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Cross-Sectional Study of Nasal Cavity, Nasal Septum and Paranasal Sinus Anatomy in Children

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ABSTRACT

Objective: Knowledge of the normal development process of the nasal and paranasal sinuses is important for diagnosis and treatment. This study aimed to analyze the normative data of the nasal cavity, nasal septum, and paranasal sinuses according to age and sex in children aged 0-14 years using cranial magnetic resonance imaging.

Methods: The images of 626 (355 males and 271 females) Caucasian children (mean age: 54.39 ± 48.91 months) were analyzed retrospectively. Sagittal and axial images were used for nasal and paranasal region measurements. Mean, standard deviation, median, minimum, and maximum values were determined for each age according to sex. The presence of paranasal sinuses was evaluated.

Results: The mean nasal septum areas for the first and 14th years were 624.2 mm^2 and 1742 mm^2, respectively. There was rapid growth in the first 4 years of life. The difference in all parameters was more pronounced in the first years of life, and the first year was significantly different compared with all age groups. There was no significant difference in the presence of septum deviation according to sex in general or at all ages ($P > .05$). Ethmoid sinuses were detected as 100% in the first year of life, and maxillary sinuses were 72.7%.

Conclusion: These results will help to know the cross-sectional data of the nose and paranasal region and to increase the success of secondary surgical approaches due to the constantly changing anatomic measurement values caused by the rapid growth process and the expected morphologic differences between societies.

Keywords: Apertura Piriformis, concha, development, magnetic resonance imaging, nasal septum, paranasal area

Introduction

The newborn facial skeleton differs from that of adults. Orbital size is proportionally larger, nasal spaces and maxilla are smaller, and paranasal sinuses are not yet developed. Understanding the normal anatomical measurements of the face is the basis for the implementation of diagnosis and treatment protocols. The first studies on the nasal septum and nasal cavity size were performed on cadavers.[1-3] These studies are not providing enough information; however, it is difficult to reach sufficient numbers with large series. X-ray imaging provides limited information. Developments in cross-sectional imaging have enabled these methods to be used in determining anatomic references. Computed tomography (CT) is the gold standard for imaging.[4-7] However, radiation exposure in CT is the most important restriction. Magnetic resonance imaging (MRI) is mostly preferred in children. For these reasons, MRI was preferred in our study to reach the numbers with which we can evaluate the anatomy.

Congenital anomalies are prominent in the newborn, and the frequency of inflammatory and traumatic processes increases with age.[8,9] When to perform surgical interventions in nasal and paranasal diseases in children has been a controversial issue.[10,11] The reason for these discussions is to prevent normal growth while facial development continues with intervention. However, in recent years, the opinion that surgical correction of the nasal septum in early childhood positively affects nasal and facial growth has become widespread.[12-14] It has been reported that early surgical intervention is safe, and untreated patients may have esthetic and functional problems over the years.[15,16] Surgical correction of septum deviation is advocated

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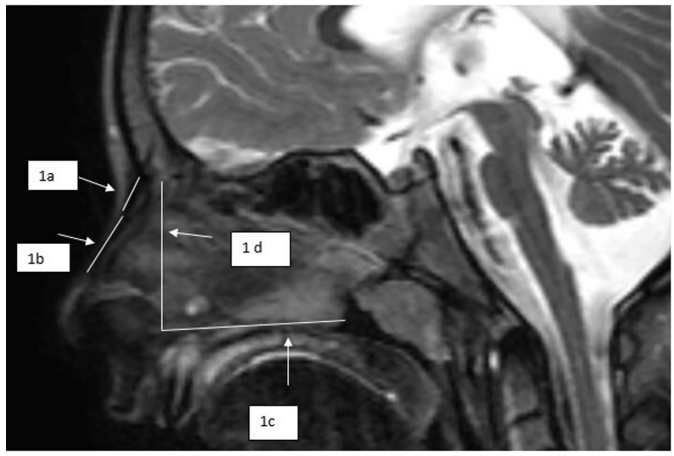

Figure 1. (1a) Dorsal cartilage length; (1b) dorsal bone length; (1c) nasal passage length; (1d) nasal passage height.

to avoid severe sequelae caused by mouth breathing and to provide harmony in facial growth, especially in children aged younger than 6 years.[3,12,13,17] In addition, endonasal skull-base surgical techniques are becoming increasingly common in the pediatric population.[18,19] Therefore, more data are needed regarding the measurements and limitations of the pediatric nasal region.[20,21] It is becoming increasingly important to define normal reference values for this region. For this purpose, we analyzed the course of the normative data of the nasal cavity, nasal septum, and paranasal sinuses according to age and sex in the 0-14 year age group using MRI.

Methods

This study was approved by Ethics committee of Aydın Adnan Menderes University (Approval No: 53043469-050.04.04 Protocol No: 2017/1060 Date: 23.01.2017). Informed consent was not obtained because our study was planned retrospectively. One thousand five hundred thirty-six brain MRI scans between January 2014 and January 2016 with different clinical indications were evaluated. Forty-three patients with known facial deformities, 11 with a history of facial surgery, and 857 cases (total of 911 cases) that did not fully penetrate the visual field of the nasal septum and whose image quality was insufficient and with differences in positioning were excluded from the study. As a result, 626 patients were included in the study.

Brain MRIs were obtained from a 1.5-T MRI scanner (Philips Achieva, TR/TE: 5857/110, FA 90, matrix size 244 × 194), with axial plane T2-weighted images (T2WI) passing through the midline, and the sagittal and nasal passages were evaluated. The slice thickness was 4 mm for those aged 3 years and younger and 5 mm for those aged over 3 years. Measurements were obtained using the workstation (SECTRA IDS 7). Two radiologists with 9 years (YDP) and 8 years (MG) of general radiology experience ensured unity in measurements by evaluating the first 10 case images together. The following variables were evaluated on the images.

Main Points

- Endonasal surgical techniques are becoming increasingly common in the pediatric population.
- Nasal region measurements differ according to populations.
- Measurements change with age and are important to know for the success of treatment.

All measurements were obtained from the medial part of the bone cortex.

T2-weighted images sagittal midline plane:

Dorsal bone length (DBL) is measured from the nasofrontal suture line to most anterior the rhinion (Figure 1a).

Dorsal cartilage length (DCL) is measured from the rhinion line to the anterior septal angle tip (Figure 1b).

Nasal passage length (NPL) is measured from the most anterior point of the maxilla's nasal spine line, ending at the most posterior point of the posterior nasal spine (Figure 1c).

Nasal passage height (NPH) measured from the frontonasal suture line to the most anterior point of the maxilla's nasal spine (Figure 1d).

Nasal septum area (cartilage and bone area) this variable measured as mm^2: A polygonal area is created by marking the nasofrontal angle in the anterior, upper, and bottom parts of the anterior wall of the sphenoid sinus in the posterior, ending at the most posterior point of the posterior nasal spine and the most anterior point of the maxilla's nasal spine (Figure 2).

T2WI axial plane passing through the nasal passage:

Right/left apertura piriformis (AP) width: the length of the horizontal line between the septum and the most medial segment of the frontal process of the right/left maxilla (Figure 3a).

Right/left nasal cavity width: the horizontal distance between the right/left maxiallary sinus medial wall and the nasal septum in the axial plane (Figure 3b).

Right/left choana width: the horizontal distance between the right/left lateral-medial bone cortex and vomer posterior section in the horizontal plane (from the level where the opening of the posterior nasal orifice to the nasopharynx is the widest) (Figure 3c).

Septum deviation (variables were noted as present or absent and all other variables were measured as mm)**:** presence of any deviation from the midline.

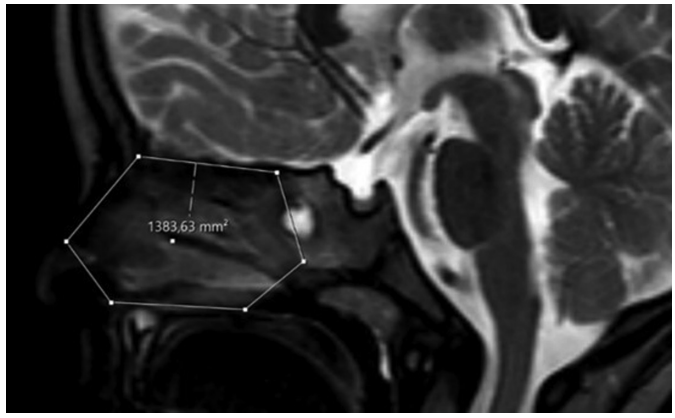

Figure 2. Nasal septum area (cartilage and bone septum area).

