

AGE DYNAMICS OF THE MORPHOMETRIC PARAMETERS OF THE ETHMOID SINUSES BASED ON CONE-BEAM COMPUTED TOMOGRAPHY DATA (CBCT)

Opolovnikova K S

Bukhara State Medical Institute, Bukhara, Uzbekistan <https://orcid.org/0009-0004-9787-4528>
opolovnikova.kristina@bsmi.uz +998914470709

Abstract: *The study presents an analysis of age-related morphometric features of the ethmoid sinuses in children and adolescents of the Bukhara region using cone-beam computed tomography (CBCT). The aim of the research was to determine normative parameters of the ethmoid cells and to analyze the patterns of their postnatal development at different age stages. The results obtained expand the understanding of age-related anatomical variability and can be applied in clinical practice and scientific research.*

Keywords: *ethmoid sinuses, ethmoidal labyrinth, paranasal sinuses, accessory sinuses, age characteristics, morphometry, cone-beam computed tomography, volume, asymmetry, children.*

INTRODUCTION

The ethmoid sinuses represent a complex system of air-filled cells located between the nasal cavity and the orbit and are among the most variable anatomical structures of the paranasal sinuses. They perform important functions in ventilation, humidification, and filtration of inhaled air, as well as contribute to the resonant and protective mechanisms of the paranasal complex. The morphometric parameters of the ethmoid cells change during growth and development, reflecting individual anatomical and physiological characteristics. These age-related transformations have significant clinical importance for the diagnosis of inflammatory diseases and the planning of endoscopic and reconstructive surgical interventions.

Cone-beam computed tomography (CBCT) is a modern high-precision imaging technique that allows detailed assessment of the internal structure of the ethmoidal labyrinth with minimal radiation exposure.

Materials and Methods. To identify the age-related patterns of growth and morphometric variability of the ethmoid sinuses, 516 practically healthy children and adolescents aged 1 to 18 years (240 boys and 276 girls) from the Bukhara region were examined using cone-beam computed tomography (CBCT) at the Lorastomservis clinic.

Scanning was performed in a standing position with head fixation, using one full rotation of the emitter and detector at 360° within approximately 20 seconds, which provided high-quality three-dimensional reconstructions with minimal radiation exposure. The subjects were divided into age groups according to the classification adopted at the VII All-Union Conference on Age Morphology. For each participant, an individual card was compiled, including information about age, sex, nationality, and cranial form.

Morphometric evaluation of the ethmoid sinuses was performed using the following parameters: number of cells, their height, width, depth, and volume of the right and left

ethmoidal labyrinth. Measurements were obtained in axial, sagittal, and coronal planes using the built-in tools of the CBCT software. The data were processed statistically with calculation of mean values (M), standard deviations (\pm SD), and significance of differences using the criterion $p < 0.05$.

Measurements of the ethmoidal labyrinth were based on standard anatomical landmarks to ensure accuracy and reproducibility of morphometric data. The analysis included three principal axes: Height (H): measured on coronal slices from the ethmoidal roof (fovea ethmoidalis) to the level of the middle nasal turbinate, perpendicular to the skull base; Width (W): measured between the lateral wall (lamina papyracea) and the medial wall of the nasal cavity at the widest section, mostly in the coronal plane; Depth (D): measured in sagittal or axial planes as the distance from the most anterior ethmoid cells (agger nasi region) to the posterior cells located anterior to the sphenoid sinus. Each measurement was repeated three times, and the mean value was recorded. The measurement error did not exceed ± 0.1 mm, ensuring high accuracy and reliability of morphometric data.

Results. The morphometric analysis of the ethmoid sinuses in children aged 1 to 18 years revealed distinct age-related growth and pneumatization patterns. In early childhood (1–3 years), no significant sex differences were found: linear parameters (height, width, depth) and volume of both sides were similar, indicating synchronous development. Slightly higher width and depth values in boys reflect more active early pneumatization. The number of ethmoid cells remained stable, averaging 3–5 per side.

During second childhood (4–7 years), the first sex differences appeared: boys demonstrated moderately higher values of length, width, depth, and volume, with the number of cells ranging 5–8, reflecting faster formation of the ethmoidal labyrinth. Girls showed more gradual growth and slightly greater shape variability.

In middle childhood (8–12 years), the differences became more pronounced: boys had larger ethmoid sinuses in both linear and volumetric dimensions, while girls showed more stable and symmetrical structures. The number of cells was comparable (average 6–10), indicating coordinated maturation of the air-containing system.

In adolescence (13–16 years), the maximal increase in size and volume was recorded, accompanied by marked sexual dimorphism. Boys had significantly higher values of all parameters (H, W, D, volume), whereas girls retained more compact and smooth contours. The number of cells reached 8–12 in boys and 8–11 in girls.

