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Age-group-specific associations between adenoid/tonsillar hypertrophy and craniofacial features

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Abstract

Background Age plays an important role in the association between adenotonsillar hypertrophy and craniofacial morphology. This study aimed to analyse the association of adenoid and tonsillar hypertrophy with craniofacial features in different age groups.

Methods Lateral cephalograms were obtained from 942 patients aged 6–15 years (433 boys, 509 girls). They were divided into three age groups: 6–9 years ($n=189$), 9–12 years ($n=383$), and 12–15 years ($n=370$). According to the different sites of pharyngeal obstruction, they were classified as control group (CG), adenoid hypertrophy group (AG), tonsillar hypertrophy group (TG) and adenotonsillar hypertrophy group (ATG). Cephalometric measurements were performed on each enrolled participant. Comparisons between groups and correlations between these cephalometric variables and obstruction sites were evaluated.

Results At 6–9 years of age, ATG and TG correlated with increased mandibular height ($B=2.2$, $p=0.029$; $B=2.6$, $p=0.042$, respectively). At the age of 9–12 years, AG showed a steep growth direction ($B=1.5$, $p=0.002$), TG showed a higher probability of Class III skeletal pattern (smaller SNB, ANB and SGn/FH, larger Go-Me) and ATG manifested a higher proportion of Class III skeletal pattern. At 12–15 years of age, there was no significant association between cephalometric measurements and pharyngeal lymphoid tissue enlargement.

Conclusions Children with isolated adenoid hypertrophy have a vertical growth direction at 9–12 years of age. Isolated adenoid hypertrophy correlated with longer mandibular body, more anterior mandible and horizontal skeletal Class III pattern at 6–12 years. Combination of obstructive adenoids and tonsils manifested similarly to children with isolated tonsil hypertrophy.

Keywords Adenoid, Tonsil, Hypertrophy, Age group, Craniofacial features

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Background

Both the adenoids and the tonsils are part of the lymphatic Waldeyer's ring at the entrance to the upper airway [1, 2]. Adenotonsillar hypertrophy increases upper airway resistance and is a significant risk factor for pediatric obstructive sleep apnea (OSA) [3]. In a select number of children, enlarged adenoids and tonsils can cause craniofacial deformity by obstructing the pharyngeal airway and altering respiratory conditions [4].

Adenoid hypertrophy(AH) is one of the most common causes of nasopharyngeal obstruction resulting in mouth breathing in children [5]. Prolonged mouth breathing may contribute to the anomalous development of the facial bone structure [6]. And the adenoid facies, characterized by an open-mouthed appearance seen in children, often accompanied by a slender nose, shortened upper lip, constricted palate, elevated palatal vault, and dental overcrowding is often associated with AH [7]. Greater antero-posterior maxillo-mandibular discrepancy and mandibular retrusion were independently associated with higher likelihood of having AH [8]. Individuals with tonsillar hypertrophy(TH) often exhibit distinctive craniofacial features, including increased length of mandibular ramus and body length, a more horizontal growth pattern, a more anterior mandibular position, and a smaller sagittal discrepancy between the maxilla and mandible compared to individuals with adenoid hypertrophy [9]. Children with isolated TH have a more anterior and superior mandibular position and a higher rate of Class III relations [10, 11]. And adenotonsillar hypertrophy (ATH) did not show a superimposed craniofacial pattern of the above two but showed the same craniofacial pattern as isolated adenoid hypertrophy and a higher rate of class II relations [11, 12]. However, conflicting results have shown that no association was seen between adenoid/tonsillar hyperplasia and the prevalence of Class II relationship, anterior open bite, and posterior cross bite [13–15]. Previous studies involved small samples and a wide age range that did not account for physiological changes in adenoid and tonsil size [9, 14, 16]. Therefore, the results of previous research have been inconsistent and contradictory. Overall, investigation of the craniofacial characteristics with different locations of hypertrophied pharyngeal lymphoid tissues requires studies in children of different ages.

In the current study, we used a relatively large hospital-based dataset to elucidate age-specific association between craniofacial characteristics and adenoids and tonsils in children. This study aimed to clarify the complex associations between craniofacial characteristics and age, adenoids, and tonsils. We hypothesized that the influence of adenoids and tonsils on craniofacial features would vary in children of different age group.

Methods and materials

Ethics

The present study was a retrospective cross-sectional study which was approved by the Ethics Committee of Stomatological Hospital of Xiamen Medical College (KS20240119001). This study is in accordance with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. And this retrospective cross-sectional study was registered in the Chinese Clinical Trial Registry (Identifier: ChiCTR2000038751).

Participants

The retrospective samples were selected from consecutive orthodontic patients, who referred to the Department of Orthodontics of Stomatological Hospital of Xiamen Medical College and had lateral cephalograms taken for routine diagnosis from April 2023 to November 2023. The inclusion criteria were as follows: (1) children aged 6 to 15 years, (2) clear identification of upper airway, adenoids and tonsils on lateral cephalograms, and (3) body mass index (BMI) below cut-off points for obesity [17]. The exclusion criteria were (1) a history of previous tonsillectomy and/or adenoidectomy, or orthodontic treatment, (2) cases of severe skeletal abnormalities requiring surgical treatment, and (3) craniofacial injury or syndromes.

