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Age Characteristics of the Development of the Maxillary Sinus in Postnatal Ontogenesis (Literature Review)

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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 maxillary sinuses.

KEYWORD: Paranasal sinuses, maxillary sinus, development, age estimation, morphometry.

Relevance: The relevance of the study is determined by the need to study the age-related features of the structure of the maxillary sinus, since the paranasal sinuses continue to develop throughout childhood, radiologists are faced with various types of anatomical variations when conducting pediatric studies. This is dictate by the rapid development of pediatric otorhinolaryngology, surgical dentistry and orthodontics. The maxillary sinus, more than other paranasal sinuses, lends itself to various pathological conditions that may require surgical treatment.

Knowledge of the stages of sinus growth is vital to distinguish normal development from abnormally large, hypo plastic or deformed sinuses. An understanding of the fundamental principles of development, anatomy, and relationships of the maxillary sinus as depicted by multimodal imaging is essential for radiologists reporting on imaging of the paranasal sinuses and midface. To this end, a brief overview of the development and anatomy of the maxillary sinus is given.

Purpose of the review: Summarize and analyze the main review articles with literature data on the dynamics of growth and development of the maxillary sinus in postnatal ontogenesis, in relation to age and gender characteristics.

The maxillary sinuses were first illustrated and described by Leonardo da Vinci in 1489, and later documented by the English anatomist Nathaniel Highmore in 1651. Nathaniel Gaimor made a valuable contribution to the development of otorhinolaryngology in the 17th century. He published the book «Corpus Disquisitio Anatomies», in which he described in detail the anatomical structure of the maxillary sinus and the passages that communicate with it. After this publication, the maxillary sinus named as the sinus Highmori. The maxillary sinus is the largest paranasal sinus and develops first. Development begins at 17 weeks of fetal development. At birth, this is a rudimentary aerated or fluid-filled fissure, oriented to the greatest extent in the anteroposterior dimension, with a volume of 60–80 mm^3, located infero-medially to the orbit [11]. Partial or complete obscuration of the maxillary sinus on x-ray in the first few years of life is normal [14].

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I.V. Gaivoronsky and co-authors carry out anatomical relationships in various variants of the structure of the maxillary sinus and the alveolar process of the upper jaw. They revealed, that the trihedral variant of the structure of the maxillary sinus is more common - in 60.1 cases; the tetrahedral form was found in 27,794 cases; slit-like - 4594; indefinite form - in 7794 cases [3].

The growth of the maxillary sinus is proportional to the growth of the facial bones. Both occur in phases, with the first phase occurring during the first 3 years of life: towards the end of this phase, the sinus expands lateral to the infraorbital canal. The height of the maxillary sinus continuously increases up to 18 years. On the contrary, the width and length (anteroposterior size) of the maxillary sinus reaches the proportions of an adult by the age of 12 [5]. The most rapid increase in the size of the maxillary sinus occurs from 0 to 4 years with a gradual increase in size from 4 to 8 years. Sex differences in maxillary sinus size develop after 8 years of age, with a plateau in girls and a slow increase in size in men up to 18 years of age [5,1]. The development of the maxillary sinus continues until the third decade in men and the second decade in women. The average volume of a fully developed maxillary sinus is greater in men than in women; in most studies, the difference is not significant. Average MS rates vary by ethnicity and tend to be higher for Japanese and Koreans [11].

