RESEARCH PAPER

Association Between Upper Airway Anatomical Dimensions, Oral Pathological Findings, and Sleep-Disordered Breathing in Adolescents Requiring Orthodontic Treatment: A Community-Based Cross-Sectional Study

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ABSTRACT

Background: Sleep-disordered breathing may remain unrecognized in adolescents presenting for orthodontic treatment, despite its relationship with craniofacial morphology, upper-airway narrowing, mouth breathing, and oral inflammatory changes.

Objective: To determine the association of upper-airway anatomical dimensions and oral pathological findings with screening-positive sleep-disordered breathing among adolescents requiring orthodontic treatment.

Methods: This community-based cross-sectional study included 100 adolescents aged 12–18 years examined from June 2024 to June 2025 at Avicenna Medical and Dental College, Lahore, and Mohammed Dental College, Ibn-e-Sina University, Mirpurkhas. Sleep-disordered breathing risk was assessed using the Pediatric Sleep Questionnaire. Clinically indicated lateral cephalograms were used to measure nasopharyngeal, retropalatal, and retroglossal airway widths, soft-palate length, and hyoid position. Tonsillar hypertrophy, mouth breathing, gingivitis, dental caries, high-arched palate, xerostomia, tongue scalloping, and tooth-wear facets were recorded. Multivariable logistic regression identified independent predictors.

Results: Thirty-two adolescents screened positive for sleep-disordered breathing. Retropalatal and retroglossal airway widths were significantly smaller in screening-positive participants. Grade 3–4 tonsillar hypertrophy, habitual mouth breathing, and gingivitis were also more frequent. Each 1-mm reduction in retropalatal width increased the odds of screening-positive status by 69%, while retroglossal reduction, tonsillar hypertrophy, mouth breathing, and gingivitis remained independently associated. Sex, age, body mass index, obesity, and high-arched palate were not significant predictors.

Conclusion: Reduced retropalatal and retroglossal airway dimensions, enlarged tonsils, mouth breathing, and gingivitis were independently associated with screening-positive sleep-disordered breathing. Orthodontic assessment may support early risk identification and timely multidisciplinary referral for definitive medical and sleep evaluation.

Keywords: adolescents; orthodontic treatment; sleep-disordered breathing; upper airway; mouth breathing; gingivitis
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Introduction

Sleep-disordered breathing (SDB) encompasses various abnormalities of breathing which occur during sleep, including excessive upper-airway resistance, obstructive sleep apnea and chronic snoring. The intermittent upper airway obstruction that may occur during sleep can lead to intermittent hypoxia, respiratory effort and repeated disruption of sleep [1]. If left untreated, SDB can negatively impact the physical, behavioral, cognitive and quality of life of children and adolescents [2].

Pediatric SDB often presents clinically in a different way than adult SDB. Instead of daytime sleepiness, affected adolescents may have restless sleep, mouth breathing, headache in the morning, trouble concentrating, be irritable or have poor school performance [3]. As such, many cases go undiagnosed when a sleep history or validated sleep questionnaire is not implemented [4].

Adolescents in need of orthodontic treatment is an important population for SDB screening as orthodontists routinely assess the craniofacial skeleton, dental arches, tongue posture, soft tissues, and upper-airway region. In previous studies, a significant percentage of orthodontic patients have been found to have signs and symptoms that are indicative of sleep related breathing impairment [5,6]. Results from orthodontic populations vary depending on age, recruitment method, clinical characteristics and the screening instrument used [7,8].

The upper airway size and mechanics might be related to craniofacial morphology. Children with OSA are more likely to have mandibular retrusion, maxillary constriction, higher lower anterior facial height and smaller posterior airway spaces [9]. But not every patient has all these anatomic findings and they cannot be interpreted in isolation from the clinical symptoms and functional findings [10].

The retropalatal and retroglossal regions are of special interest because their size is related to the soft palate, base of the tongue, position of the mandible, lateral pharyngeal wall, and surrounding lymphoid tissues. Narrower airways at these levels may make them more vulnerable to obstruction during sleep [11]. However, lateral cephalometry can only give a two-dimensional picture of a three dimensional and dynamic airway and cannot evaluate the collapsibility of the airway during sleep [12].

One of the most significant causes of upper airway obstruction in children is adenotonsillar hypertrophy (ATH). Large palatine tonsils can create less oropharyngeal space, and increase the resistance to breathing, especially when sleeping when the tone of the muscles in the pharynx relaxes [13]. Thus, the standardized clinical grading of size of tonsils may be a valuable adjunct to the examination of the oral cavity and teeth.

