hellman’s dental age were limited, further studies are needed involving many dry skulls or subjects.

The rate of the maxillary sinus showing a septum was 42% in IIIC of Hellman’s dental age. This was similar to that reported in the dentate maxilla of some previous studies. The mean septal height was reported to be from 3.55 to 9.2 mm on CT examination. The mean height (2.1 mm, s.d.: 0.5) was smaller than that in previous studies. Any septa of 2 mm or 2.5 mm or more in height were included in previous evaluations, whereas in the present study, any septum/bony bridge of 1 mm or more in height was included, since dry skulls in childhood were used. Also, the mean distance between the bony palate and base of the septum in the deciduous molar (4.7 mm, s.d.: 2.8) and in the premolar and molar (2.8 mm, s.d.: 1.5) was larger than that of previous studies (1.3 to –0.5 mm). This indicates that the growth of the maxillary sinus in the inferior direction is maintained in childhood. Moreover, the mean angle between the direction of the septum and median palatine suture was 59.9 degrees (s.d.: 12.4) in the deciduous molar and premolar and 84.8 degrees (s.d.: 26.7) in the molar. The value in the deciduous molar and premolar was close to the value of the anterior maxillary sinus in a previous study, and the value in molar was close to that of the transverse palatine suture.

All bony bridges were formed between the median maxillary sinus wall and dental germ, and bony bridges were located in the second deciduous and first molars of IIC of Hellman’s dental age, and located in the second and third molars between IIIA and IIIC. The mean angle of the pointed bony bridge in the first and second molar was 97.6 degrees, close to that in the transverse palatine suture of a previous study (100.8 degrees). Also, the differences between pointed and rounded types of bony bridge was non-significant.

The maxillary sinus inferiorly expanded along the median maxillary sinus wall from the hiatus semilunaris with growth. When expansion of the maxillary sinus avoided a site between an embedded dental germ and median maxillary wall, a bony bridge was formed. Also, a bony bridge might change to a maxillary sinus septum with growth. The configuration of bony bridges was either a pointed and rounded type. It was not clear whether the configuration of bony bridges changes according to the expansion of the maxillary sinus and dental germ eruption.

Further longitudinal studies are needed to validate our hypothesis regarding the formation of maxillary sinus septa.

Conclusion

The maxillary sinus septa and bony bridge of dry skulls in childhood were observed using CBCT. A maxillary sinus with septum presence was observed in IIA, IIC, IIIA, IIIB, and IIIC of Hellman’s dental age. Also, a bony bridge, which was observed a bony structure between the median maxillary sinus wall and dental germ, was present in IC, IIA, IIC, IIIA, IIIB, and IIIC.

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