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Measurement of nasal anterior aperture and choana by computed tomography in newborns and infants

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Abstract

Nasal obstruction is potentially severe when it affects neonates because nasal breathing is predominant during this period. An accurate assessment of nasal airway obstruction should be based on a comparison of the patient's nasal cavity dimensions with precise "normal values". For this reason, we aimed in this study to evaluate the nasal morphometry in newborns and infants with Computed Tomography (CT) in our region. CT images of 134 children who had no facial and cranial anomalies and no pathology were evaluated. In the axial section, the total choana width, right lateral width of the choana, left lateral width of the nasal cavity, the posterior width of the vomer, total aperture width (AW), right aperture width (RAW) and left aperture width were measured in all participants. The study group was divided into 4 age categories: 0-30 days, 31-90 days, 91-180 days and 181-360 days. When the choanal measurements of the groups were evaluated, there was a significant difference between the groups in the choanal measurements ($p<0.05$, for all), but no difference was observed between the groups in terms of vomer measurements. While there was a significant difference between the groups in terms of AW measurement, there was a significant difference only between Group 1 and Group 4 in terms of RAW value. There was also a positive correlation between age and choanal and aperture values ($p<0.05$ for all), while no correlation was observed with vomer measurements The normal widths of the choanal and anterior nasal aperture in infants in our region were defined according to months and gender in our study. Considering that there may be social differences, knowing the normative values in normal healthy individuals is of great importance in the evaluation of clinical and pathological conditions.

Keywords: Nasal obstruction, choanal measurement, vomer, choana width, aperture width

Introduction

Nasal obstruction is potentially severe when it affects neonates because nasal breathing is predominant during this period. This feature continues, on average, until the fifth month of life [1]. Nasal obstruction may be due to hypoplasia of the nasal cartilage and/or nasal bone, narrowing of the nasal bone entrance or pyriform aperture, septal displacement, posterior choana stenosis or atresia. Diagnosis of nasal obstruction is made by nasal endoscopy or Computed Tomography (CT). CT is the first choice for diagnosis, since nasal endoscopy is an invasive method that is difficult to perform due to the small size of the nasal cavity in very small patients. CT has the advantage of clearly evaluating the anatomy, as well as determining the level and cause of stenosis. It is also a more applicable and accessible method. At the same time, the accuracy of these quantitative measurements obtained from CT in diagnosis and their usability in the diagnosis and treatment of patients have been proven in previous studies [2].

Although there are many studies on the morphometry of the nasal cavity in healthy newborns and small infants without nasal

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stenosis, the number of anatomical studies on the dimensions of the nasal cavity in healthy children is still insufficient [3-6]. While there are no specific for the normal vomer and choanal measurements in infants, its anatomy can vary among individuals. Considering the fact that the head development is the fastest in the first year of human life and that congenital nasal obstruction is evaluated in this age group, therefore, it is necessary to determine the age-appropriate normal values of the dimensions of the choanae and vomer structures. For these reasons, in this study, we aimed to evaluate nasal morphometry in newborns and infants with CT in our region.

Material and Methods

This retrospective study included children aged 0-1 years, who were referred to the Radiology Department for cranial or maxillofacial CT examination for other reasons, between 2012 and 2021. CT images of 134 children who had no facial and cranial anomalies and no pathology were evaluated. Children with prematurity, craniosynostosis and hydrocephalus, genetic disorders (e.g., Crouzon syndrome, Pfeiffer syndrome and Apert syndrome) were excluded from the study. Examinations that were not suitable for evaluation as image quality (with motion artifacts) were also not included in the evaluation. The investigation complied with the principles outlined in the Declaration of Helsinki, and local ethics committee approval was obtained for our study (Inonu University, Local Ethical Committee, ID:2023/670).

CT scans for head examination were performed in the axial plane, 0.5 mm thick, in accordance with the standard diagnostic protocol. Images obtained from CT were saved on a workstation for analysis. The measuring plane was parallel to the hard palate. Measurements were made at the level of the floor of the nasal fossa and just above it on images with symmetry of visible structures for axial scanning. The mean of two separate measurements was used for analysis.