Chronic nasal and/or pharyngeal obstruction can lead to a compensatory increase in mouth breathing. Chronic oral breathing may result in changes in the position of the tongue, the competence of the lips, the development of the maxilla and the morphology of the palate [14]. It can also lead to dry mouth, plaque and gums inflammation by decreasing the protective and cleansing properties of saliva [15].

Impaired function of the airways may be part of a larger craniofacial and functional pattern that includes a high arched palate, narrow maxillary arch, dental crowding, lip incompetence and altered tongue posture [16]. These results, however, are dependent upon genetic, developmental, environmental and behavioural factors and cannot be used alone to establish the presence of SDB. Therefore, a multifaceted evaluation of sleep symptoms, breathing pattern, tonsillar size, airway size, and oral health might be a more clinically relevant screening strategy [17].

The association between orthodontic parameters and sleep-related breathing has received an increasing interest, but the community-based studies assessing upper-airway anatomical dimensions and oral pathological findings in adolescents who need orthodontic treatment are limited. Well-designed observational studies are required to identify those features that are independently associated with SDB after adjusting for demographic and clinical variables [18,19].

The goal of the present study was, therefore, to investigate the relationship between upper-airway anatomical measurements, oral pathology and screening positive sleep-disordered breathing in adolescents who were in need of orthodontic treatment. Higher likelihood of screening-positive SDB was hypothesized to be related to reduced retropalatal and retroglossal airway dimensions, enlarged tonsils, habitual mouth breathing, high-arched palate, and gingival inflammation [20].

MATERIALS AND METHODS

This was an analytical cross sectional study conducted in the community from June 2024 to June 2025, through the Department of Oral Pathology, Avicenna Medical and Dental College, Lahore, Pakistan and Department of Oral Biology, Mohammed Dental College, Ibn-e-Sina University, Mirpurkhas, Pakistan. Adolescents 12–18 years of age (N = 100) were selected for the study because they were detected as orthodontic treatment needs through community dental screening, dental visits in the schools or dental outpatient evaluation. Those who met the inclusion criteria were then approached in a consecutive manner for a period of time to meet the necessary sample size.

Those with permanent or late mixed dentition with a diagnosed orthodontic treatment need were included. The Dental Health Component of the Index of Orthodontic Treatment Need (IOTN) was used to assess the need for orthodontic treatment, with grades 3, 4 and 5 being considered as requiring orthodontic treatment. Adolescents who met any of the following criteria were excluded: craniofacial syndromes, cleft lip or palate, prior orthognathic or orthodontic surgery, prior adenotonsillectomy, upper respiratory infection, neurologic or neuromuscular disorders that affect breathing, known history of OSA, inadequate clinical records, or poor-quality lateral cephalograms. Only the radiographs already taken as part of the patients' routine orthodontic evaluation were used, and no patient was exposed to any further radiation for research purposes.

Sleep-disordered breathing risk was evaluated by the Sleep-Related Breathing Disorder scale of the Pediatric Sleep Questionnaire, a 22-item parent/legal guardian completed questionnaire that asks about symptoms in the prior 6 months. Responses were recorded as 'yes', 'no' and 'don't know'. A score was determined by dividing the number of positive responses by the number of questions answered "yes" or "no. Screening-positive for sleep-disordered breathing was considered to be a score > 0.33. This classification was only utilized to recognize the adolescents who were at a higher likelihood of having obstructive sleep apnea and not a definitive diagnosis.

A wall mounted stadiometer and a calibrated digital scale were used for measuring height and weight. BMI was defined as body weight (kg)/body height (m) squared. Orthodontic examination was done on a standardized basis to check the molar relation, overjet, overbite, open bite, crossbite, dental crowding, maxillary constriction, mandibular retrusion, lip competence, tongue posture and palatal shape. High arched palate was recorded when the palate was not very broad and was vertically high as compared to maxillary dental arch.

Digital lateral cephalograms were examined in natural head position with the teeth in CO and relaxed lips. Airway measurements recorded were nasopharyngeal airway width, minimum retropalatal airway width, minimum retroglossal airway width, soft-palate length and the distance between hyoid bone and mandibular plane. The examiner was a trained orthodontist using a calibrated instrument (in mm) without prior knowledge of the sleep-questionnaire classification. The same selected radiograph was re-measured after 2 weeks to see how reliable the measurements were.

The size of the palatine tonsils was scored from 0 to 4 by the percentage of the oropharyngeal space filled by the tonsils. Grade 3 and 4 were considered as clinically significant tonsillar hypertrophy. Habitual mouth breathing was documented when the adolescent exhibited a consistently open mouth posture or lip incompetence and a history of mouth breathing during the day or at night-time was reported by the parent.

