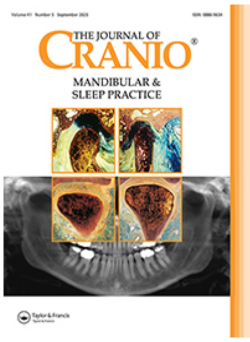

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ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/ycra20

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To cite this article: Sanaz Sadry, Ufuk Ok & Didem Öner Özdaş (2021): Is there a relationship of nasal septum deviation with pharyngeal airway dimension and craniocervical posture?, CRANIO®, DOI: 10.1080/08869634.2021.1995223

To link to this article: https://doi.org/10.1080/08869634.2021.1995223

Published online: 30 Oct 2021.

CRANIO®: THE JOURNAL OF CRANIOMANDIBULAR & SLEEP PRACTICE
https://doi.org/10.1080/08869634.2021.1995223

ORTHODONTICS

Is there a relationship of nasal septum deviation with pharyngeal airway dimension and craniocervical posture?

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ABSTRACT

Objective: This study aimed to evaluate the effects of nasal septum deviation on the pharyngeal airway and craniocervical posture measurements using cone beam computed tomography (CBCT).
Methods: This retrospective study analyzed the CBCTs of 25 patients with and without nasal septum deviation. Various parameters defining the pharyngeal airway and craniocervical and facial skeletal morphology were measured and compared between the groups after confirming intra-examiner reliability.
Results: Compared to the control group, the group with nasal septum deviation had a statistically significantly shorter nasopharyngeal length ($p < 0.001$), longer vertical airway length ($p < 0.002$), and larger cervical column curvature angle ($p < 0.006$).
Conclusion: Children with a nasal septum deviation of 4 mm or more on their CBCT scan are susceptible to unfavorable pharyngeal airway and craniocervical postural changes.

KEYWORDS
Cone-beam computed tomography (CBCT); mouth breathing; nasal septum deviation; nasal airway obstruction; pharynx

Introduction

The nasal septum is an important anatomical structure that supports the soft tissue and the midline of the nose. It divides the nasal cavity into two parts. The septum consists of hyaline cartilage anteriorly and bone posteriorly. It is mainly composed of five anatomical structures: the quadrangular septal cartilage anteriorly, the perpendicular plate of the ethmoid bone in the superior middle part, the vomer posteriorly, and a narrow strip of bone, consisting of the two crests of the maxillary and palatine bones that connect the septum to the nasal floor. The quadrangular septal cartilage, which extends from the upper nasal bones, has bilateral triangular or trapezoidal cartilage flanking its cranial half and fusing with the dorsal septum in the midline. The cartilage does not reach the external tip of the nose, but a small membranous part acts as the connection to the greater alar cartilage, forming the columella that separates the nostrils [1]. Physiologically, the nasal septum and turbinates are the structures that optimize the gas exchange in the lung alveoli by warming, cleaning, and humidifying the inspired air by creating a laminar airflow [2]. Nasal breathing is also essential for normal craniofacial growth and development [3,4]. Nasal septal deviation (NSD), a common anatomic variation, is an asymmetric tilting of the nasal septum to one side. The deviation may indicate that there is a growth disturbance or abnormal growth pattern of the septum with respect to the surrounding structures [5]. The prevalence of NSD was found to be 16.5% in preschool children, 38.7% in primary school children, and 39.9% in secondary school children [6]. In their study, Kawalski and Spiewak [7] reported that the incidence of anterior NSD could be as high as 22% in newborns delivered vaginally. Birth through cesarean section resulted in only 4% NSDs, underlining the importance of birth injury as a cause of NSD [8–12] (Figure 1). The term "mouth breathing," albeit frequently used in the literature, is somewhat misleading, as it actually refers to an oronasal respiration mode since total nasal obstruction is extremely rare in human beings [13]. Whatever the reason for a partial nasal obstruction, a growing child can adapt readily to an oronasal breathing mode. This adaptation is necessary for survival but bears a risk of altered dentofacial growth [14,15]. A predominantly oral breathing mode may lead to altered craniocervical posture as a compensation mechanism for the decreased nasal airflow to allow sufficient respiration [16]. Such postural changes may include a more inferior position of the mandible, a more anterior or inferior position of the tongue, lip-apart posture usually associated with lower tonicity of the orofacial muscles, and an altered head position in relation to the