Paranasal sinus pneumatization (variables were noted as present or absent and all other variables were measured as mm)**:** hypointense and hyperintense paranasal sinus lumens were evaluated as pneumatization and non-pneumatization, respectively.

Statistical Analysis

We performed all statistical analyses using the Statistical Package for Social Science Statistics software, version 17.0 (SPSS Inc.; Chicago, IL, USA). All data were first evaluated for normal distribution using the Kolmogorov–Smirnov test, steepness and skewness coefficients, and histograms. The distribution of measurement variables in the study was observed to be normal. Descriptive statistics are given as mean and standard deviation, median, minimum-maximum. The data obtained were compared according to sex and age groups. The chi-square test, slope chi-square test, and Mann–Whitney *U*-test were used for analytical evaluation. The type I error level was set at .05.

Results

The data of 626 children aged 0-14 years were evaluated; 271 (43.3%) were female and 355 (56.7%) were male. Their average age was 54.39 ± 48.91 (median: 36.00; minimum: 0, maximum: 165) months. There was no statistical difference in age distribution by sex ($P > .05$). All parameters other than the septum deviation that we evaluated in the entire study group are summarized in Tables 1 and 2, and our septum deviation results are presented in Table 3. The mean, standard deviation, median, minimum, and maximum values of these values by sex for all ages are shown in supplementary tables. The difference in all parameters was more pronounced in the first years of life, and the first year was significantly different compared with all age groups (Supplementary Table 1-11).

DCL: The first and second years were significantly different from all age groups.

DBL: Growth was faster in the first 5 years (Supplementary Table 2), was in the horizontal course between the sixth and 13th years, and increased again in the 14th year.

NPL: Growth was faster in the first 6 years (Supplementary Table 1).

NPH: Growth was faster in the first 6 years (Supplementary Table 9).

Right nasal cavity width: The second year was significantly different from all age groups except the third year.

Left nasal cavity width: The second year was significantly different from all age groups except the third and fourth years (Supplementary Tables 5 and 6).

Right AP width: It was significantly different from all age groups except the second, third, and fourth years.

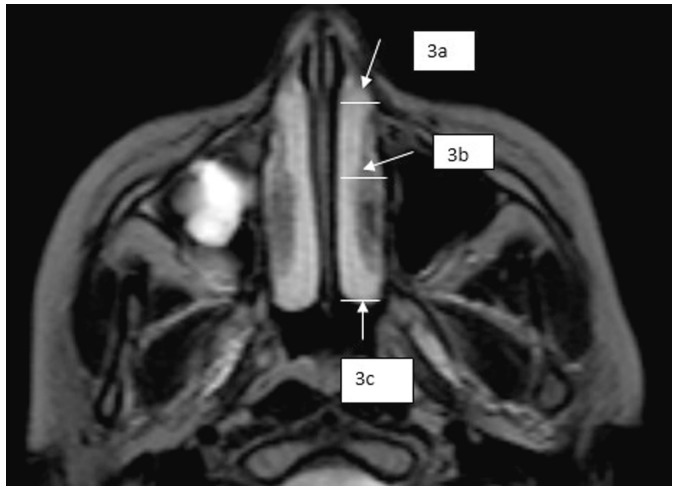

Figure 3. (3a) Width of left aperture priformis; (3b) right/left nasal cavity width; (3c) right/left koana width.

Table 1. Variables Evaluated in the Whole Study Group

	n	Mean	SS*	Median	Smallest Value (mm)	Largest Value (mm)
Dorsal cartilage length	(n=624**)	13.52	4.24	12.50	4.60	26.30
Dorsal bone length	(n=624**)	10.35	2.76	10.70	4.40	17.90
Nasal passage length	(n=626)	41.76	24.30	41.80	24.30	62.70
Nasal passage height	(n=626)	30.48	7.32	29.30	16.00	53.80
Width of right nasal cavity	(n=625**)	7.79	2.10	7.90	2.10	13.50
Width of left nasal cavity	(n=625**)	7.60	1.81	7.60	2.20	12.80
Right AP width	(n=626)	7.65	1.75	7.80	3.70	12.00
Left AP width	(n=626)	7.57	1.75	7.80	3.40	11.60
Width of right Choana	(n=621**)	7.71	1.94	8.00	1.70	13.30
Width of left Choana	(n=621**)	7.57	1.87	7.80	1.70	13.30
Nasal Septum area (mm^2)	(n=626)	1054.71	354.96	1068.50	384.00	2351.00

*SS, Standard deviation.
**Some measurements could not be made because the relevant measurement areas were not clearly visible in the image or completely entered the image area.
AP,apertura priformis.

Left AP width: The second-year age group was significantly different from all age groups except the third and fourth years. When supplementary Tables 7 and 8 are examined, the growth follows a steeper course in the first 5 years of age.

Right/left choana width: The second-year age group was significantly different from all age groups except the third and fourth years.

Left choana width: The second-year age group was significantly different from all age groups except the third and fourth years. (Supplementary Tables 10 and 11).

Nasal SA: The first year age group was significantly different from all age groups except the second and third years. According to all comparisons, there was rapid growth in the first 4 years of life, which then slowed down at age 5 years, and accelerated again at 8 and 9 years of age.

Our findings related to septum deviation are summarized in Table 3. There was no significant difference in the presence of septum deviation according to sex in general or at all ages ($P > .05$). The age of those with deviations was significantly higher ($P=.020$), and the presence of deviation increased with age ($P=.006$).

Ethmoid and maxillary sinuses are observed in all age groups from birth. The frontal sinus was not present in the first year; it was detected rudimentary in the first 5 years of age, began to become more evident from age 6 years, and was present fully in all children after age 11 years. It was observed that the sphenoid sinus was present in all age groups from the age of 7 years (Figure 4). There was no statistically significant difference between the sexes in terms of the presence of all sinuses ($P > .05$) (Table 4).

The aspects where differences were observed between the sexes were as follows: DCL ($P=.002$), right choana width ($P=.013$) in the first year group; NPL ($P=.01$), NPH ($P=.026$); NPH in the fourth year group ($P=.019$); DCL ($P=.044$), nasal SA ($P=.014$), NPH ($P=.23$); DCL in the seventh year group ($P=.021$), DBH in the eighth year group ($P=.008$), nasal SA ($P=.048$); NPL in the ninth year group ($P=.048$); right nasal cavity width in the 11th year group ($P=.033$); right AP width in the 13th year group ($P=.033$); NPL ($P=.038$) and nasal SA ($P=.019$) and left nasal cavity width ($P=.019$) were found to be significantly greater in males in the 14th year group.

Discussion

There are few morphometric studies on the nasal cavity and paranasal sinuses in healthy newborns and young children.[5,6,22,23] Radiography, CT, or MRI scans have been used in morphometric studies.[3-5] Akgüner et al evaluated data using radiographs, whereas Likus et al used CT scans. Here, we preferred to use MRI scans to evaluate our data. The main reasons to use MRI scans were as follows: no ionizing radiation, brain MRI had a wider range of indications than CT in this period, hypothesizing that the targeted cartilage septum area would be better evaluated with MRI at the beginning of the study and that the soft tissue-bone tissue separation provided by the presence of different sequences in MRI could be achieved.

It was observed that the 2 parameters (DCL and DBL) were significantly different in the first and second years compared with all other age groups. Growth was observed to be faster in the first 5 years of age in these parts. it followed a horizontal course between the ages of 6 and 13 and increased again at age 14 (Table 2). Similarly, Kim et al[4] stated that the DCL and DBL increased in the first 3 years, and then there was no significant change with age. We reported that the 2 parametres of the face reached adult values by the age of 14 years.

