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Title: **COMPARATIVE AGE CHARACTERISTICS OF FRONTAL SINUSIN POSTNATAL ONTOGENESIS**

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COMPARATIVE AGE CHARACTERISTICS OF FRONTAL SINUSIN POSTNATAL ONTOGENESIS

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Abstract: The journals, materials of scientific conferences, as well as other information sources were studied to collect reliable information on the morphometric development of the frontal sinuses.

Keywords: Paranasal sinuses; frontal sinus; development; age estimation; morphometry

Introduction

Relevance: The relevance of the study is determined by the lack of modern data related to the development and age-sex characteristics of the growth of the paranasal sinuses in certain environmental conditions. As the paranasal sinuses continue to develop throughout childhood, radiologists are faced with different kinds of anatomical variation in pediatric examinations. Knowing the growth stages of the sinuses is vital to distinguish normal development from abnormally large, hypoplastic, or deformed sinuses. To this end, we briefly review the anatomy of the frontal sinuses and discuss the mechanisms by which this sinus develops, as well as the implications for imaging.

Aim of the review: To summarize the available literature data on the dynamics of growth and development of the paranasal sinuses in postnatal ontogenesis, in relation to age, sex and ecological territorial characteristics.

The anatomy of the nasal cavities and paranasal sinuses is one of the most diverse in the human body. Due to their complex three-dimensional structure and many morphological variations, understanding these anatomical aspects is of paramount importance to the ENT surgeon. [22]

The frontal sinus (sinus frontalis) is a paired cavity located inside the frontal bone and located behind the brow arch. [10,17] The two irregular frontal sinuses are separated entirely by a bony septum, which is approximately in the midline [17,1]. Paired sinuses are almost always asymmetrical and separated by a septum. (Buyuk et al., 2017; Hacl et al., 2017; Prashar et al., 2012) The orbit and anterior cranial fossa border the sinuses. The frontal funnel (the lower part of the frontal sinus), the frontal orifice and the anterior cavity form the outgoing tract of the frontal sinus [15.5].

Frontal sinuses arise from one of several outgrowths that originate in the anterior niche of the nose, and their place of origin can be determined on the mucous membrane after 3-4 months of intrauterine development. Less commonly, the frontal sinus develops from the anterior ethmoid cells of the funnel [30,2,25]. On average, these sinuses do not reach the frontal bone until about 6 years of age. Their development is rather inconsistent, but, apparently, begins only after the second year of life [25, 14]. It is also possible that the frontal sinuses form when the ectocranial table of the frontal bone separates from the endocranial table, forming an air pocket in the bone. The endocranial table stops growing with the brain, while the ectocranial table moves forward as the facial bones continue to grow [30.6]. The frontal

sinus is absent at birth (Strandring, 2008; Tatlisumak et al., 2008; da Silva et al., 2009; Tabor et al., 2009), but becomes visible with computed tomography (CT) at about 3 years of age ... The greatest increase in the size of the frontal sinus occurs approximately 1–1.5 years after the peak of puberty, and development continues until about 18–18 years of age. 20 years old (Yassaei et al., 2019) [21]. Belaldavar et al. (2014) argues that FS complete their development by the age of 20, after which they remain stable until bone resorption, which occurs in old age, and which can lead to their increase in size.

Research A. Onodi (1911), show that in children from birth to 1 year, the height of the frontal sinuses ranges from 3.5 to 8 mm, length from 3 to 9 mm, width between 2 and 6 mm develops slowly, keeping a rounded shape. He also said that the expansion of the sinus into the frontal bone begins at 3.5 years. The average area in the occipital-frontal projection on the roentgenogram with a film focusing distance of 1 meter perpendicular to the Frankfurt horizontal was: in a 3-year-old child -0.7 cm²; for a 5-year-old 1.1 cm²; 7 years old -3.1 cm²; 9 years old - 5.1 cm²; 12-17 years old - 9.3 cm². The data presented above were revealed when studying the frontal sinuses on the radiograph of children from 3 to 17 years old Szilvassy (1981). If we compare by sex, the average value for girls was lower than that of boys in the age group of 3-5 years, but more at the age of 7-10, and at the age of 12-17 it was again lower than that of boys [12]. There is data by G. Kilian (1896, 1903) about the formed frontal sinus in a 15 month old child. Sinuses may begin to form, rather inconsistently, in people as young as two years of age. However, they are often not visible radiographically until about six years of age (Enlow and Hans, 1996; Dixon et al., 1997; Tatlisumak et al., 2008; da Silva et al., 2009; Verma et al., 2015) [19]

