Original Article

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Dentistry Section

Cephalometric Evaluation of Facial Pattern and Hyoid Bone Position among Six to Nine-Year-Old Children with and without Obstructive Sleep Apnoea: A Cross-sectional Observational Study

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ABSTRACT

Introduction: Obstructive Sleep Apnoea (OSA) is characterised by repeated instances of the upper airway partially or completely collapsing during sleep, leading to a decrease in airflow (hypopnoea) or a complete absence of airflow (apnoea) that lasts for at least 10 seconds. Craniofacial structure and hyoid bone position significantly influence airway patency. Cephalometric evaluation of these parameters in children with and without OSA can help identify early morphological indicators of airway obstruction.

Aim: To cephalometrically evaluate and compare the facial pattern and hyoid bone position among six to nine-year-old children with and without OSA in Visnagar, Gujarat, India.

Materials and Methods: A cross-sectional observational study was conducted at the Department of Paediatric and Preventive Dentistry, Narsinhbhai Patel Dental College and Hospital (NPDCH), Sankalchand Patel University (SPU), Visnagar, Mehsana, Gujarat, India from July 2023 and September of 2023. A total of 60 subjects, aged six to nine years, were divided into two groups: Group A (n=30) children diagnosed with OSA and Group B (n=30) children without OSA. Twelve parameters were examined in the lateral cephalometric study. An Independent t-test was used as the statistical analysis. A p-value<0.05 was considered statistically significant.

Results: Compared to the control group, children with OSA demonstrated significantly greater anterior lower facial height (p=0.035) and total anterior facial height (p<0.001), increases in the amount of anterior and inferior hyoid bone positions, and narrow upper and lower pharyngeal airway spaces (p<0.001).

Conclusion: The research indicates that children who have OSA experience significant and early changes in the growth and development of their faces. Children with OSA have an apparent rise in their lower and total anterior face heights. OSA patients were shown to have a more inferior and anterior hyoid bone location than healthy nasal breather children, with statistically significant differences.

Keywords: Airway obstruction, Radiography, Sleep Apnoea

INTRODUCTION

Sleep is increasingly recognised as a critical component of healthy development and overall health [1]. OSA is a condition characterised by episodes of complete or partial obstruction of the upper airway, associated with blood-gas changes and atypical sleep patterns [2]. OSA impacts a range of individuals, with prevalence rates of 1-6% in children, up to 59% in obese children, 2-24% in adults, and 70% in patients who have undergone bariatric surgery [3]. Fernandes S et al., conducted a survey and suggested the prevalence of OSA in Visnagar taluka, Mehsana district, Gujarat, was 8.13% [4].

The most common cause of OSA in children is tonsil hypertrophy [5]. Enlarged tonsils and adenoids are well-known to cause higher nasal airway resistance and reduced pharyngeal volume, leading to nasal obstruction and subsequent mouth breathing. In addition, upper airway collapse can occur, caused by various factors, such as obesity and craniofacial anomalies. Obesity increases the risk of OSA by narrowing the upper airway through increased tissue mass, reduced muscle tone, and changes in functional mechanisms modulating upper airway patency. Obesity-related paediatric OSA may be more prevalent in older age groups compared to those where tonsil and adenoid enlargement is the predominant cause. Craniofacial abnormalities are structural defects in the face and skull that can result from genetics, birth defects, or environmental exposures. Common skeletal abnormalities linked to OSA include micrognathia and midface hypoplasia, along with associated congenital disorders such as Down syndrome, Pierre Robin sequence, and Treacher Collins syndrome. Neuromuscular compensations or regulations are related to arousal, respiratory effort, neuromuscular reflexes in the upper airway, and neuromuscular disorders such as Duchenne muscular dystrophy and spinal muscular atrophy [6].

The signs and symptoms are divided into two types: daytime and night-time. Daytime symptoms are mouth breathing, nasal obstruction, daytime sleepiness and poor growth, while night-time symptoms are snoring, pauses of breathing, restless sleep, and enuresis [6]. These might cause behavioural problems, such as hyperactivity, irritability, or even aggression, as well as other behavioural and neurocognitive abnormalities. These alterations frequently show up in children as issues with social adjustment and inferior academic performance. Examination findings could include hypertrophied tonsils, adenoidal facies, high arched palate, allergic shiners, swollen nasal mucosa, micrognathia and macroglossia [7,8].