In the neonatal period, the width of the AP smaller than 8-10 mm on CT is considered diagnostic for AP stenosis.[24] When AP stenosis is considered, an MRI should be performed because of accompanying intracranial pathologies or endocrinal dysfunctions.[25] Therefore, normal reference values for AP dimensions in MRI will be a guide. On the other hand, AP is the beginning of the nasal passage, and its width may limit the approach in endonasal surgeries. London et al[20] suggested that endonasal skull base approaches would be insufficient to

Table 2. The Mean ± SD of the Parameters Obtained for Each Age

Variable (mm)	1 Age (n)	2 Age (n)	3 Age (n)	4 Age (n)	5 Age (n)	6 Age (n)	7 Age (n)	8 Age (n)	9 Age (n)	10 Age (n)	11 Age (n)	12 Age (n)	13 Age (n)	14 Age (n)
NPL	32.9 ± 3.0 (153)	37.3 ± 3.4 (102)	39.6 ± 3.4 (48)	43.0 ± 3.0 (47)	44.7 ± 3.0 (35)	46.2 ± 2.6 (23)	46.6 ± 2.5 (29)	47.3 ± 3.3 (32)	48.6 ± 2.9 (35)	49.4 ± 3.7 (26)	49.5 ± 2.5 (33)	50.5 ± 3.2 (23)	52.2 ± 4.0 (30)	54.8 ± 4.0 (10)
NPH	22.2 ± 2.4 (153)	25.6 ± 2.3 (102)	27.8 ± 2.1 (48)	29.6 ± 2.3 (47)	31.9 ± 2.4 (35)	33.7 ± 2.5 (23)	35.5 ± 2.0 (29)	36.6 ± 2.6 (32)	37.8 ± 3.3 (35)	38.7 ± 3.7 (26)	39.4 ± 2.2 (33)	39.7 ± 2.8 (23)	41.8 ± 2.1 (30)	45.9 ± 3.8 (10)
DBL	7.1 ± 1.6 (153)	8.9 ± 1.8 (102)	10.8 ± 2.0 (47)	12.8 ± 1.8 (47)	12.9 ± 2.5 (35)	11.4 ± 1.4 (23)	11.8 ± 1.1 (29)	11.8 ± 1.3 (32)	11.5 ± 1.4 (35)	11.7 ± 1.1 (26)	11.7 ± 1.2 (33)	12.6 ± 1.3 (23)	12.9 ± 1.3 (30)	14.9 ± 1.6 (10)
DCL	10.2 ± 1.7 (152)	11.0 ± 2.1 (102)	10.6 ± 2.6 (47)	9.8 ± 1.8 (47)	12.7 ± 3.2 (35)	16.6 ± 2.3 (23)	17.4 ± 1.9 (29)	17.1 ± 1.9 (29)	17.6 ± 1.7 (35	18.0 ± 2.5 (26)	18.4 ± 1. 7 (33)	18.3 ± 1.6 (23)	19.5 ± 2.0 (30)	21.4 ± 3.3 (10)
Right NCW	5.6 ± 1.1 (153)	6.9 ± 1.1 (102)	7.9 ± 1.2 (48)	8.3 ± 1.2 (47)	8.3 ± 1.3 (35)	8.8 ± 1.0 (23)	8.7 ± 1.0 (29)	9.5 ± 1.0 (32)	9.2 ± 1.1 (35)	9.4 ± 1.3 (25)	9.4 ± 1.3 (33)	9.3 ± 1.2 (23)	9.8 ± 1.5 (30)	10.1 ± 1.6 (10)
Left NCW	5.5 ± 1.0 (153)	7.0 ± 1.0 (102)	7.7 ± 1.1 (48)	7.7 ± 0.9 (47)	8.0 ± 0.9 (35)	8.2 ± 1.0 (23)	8.5 ± 1.1 (29)	8.8 ± 1.0 (32)	9.0 ± 1.0 (35)	8.7 ± 1.1 (25)	9.1 ± 1.4 (33)	9.5 ± 1.3 (23)	10.3 ± 1.2 (30)	10.0 ± 1.5 (10)
Right APW	5.7 ± 1.1 (153)	7.1 ± 1.4 (102)	7.7 ± 1.2 (48)	7.7 ± 1.1 (47)	8.3 ± 1.0 (35)	8.4 ± 0.9 (23)	9.0 ± 0.9 (29)	9.0 ± 0.9 (32)	8.9 ± 1.2 (35)	9.0 ± 0.9 (26)	8.9 ± 1.1 (33)	9.5 ± 1.2 (23)	9.2 ± 1.4 (30)	9.1 ± 1.5 (10)
Left APW	5.5 ± 1.0 (153)	6.9 ± 1.3 (102)	7.4 ± 1.3 (48)	7.7 ± 0.8 (47)	8.3 ± 1.0 (35)	8.5 ± 1.0 (23)	9.0 ± 1.0 (29)	8.9 ± 0.8 (32)	8.9 ± 0.9 (35)	9.0 ± 1.0 (26)	8.9 ± 1.0 (33)	9.4 ± 0.8 (23)	9.3 ± 1.3 (30)	9.2 ± 1.0 (10)
Right ChoW	5.3 ± 1.2 (148)	7.0 ± 1.1 (102)	7.9 ± 1.2 (48)	8.8 ± 1.1 (47)	8.6 ± 0.9 (35)	8.9 ± 0.8 (23)	8.9 ± 1.0 (29)	9.0 ± 1.0 (32)	9.0 ± 1.2 (35)	9.0 ± 1.2 (26)	9.3 ± 1.2 (33)	9.7 ± 1.0 (23)	9.7 ± 1.3 (30)	10.0 ± 1.7 (10)
Left ChoW	5.3 ± 1.1 (148)	7.0 ± 1.1 (102)	7.8 ± 1.2 (48)	7.9 ± 1.0 (47)	8.3 ± 0.6 (35)	8.5 ± 0.9 (23)	8.7 ± 1.1 (29)	8.8 ± 1.0 (32)	8.6 ± 0.9 (35)	8.4 ± 0.8 (26)	9.1 ± 1.2 (33)	9.6 ± 0.9 (23)	9.6 ± 1.2 (30)	10.1 ± 1.6 (10)
SA (mm^2)	624.2 ± 126.6 (153)	852.5 ± 149.3 (102)	1037.9 ± 147.1 (48)	1099.3 ± 131.5 (47)	1170.5 ± 127.4 (35)	1218.1 ± 162.1 (23)	1336.5 ± 217.3 (29)	1283.6 ± 155.0 (32)	1309.5 ± 173.9 (35)	1355.0 ± 145.9 (26)	1444.7 ± 135.6 (33)	1458.8 ± 160.0 (23)	1592.6 ± 208.2 (30)	1742 ± 254.5 (10)

APW, apertura priformis width, ChoW, choana width; DBL, dorsal bone length; DCL, dorsal cartilage length; NPL, nasal passage length; NPH, nasal passage height; NCW, nasal cavity width; SA, septum area.

Table 3. Presence of Septum Deviation According to Age and Gender

	Female		Male		Total	
Age (n) Female/Male	Right n (%)	Left n (%)	Right n (%)	Left n (%)	Right n (%)	Left n (%)
1 (68/85)	8 (11.8)	1 (1.5)	8 (9.4)	2 (2.4)	16 (10.5)	3 (2.0)
2 (47/55)	6 (12.8)	2 (4.3)	5 (9.1)	1 (1.8)	11 (10.8)	3 (2.9)
3 (21/27)	2 (9.5)	-	4(14.8)	1 (3.7)	6(12.5)	1(2.1)
4 (17/30)	1 (5.9)	2 (11.8)	3(10.0)	-	4(8.5)	2(4.3)
5 (14/21)	3 (21.4)	-	2 (9.5)	2 (9.5)	5(14.3)	2(5.7)
6 (11/12)	1 (9.1)	-	-	2 (16.7)	1(4.3)	2(8.7)
7 (11/18)	-	-	1(5.6)	2 (11.1)	1 (4.3)	2(6.9)
8 (12/20)	-	-	3(15.0)	-	3(9.4)	
9 (16/19)	2 (12.5)	-	3(15.8)	1(5.3)	5(14.3)	1 (2.9)
10 (9/17)	2 (22.2)	-	3(17.6)	3(17.6)	5(19.2)	3(11.5)
11 (15/18)	6 (40.0)	-	1(5.6)	2(11.1)	7(21.2)	2(6.1)
12 (13/10)	2 (15.4)	-	2 (20.0)	1(10.0)	4(17.4)	1(4.1)
13 (13/17)	2(15.4)	2 (15.4)	3(17.6)	1(5.9)	5(16.7)	3(10.0)
14(4/5)	-	1(25.0)	1(20.0)	-	1(11.1)	1(11.1)

provide space for instrumentation in cases where the right and left total AP were less than 15 mm, and alternative approaches to the skull base, such as open surgery, should be considered. Tatreau et al[21] reviewed that the width of the AP was narrowest under the age of 24 months, and there was no significant difference with adult dimensions after the age of 9-10 years. The average diameter of the AP is 15 mm at birth and reaches 18 mm at the age of 2 years and 20 mm at the age of 5 years. Likus et al[5] measured both passages separately on CT; between 7 and 12 months, the right and left PA were 7.04 ± 0.98 mm and 6.60 ± 0.82 mm, respectively; at 2 years of age, it was 7.43 ± 0.92 mm and 7.10 ± 1.06 mm; and at 3 years of age, it was 7.71 ± 0.93 mm and 7.65 ± 1.09 mm, respectively. These results are in close agreement with our results (summarized in Table 2). Based on those findings, we think that CT was not performed if the measurements with MRI scans were normal in the neonatal period.

