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Cervical and craniofacial morphology in asthmatic children: A cephalometric study

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1. Introduction

Bronchial asthma is a chronic inflammatory disorder of the airway characterized by variable airflow obstruction and airway hyper responsiveness.[1] In Asthma, there are changes in the airway due to the release of multiple inflammatory mediators such as histamine, leukotrienes and prostaglandins, which result in bronchoconstriction, excessive mucus secretion, exudation of plasma and airway hyper responsiveness. The symptoms are usually associated with widespread but variable airflow obstruction that is often reversible, either spontaneously or with medication. Asthma is the most common chronic respiratory illness of the childhood. Although people of all ages are affected by the disease, most if 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.[2]

Once the inflammatory cascade is set into motion, clinical signs and symptoms will develop in the affected individual, with the most profound effects being evident in the eye, nose, conjunctiva, posterior pharynx and in the respiratory system. The nose will display swelling of the turbinales with evidence of mucous compaction. This will often result in itching, nasal obstruction to breathing, and a post nasal drip that is frequently associated with coughing. The pharynx will show posterior cobble stoning with adherent mucous as well as hypertrophy of the tonsillar tissues and the adenoids. The mucus membrane becomes puffy and swollen. These changes, especially in the nose and the posterior pharynx, will result in decreased airflow within the passages. As a consequence of inflammatory response and increased airway resistance in the respiratory system, the subjects suffering from asthma, experience difficulty in breathing. To overcome this difficulty, their mode of breathing changes from Nasal to Oral breathing.[3] This change in the function can trigger modulations in the craniofacial growth patterns according to functional matrix theory of growth by Moss. Also the medication prescribed for asthma is in the form of aerosol, which is administered by inhalations through the mouth. This situation demands the asthmatic subjects to become obligatory mouth breathers during the medication. Prolonged duration of mouth breathing is known to cause alterations in the craniofacial morphology.[4,5] Patients with chronic asthma symptoms can present with an increased resistance of the lower airways with gas-trapping in the chest (Chaves et al., 2010).[15] The altered mechanics of breathing associated with these changes can lead to shortening of the cervical respiratory muscles, which could alter head and cervical spine posture (Hruska, 1997; Lopes et al., 2007).[16,17] This may cause dysregulation in the growth and development of the orofacial structures, including narrowing of the maxilla and lower development of the mandible (Bresolin et al., 1984).[18]

If the proposed interaction, as just explained exists between the asthma disease and the craniofacial growth, that will be of great practical interest to Pediatrician, Otorhinolaryngologist, Allergist, and Speech Physiologist and in particularly Pediatric Dentists and Orthodontist who by training are uniquely qualified to diagnose and monitor aberrant as well as normal facial growth. In the present study the pediatrcian and pulmonologist reviewed the cases as per inclusion and exclusion criteria and provided the summary of clinical status in regard to airway and pharyngeal assessments and classified them into regular and irregular medication users and medication details to include the eligible subjects into the study. Pediatric dentist and orthodontist engaged in the craniofacial growth assessment.

The presently available research findings about the effect of Asthma on the Craniofacial and Dentoalveolar morphology are meager and still in the stage of hypothesis. This study aims at resolving some aspects of the issue regarding the cause and effect relationship between asthma and craniofacial morphology.

2. Material and methods

56 Asthmatic children between 6 and 12 years of age from J S S Hospital, Mysore were included in the study. They were classified into

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subgroups (with 14 subjects in each) on the basis of sex, and regularity of medication. Selected variables from Cephalometric analysis of the study group were subjected to comparison with those of the normal group, which comprised of 28 normal children of the same age group. (Table 1).

For the inclusion in the normal group the following selection criteria were kept as norms, Children aged between 6 and 12 years, who have not undergone any orthodontic treatment hitherto. Children without any abnormal Para functional Oral Habits. Children with ideal Class I Occlusion according to Angle's molar relation. Children with negative history of any respiratory disease. Children presenting with normal physical growth without any gross asymmetry of the face. Children who do not have multiple grossly destructed teeth, or multiple teeth missing.[14]

The subjects who fulfilled the following criteria were included in the study group. Children in the age between 6 and 12 years. Diagnosed as suffering from Mild persistent or Moderate persistent Asthma. Asthmatic patient for about past 1–5 years. Not have any abnormal Oral Habits and should not have undergone any orthodontic treatment previously. Should not have multiple grossly destructed teeth, or multiple teeth missing. Present with normal physical growth without any gross asymmetry of the face due to any other cause.

