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Original Research

Changes in orientation and position of hyoid bone and pharyngeal airway space in various malocclusions: A retrospective study

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ABSTRACT:

The aim of the study is to evaluate the position and orientation of hyoid bone and pharyngeal airway space changes in pre-treatment and post -treatment parameters in different malocclusion patients and to establish corelation between them. This study comprised of 100 lateral cephalograms pre and post treatment of the patients between the age group of 15 – 22 years, irrespective of their gender, reported to the Department of Orthodontics and Dentofacial Orthopaedic, New Horizon Dental College and Research Institute, Sakri, Bilaspur, Chhattisgarh.The paired t-test was utilized to compare the pretreatment and posttreatment data, and the Pearson correlation coefficient was employed to examine the association between the pharyngeal airway size and dentofacial characteristics. The modifications to An independent t-test was used to compare the two groups' post-treatment hyoid location and pharyngeal airway size.The data are tabulated in Microsoft excel and analysed with SPSS V.24 software. The continuous variables are presented with mean and standard deviation. The categorical variables are presented with frequency and percentage. Independent t test is used for the statistical analysis. The p value ≤ 0.05 is considered statistically significant.The upper and lower pharyngeal airways were assessed according to McNamara's airways analysis. According to the results of the present study, ClassIII has the most pharyngeal space, followed by ClassI, and ClassII, which has the least. The oropharyngeal airway volumes of Class II patients were smaller when compared with ClassI and ClassIII patients. It was observed that mandibular position with respect to cranial base had an effect on the oropharyngeal airway volume.

Keywords: Angle's malocclusions, cephalometry, hyoid bone, pharyngeal airway space

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INTRODUCTION

The hyoid bone is a horseshoe-shaped bone located high in the neck[1]. Considerable attention has been given to the position of the hyoid bone in relation to the facial skeleton[2]. The hyoid bone has no bony articulation but is completely suspended by muscles. The muscles (infra and supra hyoid) connect the hyoid bone to different structures such as the tongue, the mandible, the base of the skull, the sternum, the scapula, the thyroid cartilage and the pharynx. Because of the complex attachments of the hyoid bone to different structures, changes in the position of those may influence its position in space[3].

The anatomy of the hyoid bone is composed of one central body, two ventrally located lesser horns, and two dorsally located greater horns.[4] The hyoid is the only bone of the human body which does not stablish any kind of bony articulations and it is kept in position by the action of muscles and ligaments attached on it. This bone poses unique characteristics. It is derived from the second and third branchial arches, together with the posterior portion of the tongue. Its shape reminds us a horse-shoe and its projections encircle the larynx, just above the thyroid cartilage. at the level of the epiglottis. Two great muscle groups are inserted on it, the suprahyoid muscles - depressors of the mandible - and the infrahyoid muscles - depressors of the larynx.[5]

The hyoid bone influences the tongue, the base of the skull, the thyroid cartilage, the mandible, the sternum, the scapula and the pharynx.Some authors[6] studied the morphology and the function of this bone and others[7] , through cephalometric techniques, tried to stablish the position of the hyoid bone in relation to the structures of the skull and cervical vertebrae. The resting position of hyoid bone is tied to tensional stress between suprahyoid and infrahyoid muscles.[8] Geniohyoid and mylohyoid muscles are the primary suprahyoid muscles. These muscles tolerate varying workloads depending on the position and posture of patient.[9,10]The hyoid bone plays an important role in the physiology of the tongue, whose deviations may cause severe malocclusions. There is a general agreement in orthodontics about the responsibility of the tongue functional devices such as the tongue thrust and the atypical swallowing, as being important etiological factors of some types of the malocclusion deviations.[5] The hyoid bone supports the base of the tongue, and takes part in the process of deglutition and respiration due to attachments to active muscles during these processes.[11] The hyoid bone has a strategic position and participates in numerous vital functions. It is closely connected to the larynx and takes an active part in speech.

