Original Article

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Dentistry Section

Comparison of the Linear and Angular Mandibular Measurements in Asthmatic and Non-asthmatic Children: A Cross-sectional Study

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ABSTRACT

Introduction: Chronic asthma, often associated with increased airway resistance and thoracic gas-trapping, can significantly impact respiratory biomechanics. This may result in adaptive shortening of cervical respiratory muscles, subsequently influencing head and cervical spine alignment resulting in structural changes in craniofacial development.

Aim: To assess and compare the linear and angular mandibular measurements in asthmatic and non-asthmatic children using Orthopantomographic (OPG) imaging.

Materials and Methods: The present cross-sectional study performed with a sample of 50 patients grouped into Group-A (Asthmatic children) and Group-B (Non-Asthmatic children). Standardised OPG imaging was performed for all participants. The radiographs from both groups were carefully traced and evaluated. The obtained data was subjected to statistical analysis by an expert statistician using Statistical Package for Social Sciences (SPSS) software v26.0. Independent t-test was used to analyse the linear and angular measurements between right and left-side in each group and also compare the linear and angular measurements between asthmatic breathing subjects and normal subjects. The Chi-square test was employed to assess differences in the cant of the occlusal plane and the Ag-Go-M relationship between the asthmatic and non-asthmatic groups. The p-value <0.05 was considered to be statistically significant.

Results: Statistical analysis revealed that asthmatic individuals exhibited no significant bilateral differences in most linear and angular measurements, except for a notably greater mandibular corpus height on the right-side (p=0.05). Similarly, normal-breathing subjects showed no significant asymmetries (p>0.05), apart from the Co-Go-Me angle. When comparing the two groups, asthmatic subjects demonstrated significantly increased condylar length (p=0.001) and mandibular corpus height (p=0.006). Conversely, they presented significantly reduced coronoid process length (p=0.002), the angle between the condyle and coronoid process (p=0.016), and the Co-Go-Me angle (p=0.023), relative to normal-breathing counterparts.

Conclusion: The present study demonstrated that asthmatic children exhibit distinct mandibular alterations, including increased condylar length and corpus height, along with reduced coronoid process length and angular measurements, when compared with non-asthmatic counterparts. These findings suggest that chronic asthma, through its impact on breathing patterns and head posture, may influence mandibular development during critical growth phases

Keywords: Breathing mechanics, Coronoid process length, Development of mandible, Interceptive orthodontics, Mandibular angle

INTRODUCTION

Craniofacial growth and development result from a complex interaction of intrinsic genetic factors and extrinsic environmental influences [1]. Alterations in breathing mechanics have been shown to significantly impact craniofacial development [2,3], potentially disrupting essential functions such as mastication and deglutition, which are vital for harmonious facial growth. Obstruction of the nasopharyngeal airway frequently results in mouth breathing [4] leading to compensatory changes in head posture aimed at improving airflow through the oral cavity [5]. These adaptations can contribute to imbalances in the development of orofacial structures [6].

In addition, several systemic medical conditions including type 1 diabetes [7], growth hormone deficiency [8], and asthma [9] have been associated with variations in facial morphology. Chronic asthma, characterised by increased airway resistance and thoracic gas trapping [10], may alter breathing patterns, leading to shortening of cervical respiratory muscles and changes in head and neck posture [11]. These postural adaptations may contribute to maxillary constriction and underdevelopment of the mandible [12] in individuals with persistent asthmatic symptoms. Although people of all ages are affected by the disease, most of the cases of asthma begin in childhood and peak prevalence occurs between the ages 6-11 years. It is estimated that 5- 15% of children (approximately 1 in 10 children) have asthma, including 4 million children less than 15 years of age [13].

Rubin RM and Moss ML highlighted that altered breathing patterns, particularly mouth breathing associated with asthma or airway obstruction, can profoundly influence craniofacial development, often manifesting as maxillary constriction, mandibular retrusion, or vertical growth tendencies [6,14]. Studies such as those by Bresolin D et al., has explored craniofacial morphology in asthmatic and allergic children, Solow B and Kreiborg S have emphasised the role of head posture and respiratory function in shaping mandibular growth [12,15]. However, much of the existing literature relies on cephalometric analysis or focuses broadly on craniofacial patterns, with limited emphasis on mandibular asymmetry specifically in asthmatic children. Moreover, although Cone Beam Computed Tomography (CBCT) offers precise three-dimensional assessment, its higher radiation exposure restricts use in paediatric patients, and panoramic radiographs are often underutilised despite their practicality. The present study addresses this gap by employing OPG (a cost-effective, low-radiation tool) to evaluate and compare mandibular asymmetries in asthmatic and non-asthmatic children during active growth. The novelty lies in applying OPG analysis to this specific patient population, thereby contributing evidence on the feasibility of using OPGs for early screening and intervention planning in asthmatic children.