Development and growth of the frontal sinus are closely associated with specific age periods of skull growth, as studies (Rossouw et al. 1991; Ruf and Pancherz 1996) have shown that the size of the frontal sinus is associated with growth patterns. The mechanisms responsible for the development and expansion of the frontal sinus are strictly regulated. Development is influenced by both brain expansion and midface growth (Enlow and Hans, 1996; Dixon et al., 1997). The skull grows rapidly from birth to age seven to compensate for the rapid growth of the brain (Strandring, 2008). [30,25].

Main part

According to research by W. Brown (1984), which show that the average age of the appearance of sinuses on radiographs is 3.5 years in boys, and 4.5 years in girls. After 6 years of age, the growth of the frontal sinus accelerates, and by the age of 7-8 its dimensions reach: height 17-18 mm, length 10-13 mm, width 11-12 mm, and its further development continues unevenly. He also revealed that the maximum increase in LA size occurs at the age of 15.5 years for boys, and 13.7 years for girls, due to a pubertal growth spurt. Growth in the lateral and medial direction stops at 12-14 years, and height by 25 years [11].

Mahmoud (2016) and Farias s Gonzalez (2007) found statistically significant differences between the sexes in the height of the frontal sinus in their studies. [17]. But, according to A.V. Tarenetsky, frontal sinuses can develop to a very old age, due to the fact that the vessels of the mucous membrane can resorb the adjacent bone throughout life [8].

In modern studies, there are four stages of development of the sinuses described by Shah et al [28]. At stage 0, the paranasal sinuses have not yet formed; at stage 1, a sinus was formed; in Phase 2, development continues; and

at stage 3, the sinus is considered fully developed.

According to the above (Shah et al) study describing the growth of the frontal sinus, in stage 1 and beyond, age varies greatly from person to person. [28,27,24] Because of the connection between the frontal sinus and the skull, the growth of the skull and midface affects the pneumatization of the frontal sinus in stages 2 and 3, where it expands to the level of the roof of the orbit and the vertical part of the frontal bone, respectively. [23].

Thus, although frontal sinus dilation begins at 2 years of age and older for stage 1, rapid growth occurs with childhood development and puberty from 6 to 19 years of age, when the inner table stops growing and conforms to the overall shape of the brain. [24,23]. The sinuses usually reach the level of the orbital roof by age 8 and become the vertical part of the frontal bone by age 10 [27]. Growth stops by about age 20, when the shape and size of the sinus become stable [29,7]. It has also been shown that the frontal sinuses undergo a growth attack approximately 1 year after the growth spurt, and their morphology is influenced by changes in the airways (Enlow et al. 1996; Prado et al. 2012). According to Kaitlin Mure and Anna Ross (2017), who studied the development of the frontal sinus and the assessment of adolescence on radiographs, and came to the following results: they distinguish 3 phases of LA development. Phase 1 is from 0-4 years old, when the frontal sinuses do not develop, phase 2 - was observed in children from 5-6 years old, onset of LA formation, phase 3 from 7-9 years old and up to 11-13 years of LA formation. And there came a 96% probability that the LA was fully formed at the age of 14 [23].

And in the studies of S. Chayasate, J. Baron and P. Clement, who wanted to determine whether the anatomical variations in the

paranasal sinuses of twins are the result of genetic factors or environmental influences. In their study, the differences in the anatomical structure of the paranasal sinuses between identical and non-identical pairs of twins were not statistically significant. This indicates that environmental factors are more significant than genetic factors in the development of anatomical variations in the anatomy of the paranasal sinuses [11].

Of the modern works devoted to the morphometric study of the frontal sinuses, mention should be made of the article by Lee MK, O.Sakai, GHSpiegel (2010), which, based on CT analyzes of 150 patients, provide the following data: the average sagittal size ranges from 8 to 9.3 mm, the average height in the highest part of 24.5, the average width at the level of the supraorbital eminence was 52.2 mm [16]. The degree of development of the frontal sinuses is extremely variable. With its weak development, the sinus may not go beyond the medial part of the superciliary arch. In cases of strong development, the sinus extends laterally along the supraorbital margin to the zygomatic process of the frontal bone, reaching the lesser wings, the body of the sphenoid bone and the optic canal [3].