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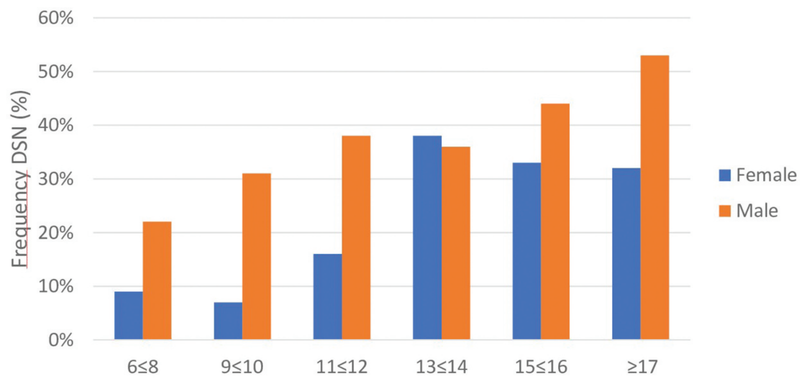

Figure 1. Incidence of nasal septum deviation depending on age and sex of the subjects. (https://synergypublishers.com).

neck compared to the posture in the nasal breathing mode [17]. Several studies have shown that individuals with obstructed nasal airways display an extended head posture [18–20]. Muto et al. [21] reported that an increase of 10° in the SN/OPT angle, caused by extension of the head, leads to an average increase of 4 mm in the pharyngeal airway space. Furthermore, orthodontists start treating children from an early age. The most objective and easily applicable method is computed tomography (CT) evaluation, which is a low-cost and standard imaging technique. This method is crucial for guiding physicians by evaluating soft tissue, bone structures, and anatomical cavities of the upper respiratory tract (URT) through distance, area, and angular parameters in both diagnosis and treatment [22].

In this study, keeping the form-function relation in mind, the authors aimed to determine whether NSD causes changes in patients' pharyngeal airway, hyoid bone position, and craniocervical posture by using CBCT analysis. Specifically, the authors wanted to test the null hypothesis that there is no significant difference in the pharyngeal airway, hyoid bone position, and cranio-cervical posture among growing preadolescent patients presenting with and without NSD.

Materials and methods

The study was conducted on the patients who were admitted to the authors' orthodontic clinic to undergo orthodontic treatment with the permission of Istanbul Aydin University Faculty of Dentistry Ethics Committee of Istanbul Aydin University of Medical Sciences, Istanbul, Turkey (code B.30.2.AYD.0.00.00.-050.06.04/416). The trial was registered at the Turkish Registry of Clinical Trials (2021/416). This retrospective study analyzed the CBCT scans of 50 children with complaints of dental malocclusion and jaw disproportion or requiring a routine exam who had been referred to the Department of Orthodontics and Pedodontics at the Faculty of Dentistry of the Istanbul Aydin University from January 2016 to December 2019. Children presenting with a NSD were selected to comprise the evaluation group (NSD group; n = 25; 12 females, 13 males). The control group consisted of children without NSD, matched by age and gender (n = 25; 11 females, 14 males). While constituting the study groups, it was ensured that patients had not undergone any operations in the maxillomandibular region (adenoidectomy, tonsillectomy, genioplasty, orthognathic surgery, etc.). It has been noted that NSD can be diagnosed with CBCT, which can clearly show the nasal septum deviation. CBCT records from the patients were obtained by using the "Flat Panel Based Cone Beam Volumetric Computed Tomography" (Morita 3D Accuitomo 170 instrument-J. Morita, Kyoto, Japan) device located in Istanbul Aydin University, Faculty of Dentistry, Oral and Maxillofacial Radiology Clinic. Scan parameters were 90 kvp, 5 mA, and 30.08 s using 250 µm voxel size and 140 × 100 cm FOV. CBCT recordings were taken with the Frankfurt plane parallel to the ground, the teeth in centric occlusion, and the lips in the resting position. The distance from the most protruding point of the deviated septum to the midline (the line passing through the anterior nasal spina and crista galli) was measured. NSD was defined as a deviation greater than 4 mm from the midline (Figure 2) [22]. Detection of nasal septum deviation and deviation angle measurement procedures were performed with the i-Dixel 2.0 software program, in which DICOM images were transferred. Septum deviation was determined as described by Bhandary et al. [23]: by examining the coronal sections, cases where the nasal septum was tilted in any direction were recorded as "deviation" and cases where the septum was straight as "no deviation." While determining the deviation angle in patients with deviation, a line was drawn from the crista gall to the maxillary spine. Again, a second line