The maxillary sinus is an approximately pyramidal cavity, the base of which is adjacent to the nasal cavity, and the blunt apex is directed towards the zygomatic bone. It has several sinus recesses: an alveolar recess directed downwards, a zygomatic recess directed laterally, a variable palatal recess (a continuation of the alveolar recess) between the floor of the nasal cavity and the roof of the oral cavity, and an infraorbital recess directed upwards, bounded by the orbital surface of the maxilla [16,6]. The walls of the maxillary sinus are six: the upper, anterior, lateral and medial walls are wide; the posterior and lower walls are narrow. A thin upper wall (which makes up most of the floor of the orbit) separates the contents of the orbit from the maxillary sinus. The anterior wall has a slightly anteriorly concave surface and a pronounced inferolateral focal bulge, canine eminence. The posterior wall is narrow and intimately connected with several branches of the maxillary artery and vein and several branches of the maxillary trigeminal nerve within the adjacent pterygopalatine fossa. The lateral wall, facing postero-laterally to the infratemporal fossa, is thin and borders below on the buccal side of the alveolar process. The medial wall also forms the lateral wall of the nasal cavity, on which the main mouth is located, located above the medial wall at or slightly below the level of the bottom of the orbit. The lower wall, or bottom of the sinus, borders on the alveolar process and contains the roots of the upper jaw [14, 16]. Septa - The septa of the maxillary sinuses are thin, linear or curvilinear plates of cortical bone that usually extend from the floor of the sinus. Septa are common and few on dental panoramic tomography. Septa can be primary (developing) or secondary (acquired). Primary and secondary septa are common, occurring in 50% of the dentate and edentulous posterior segments of the maxilla. The septa in the maxilla without teeth are shorter than in patients with teeth [17].

During development, the growth of the maxillary sinus is closely related to the body of the upper jaw [1, 14]. Pneumatization of the paranasal sinuses is a complex and not fully understood process. Numerous reports have linked the anatomical variations seen on computed tomography (CT) scans of the sinuses to specific sinus conditions. In a later period, pneumatization exceeds adjacent bones; while the maxillary sinus increases due to the maxillary processes. Pneumatization of the maxillary sinus is influenced by many factors, namely the development and eruption of teeth, pneumatization of the maxillary alveolar processes, the function of the masticatory apparatus, and the growth of the internal organs of the skull [11]. Although the presence or presence of a maxillary sinus is independent of tooth morphology, the expansion of the maxillary sinus may prevent the development of diseased teeth [12].

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Maxillary sinus volume has been shown to correlate significantly with environmental factors [1]. Currently, most anatomists consider it recognized that the average volume of the maxillary sinus ranges from 15-35 sq. see. As is known, the size of the sinuses is directly related to the resorption of the spongy substance of the body of the maxillary bone in the process of human development from birth to 20 years [19].

Depending on the degree of pneumatization of the maxillary bone, B.B. Brandsburg (1931) distinguished two extreme types of sinuses. The first type (pneumatic) is a highly developed cavity, continuing into the alveolar, zygomatic and palatine processes, the walls are thin, the edge of the orbit is blunt, and the ocular surface is convex. The second type (sclerotic) - the volume of the cavity is small, it does not continue into processes, the anterior wall is concave, the edge of the orbit is sharp, and the ocular surface is flat or concave. These extreme states, in fact, represent, in the first case, the excessive development of the sinus (or hypergenesis), in the second - underdevelopment (or hypogenesis). Between these extreme variants there is a group of normally developed sinuses, representing the vast majority, which, differing from each other in their size and shape, have common features. There are single descriptions of the complete absence (agenesis) of the maxillary sinuses on one or both sides [4].

It should be noted that the mechanism of development of the paranasal sinuses in the postnatal period has not yet been fully studied. However, it is this complex process, which depends on the interaction of many acting factors, which ultimately leads to the formation of a new organ, which, in fact, are the paranasal sinuses. Violation of the synchronization of this process leads to a “program failure”, which ultimately affects the anatomical structure and function of this organ.

Research by other scientists shows other indicators. The results (Agnieszka Przystanska), who studied the sexual dimorphism of the maxillary sinuses in children and adolescents, showed that the sexual dimorphism of the parameters of the maxillary sinus is variable and depends on the phase of ontogenesis. All studied parameters of the maxillary sinuses are greater in males at 2–3 years of age (with the exception of the length, which is greater in females by the end of three years, between six and nine years, and after 15 years). Sexual dimorphism is less pronounced during the first year of life and is most pronounced between 15 and 16 years of age. During the first two years, the size of the sinus in the female dominates, and all parameters are larger than in the male. Sexual dimorphism is most pronounced in the volume of the maxillary sinus [19].