The present study was conducted with the following study objectives,

- To evaluate the linear and angular measurements of mandible by analysis of orthopantomogram, in asthmatic children;
- To evaluate the linear and angular measurements of mandible by analysis of orthopantomogram, in non-asthmatic children;
- Comparative evaluation of linear and angular measurements between asthmatic and non-asthmatic children through orthopantomogram.

MATERIALS AND METHODS

The present cross-sectional study was conducted in the Department of Paediatric and Preventive Dentistry, Bharati Vidyapeeth Dental College and Hospital, Pune, Maharashtra, India, over a period of three months (May to July 2025) ethical clearance was obtained from the Institutional Ethical Committee (EC/NEW/INST/2021/MH/0029), and the study was registered with the Clinical Trials Registry-India (CTRI/2025/07/090159). Written informed consent was obtained from parents/guardians in accordance with the Helsinki guidelines. A total of 50 co-operative paediatric subjects were enrolled and categorised into two groups based on the presence (group A: Asthmatic children) or absence (group B: Non-asthmatic children) of asthma.

Inclusion criteria: Children aged 6-12 years with a confirmed medical diagnosis of asthma were included in group-A, while children aged 6-12 years without asthma were included in group-B. For both groups, only children with no previous orthodontic treatment, no deleterious oral habits, and no abnormalities in general physical development were considered.

Exclusion criteria: Children whose parents/guardians refused participation, those with retrognathia or conditions requiring immediate medical intervention, and those diagnosed with systemic disorders such as diabetes mellitus, haematological abnormalities, or growth hormone deficiencies were excluded.

Sample size calculation: Sample size was estimated from Silvestrini-Biavati F et al., (Indian J Dent Res 2014;25:154-9), using the two-sample comparison of means formula (Rosner, Fundamentals of Biostatistics) [16]:

$$n=\frac{(\sigma_1^2+\sigma_2^2)/(z_{1-\alpha/2}+z_{1-\beta})^2}{\Delta^2}$$

With σ_1=1.8, σ_2=2.9, expected mean difference Δ=2.2, (Δ=2.2 mm refers to the between group mean difference in the O2-C (ramus + condyle height) measurement reported by Silvestrini-Biavati F et al., -i.e., the difference between the cross bite group mean (5.1 mm) and the non-cross group mean (2.9 mm) for O2-C). Two-sided α=0.05 ($z_{1-\alpha/2}$=1.96), and target power=89.7%\ ($z_{1-\beta}$=1.263), the required size is n=25 per group, yielding a total sample of 50 participants.

Study Procedure

After identifying children who met the inclusion criteria, informed consent was obtained from their parents. OPGs for all participants were acquired using a standardised imaging protocol with the same machine, following manufacturer's instructions. Children were positioned with the Frankfort horizontal plane parallel to the floor, teeth in centric occlusion, and head stabilised with lateral supports to minimise distortion and ensure reproducibility [17]. To reduce measurement bias, all radiographs were traced manually by a single calibrated examiner. Examiner calibration was performed prior to the study by retracing 10 randomly selected OPGs at two-week intervals, and intra-examiner reliability was assessed using Intraclass Correlation Coefficient (ICC), with values >0.80 considered acceptable [18] (Intra-examiner reliability was excellent, with an ICC of 0.91 (95% CI: 0.85-0.96). To minimise observer bias, blinding procedures were followed: the examiner performing landmark identification and measurements was blinded to group allocation (asthmatic vs non-asthmatic). Statistical analysis was carried out independently by a biostatistician who was not involved in data collection.