In the end, 942 Chinese children (433 boys and 509 girls) were recruited from 1024 children aged 6 to 15 years. The date of birth and the date of lateral cephalograms were recorded for each participant. The age of each participant was calculated from the interval between their birthday and the date of their lateral cephalograms. According to age, participants were divided into the following age groups: 6–9, 9–12 and 12–15 years.

Cephalometric analysis

Lateral cephalograms were performed routinely on all patients. The lateral cephalograms were performed by an ORTHOPHOS XG 3D Ceph digital X-ray machine (Sirona Dental Systems GmbH, Bensheim, Germany). The cephalograms were taken in the upright natural head position and during the end-expiration phase. The children were asked to remain still and keep teeth in centric occlusion with tongue tip touching the incisors and to refrain from swallowing and speaking.

A single well-trained orthodontist (HLP) used Huazheng software (https://www.huazhengcl.com/) to perform lateral cephalometric tracing and analysis, which included measurements of craniofacial and pharyngeal lymphoid tissues. Lateral cephalograms reveal adenoid tissue as a convex projection attached to the roof and posterior wall of the nasopharynx, facing the superior surface of the soft palate. Palatine tonsils appear as an oval-shaped shadow in the oropharyngeal space near the root of the tongue [9, 18]. The cephalometric reference landmarks and lines used in this study are shown in Fig. 1, which based on the study by Baroni et al. [9] and Huang X et al. [12]. The measurements included angular and linear measurements. Angular measurements included: SNA-The Angle between SN and NA, indicates the maxillary position. SNB-The Angle between SN and NB, indicates the mandibular position. ANB-The Angle between NA and NB, indicates the relationship between two jaws. MP/SN-The Angle between MnP and SN plane, indicates mandibular inclination. SN-PP, The Angle between ANS-PNS and SN plane, indicates maxillary inclination. SGn/FH-The Angle between SGn and FH plane, indicates the direction of growth. Linear measurements included: ANS-PNS, the distance between ANS and PNS, to indicate maxillary length. Go-Me, the distance between Go and Me, to indicate mandibular body length. Total Nasopharyngeal Airway Space (TNAS): the distance from Nasopharynx posterior (Np) to Nasopharynx anterior (Na). Adenoid Size (AS): the distance from Np to Adenoidal point (Ad). Total Oropharyngeal Airway Space (TOAS): the distance from Oropharynx posterior (Op) to Oropharynx anterior (Oa). Tonsil Size (TS): the distance from Tonsillar point (To) to Oropharynx anterior (Oa). Adenoid hypertrophy was defined according to AS/TNAS ratio more than 0.5. Tonsillar hypertrophy was classified according to TS/TOAS ratio more than 0.5. Based on the cephalometric analysis, children were