In the studies of Gagliadi A., Winning T. (2004), statistics on the size of the frontal sinus, skeletal ossification and growth were calculated at annual intervals, and comparisons were made between the sexes. Growth rates for frontal sinus height, frontal sinus depth, and height were also calculated for both sexes. It was found that there is a pronounced growth spurt in adolescents in the frontal sinus, the peak rate of which occurs after the maximum rate of body growth. It was found that girls, on average, reach their maximum speed in sinus height earlier than boys, but they reach their peak speed in sinus depth at the same age as boys. The sequence of events of ossification of the

hand and wrist followed a similar pattern in both sexes, with the events occurring in women about a year earlier than in men. These results indicate that adolescent twitching is present in frontal sinus growth, and that twitching tends to occur after natural speed reaches its peak. It has been found that females, on average, reach their maximum sinus height velocity earlier than males, but they reach their peak sinus depth velocity at the same age as males [13].

Study by Almeida Prado a b K. Adams c L.C. Fernandez de. Craniotie studied the variability of the volume of the frontal sinuses in modern Greeks and their potential use in the process of forensic identification. The results showed that although there are statistically significant differences in shape and volume between the sexes, they are not sufficient to be used as an indicator of gender in populations around the world. The results show that the use of the anterior view of the frontal sinuses is more consistent for identification of a person and that this method is reliable if the sinuses are adequately observed on radiographs [9].

Studies by Sabine Ruf, Hans Pancherz, which studied the development of the frontal sinus depending on somatic and skeletal maturity, were analyzed in 26 men aged 9 to 22 years using longitudinal data obtained from lateral head images, radiographs of the wrists and growth curves. They were grouped and analyzed crosswise. The results showed that the final size of the frontal sinus varied significantly. Similar to the increase in height during puberty, enlargement of the frontal sinus had a similar pattern with a well-defined peak that averaged 1.4 years after peak growth. Compared to skeletal maturity, 65% of subjects reached peak sinus during the radiographic stages of MP3-G or MP3-H of the arm, while peak growth coincided with an earlier stage of maturity (MP3-FG) [26].

Research by A.K. Kosourov and Morozova V. The studying age-related changes in the paranasal sinuses in postnatal ontogenesis in the inhabitants of Karelia, have come to the following results: 1. The dependence of the growth rates of the maxillary, frontal and sphenoid sinuses on age and sex has been revealed. The regularities showing the presence of age-sexual dimorphism in the development of the paranasal sinuses were determined. In men of Karelia, the most rapid growth of sinuses is observed at the age from 6 to 10 years old and from 14 to 18 years old; in women - from 6 to 10 years old and from 12 to 16 years old. The growth of sinuses in men is completed on average 1-1.5 years later than in women. After 50 years, there is a secondary increase in the size of the sinuses, which is associated with the development of osteoporosis of the air bones of the skull. These changes occur in men on average 2.5 - 5 years later than in women. 2. Revealed the dependence of the size of the maxillary and frontal sinuses on the constitutional shape of the skull. 3. The influence of unfavorable environmental factors on the processes of pneumatization of the maxillary and frontal sinuses was determined. The growth of the sinuses under unfavorable environmental influences ends on average 2 - 2.5 years later, while the sinuses in their final size are significantly smaller than the sinuses of people of the corresponding sex and age who have not been exposed to negative environmental influences. [4]

It must be said that the morphology and size of the frontal sinus depend on race, age, sex, forehead slope and head shape (Enlow et al. 1996). Enlow et al. (1996) argues that the development of the frontal sinus is closely related to the remodeling of the nasomaxillary complex and structures adjacent to the forehead [20]. You also need to take into account the fact that the normal development of the paranasal

sinuses can continue into early adulthood; however, inflammatory conditions, fibro-osseous lesions, congenital anomalies, previous nasal surgery, or sinus malignancies can distort the bony structure of the paranasal sinuses (Bolger et al. 1997) [19,11].

Conclusion

The performed analysis of the literature confirms that a significant number of studies devoted to the study of the development and structure of the frontal sinus in postnatal ontogenesis, in relation to age, sex and ecological territorial characteristics, remained unknown for a long time, and until now have not been fully studied. This shows that the study of the morphofunctional properties of the frontal sinus is relevant today, which is reflected in a number of scientific works that reveal its topographic, anatomical and physiological features.

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