Asthmatic children on regular or daily dosage of medicines (Salbutamol Budesonide) for the disease were considered under the asthmatic group under regular medication. All the subjects in the regular medication group who used the aerosol spray through the oral route for administration of the drug. Asthmatic children who received medication only during an attack of the symptoms and not under regular regimen were grouped under Asthmatic group under irregular medication.

Standardized Lateral Cephalometric Radiographs were obtained using ROTOGRAPH 230 EWC cephalostat. The patients were exposed in the natural head position stabilized with ear rods, at 80 kVp, 15 mA for 0.8 s. The radiographs were developed using the automatic processor.

The obtained Lateral Cephalometric radiographs were subjected to radiographic analysis comprising of selected variables. Tracing of the structures was done on 0.003 inches thick acetate matte tracing film using sharp 3H drawing pencil, under the illumination of a Cephalometric X-ray view box. 10 radiographs were randomly chosen from the study collection and the tracings were repeated. The tracing results were subjected to *t*-test to determine the intraexaminer reliability. Values obtained from the all the tracings were then subjected to ANOVA statistical analysis for comparison and statistical inference of the observations. Fig. 1 and Table 2 shows the Cephalometric landmarks used in the present study and Figs. 2–4 and Table 3 illustrates the Cephalometric linear and angular measurements in the Cranial, Facial and Cervical region.

3. Results

3.1. Facial linear measurements (Table 4)

The Upper Anterior Facial Height (N-ANS) had mean of 48.04 ± 3.23 mm. in Normal subjects, 48.48 ± 3.81 mm in Asthmatics under regular

Table 1
Distribution of samples.

Groups	Group	n
I	Normal Males	14
	Normal Females	14
II	Asthmatic Male Under Regular medication	14
	Asthmatic Female Under Regular medication	14
	Asthmatic Male Under Irregular medication	14
	Asthmatic Female Under Irregular medication	14

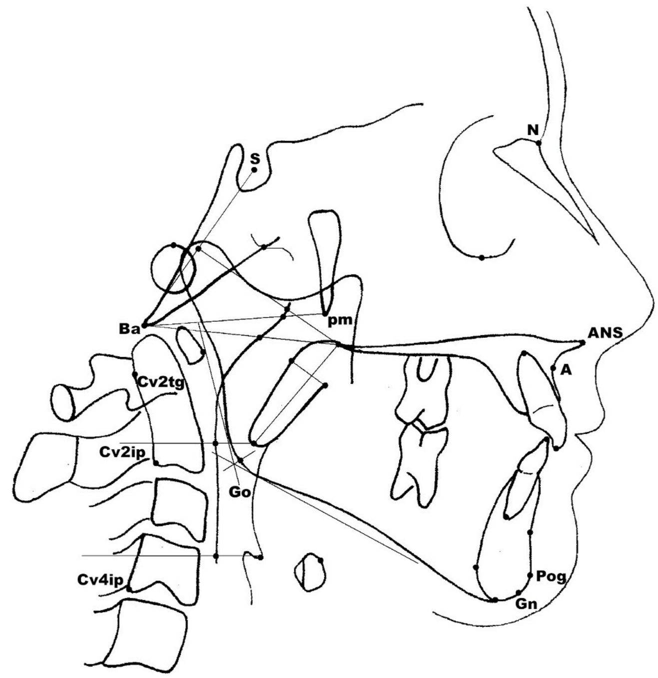

Fig. 1. Figure 1. Anatomical Landmarks used for Cephalometric analysis

medication and 48.36 ± 2.67 in Asthmatics under irregular medication. The *Upper Posterior Facial Height* (S-pm) measured 37.45 ± 3.26 mm. 35.82 ± 2.35 mm. and 36.77 ± 5.68 for the three groups respectively. The *Lower Anterior Facial Height* (ANS-Gn) recorded a mean of 55.69 ± 3.34 mm. for the Normal group, 59.79 ± 4.17 mm. for the regularly medicated and 58.41 ± 3.97 for irregularly medicated asthmatic group. The *Lower Posterior Facial Height* (pm-Go) described a mean of 41.16 ± 4.28 mm. for the Normal group, 40.64 ± 3.67 mm. and 41.07 ± 3.39 for the regularly and irregularly medicated asthmatics.

The Lower Anterior Facial Height (ANS-Gn) showed a highly significant difference between groups ($F_{Grp} = 8.282$; $P < 0.001$) where the mean values of the Asthmatic groups were found to be significantly higher than the Normal group. However there was no significant difference within the Asthmatic group irrespective of the regularity in medication.