A.Onodi (1911) studies show that the maxillary sinus in newborns has a height of 5.3 mm and a length of 10 mm. and a width of 3.5mm. In a study by Lange and Papke, it turned out that the average size of the sinus in the first year of life is 12mm, from 1-2 years old 13-16mm, at 3 years old - 18mm., 5 years old - 20.5mm, 8 years old - 23mm, 9 years old - 25mm ., 10 years old-27mm., 11-14 years old 28mm., 16-18 years old 37-40mm.. Differences between the right and left maxillary sinuses are less common than in the frontal [8].

Il-Ho Park's study of paranasal sinus development by computed tomography revealed that the maxillary sinuses were pneumatized at birth in all cases, showed a monomodal growth pattern increasing up to 15 years of age, and the mean volume after full growth was 14.83 ± 1 .36 cm. The bottom of the sinus was at the same level as the bottom of the nasal cavity at the age of 7 to 15 years. EarliSarilit and Eurek Ambar Lit in their study recorded the initial phase of maxillary sinus pneumatization in infancy. The maxillary sinus developed to reach the maximum mean maxillary sinus volume of 13,278.73 mm. in the group from 16 to 20 years, in which it subsequently decreased to 12,325.21 mm. No difference was found between the right and left maxillary sinus volumes. This

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study showed that pneumatization of the maxillary sinus begins in infancy and increases until the second decade of life, after which it slowly decreases [18].

Works by J. Bargut, Joe Pryor examined paranasal sinuses in children revealed maxillary sinuses measured at birth (mean +/- standard deviation) 7.3+/-2.7 mm in length (or in the anterior-posterior direction) / 4, 0+/-0.9 mm high (or cranio-caudal)/2.7+/-0.8 mm wide (or transverse). At 16 years, the maxillary sinus size was 38.8+/-3.5 mm/36.3+/-6.2 mm/27.5+/-4.2 mm [6].

Studies by Tiesong Zhang, Hao Shi "Comparison of sinus development in children with and without sinusitis in Yunnan Province" showed that the measured sinus diameter in children with sinusitis was larger than in healthy children ($P < 0.01$) [21].

The results of DorotaLorkiewicz-Muszynska and WojciechKociemb, ArturRevekant Alicia Sroka, who investigated "Development of the Maxillary Sinus from Birth to 18 years" showed that the maxillary sinuses are identified from the beginning of postnatal life, moreover, their presence is also reported in prenatal life. Their steady growth in size and the variable rate at which they grow have been observed in human fetuses. Initial signs of pneumatization of the maxillary sinuses can be seen at birth. Our study confirmed that the postnatal development of the maxillary sinuses begins on both sides simultaneously. Measurements of the maxillary sinuses of the youngest recorded are the following measurements at birth, which range between 7mm and 10mm; vertical varies from 3.5 to 4mm and transverse varies from 2.5mm to 4mm. The maximum-recorded dimensions in this study were anteroposterior diameter 4.613 cm, vertical 3.636 cm, transverse 3.506 cm. The largest recorded volume of the maxillary sinus was 19.151 cm3 (female) and 20.824 cm^3 (male). The maximum average value of MBV in females was calculated for groups of 14–17 years old and amounted to 13.370 ± 2.72 cm^3. In males, the maximum mean MBV was estimated in groups 15–16 and amounted to 16.711 ± 2.026 cm^3. In the same study, it was suggested that the decrease in maxillary sinus volume may be due to the loss of bone matrix in the surrounding bones as a result of aging. When examining 115 patients, it was reported that the volume of the sinuses increased up to 20 years, and then decreased [11].