In the neonatal period, the possibility of stenosis of different parts of the nasal passage should be considered in respiratory problems that cannot be explained by well-defined clinical conditions such as choanal atresia or AP stenosis. For diagnosis, it is recommended to pay attention to other parts of the nasal passage as well as the choana and AP.[22] Graham et al[22] measured the nasal airway in different planes using CT in patients with congenital nasal anomalies and tested the reliability of their results. The authors emphasized that narrowing in congenital nasal anomalies concerned specific regions and the middle and posterior nasal cavities. We think that the normal values of nasal passage dimensions that we found will be helpful in the evaluation of children with respiratory distress.

Another parameter we evaluated in our study was the nasal SA. Septum cartilage has been used safely for many years as an

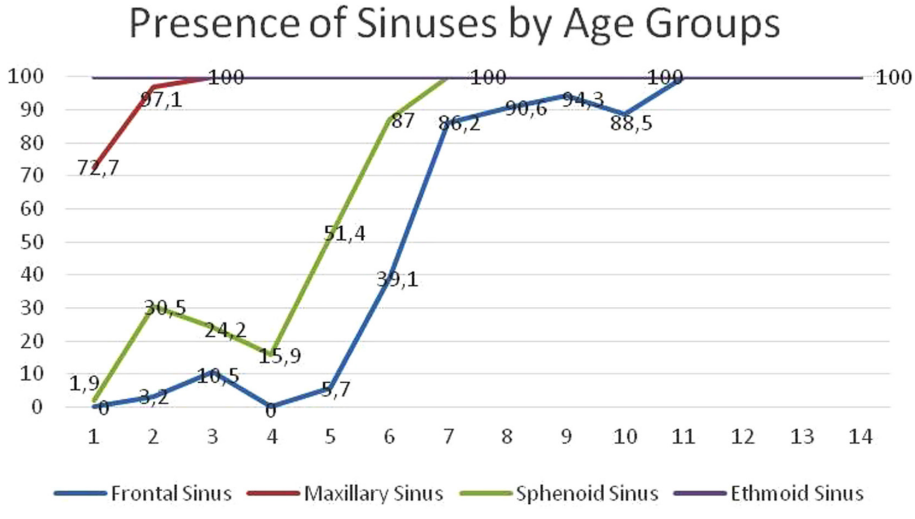

Figure 4. The presence of sinuses according to age groups is shown.

Table 4. The Radiological Detection Times of the Paranasal Sinuses and the Detection Rates of Air/Infection/Retention Cysts in the Sinus are Shown

	%					
	Existing (No Ventilation	Existing (No Ventilation)	Existing (There is Aeration and Sinusitis)	Existing (Left Side Aeration and Sinusitis)	Existing (Right Side Aeration and Sinusitis)	Existing (There is Aeration and Retention Cyst)
Frontal sinus	1.1	36.2	4.5	-	-	-
Maxillary sinus	9.8	70.8	10.4	0.3	0.2	1.3
Sphenoid sinus	7.5	40.8	6.9	-	-	0.8
Ethmoid sinus	1.7	86.5	11.4	0.4	-	-

autogenous graft material. Most publications in the literature that calculated graft area were performed on cadavers. The first study on this subject with CT scans was conducted by Kim et al. In that study, Kim et al[7] stated that despite the superiority of MRI in soft tissues, they used CT scans because of cost. They reported that the harvestable septal cartilage area in young adults was 549.84 ± 151.26 mm^2, and this area decreased due to ossification after puberty.[7] In our study, the nasal SA value for the firstt year of age was 624.2 ± 126.6 mm^2, and 1742 ± 254.5 mm^2 at the age of 14 years. According to our findings, the nasal SA grows rapidly in the first 4 years of life; this growth rate slows down in the fifth year and accelerates again in the eighth-ninth year. The number of pediatric endonasal surgeries, including skull base surgeries has increased in recent years.[26] The development of endoscopic device technologies and the detailed description of endoscopic surgical anatomy are important reasons for this increase.[20,21] Knowing the nasal cavity width, height, AP, and choana widths before undertaking endonasal endoscopic surgeries, especially in the newborn period, will facilitate the planning and implementation of the surgery. According to our study, the width of the nasal passage increases rapidly in the first 4 years of life, and the growth follows a horizontal course from the age of 5 years. The nasal passage height and length then increased rapidly until the age of 6 years (Table 2). In this case, endonasal interventions can be performed more easily by the age of 4, considering the width of the nasal passage and AP.

Many issues, such as when the septum deviation begins, its frequency, and its distribution by age, are still controversial. In the literature, the prevalence of nasal septum deviation in the general population has been reported between 0.93% and 55%.[8,9,27-30] Although sex was not accepted as a risk factor in previous studies, it was reported that increasing age was associated with nasal septum deviation due to the increased risk of possible trauma, which is also supported by our data.[8,13] In studies evaluating the neonatal period, nasal septum deviation rates showed differences. For example, Gray reported the septum deviation rate as 48%-60%, whereas Kawalski and Spiewak reported the septum deviation rate as 22.2% in newborns born by normal vaginal delivery and 3.9% in those born by cesarean section.[31,32] In our study, it was found that nasal septum deviation could be seen from the first year of life, was not associated with sex, the rate was lower (12.4%) in the first year, and increased gradually due to exposing traumas occurring in the early school-age period (Table 3).

In our study, ethmoid sinuses were detected in 100% of infants in the first year of life and maxillary sinuses in 72.7%. It has been observed that the maxillary sinuses become 100% ventilated from the age of 3 years. Therefore, the absence of maxillary sinus aeration under 2 years of age in MRI should not be interpreted as pathological. The sphenoid and frontal sinus are seen after 6 years of age (Table 4). Our findings confirm that the data known to date are similar in our patient group.[33] Sphenoid sinus aeration was found to be only 1.9% in the neonatal period. In all cases, the sphenoid sinus was identified at 7 years of age and the frontal sinus at 11 years of age. The increasing frequency of pediatric endoscopic skull base surgery has made frontal and sphenoid sinus pneumatization increasingly important to understand. The lack of pneumatization of the sinuses prevents approaches from this region, making it difficult to reach and protect important neurovascular structures such as the internal carotid artery and optic nerve.

In this study, we aimed to reveal the developmental process of the nasal and paranasal sinuses from the neonatal period to the age of 14 years, according to age and sex (Figure 4). Here, we aim to contribute to the diagnosis and treatment processes of congenital or acquired nasal pathologies in children. We observed the rapid growth period of the first 5-6 years, followed by a slower course until the 13th-14th years. In light of these findings, the nasal dorsum, which is located in the middle part of the face and contributes to the face shape, started to evolve from a childhood appearance to an adult by the age of 13-14 years.

The limitations of this study were the lack of determination of interobserver correlation. In addition, ossification centers could not be differentiated because brain MRI sections were evaluated in the images taken in most cases. For this reason, the dorsal cartilage length was used because ossification center measurements cannot be performed and it could be distinguished more easily in evaluating the septum cartilage dimensions. Another limitation was our cohort group distribution, in which the number of cases was not close to each other. In some cases, the fact that the brain MRI examination was in different oblique planes according to the head shape caused the evaluation of only axial or only sagittal plane images. In this case, it contributed to obtaining different amounts of data between the age groups.

Due to the more widespread use of paranasal interventional methods in the pediatric age group, the constantly changing anatomic measurement values caused by the rapid growth

process, and the expected morphologic differences between societies, knowing the cross-sectional data of the nose and paranasal region is important for surgical approaches and success. With new studies with larger cohort groups, the results of the few existing studies can be strengthened, and the differences can be better determined.

Ethics Committee Approval: This study was approved by Ethics committee of Aydın Adnan Menderes University (Approval No: 53043469-050.04.04 Protocol No: 2017/1060 Date: 23.01.2017).

