Prevalence of accessory septations of sphenoid sinus in paediatric population: applications to endoscopic sinus surgery

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Running head: accessory septations of sphenoid sinus in children

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Conflict of interest

None.

Abstract

Sphenoid sinus accessory septations and their possible insertion on internal carotid artery (ICA) may represent a risk for endoscopic sinus surgical procedures. However, scarce data on this variant for children are available so far.

This retrospective study included 220 maxillofacial CT-scans equally divided among males (13.4±2.1 years) and females (13.9±2.2 years). On each CT-scan prevalence of accessory septations, number of septations in sphenoid sinuses and their possible insertion onto ICA bone walls were recorded.

Significant differences in protrusion and insertion of septations onto the ICA bone walls according to sex were assessed through Chi-square test ($p<0.05$). Possible correlations between the prevalence of accessory septations, ICA insertion and number of accessory septations and age were assessed by means of Pearson's regression ($p<0.05$).

On average, 66% of males and 71% of females had at least one accessory septation, without significant differences according to sex or age ($p>0.05$): septal insertion on ICA was found in 15% of males and 13% of females, without any significant difference for sex or age ($p>0.05$). Number of septations was significantly increased with age ($p<0.05$). The present study showed that the prevalence of accessory septations and insertion onto the ICA are independent from age and these results are similar to those reported in adults. Results will be useful for the management of endoscopic sinus surgery.

Keywords: sphenoid sinus, accessory septa, CT-scan, 3D segmentation

Introduction

Sphenoid sinuses are air spaces included in the body of the sphenoid bone: they can be identified at the 3rd-4th year of life and usually reach their final shape between 12 and 16 years of age (Jaworek-Troc et al., 2018). The main characteristic is represented by the high morphological variability that involves not only the degree of pneumatisation, but also the development of accessory septations in addition to the main septum dividing the right sinus from the left one (Yune et al., 1975; Fujoka and Young, 1978; Bonneville and Dietemann, 1981; Hewaidi and Omami, 2008). In the last years, the assessment of anatomical variants of sphenoid sinuses has gained interest thanks to the progressive diffusion of endoscopic sinus surgery: this technique has been widely applied, ranging from the treatment of chronic sinusitis (Kalaycik Ertugay et al., 2018) and isolated sphenoid sinus disease in general (ISSD, Wang et al., 2019), to the more advanced and rare applications of trans-sphenoidal surgery (Jho, 1999; Lu et al., 2011; Jaworek-Troc et al., 2018). Potential complications during endoscopic surgical procedures strongly depend on developmental changes of paranasal sinuses and skull base, anatomical variants and their modifications with age (Kalaycik Ertugay et al., 2018).

The transsphenoidal surgical approach is considered the gold standard for several indications (Hebert and Bent, 1998), and its applications in children are less common than in the adults. However, such an approach is not free from complications (Anusha et al., 2014; Gibelli et al., 2019a), and again, possible adverse events are often influenced by anatomical variants (i.e. accessory septations).

Accessory septations are bone structures are of variable geometry and morphology, and usually reduce the space of sphenoid sinus, thus increasing difficulties in the placement of endoscopic surgical devices. Moreover, accessory septations may insert on the bone wall surrounding the internal carotid artery (ICA), with a high risk of catastrophic bleeding in case of their removal (Hudgins, 1993; Unal et al., 2006).

The incidence of accessory septations as well as possible insertions on ICA have been previously reported in adults (Seddighi et al., 2014; Jaworek-Troc et al., 2018; Basak et al., 1998; Jaworek-Troc et al., 2018): to our knowledge, scarce data are available in the paediatric population.

The present study aims at assessing the prevalence of accessory septations in sphenoid sinus of a paediatric population: possible relationships with ICA will be explored as well.

In addition, possible influence of sex and age will be analysed. Results will be useful for improving the safety in endoscopic sinus surgery.

Materials and methods

From a hospital CT-scan database, consecutive patients aged 10 to 17 years, who underwent CT imaging between October 2013 and May 2019, were retrospectively assessed.