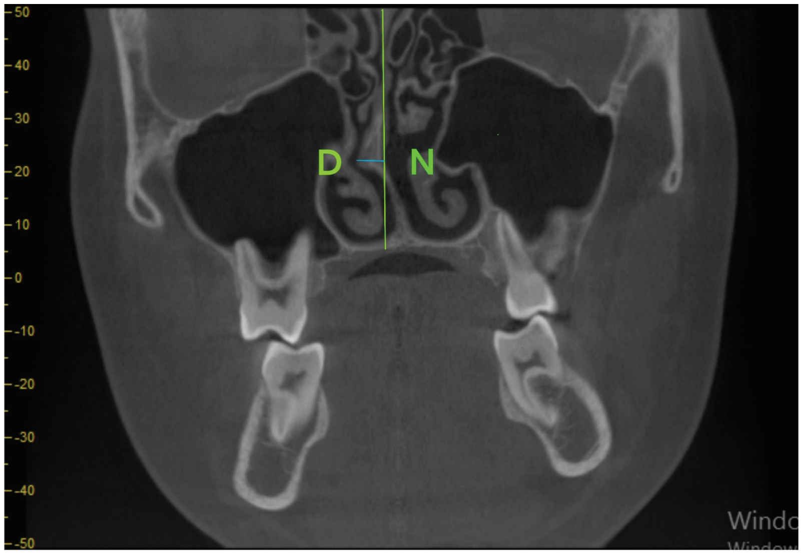

Figure 2. Deviation measurement in coronal section. Deviation width (N-D) (mm). A line was drawn from the crista galli to the maxillary spine (N). A second line was drawn from the crista galli to the most deviated part of the nasal septum (D), and the distance between these two lines was the amount of deviation.

was drawn to the part of the nasal septum that showed the greatest deviation from the crystal gall, and the angle between these two lines was accepted as the deviation width [23] (Figure 2). The direction of deviation was recorded as the side that was convex. According to the grading system described by Elahi et al. [24], values of 8º and below were considered as mild, 9–15º as moderate, and 16º and above as severe deviation. The body weight (kg) and height (cm) of all children were recorded when the radiographs were taken as a routine part of the exam. A portable scale was used to weigh the children without outer clothing, such as jackets or cardigans, and without shoes. The children's body mass index (BMI) was calculated using the formula of BMI = body weight (kg)/square of the standing height (m2). The measurements and anatomical points are illustrated in Figures 2 and 3. The pharyngeal airway extending from the nasopharynx (af1-pf1) to the hypopharynx (af4-pf4), the tongue height (TH-z), tongue length (TTEb), soft palate length (*P*-Pm), soft palate thickness (x-y), vertical airway length (Eb-pm), and vertical (HW, H-C3RGN) and horizontal position (H-RGN) of the hyoid bone were measured to determine the uvulo-glossopharyngeal morphology on the CBCT radiographs (Figures 3 a). In order to examine the cervico-craniofacial skeletal morphology on the same radiographs, the craniovertical (SN/Ver, NL/Ver), craniocervical (SN/OPT, SN/CVT), and cervico-horizontal postural relationships (OPT/Hor, CVT/Hor) and the cervical curvature angle (OPT/CVT), which expresses the position of the head in relation to the cervical column, were analyzed (Figure 4). The local research ethics committee of the Istanbul Aydin University granted approval for the study. Informed consent was waived because of the nature of the study as a retrospective file review.

Statistical analysis

The sample size was calculated based on a power analysis using the G*Power software, version 3.1.9.2 (University of Düsseldorf, Düsseldorf, Germany) with an alpha error probability of 0.05 and power of 90%. The power analysis showed that 20 participants in total were required. The authors included a total of 50 subjects in the study to strengthen the relevance of the findings. Analyses were performed using the NCSS (Number Cruncher Statistical System) 2007 (Kaysville, UT, USA) program. The normality of distribution was evaluated using the Shapiro-Wilk test. Between-group comparisons of non-normally and normally distributed variables were performed using the Mann-Whitney U test and Student's *t*-test, respectively. Spearman's correlation analysis was used to determine the relationship between quantitative variables. Statistical significance was set at $p < 0.01$, and $p < 0.05$. The authors calculated the method error and intra-examiner reliability by randomly selecting 20 CBCT scans for remeasurement. The Cronbach's alpha test for reliability showed that the intraclass correlation was over 0.991.