In axial sections of all patients; the distance between the two pterygoid processes was measured as the total choana width (CW) in the posterior nasal cavity, the distance between the right nasal cavity lateral bone wall and the septum mucosa was measured as the right lateral width of the choana (RCW), the left lateral width of the choana was measured as the lateral width (LCW) of the left nasal cavity. The distance between the bone wall and the septum mucosa was measured, and the mediolateral distance at the level of the choana was measured as the posterior width of the vomer (VW).

In the coronal plane, the distance between the sphenoid sinus inferior wall and the hard palate was measured as the height of the choana (CH). İn the axial section, the distance between the maxillary nasal prominences in the anterior (total) was measured as aperture width (AW), right aperture width (RAW) and left aperture width (LAW), the distances from the maxillary prominence to the septum on the related side were also measured (Figure 1).

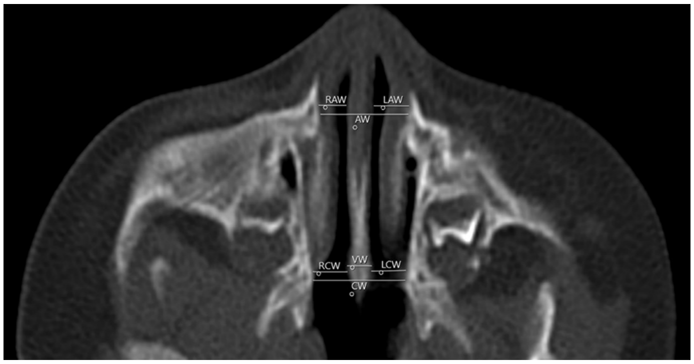

Figure 1. Illustration of choanal measurements. AW: total aperture width, CW: total choanae width, LAW: left aperture width, LCW: left choanae width, RAW: right aperture width, RCW: right choanae width

Statistical analysis

Jamovi software (version 2.3.28) was used for statistical analysis. Continuous variables were presented as mean and standard deviation, and categorical variables were presented as mean and percentage. One-way ANOVA analysis was used to compare variables between groups. Two-way ANOVA test was used to evaluate the data according to age and gender. Bonferroni correction was performed in post-hoc analyses. Pearson test was used in the correlation analysis of the data. A p value less than 0.05 was considered statistically significant.

Results

The study group was divided into 4 age categories: 0-30 days, 31-90 days, 91-180 days and 181-360 days. A total of 134 patients (63 girls, 71 boys) were recruited to this study. The mean age of the participants was 94.1 (1–360) days (Table 1).

Table 1. Demographic and tomographic measurement data of the study population

Age, months	94.1 (1-360)
Gender, male, (n, %)	71 (53.0%)
RAW, mm	4.7±1.4
LAW, mm	4.7±1.2
AW, mm	12.9±2.6
RCW, mm	5.4±1.5
LCW, mm	5.6±1.6
CW, mm	13.7±2.9
CH, mm	6.4±2.1
Vomer, mm	2.9±1.2

AW: total aperture width, CH: total choanae height, CW: total choanae width, LAW: left aperture width, LCW: left choanae width, RAW: right aperture width, RCW: right choanae width.

The choanal measurement data of the patients are given in Table 2. When the choanal measurements of the groups were evaluated, there was a significant difference between the groups in the choanal measurements (p<0.05, for all), but no difference was observed between the groups in terms of vomer measurements. In particular, the differences between group 4 and other groups were evident. When the choanal measurements of the groups were evaluated according to gender, there was no statistically significant difference between the measurements according to gender (Table 3).

The aperture measurement data of the patients are given in Table 4. While there was a significant difference between the groups in terms of AW measurement, there was a significant difference only between Group 1 and Group 4 in terms of RAW value. LAW values were similar between groups. Again, when the aperture values of the groups were evaluated according to gender, no difference was observed between the groups (Table 5).

When the correlation of data with age was evaluated, there was a positive correlation between age and choanal and aperture values (p<0.05 for all), while no correlation was observed with vomer measurements (Table 6).