All the examinations were performed on a second generation dual-source scanner, Somatom Definition Flash (Siemens®, Forchheim, Germany), with the following parameters of acquisition: reference kV: 100 (with care kV), reference mAs: 80 (with care Dose), collimation: 128 x 0.6mm, tube rotation: 1 sec; thin data: 0.75 mm; reconstruction thickness: 3 mm; pitch value: 0.8; reconstruction filters: H21s smooth for soft tissues and H60 sharp for bone. As examinations were performed in pediatric patients with a low dose CT protocol, according to the ALARA principle (WHO, 2014), the reconstruction thickness was set at 3 mm, in agreement with the set Siemens protocols, in order to obtain optimal image quality and low image noise.

The study was approved by the local ethical committee (7331/2019) and follows local and international laws and guidelines (Helsinki Declaration). All CT-scan images were fully anonymized.

On each CT-scan prevalence of accessory septations, number of accessory septations in sphenoid sinuses and possible insertion of accessory septations onto ICA bone walls were recorded. Septations are considered accessory when they further divided the sphenoid sinuses in addition to the main one (dividing the right sinus from the left one). Complete septations were defined according to their origin and insertion on the sphenoid sinus' bone walls, whereas incomplete septations have a free edge within the sinus' air space (Fig. 1). Both were included in the assessment.

Accessory septations insert on the ICA when they arise from the bony wall surrounding ICA in any point of its circumference (Fig. 2).

Each scan was evaluated by two observers, a radiologist and an anatomist: both operators had more than ten years of experience in X-ray analysis and assessment of anatomical variants. Consensus was reached after a joint review of the two observers.

Statistical analysis

Significant differences according to age between males and females were assessed by means of Student's t-test.

Significant differences in prevalence of accessory septations and possible insertion on ICA according to sex were assessed by means of Chi-square test.

Correlations between prevalence of accessory septations, possible insertion on ICA and number of accessory septations and age were assessed through calculation of Pearson's coefficient.

All the statistical analyses were performed using SPSS® software (version 26, IBM®, Armonk, New York, USA) with a level of significance of 5% ($p<0.05$).

Results

In total, 220 patients were selected for the study, equally divided among males and females. CT-scans were requested for screening of cranial fractures in trauma (57.3%), suspected sinusitis (20.0%) and neurological symptoms (12.7%). Subjects affected by traumatic injuries and pathologies involving the cranial base, agenesia of sphenoid sinuses and congenital or acquired cranial deformation were excluded from the study.

Age of males and females was 13.4±2.1 years and 13.9±2.2 years (Table 1), respectively, without statistically significant differences ($p>0.05$).

Overall results of the study are shown in Table 1. On average, 66% of males and 71% of females showed at least one accessory septation, without significant differences according to sex (Chi-square: 0.37, p: 0.543): in addition, prevalence of septations did not show any statistically significant correlation according to age (males, Pearson's coefficient: 0.62, p: 0.103; females, Pearson's coefficient: 0.41, p: 0.317, respectively).

Accessory septations took insertion on ICA bone wall in 13% of subjects without significant differences according to sex (Chi-square: 0.04; p: 0.839). Moreover, septal insertion on ICA did not show any correlation with age, independently from sex (Pearson's coefficient: 0.67, p: 0.071 in males; Pearson's coefficient: 0.53; p: 0.180 in females, respectively).

Number of accessory septations ranged between one up to six in both sexes, with significant positive correlations with age (Pearson's coefficient: 0.72, p: 0.045 for both sexes, Fig. 3); in fact, the older children had a larger number of accessory septations than the younger ones.

Discussion

Over the last decade there has been a progressive widening of the application of endoscopic sinus surgery; the main applications concern the treatment of sphenoid sinus disease in children, and especially the opacification due to inflammatory causes, including polyps, chronic sinusitis and mucoceles (Wang et al., 2019).

In parallel, a novel interest towards anatomical variants has been observed, as some of them proved to increase possible risks during these procedures. Among the others, accessory septations are most critical because they limit the space for endoscopic devices and their removal may cause severe bleeding due to their insertion on ICA (Kassam et al., 2005).

The prevalence of accessory septations in different ethnic groups has been widely investigated, ranging between 42% and 80% (Elwany et al.,1983; Abdullah et al., 2001; Mutlu et al., 2001; Lee et al., 2003; Seddighi et al., 2014; Jaworek-Troc et al., 2018). Ethnic variability influences this variant (Jaworek-Troc et al., 2018), and the Korean and Turkish groups are those with the lowest prevalence (Mutlu et al., 2001; Seddighi et al., 2014). On the other side, septal insertion on ICA ranges between 31% and 89% (Abdullah et al., 2001; Fernandez-Miranda et al., 2009). In Italy, the prevalence of accessory septations and septal insertion on ICA reached 87.1% and 20.8%, respectively (Gibelli et al., 2019b).