3.2. Facial Angular measurements (Table 4)

The *Angle of Convexity of the Face* (N A/A Pog) showed a total mean of 11.84° ± 5.77 for the Normal group, 11.07° ±5.39 for regularly medicated asthmatics and 11.41° ± 5.88 for asthmatics under irregular medication. The Facial Angle (F H/N Pog) measured 91.50° ± 4.61, 94.1250° ± 5.21 and 90.93° ± 6.12 for the groups respectively. No significant differences were observed in the mean value of angular measurements of Angle of Convexity of the Face and Facial Angle (F H/N Pog) between the groups.

3.3. Cranial linear measurements (Table 5)

The *Length of the Anterior Cranial Base* (S-N) measured 66.45 ± 3.45 mm. for the Normal group, 65.64 ± 2.78 mm for the asthmatics under regular medication and 66.60 ± 3.19 mm for asthmatics under irregular medication. The *Posterior Cranial Base* (S-Ba) had a mean of 43.61 ± 3.54 mm, 42.55 ± 2.98 mm and 41.80 ± 3.05 for the groups respectively. The *Effective Cranial Base* (Ba-N) for the groups, in order mentioned above, was 100.43 ± 5.34 mm, 98.34 ± 3.68 mm. and 95.89 ± 17.66 mm. No significant difference in the cranial bases was found among the groups.

Table 2
Lateral Cephalometric Landmarks used in the study.

Landmark		Explanation	Author	Year
ANS	Anterior Nasal Spine	Most anterior point of the nasal floor; tip of premaxilla on sagittal plane.	Viken Sassouni	1971
Ba	Basion	Point at the center of the anterior border of foramen magnum at the base of the occipital bone	Robert M Ricketts	1989
Go	Gonion	The lowest posterior-most and most outward point of the angle of the mandible. It is obtained in Cephalometrics by bisecting the angle formed by the tangents to the lower and the posterior borders of the mandible. When both angles appear on the profile cephalograms the point midway between right and left side is used.	Tweed	1946
Gn	Gnathion	The lowest point on the mandibular symphisis	Arne Bjőrk	1960
N	Nasion	Junction of the nasal and frontal bones as seen on the profile of the Cephalometric roentgenogram	T.M. Graber	1975
pm	Pterygomaxillare	Point representing the dorsal surface of the maxilla at the level of the nasal floor. The point is located on the dorsal contour of the maxilla, which, above, forms the anterior limit of the pterygo palatine fossa, where this contour intersects that of the hard and soft palates.	Arne Bjőrk	1960
Pog	Pogonion	The most anterior point on the mandible in the midline	William B. Downs	1948
Point A	Subspinale	The most posterior point of the concavity of the bone along the alveolar bony profile connecting the anterior nasal spine and the alveolar bony crest of the maxilla labial to the maxillary central incisors	William B. Downs	1948
S	Sella	The center of sella, as seen in the lateral radiograph and located by inspection	B. Holly Broadbent	1975

3.3.1. Cranial angular measurements (Table 5)

The *Cranial base angle* (Ba S N) was recorded at a total mean of 129.30° ± 4.40 for the Normal group, 131.28° ± 4.36 for the Asthmatics under regular medication and 131.44° ± 5.38 for asthmatics under irregular medication. No significant differences were observed in the mean value of angular measurements *Cranial base angle* (Ba S N) between the groups.

3.3.2. Cervical angular measurements (Table 6)

The *Craniocervical posture* (NSL/OPT) (odontoid process tangent and cranial posture) measured 91.46° ± 8.12 for the Normal group, 95.96° ± 10.60 for the asthmatics under regular medication and 95.02° ± 16.79 for the irregularly medicated asthmatics. The *Cervical Curvature* was calculated by subtracting the values of *Craniocervical posture* (NSL/OPT) with the angle formed between S-N plane with *Cervical vertebra tangent* (CVT). The values were 3.91° ± 2.00 for the Normal group, 3.45° ± 2.04 and 1.98° ± 1.65 for the asthmatic regular and irregularly medicated group. No significant differences were observed in the mean value of angular measurements *Craniocervical posture* (NSL/OPT) between the groups.