Table 2. Choanal measurement values of the patients

	Group 1 (n=51)	Group 2 (n=35)	Group 3 (n=24)	Group 4 (n=24)	ANOVA
CW, mm	12.2±2.6	13.8±3.1	14.3±2.2	16.2±1.3	<0.001 β, Φ, ¥, Ω
RCW, mm	4.8±1.4	5.3±1.7	5.8±1.0	6.6±1.2	<0.001 β, Φ, ¥
LCW, mm	5.1±1.7	5.4±1.7	5.9±1.1	6.7±1.2	<0.001 Φ, ¥
CH, mm	5.5±2.1	5.8±1.6	7.5±1.8	8.3±1.4	<0.001 β, Φ, ¥, α
Vomer, mm	2.7±0.9	3.1±1.1	3.0±1.4	3.2±1.4	0.263

β: p<0.05 in group 1 vs. group 3, Φ: p<0.05 in group 1 vs. group 4, ¥: p<0.05 in group 2 vs. group 4, Ω: p<0.05 in group 3 vs. group 4, α: p<0.05 in group 2 vs. group 3. CH: total choanae height, CW: total choanae width, LCW: left choanae width, RCW: right choanae width

Table 3. Choanal measurement values of the patients by gender

		CW	RCW	LCW	CH
Group 1 (n=51)	Male (n=25)	12.3±2.4	4.9±1.0	5.2±1.4	5.2±1.2
	Female (n=26)	12.1±2.7	4.7±1.7	4.9±1.9	5.8±2.7
Group 2 (n=35)	Male (n=19)	13.3±1.5	4.8±0.9	4.8±1.1	5.7±1.7
	Female (n=16)	14.3±4.2	5.7±2.2	5.9±1.9	5.9±1.4
Group 3 (n=24)	Male (n=15)	14.7±2.2	5.9±1.1	6.2±1.3	7.5±1.9
	Female (n=9)	13.6±2.2	5.6±0.8	5.3±1.1	7.5±1.8
Group 4 (n=24)	Male (n=12)	16.1±1.4	6.5±1.0	6.7±1.0	8.1±1.3
	Female (n=12)	16.3±1.2	6.6±1.4	6.7±1.4	8.6±1.5

CH: total choanae height, CW: total choanae width, LCW: left choanae width, RCW: right choanae width

Table 4. Aperture width data of the patients

	Group 1 (n=51)	Group 2 (n=35)	Group 3 (n=24)	Group 4 (n=24)	ANOVA
AW, mm	11.5±2.4	12.8±2.4	13.3±2.4	15.4±1.6	<0.001 β, Φ, Ω
RAW, mm	4.3±1.4	4.8±1.4	4.7±1.0	5.4±1.4	0.011 Φ
LAW, mm	4.5±1.2	4.8±1.1	4.6±1.3	5.0±1.1	0.279

β: p<0.05 in group 1 vs. group 3, Φ: p<0.05 in group 1 vs. group 4, Ω: p<0.05 in group 3 vs. group 4. AW: total aperture width, LAW: left aperture width, RAW: right aperture width

Table 5. Aperture measurement values of the patients by gender

		AW	RAW	LAW
Group 1 (n=51)	Male (n=25)	11.2±2.4	4.2±1.3	4.3±1.3
	Female (n=26)	11.7±2.3	4.2±1.4	4.6±1.15
Group 2 (n=35)	Male (n=19)	12.3±1.7	4.5±1.1	4.7±1.07
	Female (n=16)	13.3±3.0	5.1±1.5	5.0±1.15
Group 3 (n=24)	Male (n=15)	13.6±2.5	4.9±0.8	4.8±1.3
	Female (n=9)	12.9±2.0	4.2±1.2	4.2±1.3
Group 4 (n=24)	Male (n=12)	15.4±1.6	5.8±1.5	5.4±1.1
	Female (n=12)	15.2±1.6	4.8±1.2	4.6±1.0

AW: total aperture width, LAW: left aperture width, RAW: right aperture width

Table 6. Correlation table between age and parameters

	r	P value
RCW	0.435	<0.001
LCW	0.393	<0.001
CW	0.507	<0.001
RAW	0.334	<0.001
LAW	0.198	0.022
AW	0.547	<0.001
CH	0.466	<0.001
Vomer	0.126	0.148

AW: total aperture width, CH: total choanae height, CW: total choanae width, LAW: left aperture width, LCW: left choanae width, RAW: right aperture width, RCW: right choanae width

Discussion

The main findings of our study are as follows, (i) while choanal measurements increased between groups with increasing age, vomer measurements did not change, (ii) there was a significant difference between the groups in terms of AW measurement, especially in RAW value, (iii) and there was a positive correlation between age and choanal and aperture values, while no correlation was observed with vomer measurements.