Studies by Degermenchi, Muhammet, Ertekin, Tolga, studying the age-related development of the maxillary sinus in children, came to the conclusion that measurements of the volume of the maxillary sinus obtained by two methods increased with age in both sexes up to 16 years. A significant correlation was found between the two methods (ICC 0.894–1.000 for the right and 0.862–0.999 for the left maxillary sinus measurement). Depending on gender, the average volumes of the right and left maxillary sinuses were determined in men 8.30 ± 5.19 and 8.57 ± 5.53 cm^3, in women 7.60 ± 4.57 and 7.99 ± 4.73 cm^3 according to the ellipsoid formula, respectively. According to the stereological method, these values were 8.28 ± 5.26, 8.44 ± 5.35 cm3 and 7.64 ± 4.55, 7.85 ± 4.73 cm^3, respectively. There was no statistically significant difference between the volume of the maxillary sinuses from the genital and lateral sides by both methods [7].

Research Kosourova A.K. and Morozova V.V. studying age-related changes in the paranasal sinuses in postnatal ontogenesis in residents of Karelia, because of studying the dynamics of the growth of the maxillary sinuses, they found that the size of the sinuses increases unevenly in men and women. Until the age of 10, we observed a uniform growth of the sinuses in width and height, regardless of gender. The overall growth rate of sinuses in boys aged 13 to 16 is 27.4% higher than in girls. From the age of 10, the growth rate of the sinuses increases sharply, in height, especially in women. We found that there is no asymmetry in the size of the right and left maxillary sinuses on average up to 50 years, regardless of gender. The study of the growth of the maxillary sinuses with the determination of the shape of the skull allowed us to establish the dependence of the size of the

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sinuses on the shape of the skull. The analyzed digital material indicates that the width of the maxillary sinuses is greater with a brachymorphic skull shape, regardless of gender; the height is greater with the dolichomorphic shape of the skull, also regardless of gender. The overall dimensions of the sinuses are larger with a dolichomorphic skull shape, but compared with mesomorphic and brachymorphic, which is especially pronounced in men. In addition, in order to identify adverse environmental impacts on the processes of pneumatization of the maxillary sinuses, they compared the dynamics of the growth of sinuses in residents of Petrozavodsk and Nadvoits. Nadvoitsy is a zone of ecological disaster due to environmental pollution by technogenic products of the aluminum industry, especially fluorine, chlorine and their compounds. The analyzed data indicate a slowdown in the growth of the maxillary sinuses in residents of Nadvoitsy of both sexes compared to residents of Petrozavodsk. Pneumatization of the sinuses in residents of Nadvoitsy up to 7 years of age does not differ from pneumatization of the sinuses in residents of Petrozavodsk, and then there is a slowdown in the growth of the sinuses at the age of 7 to 12 years. And at an older age, the size of the maxillary sinuses is much smaller compared to the residents of Petrozavodsk. The growth of the maxillary sinuses in the inhabitants of Nadvoitsy ends on average 2 years later [2].

Conclusions: The purpose of this study was to study the development of the maxillary sinuses and evaluate changes in volume depending on age and gender. After analyzing the literature, we found that a significant number of works devoted to the study of the development and structure of the maxillary sinus in postnatal ontogenesis, due to age, sex, remained unknown for a long time, and have not been fully studied to date. It was also revealed that the environmental and social factors affect the morphogenesis of the maxillary sinus. This shows that the provision of standard values for the size of the paranasal sinuses and their changes depending on age is relevant today, which is reflected in a number of scientific papers that reveal its topographic and anatomical variations and physiological features. It should be noted that for the success of the treatment of sinonasal disorders, comprehensive knowledge and correct visualization of the anatomical conditions of the osteomeatal complex and paranasal sinuses is crucial in head and neck surgery, especially in otolaryngology, skull base surgery and maxillofacial surgery.