Results

The septal deviation and gender distribution in the two groups were not significant. There was no difference in

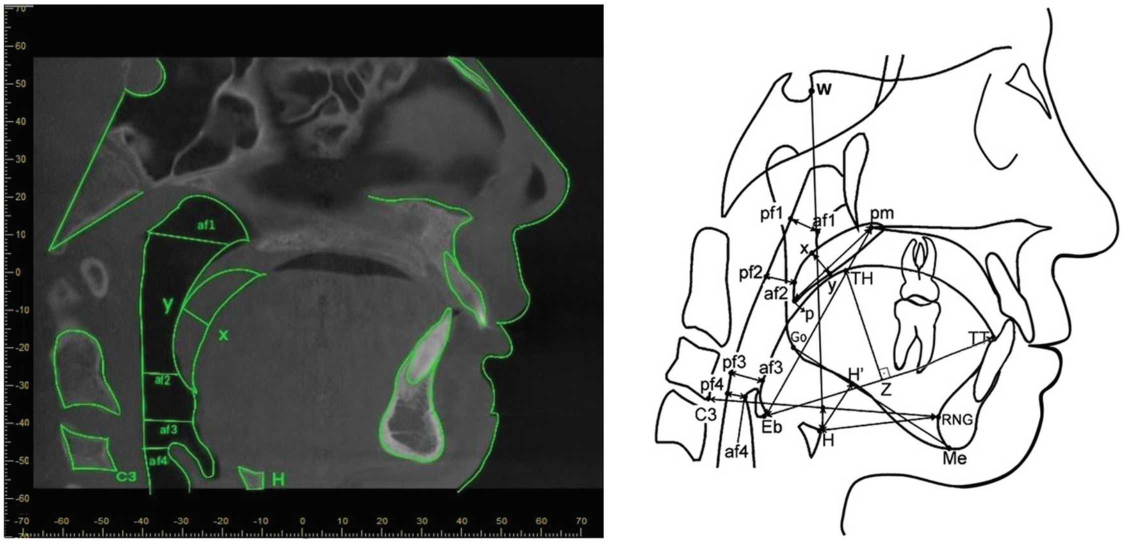

Figure 3. (a) Uvulo-glossopharyngeal measurements performed in the study. Nasopharynx (af1-pf1) (mm): the narrowest part of the nasopharynx. Nasopharyngeal airway width: The distance between PNS and posterior pharyngeal wall in the continuation of the ANS-PNS plane to the hypopharynx.(a) Velopharynx (af2-pf2) (mm): the narrowest part of the velopharynx. Nasopharyngeal airway width: Distance between the tip of the uvula (P) and the posterior pharyngeal wall.(b) Oropharynx (af3-pf3) (mm): the narrowest part of the oropharynx.Oropharyngeal airway width: The distance between the tongue root and the posterior pharyngeal wall, following the B-Go plane (the plane between the B-most anterior point of the mandible and the Gonion point in the mandible).(c) Hypopharynx (af4-pf4) (mm): the narrowest part of the hypopharynx.Hypopharyngeal airway width: The junction of the epiglottis and the root of the tongue. (Eb) – The distance between the posterior pharyngeal wall.(d) Tongue width TH-z (mm): The distance measured perpendicularly to the TH (end point of the tongue)-TT-EB (junction point of the epiglottis and tongue root) plane from the highest point of the tongue.(e) Tongue length (TT-Eb): The distance from the tip of the tongue (TT) to the junction of the epiglottis and the tongue root (Eb).(f) Length of the soft palate (*P*-pm) (mm): The distance between the palatine velum (P) and the tip of the pterygo-axillary point (pm); vertically the thickest part of the soft palate, perpendicular to the *P*-Pm line,(g) Soft palate thickness (x-y) (mm): Anteroposterior distance measured in the widest area of the uvula.(h) Vertical airway length (Eb-pm): The junction of the epiglottis and the root of the tongue (Eb) and tip of the posterior nasal spina, the distance between the junction of the soft and hard palate (Pm).(i) Vertical distance between hyoid bone (H) and Walker's point (H-W).(j) Vertical (HW) [H-C3RGN] of the hyoid bone: The distance of the most anterior and superior point (H) on the hyoid bone to the line connecting the 3rd cervical vertebra (C3) and the most posterior border of the mandibular symphysis (RGN).(k) Horizontal (H-RGN) of the hyoid bone: The distance between the most anterior and superior point (H) on the hyoid bone and the most posterior border of the mandibular symphysis (RGN).