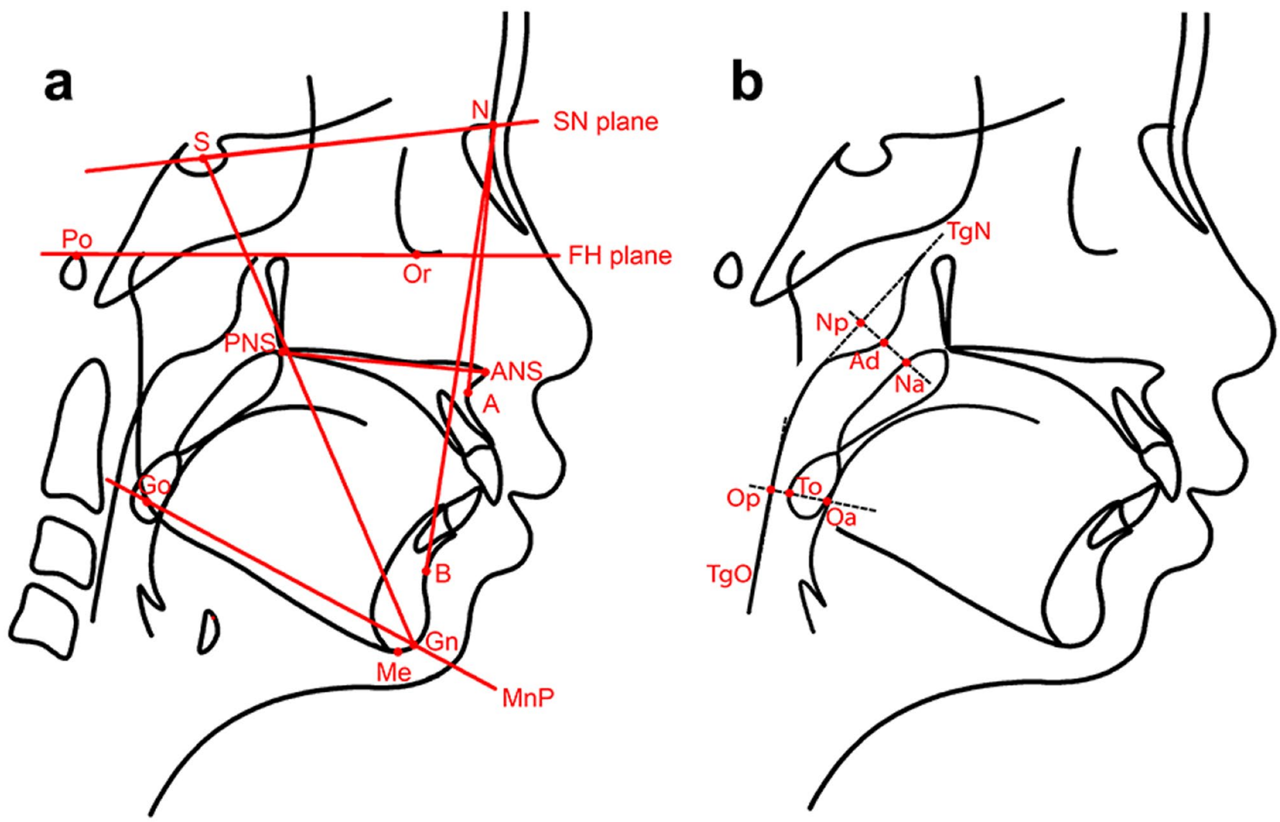

Fig. 1 Cephalometric landmarks and reference planes/lines of craniofacial features (a) and pharyngeal lymphoid tissues (b). **(a)** Landmarks: S-Sella, center of the sella turcica. N-Nasion, the deepest point in the concavity of the nasofrontal suture. Po-Porion, the most superior point of the bony external auditory meatus. Or-Orbitale, the most inferior point on the infraorbital margin. ANS-Anterior nasal spine. PNS-Posterior nasal spine. A-A point, the deepest point in the concavity of the anterior maxilla between the anterior nasal spine and the alveolar crest. B-B point, the deepest point in the concavity of the anterior mandible between the alveolar crest and pogonion. Me-Menton, the most inferior point on the body chin. Gn-Gnathion, the most anteroinferior point on the bony chin. Go-Gonion, the most posterior-inferior point on the angle of the mandible. Reference plane: SN plane-Anterior cranial base plane, the line joining S and N. FH plane-Frankfort horizontal plane, the line joining Po and Or. MnP-Mandibular plane, the line joining Go and Gn. **(b)**. Landmarks and reference lines: Ad-Adenoidal point, the most anterior point on the anterior outline of the adenoid shadow (nearest point to the soft palate). TgN-Tangent nasopharynx, line passing through the most superior and the most inferior point of the adenoid shadow, which represents the posterior wall of the nasopharyx without adenoids. Ad-TgN, Perpendicular nasopharynx, line perpendicular to TgN passing through Ad. Np-Nasopharynx posterior, intersection of the lines Ad-TgN and TgN. Na-Nasopharynx anterior, intersection of the posterior outline of the soft palate and the line Ad-TgN. To-Tonsillar point, the most posterior point of the posterior outline of the tonsillar shadow (the nearest point to theposterior wall of the oropharynx).TgO-Tangent oropharynx, tangent line to the posterior wall of the oropharynx. To-TgO, Perpendicularoropharynx, line perpendicular to TgO passing through To. Op-Oropharynx posterior, intersection of the lines TgO and To-TgO. Oa-Oropharynx anterior, intersection of the line To-TgO and the posterior outline of the tongue (or the anterior outline of the tonsils)

divided into four groups according to the locations of the pharyngeal lymphoid tissue enlargement: control group (CG)-no adenoid or tonsillar hypertrophy group, adenoid hypertrophy group (AG)-isolated adenoid hypertrophy group, tonsillar hypertrophy group (TG)-isolated tonsillar hypertrophy group, adenotonsillar hypertrophy group (ATG)-combined adenoid and tonsillar hypertrophy group. Sagittal skeletal pattern was characterized by ANB angle: Class I (3.3°≤ANB≤6.1° in mixed dentition, 0.7°≤ANB≤4.7° in permanent dentition), Class II (ANB>6.1° in mixed dentition, ANB>4.7° in permanent dentition) and Class III (ANB<3.3° in mixed dentition, ANB<0.7° in permanent dentition). Four weeks later, methodological evaluation was carried out by repeating the digitization process for 25 randomly selected radiographs. Differences calculated using Dahlberg's formula ranged from 0.23 to 0.44 mm for the linear measurements and from 0.31 to 0.39 degrees for the angular measurements. No systematic errors were detected.

Statistical analysis

According to the results of normality checked by the Kolmogorov–Smirnov test, continuous variables were identified as normally distributed data or non-normally distributed data. Normally distributed data are expressed as a mean and standard deviation (mean±SD). Levene´s test was used to examine the homogeneity of variance. The differences among groups were compared using one-way analysis of variance followed by the Bonferroni correction for multiple comparisons when the overall test result was significant. Categorical variables were summarized using percentages and compared among groups using chi-square tests with the Bonferroni correction for multiple comparisons. Multiple linear regression analysis was then used to identify craniofacial differences between groups (CG, AG, TG and ATG), with each cephalometric variable as the dependent variable and age, sex, BMI and groups (converted to dummy variables) as the independent variables.Unstandardized regression coefficients B were calculated, representing age-, BMI- and sex-adjusted differences between groups.

All data were analyzed using IBM SPSS Statistics for Mac (27.0, SPSS Inc., Chicago, IL, USA) and the software program R, v.3.6.3 (The R Foundation for Statistical Computing, Vienna, Austria). The histograms were drawn using GraphPad Prism 8. All p values given are two-sided, and the significance level was set at $p<0.05$.