The gold standard for diagnosis of OSA is attended polysomnography (level I study), which involves the collection of seven or more data channels, including electroencephalogram and electro-oculogram for sleep staging, electromyogram,

electrocardiogram, and respiratory channels. Home-based polysomnography (level II study) is not commonly used except for research [9]. Lateral cephalography is useful for evaluating skeletal and soft-tissue characteristics associated with OSA and may aid in craniofacial assessment. It is widely available in most dental clinics, relatively easy to perform, and less expensive than polysomnographic examination [10]. Several tests/questionnaires are available to screen OSA in a large populations, such as the BEARS sleep screening tool (Bedtime problems, Excessive daytime sleepiness, Awakenings during the night, Regularity and duration of sleep, and Snoring), which was used for screening sleep-related problems, FAIREST-6 (Functional Airway Evaluation Screening Tool-6) questionnaire, Berlin Questionnaire, etc.

Lack of treatment of sleep-related breathing disorders places patients at risk of developing growth delay, hyperactivity, attention deficits, learning disabilities and also increases the use of healthcare services and associated costs. It has been reported that the severity of OSA directly correlates with total annual healthcare costs and is age independent [1]. Early detection, diagnosis and treatment are critical for avoiding serious consequences [7].

Craniofacial growth and airway dimensions undergo significant changes between six and nine years of age- a period marked by transition from primary to mixed dentition and rapid skeletal development- evaluating facial pattern and hyoid bone position in this age group is especially relevant. Understanding these cephalometric correlations can assist in early detection of children at risk for OSA, enabling timely orthodontic or medical interventions to promote normal growth and airway function. Hence, this study aimed to cephalometrically evaluate and compare the facial pattern and hyoid bone position among six to nine-year-old children with and without OSA.

The primary objective of the study was to assess the pharyngeal airway space changes between children with and without OSA, while the secondary objectives were to compare the hyoid bone position and the anterior total and lower facial height in children with or without OSA.

Null Hypothesis (H_0): There is no significant difference in the facial pattern and hyoid bone position between children aged six to nine years with OSA and those without OSA.

Alternative Hypothesis (H_1): There is a significant difference in the facial pattern and hyoid bone position between children aged six to nine years with OSA and those without OSA.

MATERIALS AND METHODS

A cross-sectional observational study was conducted at the Department of Paediatric and Preventive Dentistry, NPDCH, SPU, Visnagar, Mehsana, Gujarat, India, from July 2023 to September 2023. The Ethics Committee of the College of Dentistry Research Centre at the University approved (Reg.No: NPDCH/IEC/2023/116). The CTRI number for the present study is CTRI/2023/11/059712. The study was performed with the written informed consent of parents/caregivers.

Sample size calculation: Considering an alpha error of 1% (Zα/2=2.576), study power of 99% (Zβ=2.326), pooled standard deviation (σ)=7.25, and expected mean difference (d)=10, the minimum required sample size was calculated to be 26 participants per group. To compensate for possible dropouts and improve statistical reliability, the sample size was increased to 30 participants in each group, resulting in a total sample size of 60 children.

Inclusion criteria: Children diagnosed with OSA were included in Group A, while healthy nasal breathing children without OSA were included in Group B. Children with no history of orthodontic treatment, genetic syndromes, recent acute upper airway infection, adenoidectomy or tonsillectomy were considered.

Exclusion criteria: Patients who had adjuvant orthodontic, speech therapy, or oto-rhino-laryngologic treatment, as well as patients with systemic and genetic disorders was excluded from the study.

Study Procedure

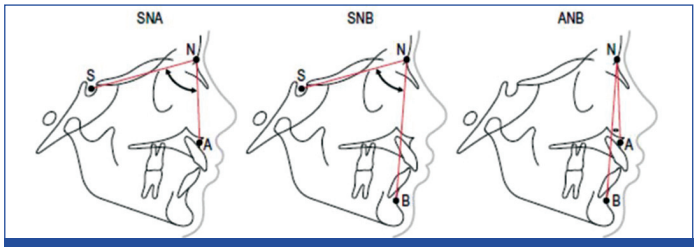
Each subject was assessed based on selection criteria and only those fulfilling the criteria were considered as eligible for selection into the study. Eligible subjects would be divided into two groups:

- Group A (n=30) - Patients from the experimental group were randomly selected from Visnagar who were screened for risk of OSA using the Functional Airway Evaluation Screening Tool (FAirEST-6) and BEARS questionnaires, followed by clinical evaluation for case allocation.
- Group B (n=30) - Patients from the control group, who were healthy nasal breathers were chosen at random from the study Institute (Group B) [8,11].