gender between the groups with and without deviation (deviation group female = 52.2%, male = 48.1%, and no deviation female = 47.8%, male = 51.9; $p < 0.77$). The mean age of children was 9.9 ± 0.7 years in the NSD group and 10.2 ± 0.6 years in the control group (Table 1). The mean BMI was 16.0 ± 2.0 in the NSD group and 15.5 ± 1.3 in the control group. The two groups were comparable for age, gender, and BMI. The means and standard deviations of the CBCT measurements of the pharyngeal airway and craniocervical measurements in both groups are shown in Table 1. In the NSD group, the nasopharyngeal length (af-pf1) was found to be statistically significantly shorter ($p < 0.001$) (Table 2), and the vertical airway length (Eb-Pm) was found to be significantly longer ($p < 0.002$) than those in the control group (Table 3). Among the measurements of the cervico-craniofacial skeletal morphology, the cervical spine curvature angle (OPT/CVT) in the NSD group was found to be significantly larger than that in the control group ($p < 0.006$). The other measurements showed no statistically significant difference between the groups (Table 4).

Table 1. Comparison of measurements according to maxilla.

Parameter		N	Mean ± SD	[a]*p*-value
BMI	Deviation	25	15.51 ± 1.3	[b]0.528
	No Deviation	25	16.08 ± 2.01	
Age	Deviation	25	10.24 ± 0.66	[b]0.194
	No Deviation	25	9.96 ± 0.78	
SNA	Deviation	25	83.28 ± 2.05	[a]0.73
	No Deviation	25	82.12 ± 2.45	
PP	Deviation	25	52.20 ± 2.19	[b]0.491
	No Deviation	25	52.00 ± 2.43	
CO-A	Deviation	25	82.20 ± 3.10	[b]0.333
	No Deviation	25	82.72 ± 2.95	

BMI: Body mass index; SNA: Angle of maxilla with base of skull; PP (ANS-PNS): Palatal plane; CO-A: Effective maxillary length. Data are presented in terms of mean ± standard deviation.
[a]Student's *t*-test.
[b]Mann-Whitney U test.
$p < 0.05$; $p < 0.01$.

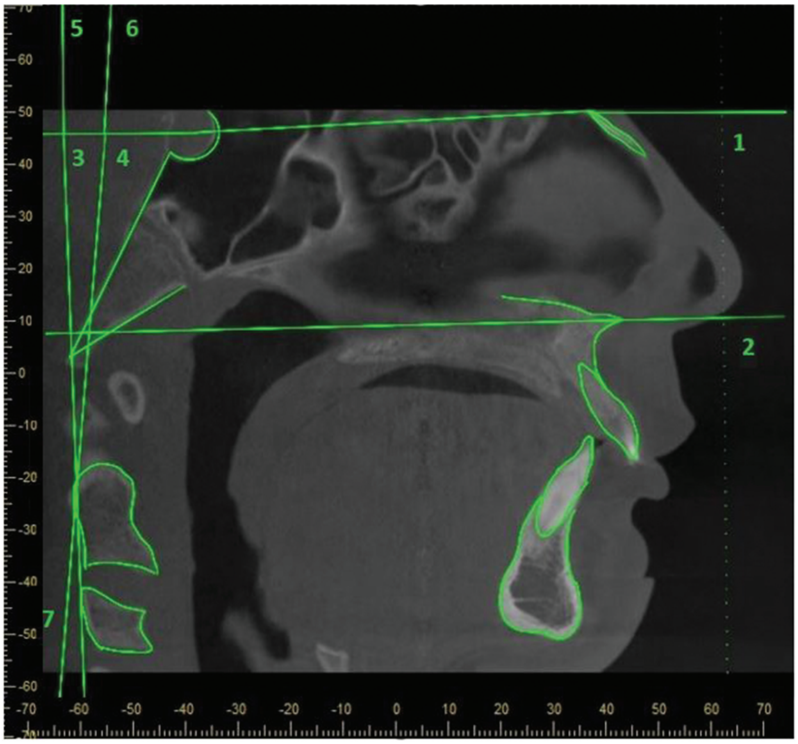

Figure 4. Cervico-craniofacial measurements performed used in the study. (1) SN / Ver: Angle formed between SN (It is the plane formed by the line connecting the Sella and Nasion points) and vertical plane.(2) PP / Ver: Angle formed between PP-Palatal plane (ANS-PNS) and vertical plane.(3) SN / OPT: The angle between OPT (Odontoid Process Tangent- It is the plane formed by the line passing through the points Cv2ip and Cv2sp) and SN lines.• Cv2ip: The second cervical spine is the lowest and posterior point of the vertebra.• Cv2sp: The uppermost and posterior point of the odontoid process of the second cervical vertebra.(4) SN / CVT: The angle between CVT (Cervical Vertebrae Tangent- It is the plane formed by the line passing through the points Cv2sp and Cv4ip) and SN lines; • Cv2sp: The uppermost and posterior point of the odontoid process of the second cervical vertebra.• Cv4ip: The lowest and posterior point of the fourth cervical vertebra.(5) OPT / Hor: angle formed between OPT and horizontal plane.(6) CVT / Hor: angle formed between CVT and horizontal plane.(7) OPT / CVT: Angle between OPT and CVT lines.