Results

Demographic characteristics of the subjects

Table 1 presents the basic demographic characteristics of the study population. The patients had an average age of 10.7±2.4 years, and 46.0% (433/942) of them were boys. The average BMI was 18.1±1.6 $kg{\cdot}m^{-2}$. Isolated adenoid hypertrophy was observed in 26.1% (246/942) of the subjects, 14.2% (134/942) of the subjects had isolated tonsillar hypertrophy, and adenotonsillar hypertrophy was observed in 27.0% (254/942) of the subjects.

Of all the subjects, 189 participants (20.0%) were aged between 6 and 9 years, 383 (40.7%) were aged between 9 and 12 years, and 370 (39.3%) were aged between 13 and 15 years. There was no significant difference in gender distribution among the three age groups. The younger age groups had a significantly higher proportion of adenoid hypertrophy and adenotonsillar hypertrophy ($p<0.001$).

Differences among CG, AG, TG and ATG by comparison of cephalometric variables in various age groups

The multi-group comparison of cephalometric variables among CG, AG, TG and ATG in various age groups is shown in Table 2; Fig. 2.

In children aged 6–9 years old, those with adenotonsillar hypertrophy showed a tendency towards a horizontal growth direction (smaller SGn/FH) compared to those with isolated obstructive adenoids. Among children aged 9–12 years old, those in the AG group exhibited a steep growth direction (larger SGn/FH), while those in the TG

Table 1 Basic characteristics of study patients

Variable	Total ($N=942$)	6–9 years ($n=189$)	9–12 years ($n=383$)	12–15 years ($n=370$)	p-value
Age (yr)	10.7±2.4	7.3±0.7	10.1±0.8 [a]	13.1±1.0 [ab]	<0.001***
Gender, boy (%)	433 (46.0)	90 (47.6)	169 (44.1)	174 (47.0)	0.638
BMI (kg/m^2)	18.1±1.6	16.6±0.9	17.7±0.8 [a]	19.3±1.5 [ab]	<0.001***
Adenoid&Tonsillar group					<0.001***
CG, n (%)	308 (32.7)	25(13.2)	116 (30.3) [a]	167(45.1) [ab]	
AG, n (%)	246 (26.1)	68 (36.0)	99 (25.8) [a]	79 (21.4) [a]	
TG, n (%)	134 (14.2)	20 (10.6)	54 (14.1)	60 (16.2)	
ATG, n (%)	254 (27.0)	76(40.2)	114 (29.8) [a]	64 (17.3) [ab]	

Note "a," "b," and "c" indicate significant difference versus the "6–9 years," "9–12 years," and "12–15 years" groups in the Bonferroni multiple comparison, respectively

* $p<0.05$, ** $p<0.01$, *** $p<0.001$

Abbreviations CG, control group; AG, adenoid hypertrophy group; TG, tonsillar hypertrophy group; ATG, adenotonsillar hypertrophy group

Table 2 Cephalometric measurements among Adenoid & Tonsillar group in different age groups