The purpose of the hyoid bone is to maintain the pharynx open and preserve the pharyngeal function on the tracheal rings.[12] The mandible can be a good reference for determining the hyoid bone position since the hyoid bone follows a path similar to the mandible in flection and extension movements of the cervical vertebrae.[13]

Positive correlation has been reported with the position of the hyoid bone and the pharyngeal airway space in a group of normally swallowing individuals.[14] The importance of the hyoid bone should now be self-evident. Without it, our facility of maintaining an airway, swallowing and preventing regurgitation, and maintaining the upright postural position of the head could not be as well controlled.[15]

Pharyngeal anatomy and dentofacial form are expected to have a mutual relation because of their close anatomical proximity, thus rationalizing orthodontic attention. The nasal airway physiology needs adequate anatomical dimensions for the airway. Oral respiration related to nasal obstruction is a common finding among orthodontic patients[16]. Obstruction of nasopharyngeal respiration is often associated with various craniofacial features, such as upward and backward growth of condyle, downward and backward rotation of mandible, anterior open bite, divergent gonial angle, and spacing in the mandibular anterior region. Significant correlation is found among hyoid bone position and width of the pharyngeal space inferiorly with the change in ANB (A point, nasion, B point) angle[17].

The lateral cephalogram is considered an effective tool intended for assessing different measurements of the pharyngeal region, the position of the hyoid bone, and their relationship with various malocclusions[18].

Pharyngeal anatomy and dentofacial form are expected to have a mutual relation because of their close anatomical proximity, thus rationalizing orthodontic attention. The present study establishes the correlation among nasopharynx and position of the hyoid bone. The relationship between airway patency and

changes in their craniofacial development, including narrow maxillary arch, posterior crossbite, anterior open bite, retroclination of maxillary and mandibular incisors, and short mandibular arch. These patients also have increased anterior face height, lower tongue posture, and increased mandibular plane angles when compared with control subjects with normal-sized adenoids. In animal studies, morphologic effects of induced nasal obstruction increase anterior face height, increase the occlusal and mandibular plane angles, lower the mandibular posture, increase the posterior dental eruption, lead to forward tongue posture, induce anterior crossbites, and can modify interdental relationships. Removing the nasal obstruction can partially reverse the palatal, occlusal, and mandibular plane angles toward those of controls.[20]

Craniofacial development is at present a highly debated subject. The controversy is not only academically important; it also has considerable clinical consequences because it can influence the orthodontist's decision as to whether active allergy management or a more aggressive therapy such as adenoidectomy should be performed for solely orthodontic reasons.[15]

The pharynx can be anatomically divided into two parts: an upper region (the nasopharynx) and a caudal area (the oropharynx).[19] We have divided it as the upper and the lower pharyngeal airway space (PAS). The pharynx increases its capacity predominantly by a vertical expansion that is dictated by the amount and direction of growth at the spheno-occipital synchondrosis and the cervical vertebrae. Certain structural features of the pharynx are under genotypic control and are associated with skeleton-facial structure. As such, the dolichocephalic somatotype is characterized by a more shallow pharyngeal depth, a longer neck that is acquired by considerable vertical cervical growth with a concomitant downward movement of the hyoid bone, and a decrease in cervical lordosis. Adult nasopharyngeal depth dimensions are established early in life. At the oropharyngeal level the same sagittal stability is exemplified by the constant position of the hyoid bone relative to the cervical column. The ultimate capacity of the pharynx depends on the growth and relative size of the soft tissues. Adenoid vegetation or tongue mass may decrease the patency of the airway and induce postural adaptations at the oropharyngeal level.

A drop in hyoid position relative to the mandible represents an attempt to secure a relatively constant anteroposterior diameter. Further neuromuscular recruitment induces alterations in the position of the mandible at rest and an extension of the cervical spine. This function adaptation may influence the existing craniofacial growth pattern. Given the possible clinical importance of these neuromuscular adaptations, more quantitative research on these reflexes is recommended.[18]The structure of the pharynx and the patency of airway affects the craniofacial development. The soft palate has been previously shown to be longer in patients with obstructive sleep apnea (OSA) than in controls. Children with enlarged adenoids that obstruct nasal breathing also exhibit certain changes in their craniofacial development, including narrow maxillary arch, posterior crossbite, anterior open bite, retroclination of maxillary and mandibular incisors, and short mandibular arch. These patients also have increased anterior face height, lower tongue posture, and increased mandibular plane angles when compared with control subjects with normal-sized adenoids. In animal studies, morphologic effects of induced nasal obstruction increase anterior face height, increase the occlusal and mandibular plane angles, lower the mandibular posture, increase the posterior dental eruption, lead to forward tongue posture, induce anterior crossbites, and can modify interdental relationships. Removing the nasal obstruction can partially reverse the palatal, occlusal, and mandibular plane angles toward those of controls.[20]

The aim of this retrospective study is to determine the long-term changes in position and orientation of hyoid bone and pharyngeal airway size after orthodontic treatment in Indian population.