Table 2. Comparison of measurements according to airway.

Parameter		N	Mean ± SD	[a]*p*-value
Af1-pf1	Deviation	25	10.12 ± 1.01	[a]**0.000****
	No Deviation	25	8.00 ± 1.11	
Af2-pf2	Deviation	25	8.32 ± 0.90	[a]0.068
	No Deviation	25	8.72 ± 0.97	
A31-pf3	Deviation	25	9.40 ± 1.41	[a]0.708
	No Deviation	25	9.36 ± 0.86	
Af4-pf4	Deviation	25	4.96 ± 0.35	[a]0.984
	No Deviation	25	4.96 ± 0.20	
P-Pm	Deviation	25	31.08 ± 2.44	[b]0.913
	No Deviation	25	30.64 ± 1.18	
X-Y	Deviation	25	7.12 ± 1.56	[b]0.357
	No Deviation	25	7.52 ± 1.19	

Nasopharynx (af1-pf1) (mm) and narrowest place of the nasopharynx; Velopharynx (af2-pf2) (mm): narrowest place of the velopharynx; Oropharynx (af3-pf3) (mm): the narrowest part of the oropharynx; Hypopharynx (af4-pf4) (mm): the narrowest part of the hypopharynx; Soft palate length (*P*-pm) (mm), distance between the palatine velum (P) and tip of pterygomaxillary point (pm); and Soft palate thickness (x-y) (mm): anteroposterior distance measured in the widest area of the uvula.
[a]Student's *t*-test.
[b]Mann-Whitney U test.
$p < 0.05$; ** $p < 0.01$. (See Figure 3).

Discussion

This study analyzed the effects of NSD on pharyngeal airway dimensions and head posture in children, using cone beam computed tomography. Based on the current findings, the null hypothesis that NSD does not lead to pharyngeal airway and craniocervical postural changes was rejected. Impaired nasal breathing and its effect on the growth and development of craniofacial structures and dentition have been studied for decades. One possible anatomical cause is NSD, which increases the nasal airflow resistance and, consequently, alters nasal breathing. When predominantly nasal breathing changes to oral breathing, the growth and development of the orofacial structures may be disturbed [25]. D'Ascanio et al. [26] used cephalometry to evaluate the craniofacial growth in 98 children (mean age 8.8 years, range 7–12 years) presenting with severe chronic nasal airway

Table 3. Comparison of measurements according to glossopharyngeal airway.

Parameter		N	Mean ± SD	^a^p-value
Eb-Pm	Deviation	25	53.16 ± 2.68	[b]*0.002***
	No Deviation	25	56.0 ± 3.02	
W-H	Deviation	25	86.84 ± 3.85	[b]*0.056*
	Non Deviation	25	89.56 ± 6.28	
H- C3RGN	Deviation	25	4.5 ± 1.19	[b]*0.064*
	Non Deviation	25	5.16 ± 0.68	
H-RGN	Deviation	25	31.52 ± 2.78	[b]*0.951*
	Non Deviation	25	31.60 ± 2.36	

EB-pm: Vertical airway length; W-H: Vertical distance between hyoid bone (H) and Walker's point; H-C3RGN: Vertical (HW) of the hyoid bone; H-RGN: Horizontal of the hyoid bone.
[a]Student's *t*-test.
[b]Mann-Whitney U test.
$p < 0.05$; ** $p < 0.01$. (See Figure 3a).

Table 4. Comparison of measurements according to posture.