Variable	CG	AG	TG	ATG	P
Total	n = 308	n = 246	n = 134	n = 254	
SNA (°)	81.1 ± 3.3	80.3 ± 3.5 [a]	81.0 ± 3.4	80.5 ± 3.5	0.017*
SNB (°)	77.7 ± 3.6	76.9 ± 4.1	78.3 ± 3.7 [b]	77.8 ± 3.9	0.003**
ANB (°)	3.4 ± 2.7	3.4 ± 3.3	2.8 ± 3.4	2.7 ± 3.5	0.026*
Sagittal skeletal pattern					< 0.001***
Class I (%)	158 (51.3)	96 (39.0) [a]	51 (38.1)	80 (31.5) [a]	
Class II (%)	91 (29.5)	71 (28.9)	38 (28.4)	67 (26.4)	
Class III (%)	59 (19.2)	79 (32.1) [a]	45 (33.5) [a]	107 (42.1) [a]	
MP/SN (°)	34.0 ± 5.3	35.1 ± 5.9	33.8 ± 5.6	35.1 ± 5.0	0.013*
SGn/FH (°)	63.5 ± 3.4	64.4 ± 3.6 [a]	63.4 ± 3.7	63.5 ± 3.4 [b]	0.006**
ANS-PNS (mm)	40.9 ± 3.7	40.1 ± 3.8	40.6 ± 3.6	39.7 ± 3.9 [a]	0.002**
Go-Me (mm)	65.0 ± 5.4	62.8 ± 5.0	65.7 ± 4.8	63.8 ± 5.2	0.242
SN-PP	8.4 ± 3.4	8.8 ± 3.6	8.0 ± 3.3	8.0 ± 3.4	0.043*
6–9 years	n = 25	n = 68	n = 20	n = 76	
SNA (°)	79.7 ± 3.3	79.5 ± 3.1	80.3 ± 2.0	80.1 ± 3.7	0.710
SNB (°)	76.9 ± 3.2	76.8 ± 4.4	77.5 ± 3.5	78.5 ± 3.8	0.051
ANB (°)	2.8 ± 3.4	2.6 ± 3.2	2.7 ± 3.5	1.5 ± 3.6	0.130
Sagittal skeletal pattern					0.169
Class I (%)	7 (28.0)	16 (23.5)	9 (45.0)	12 (15.8)	
Class II (%)	4 (16.0)	11 (16.2)	2 (10.0)	9 (11.8)	
Class III (%)	14 (56.0)	41 (60.3)	9 (45.0)	55 (72.4)	
MP/SN (°)	36.0 ± 4.7	35.6 ± 5.6	35.6 ± 3.5	35.1 ± 5.1	0.900
SGn/FH (°)	63.5 ± 3.5	64.4 ± 4.0	65.0 ± 4.1	62.7 ± 3.3 [b]	0.015*
ANS-PNS (mm)	37.7 ± 3.4	37.4 ± 3.1	38.3 ± 3.1	37.6 ± 3.5	0.812
Go-Me (mm)	58.7 ± 4.9	59.2 ± 4.0	61.3 ± 4.5	60.9 ± 4.6	0.031
SN-PP (°)	8.5 ± 2.6	8.9 ± 3.1	8.4 ± 3.0	7.8 ± 3.3	0.231
9–12 years	n = 116	n = 99	n = 54	n = 114	
SNA (°)	81.0 ± 3.4	80.2 ± 3.6	80.3 ± 3.4	80.8 ± 3.4	0.355
SNB (°)	77.3 ± 3.7	76.5 ± 4.1	78.6 ± 3.8 [b]	77.6 ± 4.2	0.017*
ANB (°)	3.6 ± 2.8	3.7 ± 3.7	1.7 ± 3.7 [abd]	3.2 ± 3.6	0.003***
Sagittal skeletal pattern					0.004**
Class I (%)	54 (46.6)	39 (39.4)	14 (25.9)	33 (28.9) [a]	
Class II (%)	36 (31.0)	30 (30.3)	12 (22.2)	37 (32.5)	
Class III (%)	26 (22.4)	30 (30.3)	28 (51.9) [a]	44 (38.6) [a]	
MP/SN (°)	34.3 ± 5.3	34.9 ± 5.9	33.3 ± 5.0	35.0 ± 5.0	0.175
SGn/FH (°)	63.4 ± 3.3	64.8 ± 3.6 [a]	62.5 ± 3.3 [b]	63.5 ± 3.5	0.001**
ANS-PNS (mm)	40.2 ± 3.3	40.4 ± 3.5	40.1 ± 3.1	40.2 ± 3.6	0.957
Go-Me (mm)	63.2 ± 4.5	62.1 ± 4.0	64.9 ± 4.8 [b]	63.6 ± 4.8	0.003**
SN-PP (°)	8.4 ± 3.6	8.9 ± 3.7	8.3 ± 3.0	8.2 ± 3.2	0.474
12–15 years	n = 167	n = 79	n = 60	n = 64	
SNA (°)	81.5 ± 3.1	81.0 ± 3.7	82.0 ± 3.7	80.7 ± 3.1	0.151
SNB (°)	78.1 ± 3.6	77.4 ± 3.8	78.3 ± 3.6	77.1 ± 3.7	0.123
ANB (°)	3.3 ± 2.6	3.7 ± 2.7	3.6 ± 2.8	3.5 ± 2.8	0.760
Sagittal skeletal pattern					0.791
Class I (%)	97 (58.1)	41 (51.9)	28 (46.7)	35 (54.7)	
Class II (%)	51 (30.5)	30 (38.0)	24 (40.0)	21 (32.8)	
Class III (%)	19 (11.4)	8 (10.1)	8 (13.3)	8 (12.5)	
MP/SN (°)	33.6 ± 5.3	34.9 ± 6.1	33.8 ± 6.6	35.1 ± 5.0	0.135
SGn/FH (°)	63.6 ± 3.5	64.0 ± 3.3	63.8 ± 3.7	64.4 ± 2.9	0.448
ANS-PNS (mm)	41.8 ± 3.6	42.0 ± 3.5	41.8 ± 3.7	41.3 ± 3.7	0.618

Table 2 (continued)

Variable	CG	AG	TG	ATG	P
Go-Me (mm)	67.3 ± 4.7	66.6 ± 4.4	67.9 ± 3.7	67.5 ± 4.5	0.384
SN-PP (°)	8.3 ± 3.4	8.7 ± 3.7	7.7 ± 3.6	8.0 ± 3.9	0.364

Note "a," "b," "c" and "d" indicate significant difference versus the "CG," "AG," "TG" and "ATG" groups in the Bonferroni multiple comparison, respectively

* $p<0.05$, ** $p<0.01$, *** $p<0.001$

Abbreviations CG, control group; AG, adenoid hypertrophy group; TG, tonsillar hypertrophy group; ATG, adenotonsillar hypertrophy group