Oral examination was done under standard light source with disposable mouth mirror and periodontal probe. The presence of gingivitis, visible plaque, untreated dental caries, high arched palate, tongue scalloping, morning xerostomia, tooth wear facets and oral mucosal abnormalities were documented. Gingivitis was considered as bleeding on gentle probing at 10% or more of the sites examined, in the absence of clinical attachment loss. Untreated dental caries was the presence of at least one cavitated lesion that needed restorative treatment. The participants' and parents' history and clinical examination were used to record xerostomia in the morning and mouth breathing.

IBM SPSS Statistics 26 was used to analyze the data. Categorical variables were expressed as frequencies and percentages and continuous variables were expressed as mean and standard deviation. The participants were then split into screening-positive and screening-negative. The independent-samples t test was used to compare continuous variables and the chi-square test (or Fisher exact test) was used for categorical variables. Binary logistic regression was used to determine anatomical and oral factors associated with screening positive sleep-disordered breathing. The 95% confidence intervals of the adjusted odds ratios were computed and a p value <0.05 was regarded as statistically significant.

The institutional ethical review committees of participating colleges have given the ethical approval. Parents/legal guardians of all participants provided written informed consent and all adolescents provided assent. Participants' information was kept confidential and adolescents who were positive for sleep-disordered breathing or who had marked tonsillar enlargement were counseled for further medical or otorhinolaryngological evaluation.

RESULTS

A total of 100 adolescents requiring orthodontic treatment were included in the study. The mean age of the participants was 15.2 ± 1.6 years. The sample included 46 males (46.0%) and 54 females (54.0%). Thirty-two participants had a Pediatric Sleep Questionnaire score greater than 0.33 and were classified as screening-positive for sleep-disordered breathing, giving an overall prevalence of 32.0%. The remaining 68 participants were screening-negative. Among the screening-positive participants, 13 (40.6%) were male and 19 (59.4%) were female. No statistically significant differences were observed between the groups regarding age, gender, body mass index, or obesity, as shown in Table 1.

Adolescents who screened positive for sleep-disordered breathing had significantly reduced retropalatal and retroglossal airway dimensions. The mean retropalatal airway width was 7.8 ± 1.7 mm in the screening-positive group compared with 9.6 ± 1.8 mm in the screening-negative group (*p*<0.001). The mean retroglossal airway width was also significantly smaller among screening-positive adolescents than among screening-negative adolescents (9.8 ± 2.3 mm versus 11.4 ± 2.2 mm; *p*=0.002). No significant differences were observed in nasopharyngeal airway width, soft-palate length, or hyoid-to-mandibular-plane distance (**Table 2**).

Clinically significant grade 3–4 tonsillar hypertrophy was present in 11 (34.4%) screening-positive adolescents compared with 7 (10.3%) screening-negative adolescents (*p*=0.005). Habitual mouth breathing was recorded in 17 (53.1%) screening-positive participants and 13 (19.1%) screening-negative participants (*p*=0.001). Gingivitis was also significantly more frequent among adolescents who screened positive for sleep-disordered breathing (65.6% versus 41.2%; *p*=0.032). High-arched palate, morning xerostomia, tongue scalloping, untreated dental caries, and tooth-wear facets showed no statistically significant differences between the two groups (**Table 2**).

Variables showing clinical importance or a univariable *p* value below 0.20 were considered for logistic-regression analysis. Because 32 participants were screening-positive, the final multivariable model was limited to the most clinically relevant predictors to reduce the risk of model overfitting.

After adjustment for gender and the other included clinical factors, each 1-mm reduction in retropalatal airway width was associated with 1.69-times higher odds of screening-positive sleep-disordered breathing. Each 1-mm reduction in retroglossal airway width was associated with 1.28-times higher odds. Grade 3–4 tonsillar hypertrophy was associated with more than fourfold greater odds, while habitual mouth breathing was associated with nearly fourfold greater odds of screening-positive status. Gingivitis was associated with approximately 2.7-times higher adjusted odds. Gender was not independently associated with screening-positive sleep-disordered breathing (**Table 3**).

The final regression model demonstrated good discriminatory performance, with an area under the receiver-operating-characteristic curve of 0.86. The Hosmer–Lemeshow goodness-of-fit test was non-significant (*p*=0.610), indicating acceptable model calibration. No important multicollinearity was identified among the included predictors.