Parameter		N	Mean ± SD	[a]p-value
SN/Ver	Deviation	25	101.44 ± 2.94	[a]*0.515*
	No Deviation	25	100.52 ± 1.53	
PP /Ver	Deviation	25	89.6 ± 2.08	[a]*0.927*
	No Deviation	25	89.63 ± 3.07	
SN/OPT	Deviation	25	89.60 ± 3.51	[a]*0.927*
	No Deviation	25	89.62 ± 1.38	
SN/CVT	Deviation	25	105.56 ± 6.45	[a]*0.225*
	No Deviation	25	103.42 ± 6.12	
OPT/Hor	Deviation	25	89.36 ± 5.15	[b]*0.242*
	No Deviation	25	90.28 ± 4.80	
CVT/Hor	Deviation	25	88.52 ± 6.15	[b]*0.094*
	No Deviation	25	90.2 ± 4.89	
OPT/ CVT	Deviation	25	2.52 ± 0.50	[b]*0.006***
	No Deviation	25	2.88 ± 0.33	

SN/Ver: Angle formed between SN and vertical plane; PP/Ver: Angle formed between PP-Palatal plane (ANS-PNS) and vertical plane; SN/OPT: The angle between OPT (Odontoid Process Tangent- It is the plane formed by the line passing through the points Cv2ip and Cv2sp) and SN lines; SN/CVT: The angle between CVT (Cervical Vertebrae Tangent- It is the plane formed by the line passing through the points Cv2sp and Cv4ip) and SN lines; OPT/Hor: Angle formed between OPT and horizontal plane; CVT/Hor: angle formed between CVT and horizontal plane; OPT/CVT: Angle between OPT and CVT lines.
[a]Student's *t*-test.
[b]Mann-Whitney U test.
$p < 0.05$; ** $p < 0.01$. (See Figure 4.)

obstruction secondary to NSD, and they compared the findings with an age- and gender-matched control group. They determined the severity and chronicity of the nasal airway obstruction by using an active anterior rhinomanometer (resistance ≤ 0.40 Pa/cm2/s at 150 Pa in each nostril) and a history of permanent mouth breathing. The authors observed a higher upper and lower facial height, larger gonial angle, and significantly more retrognathic position of the maxilla and mandible in children presenting with NSD and mouth breathing than in those without NSD. Furthermore, the NSD group with mouth breathing had a narrowed maxilla with higher palatal height and more overjet and anterior open-bite tendency toward Class II malocclusion compared to the control group. Finally, a posterior crossbite was statistically significantly more frequent in mouth breathers than nose breathers. Numerous further studies suggest a correlation between breathing modalities and dentofacial growth in children [3,4,17,20,22,26]. In a recent study, Akbay et al. [27] investigated the relationship between the depth of the maxillopalatal arch and NSD in the coronal planes of computed tomography scans of the paranasal sinuses and found a strong positive correlation between posterior septum deviation and the depth of the maxillopalatal arch. Consequently, the authors' interpretation is that the descent of the palatal bone fails during nasomaxillary growth and development in children with NSD. Furthermore, in a twin study, the anteroposterior maxillary length was found to be shorter in twins with anterior NSDs than in those without. In light of the current literature [28], certain morphological changes can be expected, such as a lower height of the anterior nasal aperture and a shorter nasal ceiling, in children presenting with a noticeable NSD that impairs nasal breathing than in children without such NSD. In the current study, the vertical airway length was found to be significantly longer in the NSD group than in the control group ($p < 0.002$). Anatomically, the pharyngeal space is surrounded by the maxilla cranially, the mandible frontally and laterally, and the cervical vertebrae dorsally. In the current study, the vertical airway length was measured from the most posterior point of the palatine bone to the floor of the epiglottis. This nasal airflow is needed to supply a continuous stimulus for the descent of the palatal bone and lateral maxillary growth. Moreover, in the current study, the nasopharynx width measured at its narrowest point in the CBCT evaluation was significantly shorter in the NSD group than in the control group. Since the two groups were matched for age, gender, and BMI, the statistically significant ($p < 0.001$) difference is a matter for further investigation. To date, no study has investigated the pharyngeal airway dimensions in relation to NSD in growing children. The adenoids (or nasopharyngeal tonsils), which are located in the cranial aspect of the nasopharynx, are a mass of lymphoid tissue forming part of Waldeyer's ring. Adenoids and tonsils play an important role in the host defense of the URT against invading antigens. In late childhood, from age 5 to 7, the lymphoid tissue throughout the body proliferates to its maximum levels, and large tonsils and adenoids are common. The obstruction of the upper airway probably triggers a physiological response in the form of an extension of the head relative to the cervical column [28]. Wenzel et al.'s [29] study showed the relationship between nasal airway resistance and head posture. They analyzed the effects of an intranasal corticosteroid (budesonide) in children with asthma and nasal obstruction. Nasal airway resistance was measured by rhinomanometry, and head posture was evaluated with cephalometry. After treatment, nasal airway resistance was reduced by 8.7 mm H2O/L/min on average, and craniocervical angulation decreased by an average of 2.3° compared with the placebo group. This study proved the relationship between the respiratory mode and head posture. Furthermore, Sousa et al. [30] noted that mouth-breathing individuals adopt a posture that allows them to breathe better through lowering the mandible and tongue, while displaying an overall decreased orofacial muscle tone. In the current study, the NSD group had a significantly larger craniocervical curvature angle ($p < 0.006$) than that of the control group. The authors conclude that patients presenting with significant NSD on their CBCT scans are prone to an extended head posture. One of the established reasons for narrowing and obstruction of the pharyngeal airways is obesity, where it is caused by increased amounts of soft tissue and fatty infiltrates around the upper airway structures [31,32]. Therefore, in the current study, the mean BMI between the NSD and control groups were compared to exclude the possibility of the pharyngeal airway and craniocervical postural changes being caused by the subject being overweight. No significant difference was found in the mean BMIs, which were, furthermore, within the normal range according to the age- and gender-specific BMI percentiles. Using the BMI-for-age is essential to obtain a correct classification in childhood [33]. It is well known that computed tomography and magnetic resonance imaging provide an accurate 3D diagnosis of NSD. Current evidence shows that anterior NSDs as small as 3–4 mm can produce significant airflow resistance changes [34]. When selecting the children for the NSD group, the authors defined a minimum of 4 mm of deviation from the midline to strictly identify critical NSDs only and eliminate the inherent risk of selection bias on the panoramic and CBCT scan. Smith et al. [35] noted that using subjective classification categories, such as mild, moderate, and severe, could affect the prevalence of NSD and might consequently have influenced the results of the current study. Orthodontists are the physicians who closely monitor craniofacial growth and development in children and treat deformities. In a cone beam computed tomography study [36], rapid maxillary expansion showed the following positive effects on NSD in growing patients (mean age 8.6 ± 1.5 years): an increase in the length of the septum in its caudal third; an improvement of the deviation and growth disturbances; a lateral inclination of the nasal cavity possibly reducing air resistance and improving breathing pattern; and an increase in the nasal cavity volume due to significant mid-palatal suture displacement and moving the entire nasomaxillary complex caudally and frontally. Similarly, studies showed rapid maxillary expansion with a hyrax appliance increased the minimum cross-sectional area in the nasal cavity evaluated with acoustic rhinometry [37,38]. Based on these results, it is suggested that patients presenting with NSD during the pre-pubertal peak period might substantially benefit from rapid maxillary expansion, as it decreases nasal resistance.