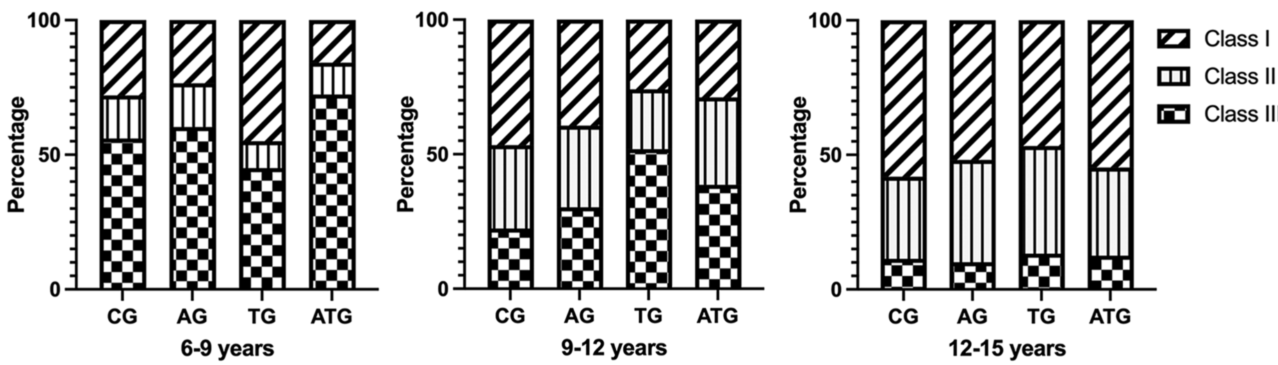

Fig. 2 Sagittal skeletal patterns in control group, adenoid hypertrophy group, tonsillar hypertrophy group and adenotonsillar hypertrophy group in different age groups. CG, control Group; AG, adenoid hypertrophy group; TG, tonsillar hypertrophy group; ATG, adenotonsillar hypertrophy group

group showed higher probability of Class III skeletal pattern (smaller SNB, ANB and SGn/FH, and larger Go-Me). Additionally, children in the ATG group also manifested a higher proportion of Class III skeletal pattern. In children aged 12–15 years old, no significant differences were observed among the CG, AG, TG and ATG groups.

Multivariable linear regression for age, cephalometric variables, and different obstructive sites of upper airway

After controlling for the age, gender, and BMI, multiple linear regression (Table 3) revealed a different association between obstructive lymphoid tissues and craniofacial variables. In children aged 6–9 years old, TG was positively correlated with Go-Me (unstandardized regression coefficient B = 2.6, 95%CI 0.1–5.2, $p=0.042$) when compared with CG. Similarly, ATG was positively correlated with Go-Me (unstandardized regression coefficient B = 2.2, 95%CI 0.2–4.1, $p=0.029$) when compared with CG. In other words, children with obstructive adenoids and tonsils or isolated tonsillar hypertrophy correlated with increased mandible body length. No significant association was found between adenoid hypertrophy and craniofacial variables. Among children aged 9–12 years old, AG was found to be related to a larger SGn/FH angle (unstandardized regression coefficient B = 1.5, 95%CI 0.5–2.4, $p=0.002$) when compared with CG. Children with isolated tonsillar hypertrophy correlated with protruded mandible, increasing mandible length and skeletal Class III pattern. Multiple linear regression analysis showed no significant association between cephalometric measurements and pharyngeal lymphoid tissue enlargement in children aged 12–15 years old.

Discussion

According to the MOSS functional matrix theory, respiratory function imbalance will cause changes in the growth and development of craniofacial and dentofacial structures, eventually leading to malocclusion [19]. Enlarged adenoids and tonsils may block the nasopharynx and oropharynx, causing the child to breathe through the mouth to obtain adequate airflow [20]. Several studies have investigated the association between obstructive adenoids and/or tonsils and their impact on craniofacial growth and development [8, 12–14, 21–23]. Since the impact of adenoids and tonsils on growth is generally concentrated before puberty, whether the impact is significantly different at different ages and growth and developmental stages has important clinical implications for the impact on facial development of clinical patients. However, traditional studies are unable to obtain corresponding growth and age groups due to small sample sizes and wide age ranges, leading to inconsistent and conflicting results in previous studies. To address this issue, this study divided children into three age groups to minimize the effect of age. Based on age groupings, this study found age-specific associations between craniofacial features and upper airway obstruction due to adenoid/tonsillar hypertrophy.

The nasopharyngeal space and oropharyngeal space develop and increase with age [24, 25]. Adenoids begin to grow in infancy. The peak age of adenoid growth occurs between 7 and 10 years old, and then gradually shrinks [12, 26–28]. The growth of the palatine tonsils reaches its peak at the age of 5 years [12, 29]. Therefore, excessive enlargement of adenoids and tonsils may have different

Table 3 Multiple linear regression analysis of cephalometric variables in adenoid hypertrophy group, tonsillar hypertrophy group, adenotonsillar hypertrophy group and control group