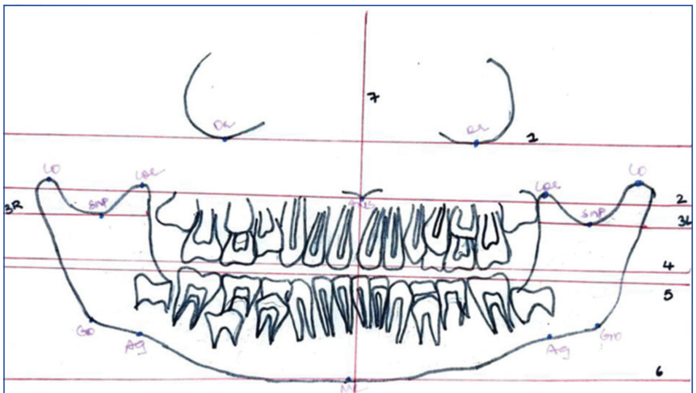
Following landmarks, horizontal and vertical planes were marked as given by Gupta S et al., [19]:

Landmarks

1. Orbitale (Or): Lowest point on bony orbit
2. Anterior nasal spine (ANS): Tip of bony anterior nasal spine
3. Condylion (Co): Most superior point on head of mandibular condyle
4. Coronoid point (Cor): Most superior point on coronoid process
5. Sigmoid notch point (Snp): Deepest point on sigmoid/ mandibular notch
6. Gonion (Go): Most posteroinferior point at the angle of mandible
7. Antegonion (Ag): Highest point of the notch or concavity of the lower border of the ramus where, it joins the body of the mandible.
8. Mandibular midpoint (M): Located by projecting the mental spine on the lower mandibular border parallel to ANS vertical plane.

Horizontal Plane: (Gupta S et al.,) [Table/Fig-1] [19]

1. Orbitale plane: Line connecting point orbitale bilaterally.
2. ANS horizontal plane: Tangent drawn from ANS parallel to orbitale plane.
3. Sigmoid notch planes: Tangent drawn from the deepest point on sigmoid notch parallel to orbitale plane (drawn on the right and left sides separately).
4. Upper occlusal plane: Line connecting mesiobucccal cups of right and left maxillary permanent first molar.
5. Lower occlusal plane: Line connecting mesiobucccal cups of right and left mandibular permanent first molar
6. Mandibular plane: Line drawn from the lowermost point on mandible parallel to orbitale plane.

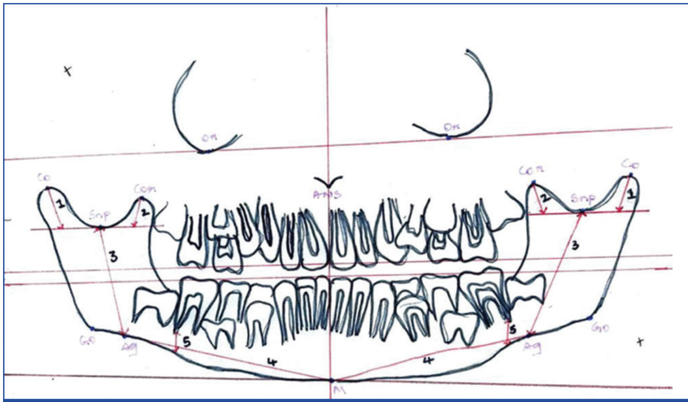


[Table/Fig-1]: OPG Tracing showing horizontal and vertical planes: (1) Orbitale plane. (2) ANS horizontal plane (3) Sigmoid notch plane (4) upper occlusal plane (5) Lower occlusal plane (6) mandibular plane (7) ANS Vertical plane.

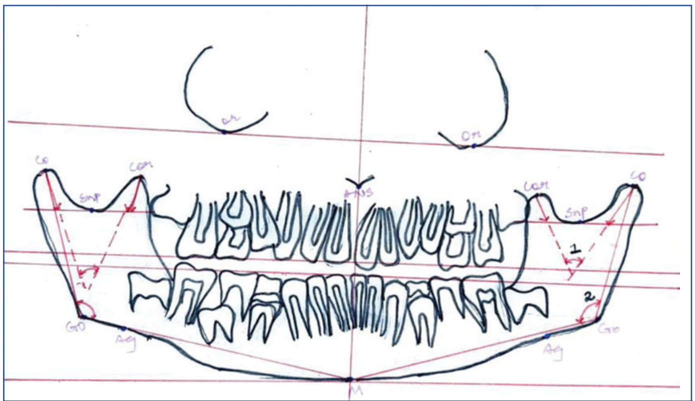
Vertical Plane: (Gupta S et al., [19]) [Table/Fig-1]

1. ANS vertical plane: Vertical line drawn from the ANS perpendicular to the orbitale plane.

   Following measurements were made as given by Gupta S et al., [19] [Table/Fig-2,3]



[Table/Fig-2]: OPG Tracing Showing Linear measurement: (1) condylar length (2) coronoid length (3) Length of ramus (4) Length of mandibular corpus (5) Height of mandibular corpus.