Conclusion

Children with NSD show significant differences in their pharyngeal airway and craniocervical posture compared to children without NSD. Orthodontists should be aware that NSD might cause pharyngeal airway and craniocervical postural disturbances when evaluating cone beam computed tomography in the diagnosis and treatment planning of growing children. Early recognition of the signs and symptoms of upper airway obstruction in preadolescent orthodontic patients enables timely and effective treatment and otorhinolaryngology referral.

Acknowledgments

Several authors choose to acknowledge Elsevier Premium Language Editing editorial support in their paper. According to prominent publication guidelines such as the ICMJE guidelines on authorship, editing or writing support should be acknowledged in the paper. Such acknowledgments also serve to assure journal editors/reviewers that the English has been thoroughly reviewed, and meets the required standards for publication. We would like to thank Elsevier Language Editing Plus for English language and sintifice editing.The authors would like to thank the Vice Chancellor for research, Istanbul Aydin University for supporting the research. In addition, we express our gratitude to Dr. Beyza Kircelli for his valuable contribution to the article interpretation.

Availability of data and materials

The data that support the findings of this study are available from the corresponding author upon reasonable request from sanazsadry@hotmail.com.

The authors agree with sharing, copying, and modifying the data used in this article, even for commercial purposes, so long as appropriate credit is given, and possible changes are indicated. The present study was approved by the Ethics Committee of Istanbul Aaydin University of Medical Sciences, Istanbul, Turkey (code B.30.2.AYD.0.00.00.-050.06.04/416). The trial was registered at the Turkish Registry of Clinical Trials (2021/416).

Disclosure statement

No conflict of interest for all authors.

Funding

No funding sources were used. All funding sources for the reported research have been covered by Sanaz Sadry. All consumables used in the study were paid by Sanaz SADRY. The acquisition, measurement and analysis of the data in the study were carried out at the labs of Istanbul Aydin University.

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