MATERIALS AND METHOD

This study comprised of 100 lateral cephalograms pre and post treatment of the patients between the age group of 15 – 22 years, irrespective of their gender, reported to the Department of Orthodontics and Dentofacial Orthopaedic, New Horizon Dental College and Research Institute, Sakri, Bilaspur, Chhattisgarh.The patients were diagnosed for their malocclusion and their treatment was planned after case presentation and discussions. Inclusion criteria:Subject selected were between the age group of 15years to 22years, comprehensive medical and dental history ruling out any systemic illness, all ethnicities were included,all Class I malocclusion patients with an ANB value between 1° to 4°,all Class II malocclusion patients with an ANB value more than 4°, all Class I bimaxillary protrusion patients to be included, all permanent teeth from second molar to second molar were present.Exclusion criteria:patient who had already undergone orthodontic treatment before, patient with TMJ problems or any facial or skeletal deformity, patients having missing or carious molar teeth, patient having any prosthesis. The materials required are lead pencil 0.3mm, acetate paper, ruler, protractor, lateral cephalograms with good quality image and well oriented (fig; 1).In this study 100 randomly selected lateral cephalograms pre-treatment and post treatment of the patients between the age group of 15 – 22 years who have undergone orthodontic treatment were selected from the archives of Department of Orthodontics and Dentofacial Orthopedics from New Horizon Dental College and Research Institute.

The lateral cephalogram taken with natural head position were manually traced on matte acetate sheets.

Fig 1: Tracing materials

HYOID BONE

landmark

The following cephalometric landmarks were used for the study of position and orientation of Hyoid bone:

1. S- Sella turcica
2. N- Nasion
3. P- Porion
4. Or- Orbitale
5. Go- Gonion
6. Me- Menton
7. H- Hyoidale
8. C3- Third cervical vertebrae
9. Point A- Subspinale
10. Point B- Supramentale
11. ANS- Anterior nasal spine
12. PNS- Posterior nasal spine

Fig 2: Landmarks

For linear and angular measurements, a ruler and protractor were used and readings were recorded to the nearest of 0.5 mm and half degree, respectively.

MEASUREMENTS
The following linear and angular measurements were analysed:

Linear measurements (fig: 3)-
1. SN- Sella-nasion plane
2. FH- Frankfort horizontal plane
3. MP- Mandibular plane
4. H-SN- perpendicular: linear distance along a perpendicular from H to the S-N plane.
5. H-FH-perpendicular: linear distance along a perpendicular from H to the Frankfort plane.
6. H-MP perpendicular: linear distance along a perpendicular from H to the mandibular plane (Go-Gn).
7. H-C3-Linear distance between H and C3
8. H-Me- Linear distance between Hyoidale andMenton
9. H-Go- Linear distance between Hyoidale and the Gonion

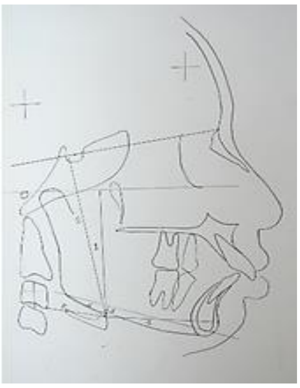


Fig 3: Linear measurements

Angular measurements (fig: 4)-
1. SNA: The angle from Sella to Nasion to point A.
2. SNB: The angle from Sella to Nasion to point B.
3. ANB: The angle joining point A to Nasion (N) to point B, (SNA-SNB difference).
4. NSH: The angle from Nasion to Sella to Hyoidale.
5. MPH: The angle from Gonion to Gnathion to Hyoidale.

Fig 4: Angular measurements

For pharyngeal airway (fig: 5) -
According to McNamara analysis the following measurements were analysed:
Upper pharynx- a) Posterior outline of the soft palate
b) Closest point on pharyngeal wall
Lower pharynx- a) Point of intersection of posterior border of tongue and inferior border of the mandible.
b) closest point on posterior wall of pharynx.