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Supplementary Table 1. Descriptive Statistics of Nasal Passage Length (mm) by Age and Sex

Age	Sex	n	Mean	SS*	Median	Smallest value	Greatest value
1	Female	68	32.4	3.0	33.0	24.3	37.7
	Male	85	33.3	3.0	33.1	25.2	40.2
	Total	**153**	**32.9**	**3.0**	**33.1**	**24.3**	**40.2**
2	Female	47	36.4	3.4	36.0	31.6	48.6
	Male	55	38.4	3.2	38.0	27.3	42.8
	Total	**102**	**37.3**	**3.4**	**37.1**	**27.3**	**48.6**
3	Female	21	39.7	2.5	39.9	36.0	43.5
	Male	27	39.5	3.9	39.2	33.2	49.8
	Total	**48**	**39.6**	**3.4**	**39.7**	**33.2**	**49.8**
4	Female	17	42.4	3.4	42.7	35.5	48.6
	Male	30	43.3	2.7	42.8	37.4	51.7
	Total	**47**	**43.0**	**3.0**	**42.8**	**35.5**	**51.7**
5	Female	14	44.1	2.8	43.6	40.1	49.0
	Male	21	44.9	3.1	44.9	40.4	50.6
	Total	**35**	**44.7**	**3.0**	**44.7**	**40.1**	**50.6**
6	Female	11	45.8	2.0	45.3	43.8	50.8
	Male	12	46.6	3.1	46.5	42.4	52.7
	Total	**23**	**46.2**	**2.6**	**45.6**	**42.4**	**52.7**
7	Female	11	46.6	1.9	47.4	43.6	49.2
	Male	18	46.5	2.8	46.1	43.4	53.4
	Total	**29**	**46.6**	**2.5**	**46.2**	**43.4**	**53.4**
8	Female	12	46.9	3.5	45.7	41.4	54.4
	Male	20	47.7	3.1	47.7	41.3	52.8
	Total	**32**	**47.3**	**3.3**	**47.2**	**42.3**	**54.4**
9	Female	16	47.8	2.8	47.4	43.9	55.7
	Male	19	49.3	2.8	49.2	42.9	55.0
	Total	**35**	**48.6**	**2.9**	**48.3**	**42.9**	**55.7**
10	Female	9	48.6	3.1	48.4	44.3	52.6
	Male	17	49.7	3.9	49.8	44.0	57.1
	Total	**26**	**49.4**	**3.7**	**49.1**	**44.0**	**57.1**
11	Female	15	49.2	2.7	49.4	44.5	54.1
	Male	18	49.7	2.3	48.9	46.7	54.9
	Total	**33**	**49.5**	**2.5**	**49.3**	**44.5**	**54.9**
12	Female	13	49.3	3.2	50.0	43.9	53.2
	Male	10	51.9	4.2	51.6	47.0	60.0
	Total	23	50.5	3.9	50.6	43.9	60.0
13	Female	13	52.5	3.2	53.7	47.8	56.3
	Male	17	51.9	4.6	51.5	43.2	59.3
	Total	**30**	**52.2**	**4.0**	**51.9**	**43.2**	**59.3**
14	Female	4	*	*	52.7	47.3	54.8
	Male	6	56.8	3.1	56.0	53.4	62.7
	Total	10	54.8	4.0	55.0	47.3	62.7
All age groups		626	41.7	24.3	41.8	24.30	62.7

*n is not calculated because it is too small

Supplementary Table 2. Descriptive Statistics of Septum Size Bone (mm) by Age and Sex

Age	Sex	n	Mean	SS*	Median	Smallest value	Greatest value
1	Female	68	7.1	1.5	7.0	4.6	12.6
	Male	84	7.1	1.6	6.7	4.7	13.3
	Total	152	7.1	1.6	6.9	4.6	13.3
2	Female	47	8.9	1.8	8.7	4.7	12.9
	Male	55	8.9	1.7	8.6	4.4	14.5
	Total	102	8.9	1.8	8.7	4.4	14.5
3	Female	21	10.6	1.9	10.1	8.3	15.0
	Male	26	108	2.1	10.5	7.4	15.8
	Total	47	10.8	2.0	10.4	7.4	15.8
4	Female	17	12.1	1.6	12.4	9.2	14.2
	Male	30	13.1	1.9	13.1	8.6	17.3
	Total	47	12.8	1.8	12.7	8.6	17.3
5	Female	14	12.5	2.7	11.9	8.2	17.9
	Male	21	13.1	2.4	12.6	9.8	17.1
	Total	35	12.9	2.5	12.1	8.2	17.9
6	Female	11	11.0	1.1	10.9	9.4	12.7
	Male	12	11.8	1.5	11.9	8.4	14.2
	Total	23	11.4	1.4	11.5	8.4	14.2
7	Female	11	18.1	1.4	18.1	10.8	13.1
	Male	18	11.8	1.3	11.5	10.1	15.0
	Total	29	11.8	1.1	11.7	10.1	15.0
8	Female	12	10.9	1.4	10.6	9.0	13.5
	Male	20	12.3	0.9	12.4	10.3	13.9
	Total	32	11.8	1.3	12.2	9.0	13.9
9	Female	16	11.5	1.2	11.7	9.3	13.9
	Male	19	11.4	1.4	11.4	9.2	14.6
	Total	35	11.5	1.4	11.5	9.2	14.6
10	Female	9	11.5	0.8	11.8	10.3	13.2
	Male	17	11.7	1.2	12.0	9.0	13.7
	Total	26	11.7	1.1	11.9	9.0	13.7
11	Female	15	11.4	1.1	11.2	10.0	14.1
	Male	18	12.0	1.1	11.9	10.6	15.6
	Total	33	11. 7	1.2	11.7	10.0	15.6
12	Female	13	12.3	1.4	12.1	10.1	15.1
	Male	10	13.0	1.0	12.8	11.4	14.9
	Total	23	12.6	1.3	12.6	10.0	15.1
13	Female	13	12.6	1.3	12.4	9.7	14.4
	Male	17	13.1	1.3	13.0	10.9	15.8
	Total	30	12.9	1.3	12.8	9.7	15.8
14	Female	4	14.6	1.6	15.0	12.4	16.1
	Male	6	56.8	3.1	56.0	53.4	62.7
	Total	10	14.9	1.6	14.8	12.4	17.5
All age groups		624	10.3	2.7	10.7	4.4	17.9

Supplementary Table 3. Descriptive Statistics of Septum Size Cartilage (mm) by Age and Sex

Age	Sex	n	Mean	SS*	Median	Smallest value	Greatest value
1	Female	68	9.8	1.7	9.6	4.6	15.0
	Male	84	10.6	1.6	10.5	7.1	15.4
	Total	152	10.2	1.7	10.1	4.6	15.4
2	Female	47	11.0	2.1	10.7	5.7	16.1
	Male	55	11.0	2.2	11.0	6.0	15.6
	Total	102	11.0	2.1	10.9	5.7	16.1
3	Female	21	10.2	2.6	10.1	6.4	16.6
	Male	26	10.9	2.6	10.2	6.9	15.1
	Total	47	10.6	2.6	10.2	6.4	15.6
4	Female	17	9.6	2.3	8.9	7.0	15.0
	Male	30	9.9	1.4	9.8	7.9	13.9
	Total	47	9.8	1.8	9.8	7.0	15.0
5	Female	14	12.9	3.0	12.3	7.9	17.1
	Male	21	12.5	3.4	11.5	8.2	20.6
	Total	35	12.7	3.2	12.2	7.9	20.6
6	Female	11	15.6	2.4	15.8	11.9	20.5
	Male	12	17.5	1.8	17.1	15.0	20.8
	Total	23	16.6	2.3	16.5	11.9	20.8
7	Female	11	18.1	1.4	18.1	15.8	21.0
	Male	18	16.9	2.1	16.6	137	22.8
	Total	29	17.4	1.9	17.2	13.7	22.8
8	Female	12	16.8	1.4	17.0	13.6	19.2
	Male	20	17.3	1.8	17.0	15.1	22.9
	Total	32	17.1	1.7	17.0	13.6	22.9
9	Female	16	17.6	1.4	17.5	14.9	20.1
	Male	19	17.5	1.8	18.0	12.3	20.3
	Total	35	17.6	1.7	17.9	12.3	20.3
10	Female	9	17.8	2.8	16.8	14.9	23.0
	Male	17	18.1	2.4	18.5	13.4	23.0
	Total	26	18.0	2.5	18.4	13.4	23.0
11	Female	15	18.2	1.8	18.6	16.1	22.4
	Male	18	18.1	1.5	18.4	15.5	20.0
	Total	33	18.4	1.7	18.4	15.5	22.4
12	Female	13	18.8	1.2	18.5	17.3	21.9
	Male	10	17.7	1.7	18.1	14.8	20.0
	Total	23	18.3	1.6	18.4	14.8	21.9
13	Female	13	19.8	2.2	20.2	16.1	25.1
	Male	17	19.1	1.8	19.3	16.2	21.8
	Total	30	19.5	2.0	19.7	16.1	25.1
14	Female	4	20.9	3.0	20.5	17.5	25.0
	Male	6	21.8	3.6	21.1	16.7	26.3
	Total	10	21.4	3.3	21.0	16.7	26.3
All age groups		624	13.5	4.2	12.5	4.6	26.3