References

1. Ополовникова К., Харибова Е. Сравнительная возрастная характеристика околоносовых пазух в постнатальном онтогенезе (обзор литературы) //Общество и инновации. – 2021. – Т. 2. – №. 6/S. – С. 1-8.
2. Косоуров А. К., Морозова В. В. Влияние неблагоприятных экологических факторов на постнатальный онтогенез лобной и верхнечелюстной пазух у жителей Карелии// Тез. докл. Всерос. конф. "XXI век: акту альные задачи морфологии", симпозиума "морфологические и экологические проблемы пульмонологи и". 12-14 сентября 2001. Саратов. "Морф ология" 2001 г.. Т. 120, Вып. 4 С. 76
3. Гайворонский И. В., Смирнова М. А., Гайворонская М. Г. Анатомические корреляции при различных вариантах строения верхнечелюстной пазухи и альвеолярного отростка верхней челюсти // Вестник Санкт-Петербургского университета. Медицина. 2008. №3. 95-99
4. Ata-Ali J, Diago-Vilalta JV, Melo M, Bagán L, Soldini MC, Di-Nardo C, Ata-Ali F, Mañes-Ferrer JF. What is the frequency of anatomical variations and pathological findings in maxillary sinuses among patients subjected to maxillofacial cone beam computed tomography? A systematic review. Med Oral Patol Oral Cir Bucal. 2017 Jul 1;22(4):e400-e409. doi: 10.4317/medoral.21456. PMID: 28578369; PMCID: PMC5549512.

ISSN 2690-9626 (online), Published by "Global Research Network LLC"
under Volume: 3 Issue: 2 in February-2022 https://grnjournals.us/index.php/AJSHR

5. Bhushan B, Rychlik K, Schroeder JW Jr. Development of the maxillary sinus in infants and children. Int J PediatrOtorhinolaryngol. 2016 Dec;91:146-151. doi: 10.1016/j.ijporl.2016.10.022. Epub 2016 Oct 26. PMID: 27863629.

6. Barghouth G, Prior JO, Lepori D, Duvoisin B, Schnyder P, Gudinchet F. Paranasal sinuses in children: size evaluation of maxillary, sphenoid, and frontal sinuses by magnetic resonance imaging and proposal of volume index percentile curves. EurRadiol. 2002 Jun;12(6):1451-8. doi: 10.1007/s00330-001-1218-9. Epub 2002 Feb 2. PMID: 12042953.

7. Değermenci M, Ertekin T, Ülger H, Acer N, Coşkun A. The Age-Related Development of Maxillary Sinus in Children. J Craniofac Surg. 2016 Jan;27(1):e38-44. doi: 10.1097/SCS.0000000000002304. PMID: 26703070

8. Flood, L. (2016). ANATOMY FOR PLASTIC SURGERY OF THE FACE, HEAD, AND NECKK Watanabe, M MShoja, M Loukas, R S Tubbs Thieme, 2016 ISBN 978 1 62623 091 0 eISBN 978 1 62623 092 7 pp. The Journal of Laryngology & Otology, 130(7), 698-698. doi:10.1017/S0022215116007921

9. Kishimoto K, Kobayashi R, Hori D, Matsushima S, Yanagi M, Sano H, Suzuki D, Kobayashi K. Paranasal sinusitis at the initiation of chemotherapy is a risk factor for invasive fungal disease in children and adolescents with cancer. Support Care Cancer. 2021 Oct;29(10):5847-5852. doi: 10.1007/s00520-021-06143-7. Epub 2021 Mar 22. PMID: 33754198.

10. Lee S, Fernandez JW, Mahadevan M, Tarr G, Mirjalili A. Using 3D-reconstruction to analyse typical growth trends of the maxillary sinus in children. Int J PediatrOtorhinolaryngol. 2020 Nov;138:110334. doi: 10.1016/j.ijporl.2020.110334. Epub 2020 Aug 29. PMID: 32919161.

11. Lorkiewicz-Muszyńska D, Kociemba W, Rewekant A, Sroka A, Jończyk-Potoczna K, Patelska-Banaszewska M, Przystańska A. Development of the maxillary sinus from birth to age 18. Postnatal growth pattern. Int J PediatrOtorhinolaryngol. 2015 Sep;79(9):1393-400. doi: 10.1016/j.ijporl.2015.05.032. Epub 2015 Jun 30. PMID: 26162781

12. Marulanda J, Murshed M. Role of Matrix Gla protein in midface development: Recent advances. Oral Dis. 2018 Mar; 24(1-2):78-83. doi: 10.1111/odi.12758. PMID: 29480643.