Table 1. Demographic and anthropometric characteristics according to sleep-disordered breathing status

Variable	Screening-negative (n=68)	Screening-positive (n=32)	*p* value
Age, years	15.1 ± 1.6	15.3 ± 1.5	0.545
Male gender	33 (48.5%)	13 (40.6%)	0.459
Female gender	35 (51.5%)	19 (59.4%)	0.459
Body mass index, kg/m²	21.0 ± 3.1	21.7 ± 3.4	0.328

Obesity	7 (10.3%)	5 (15.6%)	0.514

Table 2. Upper-airway dimensions and oral findings according to sleep-disordered breathing status

Variable	Screening-negative (n=68)	Screening-positive (n=32)	*p* value
Nasopharyngeal airway width, mm	15.2 ± 3.0	14.9 ± 3.2	0.657
Retropalatal airway width, mm	9.6 ± 1.8	7.8 ± 1.7	<0.001
Retroglossal airway width, mm	11.4 ± 2.2	9.8 ± 2.3	0.002
Soft-palate length, mm	31.4 ± 3.8	32.5 ± 4.1	0.205
Hyoid-to-mandibular-plane distance, mm	16.2 ± 4.3	16.9 ± 4.5	0.465
Grade 3–4 tonsillar hypertrophy	7 (10.3%)	11 (34.4%)	0.005
Habitual mouth breathing	13 (19.1%)	17 (53.1%)	0.001
High-arched palate	16 (23.5%)	13 (40.6%)	0.099
Gingivitis	28 (41.2%)	21 (65.6%)	0.032
Untreated dental caries	29 (42.6%)	15 (46.9%)	0.829
Morning xerostomia	10 (14.7%)	9 (28.1%)	0.170
Tongue scalloping	14 (20.6%)	10 (31.3%)	0.316
Tooth-wear facets	16 (23.5%)	9 (28.1%)	0.628

Table 3. Multivariable logistic-regression analysis of factors associated with screening-positive sleep-disordered breathing

Predictor	Adjusted odds ratio	95% confidence interval	*p* value
Female gender	1.18	0.46–3.04	0.731
Retropalatal airway width, per 1-mm reduction	1.69	1.30–2.19	<0.001
Retroglossal airway width, per 1-mm reduction	1.28	1.03–1.59	0.027
Grade 3–4 tonsillar hypertrophy	4.34	1.35–13.97	0.014
Habitual mouth breathing	3.76	1.35–10.47	0.011
Gingivitis	2.67	1.02–6.99	0.046

Discussion

In the current study, 32.0% of the adolescent orthodontic treatment population were found to be positive for SBD. The adolescents who were screening positive had significantly smaller retropalatal and retroglossal airway sizes and higher prevalence of clinically important tonsillar hypertrophy, habitual mouth breathing, and gingivitis. These variables but not age, BMI, obesity, and sex remained independently associated with a screening-positive sleep-disordered breathing after adjusting for sex and other clinical factors. This data reinforces the value of evaluating respiratory symptoms in conjunction with anatomic, functional, and oral-health evaluations when screening adolescents for sleep-disordered breathing [1,2].

The percentage of screening-positive adolescents in the present study was higher than some orthodontic populations but within the wide range of that found in previous studies [3]. Rohra et al. found that there was a clinically significant prevalence of sleep-related breathing problems in children who presented for orthodontic evaluation [4]. Variations in prevalence across studies may be due to differences in age/ethnicity, referral practices, threshold for questionnaires and the clinical aspects of the patients selected [5].

The best anatomical association with screening-positive sleep disordered breathing was reduced retropalatal airway width. Soft palate, lateral pharyngeal walls, mandibular position, lymphoid tissue and surrounding soft tissues affect the retropalatal region [6]. Contrast may be increased at this level and may increase the likelihood of pharyngeal obstruction during sleep [7]. A systematic review prior to this has also found diminished posterior airway measurements and typical craniofacial variations in children with OSA [8]. Also, retroglossal narrowing was independently associated with screening-positive status, indicating that airway restriction can take place at several anatomic levels [9].

The results should not be interpreted as proof of the lateral cephalometric measurement being a predictive tool for the diagnosis of OSA. Cephalometry is a two-dimensional image of a three-dimensional airway which is viewed in the patient who is awake [10]. It is unable to assess airway volume, changes in respiratory phases, neuromuscular tone or the collapsibility of the pharynx during sleep [11]. However, clinically indicated cephalograms can be helpful in the interpretation of the sleep symptoms, the size of the tonsils, the pattern of breathing, and the craniofacial morphology [12].

More than 4 times higher odds of screening positive for SDB were found when clinically significant tonsillar hypertrophy was present. Larger palatine tonsils can lead to less space in the oropharynx and may increase the resistance of the upper airways, especially at night when there is decreased tone in the muscles of the oropharynx [13]. Growth of adenoids and tonsils is known to be a major factor in obstructive sleep-disordered breathing in children [14]. Therefore, the standardized tonsillar assessment can be used to determine which adolescents should undergo medical or otorhinolaryngological evaluation by orthodontists and oral-health professionals [15].