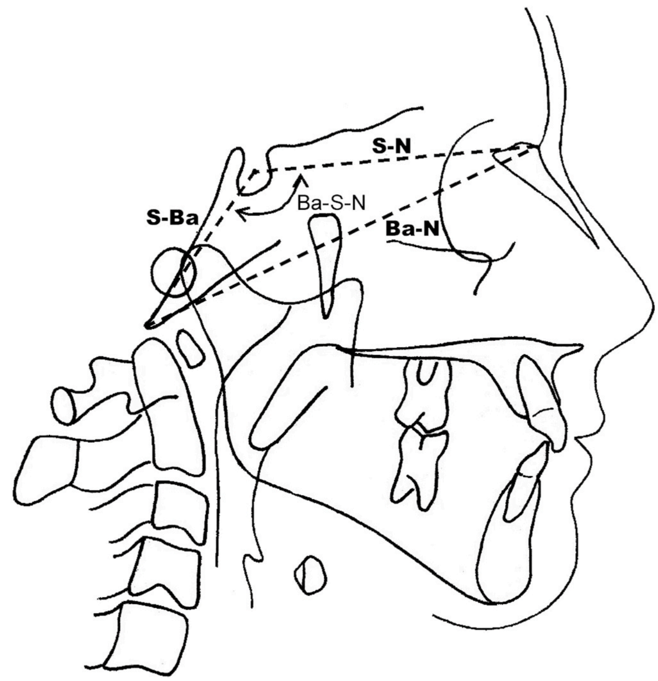

Fig. 2. Figure 2. Cranial linear and angular measurements

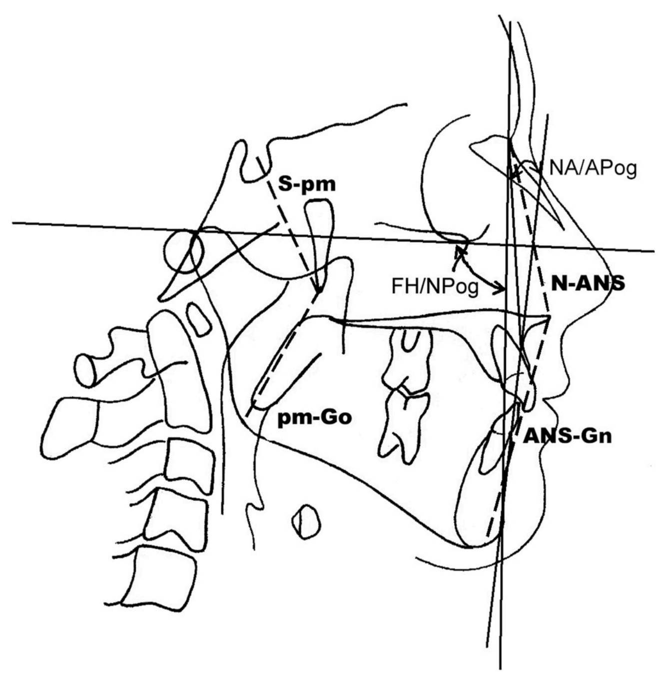

Fig. 3. Figure 3. Facial linear and angular measurements

The *Cervical Curvature* showed a highly significant difference in the mean of the groups ($F = 8.181$; $P < 0.001$). Subjects of asthmatics under irregular medication group showed significant lower values as compared to the asthmatics under regular medication and the Normals. Though there was a fall in the values in regular medication group as compared to the Normals, it was however non significant.

4. Discussion

The regularity of medication was chosen for establishing

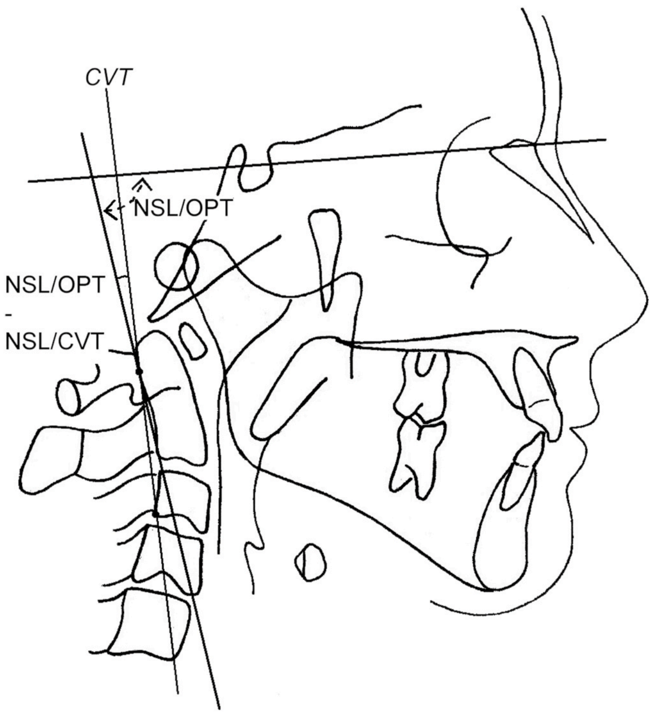

Fig. 4. Figure 4. Cervical angular measurements

Table 3
Lateral Cephalometric Linear and Angular Parameters analysed in the study.