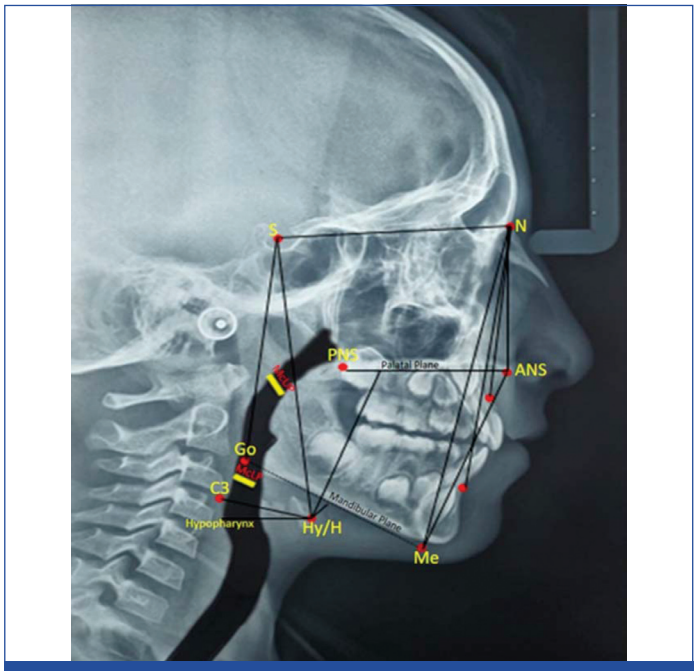
Lateral cephalographic radiographs were taken in a normal standing position, where the tongue will be in rest position, lips will be in relaxed position, head in normal position and teeth in maximum intercuspation.

Cephalometric analyses were performed independently by single calibrated examiners (postgraduate residents under the supervision of a faculty member with more than 10 years of experience). Examiner underwent training for landmark identification and tracing procedures. Intra-examiner reliability was evaluated by repeating measurements on 10 randomly selected radiographs after two weeks. The Intraclass Correlation Coefficient (ICC) values ranged from 0.85 to 0.92, indicating excellent reproducibility.

A complete orthodontic evaluation and documentation were performed in each child, including a lateral cephalometric radiograph. The tracing of the lateral cephalograph was traced on tracing paper. Based on this examination, the following measurements were obtained [Table/Fig-1,2]:



[Table/Fig-1]: Landmarks for lateral cephalometry study (Landmark 1).



[Table/Fig-2]: Landmarks for lateral cephalometry study (Landmark 2 to 12).

1. SNA, SNB and ANB;
2. N-Me: A space between N (nasion) and Me (menton);
3. N-ANS: A space between N and ANS (Anterior Nasal Spine);
4. ANS-Me: A space between ANS and Me;
5. S-Go: A space between S (sella) and Go (gonion);
6. Hy-S: A space between S and Hy (upper point of the hyoid);
7. VertD-H: A space between the palatal plane and H point (anterior part of the hyoid);
8. Hy-MP: A space between the mandibular plane and Hy;
9. HorizD-H: A space between H and the Hypopharynx (Posterior wall);
10. C3-H: A space between the H and the inferior and anterior point of C3;
11. McUP (McNamara Upper Pharyngeal Width): The shortest distance from the posterior pharyngeal wall to the soft palate;
12. McLP (McNamara Lower Pharyngeal Width): The shortest distance from the base of the tongue to the posterior pharyngeal wall.

STATISTICAL ANALYSIS

The data was systematically collected and entered in an MS Excel spreadsheet before statistical analysis using Statistical Package for Social Sciences (SPSS) version 25.0. An Independent t-test was used for comparison of continuous variables between the groups. A p-value <0.05 was considered statistically significant. Intra-examiner reliability for cephalometric tracings was done using the ICC with values >0.85.

RESULTS

Out of the 60 children, 30 were in group B with a mean age of 8.07±0.98 years, and 30 were in group A with a mean age of 8.23±0.9 years. [Table/Fig-3] shows the age and gender distribution for both groups.