Fig 5. Pharyngeal airway space

All the above-mentioned landmarks were traced to obtain linear and angular measurements and for each variable arithmetic mean, standard deviation and level of significance was calculated.

Statistical analysis
The data are tabulated in Microsoft excel and analysed with SPSS V.24 software. The continuous variables are presented with frequency and percentage. Independent t-test is used for the statistical analysis. The p value ≤ 0.05 is considered statistically significant.

RESULTS
This study was conducted to evaluate changes in orientation and position of hyoid bone and pharyngeal airway space in various malocclusions (Table:1). All 100 lateral cephalograms of pre- and post-treatment of the patients were collected from archive and OPD reported to the Department of Orthodontics and Dentofacial Orthopaedic, New Horizon Dental College and Research Institute, Sakri, Bilaspur, Chhattisgarh.
In this study, the linear and angular measurements of the study have been tabulated in Table 2, 3, 4, 5. The linear measurements of H-FH, H-SN, H-MP, H-Pog, H-C3, H-Go showed statistically significant differences in Class I, Class II and Class III. The angular measurements of SNA, SNB, ANB, SNH, MPH were statistically significant differences in respective skeletal malocclusions.These results demonstrate that, in contrast to ClassII malocclusion, which has the hyoid bone positioned more superiorly,

ClassIII malocclusion has it more inferiorly. Hyoid position in relation to mandible utilizing H-Pog, H-Me, and H-C3 parameters has demonstrated that the mandible is positioned more anteriorly in ClassIII malocclusion and more posteriorlyin ClassII malocclusion. ClassII malocclusions have the hyoid bone more posteriorly and superiorly positioned, whereas ClassIII malocclusions have it anteriorly and inferiorly positioned, according to the angular measurements of SNH and MPH. The mandible in ClassIII grew vertically, approximately reaching the level of the cervical vertebra, as indicated by the linear measurement from the cervical vertebra to the symphysis, which was least in that class and highest in ClassI. The pharyngeal cephalometric analysis in this study revealed significant dimensional differences in the superior and inferior part of the upper and lower airway among different malocclusion.