Facial Linear Measurements	
Upper anterior facial height	(N-ANS)
Upper posterior facial height	(S-pm)
Lower anterior facial height	(ANS-Gn)
Lower posterior facial height	(pm-Go)
Cranial Linear Measurements	
Length of anterior cranial base	(S-N)
Length of posterior cranial base	(S-Ba)
Effective cranial base length	(Ba-N)
Facial Angular Measurements	
Angle of convexity	(N A/A Pog)
Facial angle	(F H/N P)
Cranial Angular Measurements	
Cranial base angle	(Ba S N)
Cervical Angular Measurements	
Cranial posture	(NSL/OPT)
Cervical curvature	(NSL/OPT) – (NSL/CVT)

standardization in categorizing the subjects. Out the routes available, Inhalation of the aerosols is the commonly used route. Such a means of drug administration requires the patient to breathe through the mouth. This would mean the changed mode of breathing, from nasal breathing to mouth breathing at the time of medication. Hence the asthmatic patient would become an obligatory mouth breather during the intake of medication. Though the changed mode of breathing is only for few minutes a day, it would really become accountable and significant if it was to continue daily for a long time and especially during the periods of active growth.[3,4,11]

Asthma is a chronic disease which requires long term medication or medication (Salbutamol Budesonide) at the time of attack (which might occur at any time of the day, sometimes several times in a day). Therefore, if the effect of asthma on the morphology has to be studied the duration of the disease, duration as well as regularity of medication has to be taken into consideration. Hence the subjects were grouped according to regular or irregular intake of medication.

4.1. Facial relations

The increase in the lower facial height was seen in mouth breathers as well as in case of nasal obstruction (where mouth breathing was secondary to obstruction)[3,4,6–10] The increase in the Lower anterior facial height can be explained as a reactionary mechanism occurring in mouth breathers to increase the volume of the oral cavity (functional adaptation to Oral Breathing). In the present study both asthmatics under irregular and regular medication were affected with increased lower facial height. This can be explained due to the mouth breathing caused by the disease process in both the groups. Further, the asthmatics under regular medication present with greater change when compared to asthmatics under irregular medication. This can be attributed to synergistic effect of regular medication (Inhalation) along with the mouth breathing caused by the disease process. It appears both the disease and the treatment for the disease are together responsible for the increase in the Lower Anterior Facial Height.

4.2. Cranial relations

No significant difference in the cranial bases is suggestive of the changes restricted to the region around the functional matrix, that is, the Upper airway. The effect of the disease and the duration and route of administration of medication seems to predominate in the facial region than in the cranial region.

4.3. Cervical region

No significant differences in the mean value of angular measurements Craniocervical posture (NSL/OPT) between the groups suggests that the head tilt over the cervical vertebral column was not affected in asthmatics. Subjects of asthmatics under irregular medication showed significant lower values as compared to the asthmatics under regular medication and the normal. Though there was a decrease in the values in asthmatics under regular medication as compared to the normal, it was

Table 4
Comparison of Lateral Cephalometric Facial Variables of the Normal and the Asthmatic groups.

	Normal				Asthmatics Under Regular Medication				Asthmatics Under Irregular Medication				F value
	Male		Female		Male		Female		Male		Female		
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
N-ANS	48.93	3.55	47.14	2.72	48.36	3.08	48.61	4.55	49.21	2.69	47.50	2.44	0.14
S-pm	38.21	3.14	36.68	3.31	36.15	2.73	35.50	1.95	38.93	5.90	34.60	4.71	1.26
ANS-Gn	56.93	3.32	54.46	2.99	60.43	4.18	59.14	4.22	58.68	4.55	58.14	3.44	*** 8.28
pm-Go	40.86	3.99	41.46	4.67	40.96	3.31	40.32	4.09	41.07	4.08	41.07	2.70	0.14
NA/A Pog	12.50	6.36	11.18	5.28	11.86	6.21	10.29	4.54	11.61	6.19	11.21	5.78	0.13
FH/NPog	90.79	3.36	92.21	5.64	94.71	5.86	93.54	4.60	90.50	6.67	91.36	5.74	2.77

[a] $p < .05$.
[b] $p < .01$.
[c] $p < .001$.