However, all the above reported data have been collected in adults: very few studies are available on anatomical variations of nose and paranasal sinuses in children. An example was provided by Cohen et al. who analysed the prevalence of deviated septum, Kuhn cells, Haller cells, Onodi cells and concha bullosa in children aged between 0 and 17 years. Results showed that sex did not influence the prevalence of these anatomical variations, and that prevalence of concha bullosa and deviated septum were positively related with age (Cohen et al., 2019).

Another contribution was given by Odat et al. who studied anatomical variants of sphenoid sinuses in a paediatric population aged between 4 and 16 years, focusing on the prevalence of single and multiple septations. The results highlighted that prevalence of accessory septations and ICA bulging significantly increase with age (Odat et al., 2019). However, no information is available in literature about the relationship between the number of accessory septations, and sex and age.

This study first verified the number of accessory septations and septal insertion on ICA in a paediatric population aged between 10 and 17 years and its possible relationship with sex and age: results provided interesting hints for improving our knowledge of these anatomical variants with risky correlates in endoscopic procedures.

First, prevalence of accessory septation did not show significant differences according to sex or age and is similar to the same value found in the adult population (Gibelli et al., 2019b): this means that in each age range the same percentage of individuals is affected by this variant. In addition, accessory septations can be found since the age of 10 years. This result seems in discordance with data by Odat et al. who found an increase in prevalence of accessory septations with age in a sample of 50 healthy children (Odat et al., 2019). However, they analysed a wider age range (between 4 and 16 years): in addition, the statistical analyses were performed taking three age groups (4-8 years, 9-

12 years, 13-16 years) into consideration. It is possible that prevalence of accessory septations may increase in younger age groups and become stable between 10 and 17 years. Further studies on a larger CT-scan group, including children aged between 4 and 10 years, would provide additional data about this point: however, this would bring about difficulties in reaching an adequate sample size, as reasons for CT-scans in young children are rare.

On the other side, the number of accessory septations proved to increase with age and to reach the adult average value (two septa for individuals) at 16 years (Gibelli et al., 2019). Unfortunately, the retrospective nature of this study prevents from concluding if the same individuals show an increase in number of septations with growth. However, the present data show that age represents a crucial factor to determinate the number of accessory septations.

Another interesting result concerns the prevalence of septal insertion on ICA which does not change according to sex or age, and again is close to the same value found in adults of the same population group (Gibelli et al., 2019b). However, this variant was mainly verified since the age of 13 years.

The formation of sphenoid air spaces begins at the 3rd-4th year of life and ends between 12 and 16 years (Jaworek-Troc et al., 2018); however, the prevalence of accessory septations and ICA septal insertions is not influenced by the progressive pneumatisation of sphenoid sinuses. This is an interesting result that has not been reported yet and may provide useful data for predicting these risky variants in patients treated through endoscopic sinus procedures.

In addition, the present study found that these risky variants of sphenoid septations are not rare even in children and therefore should be considered with caution. A precise pre-operative radiological analysis is crucial to find possible septations and check their insertion on ICA (Unal et al., 2006).

This study has some limitations that should be acknowledged: first, it is a retrospective study, and therefore it is not possible to ascertain the modifications of variants within the same individual with time. However, a prospective study of this type cannot be done with the similar sample size, as it would require several CT-scans performed on the same paediatric population, with a clear risk of excessive radiation exposure. Secondarily, the study took into consideration every accessory septation: however, not all of them configure a risk for endoscopic surgery, as it depends on the reasons, type and management of intervention.

In conclusion, our study provided data about the prevalence of risky variants of sphenoid sinuses in endoscopic surgery in a paediatric population: results contribute in increasing our knowledge of these variants and will be useful for improving management of surgical procedures.

Conflict of interest

None.