Nasal airway obstruction in infants can be caused by various factors, including anatomical abnormalities, inflammation, and congestion. One common anatomical cause of nasal airway obstruction is a deviated nasal septum, where the wall that separates the nostrils is crooked or displaced. It may sometimes present as stenosis of the entire nasal passage and sometimes as stenosis or atresia of the anterior nasal passage and stenosis or atresia of the choanal. The size of the nasal cavity can show social and personal variability. It is important to distinguish variability due to pathological causes from these physiological changes. Morphological and morphometric evaluations will be beneficial in both diagnosis and treatment.

Morphometric parameters of the nasal cavity in children play an important role in assessing nasal health, diagnosing nasal disorders, and determining appropriate treatment options [3,7-10]. In studies comparing the measurements of the nasal cavity structures of children with bilateral posterior nares anthesis and children under one year of age without nasal patency problems, significant differences were found between these two patient populations [3]. In a study of 56 CT images obtained from children under one year of age with nasal patency problems, differences were found in terms of the width of the choanae between the groups of children examined [5]. These studies show that the correct knowledge of the dimensions of the nasal cavity in children without nasal obstruction reveals the necessity of diagnosing diseases. The determination of these clinically important measurements in our region has also been the subject of our study.

In one study, it was reported that two parameters useful in the evaluation of choanal atresia were vomer width and choanal width and, in particular, a vomer width greater than 0.67 mm caused nasal stenosis [4]. Similarly, the importance of vomer width was emphasized by Hansberger and Vanzieleghem et al. [11,12]. When the existing literature is examined, it is stated that the vomer sizes taken 5 mm above the hard palate are 0.23 mm in the 0-8 age group and 0.28 mm in the 8-20 age group [4].

In our study, when the widest part of the vomer was measured, we found a mean of 2.9 mm in children under 1 year of age and no statistically significant difference was found between the age groups. In terms of choana dimensions measured at the nasal piriform level, it was observed that there was a significant difference between distant age groups, although not in the

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immediate age range in children. In their study, Aslan et al. [3] found the total choana width to be 1.43±0.16 cm, 0.58±0.10 cm on the right side and 0.58±0.13 cm on the left side in children under one year old. Although choanal measurements in our study showed similar results with this study, it was observed that normal values could be larger for the vomer and smaller for the choana widths.

In a CT study, piriform aperture size and nasal cavity width were measured in children under 1 year of age with congenital nasal piriform aperture stenosis (CNPAS) and showed significant differences in children with CNPAS compared with healthy children in the same age range [13]. Lee et al. measured the sizes of the piriform aperture in their three-dimensional computed tomography (3D-CT) study and showed that CT imaging of the aperture is useful in the pre- and postoperative evaluation, especially in children [14]. Aslan et al. was found the dimensions measured for this part of the nasal cavity to be 0.58±0.13 cm on the left side and 1.43±0.16 cm on the right side, respectively [3]. In our study, we obtained lower values in the measured parameters compared to the results found for the anterior region of the nasal cavity. Analysis of our results regarding anterior aperture dimensions measured at the piriform aperture level revealed a statistically significant positive correlation with the child's age. A significant difference between the newborn period and the groups after 6 months may testify to a uniform growth rate before 6 months of age and accelerated growth at 6 to 12 months [15].

Previous studies conducted to evaluate whether there is a difference in terms of gender have shown that the size of the air space in the nasal cavity is not related to gender, but only to age in a statistically significant way [15,16]. In our study, it was also confirmed that there was no statistically significant difference between the patient and control groups when nasal choanal and aperture measurements were evaluated according to gender.

One of the main limitations of our study are the small number of patients and the single-center design of our study. It is important to design new studies in terms of multi-center and comprehensive patient numbers and social rhetoric.

Conclusion

In conclusion, in this study, the normal widths of the choanal and anterior nasal aperture in infants in our region were defined according to months and gender. Considering that there may be social differences, knowing the normative values in normal healthy individuals is of great importance in the evaluation of clinical and pathological conditions.

Conflict of Interests
The authors declare that there is no conflict of interest in the study.

Financial Disclosure
The authors declare that they have received no financial support for the study.

Ethical Approval
Local ethics committee approval was obtained for our study (Inonu University, Local Ethical Committee, ID:2023/670).

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