By 17–18 years, the final anatomical outlines of the ethmoid sinuses were established. Boys maintained higher linear and volumetric values, while girls exhibited a more rounded and symmetrical configuration. The average number of ethmoid cells was 11–12 in boys and 10–11 in girls.

Between the sides, the right and left ethmoid sinuses developed symmetrically in early childhood (1–7 years). From 8–16 years, a moderate right-sided dominance appeared, where the right sinus was slightly larger and more voluminous, particularly during puberty. By 17–18 years, this asymmetry stabilized and remained within the range of anatomical norm.

Thus, from 1 to 18 years, the ethmoid sinuses show a progressive increase in height, width, depth, and volume, as well as an increase in the number of cells from 3–5 to 10–12 or

more. Sexual differences are minimal in early childhood, become evident during the school and adolescent periods, and reach their maximum during puberty. Boys demonstrate larger sinus dimensions and volume, whereas girls retain greater symmetry and compactness. The overall architecture of the ethmoidal labyrinth remains harmonious, showing a mild right-sided predominance.

Table 1.

Age-related morphometric parameters of the ethmoid sinuses in children of the Bukhara region

Age (years)	Sex	Length (mm)	Width (mm)	Depth (mm)	Volume (cm ³)	Number of Cells
1-3	Boys	11.9 ± 0.13 (10.8-13.7)	8.19 ± 0.49 (7.5-9.4)	27.0 ± 0.51 (22.5-31.4)	1.39 ± 0.48 (1.28-1.89)	3-5 (3.33 ± 0.59)
	Girls	11.6 ± 0.12 (10.5-13.3)	8.06 ± 0.07 (7.3-9.4)	25.2 ± 0.43 (21.8-30.5)	1.28 ± 0.94 (0.92-1.78)	3-5 (3.35 ± 0.10)
4-7	Boys	13.2 ± 0.10 (12.1-16.1)	9.45 ± 0.16 (7.5-12.6)	31.8 ± 0.18 (29.5-36.1)	2.09 ± 0.56 (1.57-3.55)	5-8 (6.15 ± 0.11)
	Girls	12.7 ± 0.11 (11.4-16.1)	8.99 ± 0.12 (7.5-12.1)	30.9 ± 0.24 (26.2-35.1)	1.86 ± 0.50 (1.30-3.37)	3-8 (5.40 ± 0.15)
8-12	Boys	16.2 ± 0.26 (12.0-21.9)	11.8 ± 0.16 (10.5-15.8)	34.2 ± 0.20 (31.2-38.3)	3.44 ± 0.86 (2.13-5.05)	6-10 (7.43 ± 0.13)
	Girls	15.7 ± 0.29 (12.0-21.9)	11.4 ± 0.14 (8.5-15.8)	34.1 ± 0.22 (31.2-38.3)	3.22 ± 0.10 (1.91-5.05)	5-10 (7.10 ± 0.13)
13-16	Boys	18.5 ± 0.30 (14.6-22.8)	13.1 ± 0.25 (11.0-20.0)	37.1 ± 0.36 (32.4-44.0)	4.81 ± 0.14 (3.19-8.44)	6-12 (9.54 ± 0.22)
	Girls	17.8 ± 0.32 (14.5-22.8)	12.7 ± 0.22 (10.8-16.3)	36.3 ± 0.35 (32.0-44.0)	4.32 ± 0.13 (2.80-6.74)	6-12 (8.75 ± 0.19)
17-18	Boys	20.9 ± 0.33 (17.4-23.7)	14.6 ± 0.29 (12.2-20.0)	39.6 ± 0.45 (35.1-46.2)	6.35 ± 0.21 (4.62-9.13)	8-14 (11.3 ± 0.35)
	Girls	20.4 ± 0.31 (14.7-23.7)	14.2 ± 0.29 (11.0-20.1)	39.2 ± 0.34 (33.8-46.2)	6.03 ± 0.19 (3.28-9.13)	7-14 (10.7 ± 0.19)

Note: * — level of significance. For statistically significant differences, the following levels were accepted: high — *** $p < 0.001$; moderate — ** $p < 0.01$; low (borderline) — * $p < 0.05$.

Conclusion. The morphometric study conducted using cone-beam computed tomography (CBCT) revealed a consistent increase in the linear and volumetric parameters of the ethmoid sinuses from 1 to 18 years, accompanied by an increase in the number of cells from 3-5 to 10-12 or more. During early childhood (1-7 years), development of both sides proceeds synchronously, while from 8 years onward, a moderate right-sided dominance appears. Sexual dimorphism becomes pronounced during school and adolescence, with boys showing larger dimensions and volumes, while girls display greater symmetry and stability of form. By 17-18 years, the final anatomical configuration of the ethmoid sinuses is established, reflecting completion of pneumatization. The application of CBCT ensured high-precision visualization, enabling the establishment of age-related normative data and identification of individual morphological features of the ethmoidal labyrinth.