Table 5
Comparison of Lateral Cephalometric Cranial Variables of the Normal and the Asthmatic groups.

	Normal				Asthmatics Under Regular Medication				Asthmatics Under Irregular Medication				F value
	Male		Female		Male		Female		Male		Female		
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
S-N	67.79	3.49	65.11	2.95	66.07	2.79	65.21	2.80	68.14	3.03	65.07	2.61	0.85
S-Ba	44.04	4.63	43.18	2.05	42.57	3.52	42.54	2.46	42.61	3.39	41.00	2.54	2.22
Ba-N	102.1	6.76	98.71	4.05	98.00	3.96	98.68	3.50	94.92	24.86	96.86	5.29	1.17
BaSN	129.3	4.23	129.3	4.73	130.3	3.85	132.3	4.77	131.7	5.05	131.2	5.88	1.73

[a] $p < .05$.
[b] $p < .01$.
[c] $p < .001$.

Table 6
Comparison of Lateral Cephalometric Cervical Variables of the Normal and the Asthmatic groups.

	Normal				Asthmatics Under Regular Medication				Asthmatics Under Irregular Medication				F value
	Male		Female		Male		Female		Male		Female		
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
NSL/OPT	89.50	4.49	93.43	10.42	95.86	9.69	96.07	11.81	93.57	15.79	96.46	18.22	1.00
Cervical Curvature	3.25	1.81	4.57	2.03	2.93	2.30	3.96	1.66	1.64	1.90	2.32	1.32	8.18***

[a] $p < .05$.
[b] $p < .01$.
[c] $p < .001$.

however non-significant. The results of this study come in agreement with the values reported in a study conducted on patients with restricted upper airway by Vivat Tangugsorn, Olav Skatvedt, Olaf Krogstad and Torstein Lyberg. An increased cervical curvature and extended cervical vertebral column was observed in the patients with restricted upper Airway. It was hypothetically concluded by the authors that the increased cervical curvature occurred to restore the airway deficiency.[11,18,19]

In the present study also, a significant restriction of the upper airway had occurred. Applying the similar logical reasoning, the increased Curvature in the Cervical Vertebral Column, in the present study, can be attributed to an attempt to increase the diameter of the Upper airway, which lies just anterior to the vertebrae.

"The form of an object is its diagram of forces." This was the sentence which was used in describing the formation of an Anatomical structure as influenced and governed by its function. Increased demands or altered functions forced on the functional matrices cause the related changes in the skeletal units. This statement can be effectively applied to explain the changes which were seen in the patients with altered mode of respiration from nasal to Oral. Many studies have contributed positively on the influence of changed mode or respiration on the Craniofacial and Dentoalveolar Morphology.[3,7,8,12,13,15,18,19] But the scientific data to prove the effects of the allergic disease such as asthma on Craniofacial and Dentoalveolar morphologic patterns are meager and require greater depth of analysis and work for a definite conclusion. Though the studies have showed the females are more prone to asthma and its effects on the craniofacial morphology, the present study has a limitation that gender differences has not been considered and as well as sample size is limited to a small number of subjects.

However,the results of the present study emphasize the cause-and-effect relationship between asthma and the regional morphologic changes that occur in the craniofacial and the cervical regions which could be based on the clinical condition and medication usage. An attempt has been made here to logically arrive at possible mechanism(s) acting upon the structures to cause a morphologic change. Longitudinal studies to determine the proportionality involved in this cause-and-effect relationship are required to provide a better insight over the topic.

5. Conclusion

Asthma has a definite influence on the facial and the cervical morphology. The increased lower facial height in the asthmatic patients can be hypothesized to be an effect of the compensatory mechanism occurring to increase the volume of the oral cavity to facilitate the altered mode of respiration (mouth breathing). Early deduction of these changes can be taken for interceptive orthodontics to redirect to near normal growth pattern. While among those diagnosed late for dental changes in whom the growth has been completed may require to be considered for orthognathic jaw correction surgeries.

Though the head tilt in relation to the cervical region remains unchanged, the cervical curvature showed exaggeration in the asthmatic subjects. This change in the curvature of the cervical spine may occur in an attempt to compensate the narrow airway space in the affected subjects. The cranial region was not affected and showed no morphological changes in the asthmatic subjects.

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