Predictor	AG [a]		TG [a]		ATG [a]	
	B(95%CI)	*p*-value	B(95%CI)	*p*-value	B(95%CI)	*p*-value
6–9 years						
Sagittal						
SNA (°)	-0.3(-1.8-1.2)	0.701	0.5(-1.5-2.5)	0.628	0.3(-1.2-1.8)	0.706
SNB (°)	-0.1(-1.9-1.7)	0.932	0.6(-1.7-3.0)	0.591	1.7(-0.1-3.5)	0.067
ANB (°)	-0.2(-1.8-1.4)	0.788	-0.2(-2.2-1.9)	0.887	-1.4(-3.0-0.2)	0.089
ANS-PNS (mm)	-0.2(-1.7-1.3)	0.799	0.4(-1.5-2.3)	0.699	-0.3(-1.8-1.2)	0.658
Go-Me (mm)	0.8(-1.2-2.8)	0.438	2.6(0.1–5.2)	0.042*	2.2(0.2–4.1)	0.029*
Vertical						
MP/SN (°)	-0.5(-2.9-1.8)	0.668	-0.8(-3.8-2.2)	0.610	-1.1(-3.4-1.2)	0.353
SN-PP (°)	0.3(-1.1-1.7)	0.692	-0.3(-2.1-1.5)	0.747	-0.9(-2.3-0.5)	0.220
Growth direction						
SGn/FH (°)	0.8(-0.9-2.5)	0.365	1.3(-0.9-3.4)	0.250	-0.9(-2.6-0.7)	0.265
9–12 years						
Sagittal						
SNA (°)	-0.5(-1.4-0.5)	0.307	-0.6(-1.7-0.5)	0.295	0.0(-1.0-0.9)	0.925
SNB (°)	-0.6(-1.7-0.4)	0.246	1.3(0.0-2.6)	0.042*	0.3(-0.7-1.4)	0.514
ANB (°)	0.1(-0.8-1.1)	0.757	-1.9(-3.0–0.8)	0.001**	-0.4(-1.3-0.5)	0.395
ANS-PNS (mm)	0.4(-0.5-1.3)	0.364	-0.2(-1.3-0.9)	0.709	-0.1(-0.9-0.8)	0.895
Go-Me (mm)	0.3(-1.5-0.8)	0.552	1.7(0.3-3.0)	0.015*	0.4(-0.7-1.5)	0.449
Vertical						
MP/SN (°)	0.6(-0.8-2.1)	0.389	-1.1(-2.8-0.7)	0.222	0.7(-0.7-2.1)	0.300
SN-PP (°)	0.5(-0.4-1.5)	0.278	-0.1(-1.2-1.0)	0.873	-0.2(-1.1-0.7)	0.725
Growth direction						
SGn/FH (°)	1.5(0.5–2.4)	0.002**	-0.9(-2.0-0.2)	0.115	0.2(-0.7-1.1)	0.689
12–15 years						
Sagittal						
SNA (°)	-0.1(-1.1-0.8)	0.760	0.6(-0.4-1.6)	0.236	-0.5(-1.5-0.5)	0.357
SNB (°)	-0.5(-1.5-0.5)	0.293	0.3(-0.8-1.4)	0.588	-0.8(-1.8-0.3)	0.171
ANB (°)	0.4(-0.4-1.1)	0.299	0.3(-0.5-1.1)	0.455	0.3(-0.5-1.1)	0.483
ANS-PNS (mm)	0.2(-0.7-1.2)	0.624	-0.1(-1.1-0.9)	0.903	-0.4(-1.4-0.7)	0.494
Go-Me (mm)	-0.4(-1.6-0.8)	0.505	0.7(-0.6-1.9)	0.298	0.7(-0.6-2.0)	0.293
Vertical						
MP/SN (°)	1.3(-0.3-2.9)	0.101	0.2(-1.5-1.9)	0.800	1.5(-0.2-3.2)	0.079
SN-PP (°)	0.4(-0.6-1.4)	0.467	-0.7(-1.7-0.4)	0.215	-0.3(-1.4-0.8)	0.604
Growth direction						
SGn/FH (°)	0.2(0.07–1.2)	0.616	0.2(-0.9-1.2)	0.768	0.7(-0.4-1.7)	0.212

AG, adenoid hypertrophy group, TG, tonsillar hypertrophy group, ATG, adenotonsillar hypertrophy group

B value: unstandardized regression coefficients representing age-, BMI- and sex-adjusted differences between groups

a Reference group: control group

* $p<0.05$, ** $p<0.01$, *** $p<0.001$

effects on craniofacial features at different ages. Previous studies have shown that children with adenoid hypertrophy present with increased sagittal differences between the maxilla and mandible, mandibular retrusion and excessive divergence [8, 12, 30]. In this study, we found that children aged 9 to 12 years with adenoid hypertrophy showed a vertical growth direction, consistent with previous studies. No other significant differences were found between adenoid hypertrophy and craniofacial morphology. Adenoid hypertrophy did not significantly affect craniofacial characteristics in children aged 6–9 and 12–15 years. Adenoid enlargement is currently considered to be the cause of many Class II patients in early childhood correction. This study shows that the presence of adenoid hypertrophy does not play such an important role in craniofacial development. For the cause of the patients with skeletal Class II pattern, it may be necessary to pay more attention to factors such as genetics and bad habits. Adenoid hypertrophy is normal in children aged 6 to 9 years and is a result of immune activity [31]. Therefore, it does not affect craniofacial parameters compared with children with normal-sized adenoids. These findings are consistent with the study of Chambi-Rocha and colleagues [32]. While in teenagers (aged 9–12 in the present study), the adenoids start to shrink. Enlarged adenoids force patients to downward their mandible to breathe properly, resulting in vertical growth direction. In adolescents aged 12–15, the dimensions of the nasopharyngeal section increase with the growth of other body tissues. During this growth period, the adenoids start to diminish, which alleviates the effect of adenoid hypertrophy on craniofacial growth. Furthermore, changes in maxillofacial development appear as a result of long-term disease duration rather than the presence of the disease [21].