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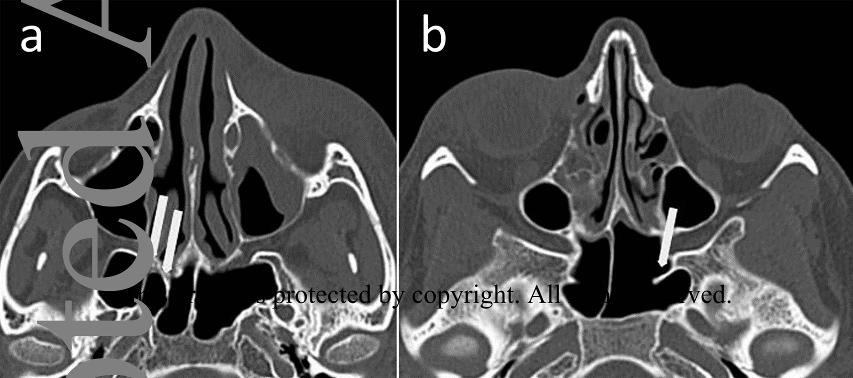
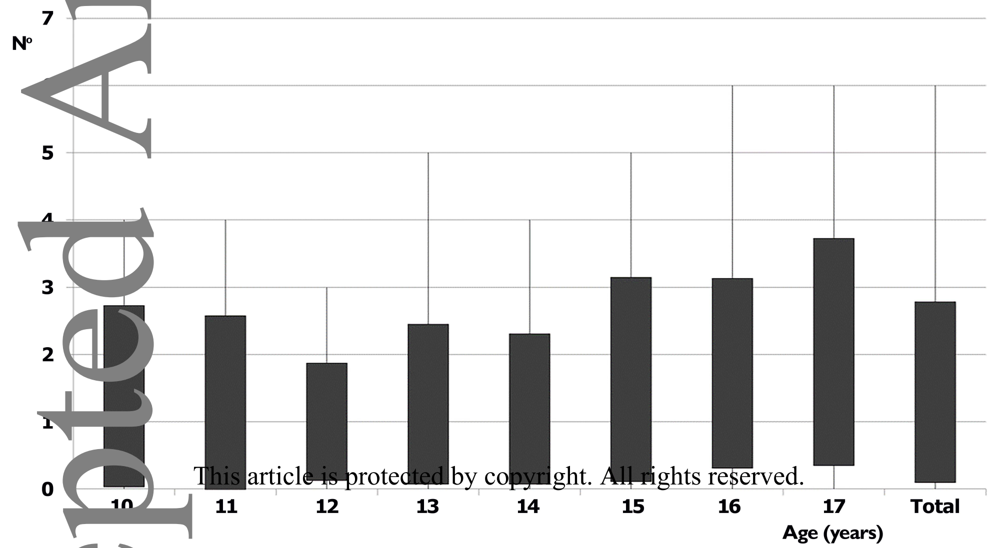
Figure legends

Fig. 1: image of a CT-scan showing cases of complete (a) and incomplete (b) septations (indicated by the white arrow)

Fig. 2: image of a CT-scan with an incomplete accessory septation (on the right side) inserting onto the ICA bone wall (indicated by the white arrow)

Fig. 3: average number of accessory septations at different ages: black boxes indicate the average number +/- 1 standard deviation (DS), whereas the lines indicate maximum and minimum values


a
b


Nº
0
1
2
3
4
5
7
10
11
12
13
14
15
16
17
Total
Age (years)

	N°		Prevalence accessory septations		N° accessory septations (mean)		Prevalence of ICA insertion	
	Males	Females	Males	Females	Males	Females	Males	Females
10 years	13	11	0.54	0.73	1.31	1.36	0.00	0.00
11 years	11	10	0.64	0.50	1.45	1.00	0.09	0.00
12 years	12	10	0.58	0.80	1.33	1.20	0.00	0.20
13 years	23	11	0.74	0.64	1.26	1.27	0.04	0.18
14 years	18	14	0.61	0.64	1.22	1.14	0.33	0.21
15 years	13	22	0.62	0.77	1.38	1.77	0.00	0.05
16 years	10	19	0.90	0.74	2.10	1.47	0.30	0.21
17 years	10	13	0.70	0.77	2.20	1.92	0.30	0.15
Total	110	110	0.66	0.71	1.46	1.45	0.13	0.13

Table 1: prevalence and number of accessory septations, and frequency of insertion on ICA bone wall in different age groups and sexes; prevalence is expressed as ratio between number of subjects with septations and the number of subjects for age group