[Table/Fig-3]: OPG Tracing Showing Angular measurements: (1) Angle between condyle and coronoid process (2) Co-Go-M Angle.

1. Length of condyle: Measured from the Co to sigmoid notch plane along the long axis of condylar process.
2. Length of coronoid: Measured from the Cor to sigmoid notch plane along the long axis of condylar process.
3. Length of ramus (minus condyle and coronoid process): Measured from point Snp to point Ag.
4. Length of corpus: Measured from point Ag to point M.
5. Height of corpus: Distance between the distal root apex of mandibular first molar and inferior mandibular border.
6. Assessment of mandibular morphology: Left and right triangles were formed by connecting points Co, Go, M, angle Co-Go-M was measured. Angle between condyle and coronoid process was also measured.
7. Relationship of point Ag to Go-M line was observed and compared on both sides.
8. Cant of occlusion: Upper and lower occlusal planes were drawn by line connecting the mesiobuccal cusps of right and left upper and lower first permanent molars, respectively.

To assess the cant of occlusion, the parallelism of occlusal plane is compared with the orbitale plane. The measurements made on the right and left-sides were compared and inference was drawn.

STATISTICAL ANALYSIS

The obtained data was subjected to statistical analysis by an expert statistician using SPSS software v26.0. Independent t-test was used to analyse the comparison of linear and angular measurements between right and left-side in each group and also to compare the linear and angular measurements between asthmatic/mouth breathing subjects and normal subjects. The Chi-square test was employed to assess differences in the cant of the occlusal plane and the Ag-Go-Me relationship between the asthmatic and non-asthmatic groups. The p-value <0.05 was considered to be statistically significant.

RESULTS

The present study included a total of 50 participants, divided equally into two groups: 25 asthmatic children and 25 non-asthmatic children. The mean age of children in the asthma group was 9.48±1.91 years (range: 6-12 years), while the mean age of those in the normal group was 9.52±1.70 years (range: 7-12 years). With respect to gender distribution, the asthma group comprised 9 (36%) females and 16 (64%) males, whereas the normal group included 12 (48%) females and 13 (52%) males [Table/Fig-4].

Variable	Group A Asthma (n=25)	Group B Normal (n=25)
Age (years)	Mean±SD: 9.48±1.91 Range: 6-12	Mean±SD: 9.52±1.70 Range: 7-12
Gender	Female: 9 (36%) Male: 16 (64%)	Female: 12 (48%) Male: 13 (52%)

[Table/Fig-4]: Demographic details of the study population.

[Table/Fig-5] compares the linear and angular measurements between right and left-side in each group. In asthmatic subjects, there was a non-significant difference in the linear (p=0.193) and angular measurements (p>0.05) between right and left-side except for height of corpus (p=0.05). Height of corpus on right side was significantly greater (p=0.05) than on the left-side in asthmatic subjects. Similarly, in the normal breathing subjects, there was a non-significant difference in the linear (p=0.212,p=0.111, p=1.000, p=0.424, p=0.645) and angular measurements (p=0.231) between right and left-side except for Co-Go-M angular measurement (p=0.004). The Co-Go-M angular measurement on right-side was significantly greater than on the left-side in normal subjects.

	Right		Left		
Variables	Mean	SD	Mean	SD	p-value
Asthmatic					
Length of condyle	2.30	0.55	2.09	0.51	0.162
Length of coronoid	0.96	0.36	1.08	0.50	0.314
Angle between condyle and coronoid process	37.31	2.54	35.58	6.83	0.235
Length of ramus	5.16	0.74	5.10	0.66	0.783
Length of corpus	7.34	0.59	7.03	1.03	0.193
Height of corpus	1.46	0.50	1.24	0.27	0.050*
Co-Go-M angular measurement	118.15	5.58	118.27	2.43	0.923
Non-asthmatic					
Length of condyle	1.74	0.33	1.84	0.23	0.212
Length of coronoid	1.27	0.32	1.10	0.44	0.111
Angle between condyle and coronoid process	42.31	9.62	38.65	11.96	0.231
Length of ramus	4.85	0.39	4.85	0.49	1.000
Length of corpus	7.10	0.59	6.96	0.68	0.424
Height of corpus	1.15	0.24	1.12	0.24	0.645
Co-Go-M angular measurement	122.19	6.78	117.12	5.24	0.004*