Hypertrophied tonsils can cause obstructions in the oropharyngeal airway and force the tongue to posture forward, eventually lead to mandibular forward growth [19, 33]. The present study showed children aged 6 to 9 with tonsillar hypertrophy were characterized by longer mandible. In addition, at 9 to 12 years of age, children with obstructive palatal tonsils showed a correlation with a longer mandibular body, a more anterior mandible, and a horizontal skeletal Class III pattern. Similar to previous studies, our findings suggest that larger tonsil size is associated with more horizontal facial growth and a more prognathic face [12]. The findings confirm that oropharyngeal obstruction forces the tongue to posture forward, resulting in increased mandible body length. It is speculated that the oropharyngeal space is smaller than the nasopharyngeal space, making the oropharynx more prone to obstruction in early childhood [32].

Previous studies have shown that children with adenoidonsillar hypertrophy exhibit the combined characteristics of adenoid enlargement and tonsillar obstruction [9, 10]. Some researchers also believe that children with obstructive adenoids and tonsils are associated with mandibular retrusion, increased sagittal difference between the maxilla and mandible, steep mandible, and a higher incidence of Class II relationship, which is similar to children with simple adenoidal hypertrophy [11, 12]. However, adenotonsillar hypertrophy was associated with increased mandibular body length and horizontal growth direction in children aged 6 to 9 years in this study. Among children aged 9–12 years, the proportion of skeletal type III was higher in the adenotonsillar hypertrophy group. Simultaneous obstructive adenoids and tonsils can affect breathing patterns and induce a horizontal growth pattern in children aged 6–9 years. In children with adenoid hypertrophy, hypertrophic tonsils appear to have a greater impact on respiratory patterns than hypertrophic adenoids, resulting in craniofacial features characterized by a skeletal Class III pattern similar to that in the TG group. Due to the difference in growth and development of the maxilla and mandible between 6 and 8 years of age, the growth of the maxilla exceeds that of the mandible at this stage. Taking this into account, this study shows that the tonsils may play a more important role in craniofacial morphology. This study suggests that clinical growth and development monitoring of patients during the mixed dentition period should focus more on pathological changes in the tonsils, bad habits and abnormal muscle function. Adenotonsillectomy or orthodontic treatment (including functional therapy and some early orthodontic treatment) may help relieve upper airway obstruction and prevent the development of craniofacial structural abnormalities caused by upper airway obstruction [34–36].

Overall, the enlargement of adenoids and tonsils may contribute to craniofacial development mainly in age group of 9–12. In clinical practice, if enlarged adenoids or tonsils are found on a lateral cephalogram in a child aged 9–12 years, the child should be advised to see an otolaryngologist for further evaluation and, if necessary, to undergo adenotonsillectomy or other treatment of the enlarged adenoids and tonsils to avoid adverse effects on the child's craniofacial development. In the field of orthodontics, appropriate early treatment means can be used depending on the situation. While in children aged 12–15 years old, obstructive adenoids and tonsils showed no significant association with craniofacial features. The underlying reason for this finding is that the growth and development of the pharyngeal airway space is near maturity at the age of 12 to 15. And adenoids and tonsils shrink at this stage, resulting in a decrease in the severity of obstruction [12, 26, 37].

There are several limitations in present study. First, the retrospective study design may have introduced referral bias into the study population. Second, the study was based on lateral cephalogram, a two-dimensional imaging method. However, standardized lateral cephalogram is routinely used for orthodontic diagnoses and still suitable for evaluating craniofacial and pharyngeal airway characteristics since it is easy, well-standardized, low-cost, low-radiation and is widely available in the majority of hospitals [38, 39]. Third, our study only focused on the influence of enlarged adenoids and tonsils on craniofacial structure, but did not explore the underlying factors (such as hormones and inflammation) that cause enlarged adenoids and tonsils. Fourth, samples of the study came from children in orthodontic departments, making them not representative of the general population. Further longitudinal studies are necessary to investigate the association between pharyngeal lymphoid tissues enlargement and altered craniofacial features in the general population.

Conclusion

In children aged 9–12 years old with isolated adenoid hypertrophy, a vertical growth direction is exhibited. Isolated tonsil hypertrophy in children aged 6–9 years old and teenagers aged 9–12 years old is correlated with a longer mandibular body, a more anterior mandible, and a skeletal Class III horizontal pattern. The combination of obstructive adenoids and tonsils manifests similarly to children with isolated tonsil hypertrophy. Adolescents (aged 12–15) showed no effect on craniofacial morphology from adenoid and tonsil enlargement.

Abbreviations

OSA	Obstructive sleep apnea
AH	Adenoid hypertrophy
TH	Tonsillar hypertrophy
ATH	Adenotonsillar hypertrophy
BMI	Body mass index

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Not applicable.

Author contributions

Liping Huang helped with the interpretation of the data and mainly wrote of the manuscript. Liping Huang and Liyuan Zheng collected the data and assisted with statistical analysis. Xiaobo Chen assisted with study design and supervised data collection. Liping Huang conceived the idea, conducted the study and helped with interpretation of the results. Yuming Bai designed the study, supervised data collection, analyzed the data and supervised writing.

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Not applicable.

Data Availability

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics and consent to participate

The retrospective study was approved by Ethics Committee of Stomatological Hospital of Xiamen Medical College (KS20240119001). All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. Written consent was waived by the Ethics Committee of Stomatological Hospital of Xiamen Medical College for this retrospective study because the data and patient details were anonymized.

Consent for publication

Not applicable

Competing interests

The authors declare no competing interests.

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