Supplementary Table 4. Descriptive Statistics of Septum Area (mm) by Age and Sex

Age	Sex	n	Mean	SS*	Median	Smallest value	Greatest value
1	Female	68	608.0	127.2	585.0	385.0	975.0
	Male	85	636.3	125.4	625.0	384.0	999.0
	Total	153	624.2	126.6	604.0	384.0	999.0
2	Female	47	844.8	155.2	807.0	618.0	1393.0
	Male	55	859.0	145.2	835.0	509.0	1196.0
	Total	102	852.5	149.3	829.0	509.0	1393.0
3	Female	21	1014.1	121.2	1012.0	756.0	1214.0
	Male	27	1056.4	164.2	1032.0	798.0	1347.0
	Total	48	1037.9	147.1	1020.0	756.0	1347.0
4	Female	17	1065.4	127.9	1036.0	885.0	1277.0
	Male	30	1118.0	131.6	1118.0	859.0	1381.0
	Total	47	199.3	131.5	1104.0	859.0	1381.0
5	Female	14	1152.0	123.1	1194.0	927.0	1319.0
	Male	21	1182.7	131.6	1165.0	993.0	1468.0
	Total	35	1170.5	127.4	1167.0	927.0	1468.0
6	Female	11	1127.4	154.7	1121.0	830.0	1405.0
	Male	12	1301.1	122.5	1236.0	1184.0	1519.0
	Total	23	1218.1	162.1	1214.0	830.0	1519.0
7	Female	11	1359.4	194.6	1319.0	1155.0	1672.0
	Male	18	1322.4	234.4	1251.0	1059.0	2104.0
	Total	29	1336.5	217.3	1268.0	1059.0	2104.0
8	Female	12	1215.5	106.9	1204.5	1011.0	1356.0
	Male	20	1324.3	167.1	1367.5	1024.0	1558.0
	Total	32	1283.6	155.0	1303.5	1011.0	1558.0
9	Female	16	1278.8	163.3	1273.0	931.0	1542.0
	Male	19	1335.4	182.5	1324.0	1026.0	1723.0
	Total	35	1309.5	173.9	1317.0	931.0	1723.0
10	Female	9	1312.3	120.3	1334.0	1138.0	1477.0
	Male	17	1377.7	156.3	1383.0	1100.0	1687.0
	Total	26	1355.0	145.9	1378.0	1100.0	1687.0
11	Female	15	1422.5	121.1	1430.0	1212.0	1603.0
	Male	18	1463.2	147.4	1429.0	1244.0	1757.0
	Total	33	1444.7	135.6	1430.0	1212.0	1757.0
12	Female	13	1443.4	145.3	1439.0	1207.0	1697.0
	Male	10	1478.7	183.5	1465.5	1136.0	1796.0
	Total	23	1458.8	160.0	1450.0	1136.0	1796.0
13	Female	13	1616.9	196.9	1580.0	1309.0	1912.0
	Male	17	1574.0	220.6	1580.0	1162.0	2013.0
	Total	30	1592.6	208.2	1580.0	1162.0	2013.0
14	Female	4	1572.2	107.3	1568.0	1479.0	1674.0
	Male	6	1855.3	266.8	1741.0	1659.0	2351.0
	Total	10	1742	254.5	1676.5	1479.0	2351.0
All age groups		626	1054.7	354.9	1068.5	384.0	2351.0

Supplementary Table 5. Descriptive Statistics of Right Nasal Cavity Width (mm) by Age and Sex

Age	Sex	n	Mean	SS*	Median	Smallest value	Greatest value
1	Female	68	5.4	1.1	5.4	2.1	7.8
	Male	85	5.7	1.0	5.7	3.1	8.2
	Total	153	5.6	1.1	5.5	2.1	8.2
2	Female	47	6.9	1.2	6.9	3.4	9.4
	Male	55	7.0	1.0	6.6	5.4	9.5
	Total	102	6.9	1.1	6.8	3.4	9.5
3	Female	21	7.8	1.1	8.0	5.9	9.9
	Male	27	7.9	1.4	8.1	3.1	11.0
	Total	48	7.9	1.2	8.0	3.1	11.0
4	Female	17	8.3	1.2	8.2	6.6	11.0
	Male	30	8.2	1.2	8.2	6.2	11.4
	Total	47	8.3	1.2	8.2	6.2	11.4
5	Female	11	7.9	1.1	8.2	6.0	9.8
	Male	21	8.5	1.3	8.4	6.6	12.1
	Total	35	8.3	1.3	8.3	6.0	12.1
6	Female	11	8.7	1.1	8.5	7.6	11.3
	Male	12	8.9	0.9	9.1	6.7	10.3
	Total	23	8.8	1.0	8.8	6.7	11.3
7	Female	11	8.5	0.8	8.6	7.2	10.1
	Male	18	8.8	1.1	8.8	6.5	10.6
	Total	29	8.7	1.0	8.6	6.5	10.6
8	Female	12	9.1	0.7	9.3	7.7	10.6
	Male	20	9.7	1.0	9.8	7.3	11.3
	Total	32	9.5	1.0	9.5	7.3	11.3
9	Female	16	9.3	1.1	9.4	7.2	11.0
	Male	19	9.1	1.0	9.2	7.1	11.7
	Total	35	9.2	1.1	9.3	7.1	11.7
10	Female	8	9.5	1.0	9.2	8.3	11.4
	Male	17	9.4	1.4	9.3	7.3	13.5
	Total	25	9.4	1.3	9.3	7.3	13.5
11	Female	15	8.9	1.4	8.6	6.8	12.1
	Male	18	9.8	1.1	9.8	8.1	11.9
	Total	33	9.4	1.3	9.4	6.8	12.1
12	Female	13	9.4	1.1	9.3	8.0	11.8
	Male	10	9.3	1.2	8.9	8.0	11.3
	Total	23	9.3	1.2	9.0	8.0	11.8
13	Female	13	9.9	1.8	10.2	5.7	12.2
	Male	17	9.7	1.2	9.4	8.1	12.1
	Total	30	9.8	1.5	10.0	5.7	12.2
14	Female	4	9.7	0.7	9.7	8.8	10.5
	Male	6	10.3	2.0	11.1	7.7	12.3
	Total	10	10.1	1.6	10.3	7.7	12.3
All age groups		625	7.7	2.1	7.9	2.1	13.5

Supplementary Table 6. Descriptive Statistics for Left Nasal Cavity Width (mm) by Age and Sex