[Table/Fig-5]: Comparison of linear measurements (in cm) and angular measurements (in degree) between right and left-side in each group.
Independent t-test; *indicates a significant difference at p≤0.05

[Table/Fig-6] compares the linear and angular measurements between asthmatic subjects and normal subjects. On right-side, length of condyle (p<0.001) and height of corpus (p=0.006) among the asthmatic subjects was significantly greater than in the normal subjects; whereas, length of coronoid (p=0.002), angle between condyle and coronoid process (p=0.016), and Co-Go-M angular measurement (p=0.023) was significantly lower among asthmatic subjects than in the normal subjects. There was a non-significant difference in the length of ramus (p=0.067) and corpus (p=0.163) between normal and asthmatic/mouth breathing subjects on right side. However, on left-side, there was a non-significant difference

Variable	Normal		Asthmatic		p-value
	Mean	SD	Mean	SD	
Right					
Length of condyle	1.74	0.33	2.30	0.55	<0.001*
Length of coronoid	1.27	0.32	0.96	0.36	0.002*
Angle between condyle and coronoid process	42.31	9.62	37.31	2.54	0.016*
Length of ramus	4.85	0.39	5.16	0.74	0.067
Length of corpus	7.10	0.59	7.34	0.59	0.163
Height of corpus	1.15	0.24	1.46	0.50	0.006*
Co-Go-M angular measurement	122.19	6.78	118.15	5.58	0.023*
Left					
Length of condyle	1.84	0.23	2.09	0.51	0.907
Length of coronoid	1.10	0.44	1.08	0.50	0.262
Angle between condyle and coronoid process	38.65	11.96	35.58	6.83	0.654
Length of ramus	4.85	0.49	5.10	0.66	0.122
Length of corpus	6.96	0.68	7.03	1.03	0.787
Height of corpus	1.12	0.24	1.24	0.27	0.091
Co-Go-M angular measurement	117.12	5.24	118.27	2.43	0.315

[Table/Fig-6]: Comparison of linear and angular measurements between normal and asthmatic subjects.
Independent t-test; *indicates a significant difference at p≤0.05

in the linear and angular measurements between normal and asthmatic subjects (p>0.05).

In the present study, analysis of categorical parameters revealed significant group differences. The cant of the occlusal plane was predominantly divergent among asthmatic children 17 (68%) compared to a parallel orientation in the majority of non-asthmatic children 17 (68%) (p=0.021). Similarly, the Ag-Go-Me relationship showed greater asymmetry in asthmatic subjects 18 (72%), whereas non-asthmatic children more frequently exhibited symmetry 16 (64%) (p=0.013). These findings indicated that both occlusal plane inclination and Ag position are significantly associated with asthma status, reflecting altered mandibular growth patterns in asthmatic children [Table/Fig-7].

Parameters	Measurement Parameters	Asthmatic (n=25)	Non asthmatic (n=25)	p-value
Cant of occlusal plane	Parallel to orbitale plane	8 (32%)	17 (68%)	0.021*
	Slightly divergent	17 (68%)	8 (32%)	
Ag-Go-Me relationship	Symmetrical (Ag on Go-Me line)	7 (28%)	16 (64%)	0.013*
	Asymmetrical (Ag displaced)	18 (72%)	9 (36%)	

[Table/Fig-7]: Comparison of cant of occlusion and Ag-Go-Me relationship between normal and asthmatic subjects.
Chi-square test; *indicates a significant difference at p≤0.05

DISCUSSION

The present study assessed linear and angular measurements of mandible in asthmatic and non-asthmatic children aged 6-12 years using OPG. The principle finding was that asthmatic children exhibited significantly greater condylar length and mandibular corpus height on the right side, while showing reduced coronoid process length, condyle-coronoid angle, and Co-Go-M angle compared with non-asthmatic children. Inter group comparisons revealed minimal asymmetry in both groups, except for corpus height in asthmatic children and the Co-Go-Me angle in non-asthmatic children. These findings suggest that chronic asthma, through altered breathing patterns and associated postural adaptations, may contribute to changes in mandibular morphology.