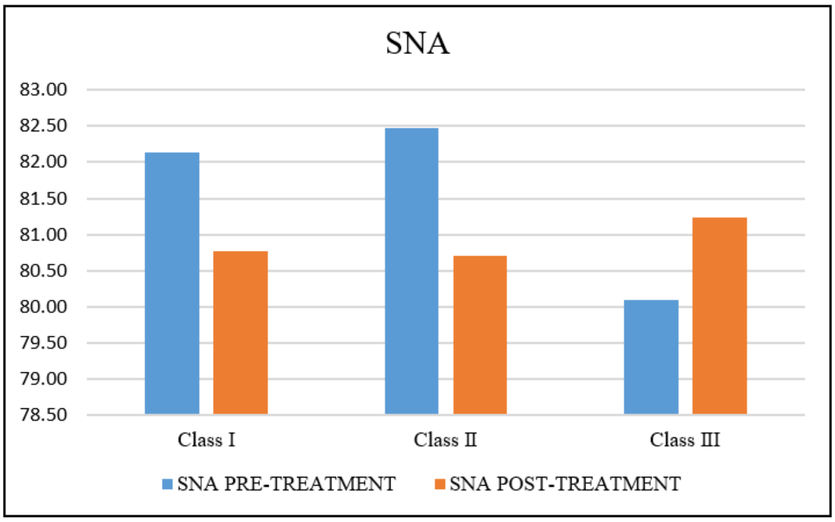
Table 1: Distribution of malocclusions

Malocclusion	N	%
ClassI	69	69%
ClassII	24	24%
ClassIII	7	7%

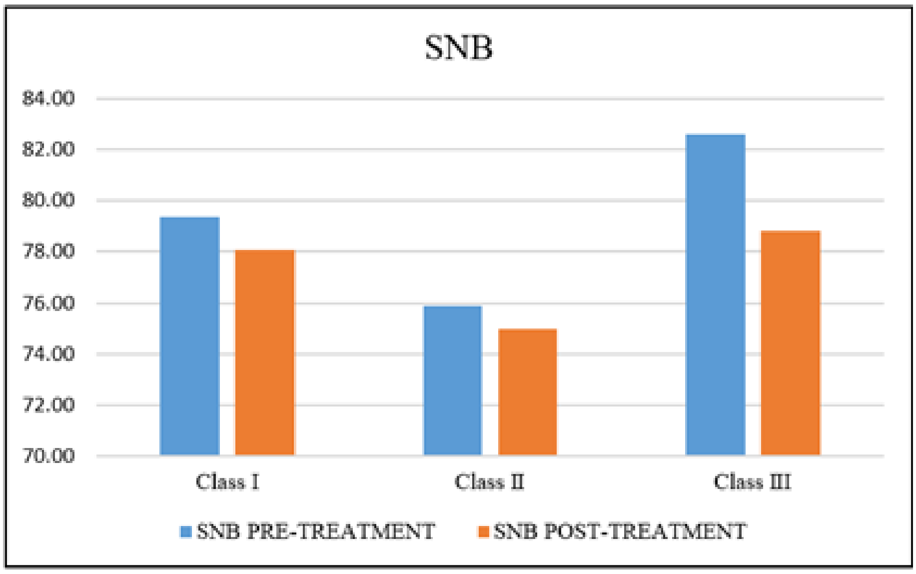
Table 2. Comparison of Angular parameters - pre-treatment between the classes

Angular parameters - pre-treatment	Group	Mean(°)	SD	P value
SNA pre-treatment	ClassI	82.13	1.56	.001
	ClassII	82.48	0.43	
	ClassIII	80.10	0.71	
SNB pre-treatment	ClassI	79.39	1.46	<0.001
	ClassII	75.89	1.13	
	ClassIII	82.60	1.52	
ANB pre-treatment	ClassI	2.74	0.68	<0.001
	ClassII	6.24	0.75	
	ClassIII	-2.50	0.58	
SNH pre-treatment	ClassI	53.57	3.39	<0.001
	ClassII	50.33	1.93	
	ClassIII	59.00	2.06	
MPH pre-treatment	ClassI	8.70	2.94	<0.001
	ClassII	10.67	2.10	
	ClassIII	4.00	1.77	

Statistically significant difference present between the Classes.



Graph 1. Comparison of pre and post-treatment SNA



Graph 2. Comparison of pre and post-treatment SNB

Table 2. Comparison of Angular parameters - pre-treatment between the classes

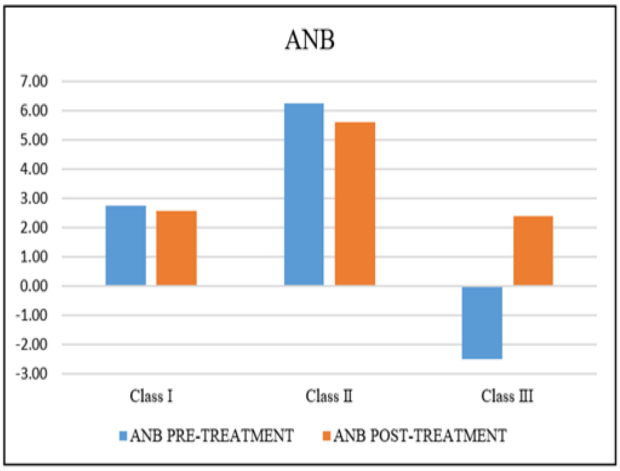
Angular parameters - pre-treatment	Group	Mean(°)	SD	P value
SNA pre-treatment	ClassI	82.13	1.56	.001
	ClassII	82.48	0.43	
	ClassIII	80.10	0.71	
SNB pre-treatment	ClassI	79.39	1.46	<0.001
	ClassII	75.89	1.13	
	ClassIII	82.60	1.52	
ANB pre-treatment	ClassI	2.74	0.68	<0.001
	ClassII	6.24	0.75	
	ClassIII	-2.50	0.58	
SNH pre-treatment	ClassI	53.57	3.39	<0.001
	ClassII	50.33	1.93	
	ClassIII	59.00	2.06	
MPH pre-treatment	ClassI	8.70	2.94	<0.001
	ClassII	10.67	2.10	
	ClassIII	4.00	1.77	

Statistically significant difference present between the Classes.