Age	Sex	n	Mean	SS*	Median	Smallest value	Greatest value
1	Female	68	5.4	1.0	5.5	2.2	7.1
	Male	85	5.6	1.0	5.6	3.2	7.9
	Total	153	5.5	1.0	5.5	2.2	7.9
2	Female	47	6.9	1.2	6.9	4.0	11.6
	Male	55	6.9	0.8	6.8	5.4	9.2
	Total	102	7.0	1.0	6.8	4.0	11.60
3	Female	21	7.6	0.8	7.6	6.2	9.6
	Male	27	7.8	1.3	8.0	3.1	11.0
	Total	48	7.7	1.1	7.9	3.1	11.0
4	Female	17	7.5	0.9	7.4	0.9	6.1
	Male	30	7.7	0.8	7.7	5.9	10.2
	Total	47	7.7	0.9	7.6	5.9	10.2
5	Female	14	7.7	0.8	7.7	6.2	9.3
	Male	21	8.2	0.8	8.4	6.9	10.2
	Total	35	8.0	0.9	8.0	6.2	10.2
6	Female	11	8.0	0.9	8.4	6.4	9.0
	Male	12	8.3	1.1	8.5	6.3	10.0
	Total	23	8.2	1.0	8.5	6.3	10.0
7	Female	11	8.6	1.0	8.5	7.4	10.3
	Male	18	8.4	1.2	8.3	6.8	10.8
	Total	29	8.5	1.1	8.5	6.8	10.8
8	Female	12	8.4	0.9	8.6	7.0	10.1
	Male	20	9.0	1.4	8.8	7.0	12.5
	Total	32	8.8	1.3	8.7	7.0	12.5
9	Female	16	9.3	1.0	9.3	7.8	11.2
	Male	19	8.7	0.8	8.8	7.4	10.5
	Total	35	9.0	1.0	8.9	7.40	11.2
10	Female	8	8.5	0.9	8.1	7.5	9.8
	Male	17	8.7	1.2	9.1	6.4	10.6
	Total	25	8.7	1.1	8.7	6.4	10.6
11	Female	15	9.2	1.4	9.1	6.1	11.1
	Male	18	8.9	1.4	8.8	6.1	11.7
	Total	33	9.1	1.4	9.0	6.1	11.7
12	Female	13	9.8	1.3	9.9	7.1	12.1
	Male	10	9.0	1.1	9.2	7.0	10.9
	Total	23	9.5	1.3	9.7	7.0	12.1
13	Female	13	10.3	1.1	10.5	7.8	11.8
	Male	17	10.2	1.2	10.6	8.3	12.0
	Total	30	10.3	1.2	10.5	7.8	12.0
14	Female	4	8.7	0.8	8.8	7.7	9.7
	Male	6	10.8	1.1	10.4	9.5	12.8
	Total	10	10.0	1.5	10.0	7.7	12.8
All age groups		625	7.6	1.8	7.6	2.2	12.8

Supplementary Table 7. Descriptive Statistics of Right Aperture Priformis Length (mm) by Age and Sex

Age	Sex	n	Mean	SS*	Median	Smallest value	Greatest value
1	Female	68	5.5	1.0	5.4	3.8	8.3
	Male	85	5.7	1.1	5.5	3.7	8.9
	Total	153	5.7	1.1	5.5	3.7	8.9
2	Female	47	7.2	1.2	7.1	5.0	10.6
	Male	55	6.9	1.5	6.9	4.7	11.5
	Total	102	7.1	1.4	6.9	4.7	11.5
3	Female	21	7.6	1.1	7.4	5.7	10.3
	Male	27	7.6	1.2	7.6	5.4	10.4
	Total	48	7.7	1.2	7.5	5.4	10.4
4	Female	17	7.5	0.9	7.7	6.0	9.2
	Male	30	7.8	1.1	7.8	4.6	10.6
	Total	47	7.7	1.1	7.8	4.6	10.6
5	Female	14	8.0	1.0	8.3	6.2	9.5
	Male	21	8.5	0.9	8.4	7.3	10.8
	Total	35	8.3	1.0	8.4	6.2	10.8
6	Female	11	8.5	1.1	8.7	6.7	10.0
	Male	12	8.3	0.7	8.1	7.3	9.7
	Total	23	8.4	0.9	8.3	6.7	10.0
7	Female	11	9.1	1.2	9.7	6.6	10.3
	Male	18	8.8	0.7	9.0	0.7	10.1
	Total	29	9.0	0.9	9.2	6.6	10.3
8	Female	12	8.6	0.9	8.5	7.5	10.5
	Male	20	9.1	0.8	9.3	5.5	10.8
	Total	32	9.0	0.9	9.0	7.5	10.8
9	Female	16	9.2	1.1	9.2	7.3	11.6
	Male	19	8.7	1.2	8.6	7.0	11.0
	Total	35	8.9	1.2	9.1	7.0	11.6
10	Female	9	8.9	1.0	9.2	7.4	10.4
	Male	17	8.9	0.8	9.0	7.3	10.6
	Total	26	9.0	0.9	9.0	7.3	10.6
11	Female	15	9.0	1.0	8.8	7.8	10.9
	Male	18	8.7	1.1	8.6	6.8	11.3
	Total	33	8.9	1.1	8.6	6.8	11.3
12	Female	13	9.3	1.2	9.6	6.8	11.0
	Male	10	9.7	1.3	9.5	7.6	12.0
	Total	23	9.5	1.2	9.6	6.8	12.0
13	Female	13	8.7	1.0	8.6	6.9	10.4
	Male	10	9.7	1.3	9.5	7.6	12.0
	Total	30	9.2	1.4	9.4	6.2	11.8
14	Female	4	9.1	0.7	8.9	8.6	10.2
	Male	6	9.0	1.9	10.1	6.0	10.5
	Total	10	9.1	1.5	9.5	6.0	10.5
All age groups		626	7.6	1.7	7.8	3.7	12.0

Supplementary Table 8. Descriptive Statistics of Left Aperture Priformis Length (mm) by Age and Sex

Age	Sex	n	Mean	SS*	Median	Smallest value	Greatest value
1	Female	68	5.4	0.9	5.3	3.4	8.3
	Male	85	5.6	1.1	5.5	3.5	9.4
	Total	153	5.5	1.0	5.4	3.4	9.4
2	Female	47	7.1	1.2	7.2	5.0	10.3
	Male	55	6.8	1.4	6.3	4.9	10.7
	Total	102	6.9	1.3	6.7	4.9	10.7
3	Female	21	7.4	1.2	7.2	5.3	10.3
	Male	27	7.4	1.3	7.4	5.2	10.4
	Total	48	7.4	1.3	7.3	5.2	10.4
4	Female	17	7.6	0.7	7.6	6.2	9.0
	Male	30	7.6	0.9	7.6	5.7	9.1
	Total	47	7.7	0.8	7.6	5.7	9.1
5	Female	14	8.1	0.8	7.8	6.8	10.1
	Male	21	8.3	0.8	8.1	6.5	10.1
	Total	35	8.2	0.9	8.0	6.5	10.1
6	Female	11	8.5	1.0	8.3	6.4	10.0
	Male	12	8.4	0.9	8.3	7.5	10.6
	Total	23	8.5	1.0	8.3	6.4	10.6
7	Female	11	8.7	1.2	9.3	6.3	10.3
	Male	18	9.2	0.8	9.3	7.6	11.5
	Total	29	9.0	1.0	9.3	6.3	11.5
8	Female	12	8.8	1.0	8.8	7.3	10.6
	Male	20	8.9	0.6	9.0	7.8	9.7
	Total	32	8.9	0.8	8.9	7.3	10.6
9	Female	16	8.8	0.8	8.7	7.3	10.3
	Male	19	8.8	0.8	9.0	7.1	10.0
	Total	35	8.9	0.9	8.8	7.1	10.3
10	Female	9	9.1	0.8	9.3	7.7	10.2
	Male	17	8.9	1.1	9.0	6.6	10.8
	Total	26	9.0	1.0	9.2	6.6	10.8
11	Female	15	9.0	1.0	9.0	7.0	10.9
	Male	18	8.7	0.8	8.8	6.4	10.6
	Total	33	8.9	1.0	9.0	6.4	10.9
12	Female	13	9.3	0.8	9.4	8.2	11.1
	Male	10	9.5	0.9	9.4	8.2	11.0
	Total	23	9.4	0.8	9.4	8.2	11.1
13	Female	13	9.0	1.0	8.6	7.3	11.6
	Male	17	9.4	1.3	9.2	6.8	11.4
	Total	30	9.3	1.3	9.1	6.8	11.6
14	Female	4	9.3	1.3	9.7	7.5	10.5
	Male	6	9.1	0.9	9.2	7.9	10.1
	Total	10	9.2	1.0	9.6	7.5	10.5
All age groups		626	7.5	1.7	7.8	3.40	11.6

Supplementary Table 9. Descriptive Statistics of Nasal Passage Height (mm) by Age and Sex