Variables	Group A	Group B
Age (in years) (Mean±SD)	8.23±0.9	8.07±0.98
Gender		
Girls	16	15
Boys	14	15
Total	30	30

[Table/Fig-3]: Sociodemographic data.

The anterior total facial height (p-value <0.001) as well as the anterior lower facial height (p-value=0.006) were significantly greater in children with OSA. There was no statistically significant difference in the posterior total height (p-value=0.2), but there was a statistically significant difference in the anterior upper height (p-value=0.035) in children with OSA. These parameters suggest that OSA was associated with increased anterior facial height measurements. [Table/Fig-4].

Parameters	Group A OSA (n=30) (Mean±SD)	Group B Healthy (n=30) (Mean±SD)	t-value	p-value
N-Me	102.77±5.67 mm	96.8±3.6 mm	-4.87	<0.001
N-ANS	45.53±3.71 mm	43.73±2.65 mm	-2.161	0.035
ANS-Me	63.4±4.52 mm	60.33±3.71 mm	-2.872	0.006
S-Go	65.27±3.94 mm	64.07±3.19 mm	-1.296	0.2

[Table/Fig-4]: Measurements for facial heights.
Independent t test is used; N-Me: A space between N (nasion) and Me (menton); N-ANS: A space between N and ANS (Anterior Nasal Spine); ANS-Me: A space between ANS and Me; S-Go: A space between S (sella) and Go (gonion); mm- Millimetre; p<0.05 considered as statistically significant

The measurements of the hyoid bone revealed a significantly lower position with respect to the base of the skull (p<0.001), the palatal plane (p<0.001), and the mandibular plane (p<0.001) in children with OSA. An anterior position with respect to the nasopharynx's posterior wall (p<0.001) and C3 (p<0.001) in children with OSA. This result suggested the anterior and inferior position of the hyoid bone in children with OSA [Table/Fig-5].

Parameters	Group A OSA (n=30) (Mean±SD)	Group B Healthy (n=30) (Mean±SD)	t-value	p-value
HY-S	97.4±5.39 mm	87.1±3.45 mm	-8.815	<0.001
VertD-H	56.07±1.8 mm	47.1±1.85 mm	-19.059	<0.001
HY-MP	15.93±1.74 mm	7.7±2.2 mm	-16.077	<0.001
HorizD-H	27.2±1.19 mm	25.17±1.15 mm	-6.749	<0.001
C3-H	32.5±1.46 mm	30.17±1.26 mm	-6.633	<0.001

[Table/Fig-5]: Measurements for hyoid bone.
Independent t-test; Hy-S: A space between S to Hy (upper point of the hyoid); vert.d-H: A space between the palatal plane to H (anterior part of the hyoid); Hy-MP: A space between the mandibular plane to Hy; HorizD-H: A space between H to the Hypopharynx (Posterior wall); C3–H: A space between the H to the inferior and anterior point of C3; mm: Millimetre; p<0.001 considered as statistically significant

The experimental group had considerably reduced McNamara upper and lower pharyngeal airway space values compared to the control group. The p-value suggested that there is a significant difference between the two groups (p<0.001). This suggested that children with OSA had reduced pharyngeal airway space [Table/Fig-6].

Parameters	Group A OSA (n=30) (Mean±SD)	Group B Healthy (n=30) (Mean±SD)	t- value	p-value
MCUP	11.1±1.24 mm	13.1±1.69 mm	5.226	<0.001
MCLP	6.97±1.13 mm	8.93±1.23 mm	6.452	<0.001

[Table/Fig-6]: Measurements for pharyngeal airway spaces.
Independent t-test; McUP (McNamara Upper Pharyngeal Width): The shortest distance from the posterior pharyngeal wall to the soft palate; McLP (McNamara Lower Pharyngeal Width): The shortest distance from the base of the tongue to the posterior pharyngeal wall; mm: Millimetre; p<0.001 considered as statistically significant

DISCUSSION

The predisposing characteristics of OSA on the craniofacial structures are a narrowed posterior airway space, a long and elongated pharynx, a thicker soft palate, a long and large tongue, a lower position of the hyoid bone, increased anterior lower facial height, and decreased sagittal dimension of the cranial base. The lateral cephalogram has been acknowledged as the tool confirming the potential relevance of OSA in patients with suspected symptoms [12,13].