13. Omer Erdur, FarukIzzetUcar, Ahmet ErcanSekerci, MevlutCelikoglu, SuleymanKutalmısBuyuk,Maxillary sinus volumes of patients with unilateral cleft lip and palate. International Journal of Pediatric Otorhinolaryngology, Volume 79, Issue 10, 2015, pp. 1741-1744

14. Opolovnikova K.S., Sh.J. Teshayev COMPARATIVE AGE CHARACTERISTICS OF FRONTAL SINUSIN POSTNATAL ONTOGENESIS. Volume 10, Issue 06, Pages: 192-198. DOI: 10.48047/IJIEMR/V10/I06/39

15. Przystańska A, Kulczyk T, Rewekant A, Sroka A, Jończyk-Potoczna K, Gawriołek K, Czajka-Jakubowska A. The Association between Maxillary Sinus Dimensions and Midface Parameters during Human Postnatal Growth. Biomed Res Int. 2018 May 15;2018:6391465. doi: 10.1155/2018/6391465. PMID: 29862281; PMCID: PMC5976946.

16. Sánchez-Pérez A, Boracchia AC, López-Jornet P, Boix-García P. Characterization of the Maxillary Sinus Using Cone Beam Computed Tomography. A Retrospective Radiographic Study. Implant Dent. 2016 Dec;25(6):762-769. doi: 10.1097/ID.0000000000000485. PMID: 27540848.

ISSN 2690-9626 (online), Published by "Global Research Network LLC"
under Volume: 3 Issue: 2 in February-2022 https://grnjournals.us/index.php/AJSHR

17. Schriber M, von Arx T, Sendi P, Jacobs R, Suter VG, Bornstein MM. Evaluating Maxillary Sinus Septa Using Cone Beam Computed Tomography: Is There a Difference in Frequency and Type Between the Dentate and Edentulous Posterior Maxilla? Int J Oral Maxillofac Implants. 2017 Nov/Dec;32(6):1324-1332. doi: 10.11607/jomi.5854. PMID: 29140376.

18. Sarilita E, Lita YA, Nugraha HG, Murniati N, Yusuf HY. Volumetric growth analysis of maxillary sinus using computed tomography scan segmentation: a pilot study of Indonesian population. Anat Cell Biol. 2021 Dec 31;54(4):431-435. doi: 10.5115/acb.21.051.

19. Whyte A, Boeddinghaus R. The maxillary sinus: physiology, development and imaging anatomy. DentomaxillofacRadiol. 2019 Dec;48(8):20190205. doi: 10.1259/dmfr.20190205. Epub 2019 Aug 13. Erratum in: DentomaxillofacRadiol. 2019 Sep 10;:20190205c.

20. Yaylacı A, Alparslan B. Anterior maxillary wall and lacrimal duct relationship in pediatric patients - CT analysis for the feasibility of the prelacrimal recess approach. AurisNasus Larynx. 2021 Dec 14:S0385-8146(21)00274-1. doi: 10.1016/j.anl.2021.11.013. Epub ahead of print. PMID: 34920908.

21. Zhang T, Shi H, Lin J, Zhao S, Lu T. [Comparison of the nasal sinus development of children with or without sinusitis in Yunnan province]. Lin Chung Er Bi Yan HouTou Jing Wai KeZaZhi. 2010 Jun;24(11):511-3. Chinese. PMID: 20737964. Zhang T, Shi H, Lin J, Zhao S, Lu T. [Comparison of the nasal sinus development of children with or without sinusitis in Yunnan province]. Lin Chung Er Bi Yan HouTou Jing Wai KeZaZhi. 2010 Jun;24(11):511-3. Chinese. PMID: 20737964.

ISSN 2690-9626 (online), Published by "Global Research Network LLC"
under Volume: 3 Issue: 2 in February-2022 https://grnjournals.us/index.php/AJSHR