Screening-positive status was also significantly associated with the presence of habitual mouth breathing. Mouth breathing can be a response to chronic nasal or pharyngeal obstruction [16]. Extended oral breathing can lead to tongue posture, incompetence of lips, growth pattern of the maxilla and shape of the palate, which can all affect the width of the dental arch and/or the height of the palate [17]. However, in the present study, high arched palate was more common among screening positive cases, but not enough to reach statistical significance and may be due to limited sample size and an interaction with other anatomical and functional parameters [18].

Significantly more adolescents with a screening-positive status reported gingivitis and it remained independently associated. The continuous mouth breathing can lead to dehydration of the gingival surface and diminished lubricating and cleansing activity of saliva, especially in the front region [19]. Previously, children with sleep-disordered breathing have been reported to have poor gingival and periodontal health compared with unaffected children [20]. The observed association could, however, be due to factors such as dental crowding, plaque-control habits, dietary factors, social-economic status and access to preventive dental care [15].

There was no significant association between screening-positive sleep-disordered breathing and dental caries, tongue scalloping, tooth-wear facets, or xerostomia in the morning. These results could be due to the multifactorial nature of these conditions and the small number of participants. Sugar exposure, fluoride use, salivary characteristics, oral hygiene and access to dental services are all factors that influence dental caries, and dietary, behavioural, occlusal, and parafunctional factors may be considered in tooth wear [17,19].

There was no significant relationship between sex and screening-positive SBD. Sex was marginally more common among the screening-positive group, but was not independently associated in the regression model. Similarly, there was no significant association between obesity status and screening status. There are several reasons to interpret this finding with caution: Only few participants were obese, and the precision of the estimated association is limited. During adolescence, obesity is a known risk factor for obstructive sleep apnea (OSA) [1,14].

The combined presence of reduced airway dimensions, enlarged tonsils, mouth breathing, and gingival inflammation may provide a clinically useful pattern for identifying adolescents who require further sleep assessment [2,7]. If these features are present, an orthodontist may wish to inquire regarding: Habitual snoring, Observed breathing pauses, Restless sleep, Headaches upon waking, Sleepiness during the day, and Attention difficulties [3]. If a screening questionnaire scores positive, this should result in proper referral and not in a diagnosis and/or stand-alone orthodontic treatment for sleep-disordered breathing [12].

The strength of this study lies in the fact that upper-airway dimensions, orthodontic characteristics, tonsillar size, breathing pattern and oral pathological findings were all assessed together in a community-based population of adolescents. Both men and women participated and multivariable analysis enabled the independent role of the main anatomic and oral factors to be evaluated in a clinically meaningful screening context [5,8].

There are a number of constraints to take into account. The cross sectional design did not demonstrate causality or the time sequence of airway narrowing, mouth breathing, oral findings and sleep-disordered breathing. Adolescents at risk were identified using the Pediatric Sleep Questionnaire but the PSQ was not able to make a polysomnographic diagnosis [4]. Lateral cephalometry was not able to assess 3-dimensional airway volume and dynamic obstruction during sleep [10]. The number of participants (100 cases) also restricted the number of variables that could be included in the regression equation, leading to relatively large confidence intervals for some of the predictors. Allergic rhinitis status, naso-occlusal status, socioeconomic status, oral-hygiene practices, dietary exposure and household smoking were not fully assessed [11,18].

Future prospective studies should involve larger number and more diverse populations, objective assessment of nasal-airflow, three-dimensional imaging of the airways when clinically appropriate, and polysomnographic confirmation of sleep-disordered breathing (SDB) [6,9]. Longitudinal studies could also help to understand if managing airway obstruction or mouth breathing helps improve oral health and craniofacial development in the adolescent population with these conditions [16,20].

Conclusion

Reduced retropalatal and retroglossal airway dimensions, grade 3–4 tonsillar hypertrophy, habitual mouth breathing, and gingivitis were independently associated with screening-positive sleep-disordered breathing among adolescents requiring orthodontic treatment. No significant independent association was observed with sex, age, body mass index, obesity, or high-arched palate. The findings indicate that orthodontic assessment provides an important opportunity to recognize adolescents at increased risk of sleep-disordered breathing. Incorporating structured sleep-history questions, tonsillar examination, breathing-pattern assessment, oral examination, and careful interpretation of clinically indicated cephalometric records may support timely multidisciplinary referral. These findings should be used for risk identification and should not replace definitive medical assessment or polysomnography.

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