Age	Sex	n	Mean	SS*	Median	Smallest value	Greatest value
1	Female	68	21.8	2.3	22.1	16.0	26.7
	Male	85	22.5	2.4	22.0	17.7	29.0
	Total	153	22.2	2.4	22.1	16.0	29.0
2	Female	47	25.1	2.2	24.9	20.6	32.2
	Male	55	26.0	2.3	26.3	19.8	29.8
	Total	102	25.6	2.3	25.5	19.8	32.2
3	Female	21	27.3	1.4	26.8	25.3	29.5
	Male	27	28.1	2.5	27.9	23.1	34.1
	Total	48	27.8	2.1	27.7	23.1	34.1
4	Female	17	28.6	1.7	28.5	25.7	31.6
	Male	30	30.1	2.4	30.2	24.9	34.5
	Total	47	29.6	2.3	30.0	24.9	34.5
5	Female	14	31.4	3.0	32.0	23.9	35.2
	Male	21	32.1	1.9	31.8	29.3	36.8
	Total	35	31.9	2.4	31.8	23.9	36.8
6	Female	11	32.5	2.0	32.5	28.8	35.9
	Male	12	34.7	2.4	34.8	29.7	40.0
	Total	23	33.7	2.5	34.1	28.8	40.0
7	Female	11	35.2	2.1	35.7	31.8	38.9
	Male	18	35.5	1.8	36.0	30.7	38.8
	Total	29	35.5	2.0	35.9	30.7	38.9
8	Female	12	36.1	1.6	36.0	33.9	39.2
	Male	20	36.7	3.0	36.3	30.5	41.1
	Total	32	36.6	2.6	36.1	30.5	41.1
9	Female	16	37.6	2.6	37.7	34.2	41.8
	Male	19	37.8	2.8	38.8	32.0	42.0
	Total	35	37.8	2.7	38.3	32.0	42.0
10	Female	9	37.8	2.3	39.3	34.0	40.4
	Male	17	39.1	3.4	38.9	33.3	46.3
	Total	26	38.7	3.2	38.9	33.3	46.3
11	Female	15	39.5	2.5	39.2	32.8	43.8
	Male	18	39.3	1.9	39.6	36.0	42.4
	Total	33	39.4	2.2	39.5	32.8	43.8
12	Female	13	40.1	3.0	41.5	35.1	44.0
	Male	10	39.1	2.6	39.3	35.7	42.8
	Total	23	39.7	2.8	40.3	35.1	44.0
13	Female	13	41.6	2.2	41.3	38.8	46.5
	Male	17	41.8	2.1	41.3	38.2	45.7
	Total	30	41.8	2.1	41.3	38.2	46.5
14	Female	4	43.3	2.4	42.9	41.3	46.1
	Male	6	47.5	3.7	47.1	43.6	53.8
	Total	10	45.9	3.8	45.0	41.3	53.8
All age groups		626	30.4	7.3	29.3	16.0	53.8

Supplementary Table 10. Descriptive Statistics for Right Choana Distance (mm) by Age and Sex

Age	Sex	n	Mean	SS*	Median	Smallest value	Greatest value
1	Female	67	5.0	1.2	5.0	2.6	9.6
	Male	81	5.4	1.1	5.4	1.7	8.2
	Total	148	5.3	1.2	5.2	1.7	9.6
2	Female	47	6.9	1.1	7.1	4.6	9.9
	Male	55	7.1	1.0	7.0	4.6	9.2
	Total	102	7.0	1.1	7.0	4.6	9.9
3	Female	21	7.8	0.8	7.9	5.9	9.6
	Male	27	7.9	1.4	8.2	2.5	11.0
	Total	48	7.9	1.2	7.9	2.5	11.0
4	Female	17	8.0	1.2	7.9	6.0	10.6
	Male	30	8.0	1.0	8.1	5.3	9.9
	Total	47	8.0	1.1	8.0	5.3	10.6
5	Female	14	8.3	0.8	8.6	7.0	9.2
	Male	21	8.7	1.0	8.7	6.8	11.3
	Total	35	8.6	0.9	8.6	6.8	11.3
6	Female	11	9.0	0.8	9.2	7.3	10.1
	Male	12	8.8	0.8	8.6	7.8	10.3
	Total	23	8.9	0.8	8.8	7.3	10.3
7	Female	11	8.8	0.6	8.8	7.8	10.1
	Male	18	8.8	1.2	8.6	7	12.1
	Total	29	8.9	1.0	8.8	7.0	12.1
8	Female	12	8.9	0.6	8.9	8.3	10.5
	Male	20	9.0	1.1	9.3	7	10.9
	Total	32	9.0	1.0	9.1	7.0	10.9
9	Female	16	8.9	1.3	8.6	7.4	11.7
	Male	19	9.1	1.0	9.0	7.1	11.2
	Total	35	9.0	1.2	9.0	7.1	11.7
10	Female	9	8.8	0.6	8.8	7.6	9.9
	Male	17	9.0	1.4	9.0	6.9	13.1
	Total	26	9.0	1.2	8.9	6.9	13.1
11	Female	15	8.9	1.0	9.0	6.7	10.6
	Male	18	9.6	1.2	9.6	6.8	11.6
	Total	33	9.3	1.2	9.2	6.7	11.6
12	Female	13	9.8	1.0	9.9	8.0	11.8
	Male	10	9.6	0.9	9.4	8.3	11.5
	Total	23	9.7	1.0	9.7	8.0	11.8
13	Female	13	9.4	1.5	9.0	7.1	7.9
	Male	17	9.9	1.0	10.3	8.4	12.0
	Total	30	9.7	1.3	9.7	7.1	12.3
14	Female	4	9.6	0.5	9.7	9.0	10.3
	Male	6	10.3	2.1	10.7	7.8	13.3
	Total	10	10.0	1.7	10.1	7.8	13.3
All age groups		621	7.7	1.9	8.0	1.70	13.3

Supplementary Table 11. Descriptive Statistics for Left Choana Distance (mm) by Age and Sex

Age	Sex	n	Mean	SS*	Median	Smallest value	Greatest value
1	Female	67	5.1	1.0	5.2	2.6	8.8
	Male	81	5.3	1.1	5.2	1.7	7.9
	Total	148	5.3	1.1	5.2	1.7	8.8
2	Female	47	6.9	1.2	6.8	4.3	10.9
	Male	55	7.0	1.0	7.2	4.3	9.2
	Total	102	7.0	1.1	7.0	4.3	10.9
3	Female	21	7.7	0.9	7.6	5.3	9.6
	Male	27	7.8	1.4	7.6	3.4	10.7
	Total	48	7.8	1.2	7.6	3.4	10.7
4	Female	17	8.1	1.0	7.7	6.8	10.7
	Male	30	7.7	1.0	7.6	5.3	10.0
	Total	47	7.9	1.0	7.6	5.3	10.7
5	Female	14	8.0	0.4	7.9	7.5	8.9
	Male	21	8.4	0.7	8.4	7.1	9.4
	Total	35	8.3	0.6	8.2	7.1	9.4
6	Female	11	8.4	0.8	8.3	7.7	10.2
	Male	12	8.4	1.0	8.2	7.1	11.4
	Total	23	8.5	0.9	8.2	7.1	11.4
7	Female	11	8.8	0.9	8.6	7.8	11.0
	Male	18	8.5	1.2	8.4	6.3	11.4
	Total	29	8.7	1.1	8.6	6.3	11.4
8	Female	12	8.6	0.5	8.7	7.8	9.6
	Male	20	8.9	1.1	9.1	7.0	11.2
	Total	32	8.8	1.0	8.8	7.0	11.2
9	Female	16	8.7	0.9	8.4	7.4	11.2
	Male	19	8.4	0.8	8.3	7.0	17.0
	Total	35	8.6	0.9	8.3	7.0	11.2
10	Female	9	8.3	0.8	8.2	7.1	10.0
	Male	17	8.4	0.8	8.4	7.0	9.7
	Total	26	8.4	0.8	8.3	7.0	10.0
11	Female	15	9.0	1.2	9.2	6.6	11.1
	Male	18	9.2	1.1	9.0	7.2	11.4
	Total	33	9.1	1.2	9.0	6.6	11.4
12	Female	13	9.8	1.0	9.7	7.8	11.4
	Male	10	9.4	0.7	9.1	8.3	10.4
	Total	23	9.6	0.9	9.7	7.8	11.4
13	Female	13	9.1	1.0	9.0	7.9	11.3
	Male	17	9.9	1.1	9.9	8.0	12.2
	Total	30	9.6	1.2	9.6	7.9	12.20
14	Female	4	9.3	1.1	9.8	7.7	10.1
	Male	6	10.7	1.7	10.4	9.0	13.3
	Total	10	10.1	1.6	9.9	7.7	13.3
All age groups		621	7.57	1.87	7.80	1.70	13.30