The increased condylar length and corpus height observed in asthmatic children may represent compensatory growth responses to functional alterations in airway mechanics. Conversely, the reduced angular measurements could reflect deviations in mandibular morphology resulting from adaptive remodelling [15]. Clinically, such asymmetries emphasise the importance of early monitoring in asthmatic children to prevent long-term functional and aesthetic consequences.

The present study results align with the observations of Al Ali A et al., who demonstrated a relationship between asthma and altered craniofacial growth, including increased mandibular dimensions in asthmatic children [9]. Similarly, Bresolin D et al., reported that children with mouth breathing and allergic conditions exhibited increased facial height and mandibular inclination findings consistent with the altered angular values in the present study [12]. More recent evidence also supports these associations: cephalometric and CBCT studies in children with asthma or airway obstruction have consistently shown increased vertical growth tendencies, altered mandibular inclination, and airway-related skeletal changes [10,20].

However, not all findings in the literature are consistent. Franco LP et al., highlighted that craniofacial variations depend strongly on the underlying etiology of airway obstruction, with differences between children affected by palatine tonsil hypertrophy versus adenoidal hypertrophy [20]. This differs from the present study, since the focus has been clinically diagnosed asthma, instead of individual anatomical changes such as palatine tonsillar hypertrophy versus adenoidal hypertrophy.

The role of OPG in assessing asymmetry must also be interpreted with caution. While it provides a cost-effective and low-radiation screening tool, OPG is inherently limited by its two-dimensional nature and potential for distortion. Nonetheless, prior studies by Habets LL et al., 1988 [21]; Kambylafkas P et al., 2006 [18] have shown that OPG can reliably detect vertical asymmetries when proper patient positioning is maintained. Hence, the detection of increased corpus height on the right side in asthmatic children, supports the interpretation of true asymmetry rather than technical artefact [21].

The findings of the present study, which demonstrated increased condylar length and corpus height with reduced coronoid process length and mandibular angular measurements in asthmatic children, are consistent with the evidence that asthma influences craniofacial growth through altered functional patterns. The present results can be compared with the study by Prashanth S and Nandlal B who investigated cervical and craniofacial morphology in asthmatic children using cephalometric analysis [22].

Recent CBCT and cephalometric imaging studies further validate these findings by demonstrating condylar, ramal, and corpus remodelling associated with airway compromise [10,22]. They provide more precise localisation of changes but involve higher radiation doses, which is an important consideration in paediatric populations. Therefore, OPG remains a valuable first-line imaging modality for screening, while CBCT should be reserved for complex diagnostic cases or orthodontic planning.

The current findings highlight that asthma may influence mandibular growth during critical developmental phases, justifying early orthodontic evaluation in these children. OPG can be used as a preliminary tool for detecting asymmetry, while CBCT may be considered where detailed assessment is required. Early intervention can help mitigate the functional and Aesthetic impact of craniofacial changes in asthmatic children and reduce the need for corrective orthognathic surgeries at an advanced age due to deforming craniofacial malformations.

Limitation(s)

The study has reliance on two-dimensional imaging which may not be most accurate measurement of three-dimensional anatomical structures (mandible). Moreover, asthma severity, duration, and corticosteroid use were not evaluated, though these factors may affect craniofacial growth. Future research should include larger, stratified cohorts, longitudinal follow-up, and multimodal imaging to clarify the relationship between asthma and mandibular development.

CONCLUSION(S)

The present study demonstrated that asthmatic children exhibit distinct mandibular alterations, including increased condylar length and corpus height, along with reduced coronoid process length and angular measurements, when compared with non-asthmatic counterparts. These findings suggest that chronic asthma, through its impact on breathing patterns and head posture, may influence mandibular development during critical growth phases. Although OPG cannot replace advanced three-dimensional imaging, it serves as a reliable, cost-effective screening tool for detecting mandibular asymmetries in children. Early identification of mandibular changes in asthmatic children using simple radiographic tools like OPG can guide timely orthodontic monitoring and intervention, helping prevent long-term functional and aesthetic consequences.

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PLAGIARISM CHECKING METHODS: [Jain H et al.]
- Plagiarism X-checker: Jul 27, 2025
- Manual Googling: Sep 15, 2025
- iThenticate Software: Sep 20, 2025 (18%)

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- Was Ethics Committee Approval obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? Yes
- For any images presented appropriate consent has been obtained from the subjects. NA

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