Nocturnal polysomnography is the gold standard for diagnosing OSA; several advanced technologies, like computerised tomography and Magnetic Resonance Imaging (MRI), are being used to evaluate sites of obstruction in upper airway and craniofacial structures. However, the traditional cephalometric method has been the most practical and commonly used [14]. Cephalometry is a two-dimensional representation of a three-dimensional structure; it has been extensively used to quantify the skeletal, dental, and soft-tissue relationships of the craniofacial complex [15]. The choice for the cephalometric analysis used in the current study was due to its large use in radiological and orthodontic clinics and for its embracing measures in all regions susceptible to obstruction [16]. Nonetheless, there is a lack of cephalometric research on this population in the literature, and there is conflicting data regarding the association between non syndromic craniofacial anomalies and OSA in children.

In the present study, authors found that, in comparison to the control group, children with OSA had significantly greater total anterior facial height (N-Me), primarily due to increased lower anterior facial height

(ANS-Me) across the groups. The posterior facial height (S-Go) did not differ significantly across the groups; however the upper anterior (N-ANS) facial heights (N-ANS), showed a statistically significant increase in children with OSA.

The current results are consistent with the findings presented by Zettergren-Wijk L et al., in which he found the OSA children exhibited a more posteriorly inclined mandible ($p<0.05$), a more anteriorly inclined maxilla ($p<0.001$), a greater lower anterior face height ($p<0.01$), a shorter anterior cranial base ($p<0.01$), retroclined upper and lower incisors ($p<0.05$ and $p<0.01$, respectively), and reduced airway space ($p<0.05$ and $p<0.01$) [17].

Juliano ML et al., found that mouth-breathing children were more likely to have a retruded mandible, more inclined occlusal and mandibular planes, a smaller airway space, and a smaller superior pharyngeal airway space ($p<0.01$) [18].

Gungor AY et al., found in the results that the distance between the hyoid and mandible was significantly greater in the OSA group than in the controls, indicating that the hyoid bone was positioned more downward in the OSA group ($p<0.05$) [10].

Tanellari O et al., suggested OSA patients exhibited significantly increased anterior facial height and reduced posterior facial height compared to controls. The hyoid bone was positioned lower and more posteriorly in OSA patients, with significant differences in its distance to the C3 vertebra and mandibular plane [19].

The null hypothesis was rejected because significant differences existed between groups. There were significant differences in anterior lower and total facial height, anterior and inferior hyoid bone positions, and upper and lower pharyngeal airways.

Future research can expand the current study by including larger and more diverse paediatric populations to establish stronger cephalometric predictors of OSA. Longitudinal studies are needed to assess how craniofacial growth and hyoid bone position change over time in children with OSA. Advanced imaging techniques such as Cone beam Computed Tomography (CBCT) and 3D airway analysis may provide more comprehensive insights into anatomical variations. Further studies can also evaluate the impact of early orthopaedic or myofunctional interventions on modifying risk factors identified through cephalometry. Integrating clinical, radiographic and polysomnographic data will help develop more accurate, multidisciplinary screening protocols for paediatric OSA.The present study emphasises that characteristic craniofacial patterns and an inferiorly positioned hyoid bone are potential cephalometric characteristics associated with OSA risk in children. Recognising these morphological features on routine lateral cephalograms allows paediatric dentists and orthodontists to identify at-risk children early, even before overt clinical symptoms appear. Early diagnosis facilitates timely multidisciplinary management- including myofunctional therapy, orthodontic intervention, and referral for airway evaluation- thereby preventing long-term complications related to growth, sleep quality, and neurocognitive development.

Limitation(s)

Cephalometry provides information for anteroposterior but not lateral pharyngeal structures that are implicated in the pharyngeal narrowing, which can be depicted on MRI (But it requires sedation or general anaesthesia in children, and is expensive comparitively). A longitudinal study with a larger sample would be more accurate and is recommended. Confounding factors such as body mass index and adenoid size were not analysed.

CONCLUSION(S)

According to the findings of the current study, children with OSA have noticeable changes in their facial development and growth, including an apparent rise in their lower and total anterior face heights. OSA patients were shown to have a more inferior and anterior hyoid bone location than nasal breathers, with statistically significant differences.

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