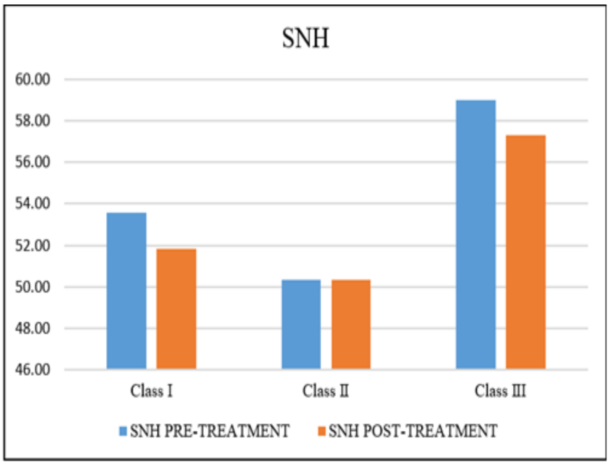
Table 3. Comparison of Angular parameters - post-treatment between the classes

Angular parameters - post-treatment	Group	Mean(°)	SD	P value
SNA post-treatment	ClassI	80.76	1.30	.003
	ClassII	80.70	0.58	
	ClassIII	81.23	0.92	
SNB post-treatment	ClassI	78.06	1.24	<0.001
	ClassII	74.97	1.50	
	ClassIII	78.82	1.31	
ANB post-treatment	ClassI	2.59	0.69	<0.001
	ClassII	5.60	1.23	
	ClassIII	2.41	0.55	
SNH post-treatment	ClassI	51.81	3.37	<0.001
	ClassII	50.33	1.93	
	ClassIII	57.30	3.63	
MPH post-treatment	ClassI	8.74	3.41	.012
	ClassII	10.00	2.50	
	ClassIII	6.00	1.92	

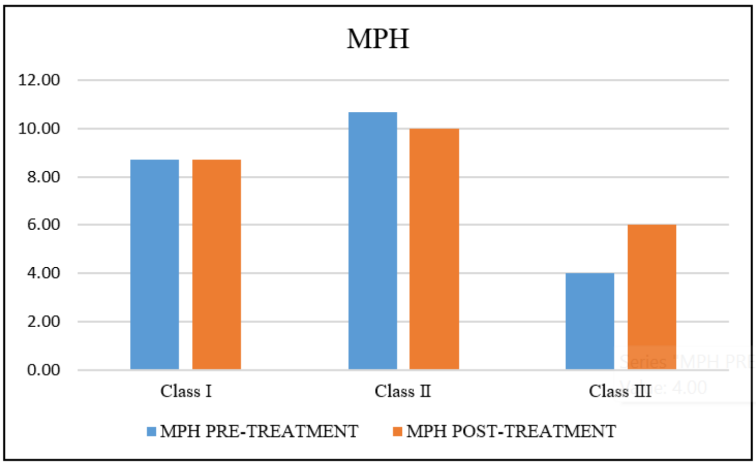
Statistically significant difference present between the Classes.



Graph 3. Comparison of pre and post-treatment ANB



Graph 4. Comparison of pre and post-treatment SNH



Graph 5. Comparison of pre and post-treatment MPH

Table 4. Comparison of Linear parameters - pre-treatment between the classes

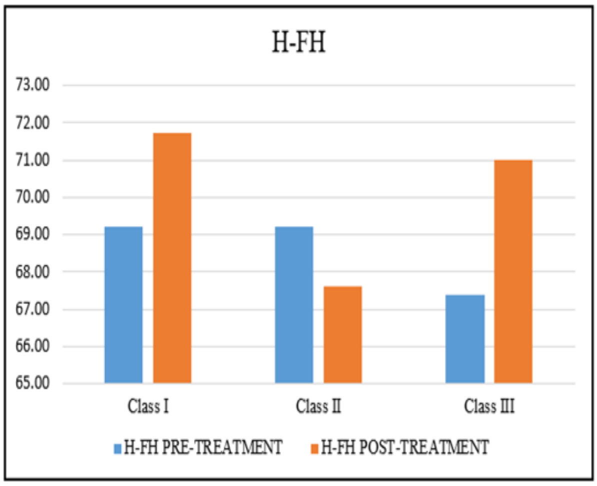
Linear parameters - pre-treatment	Group	Mean(mm)	SD	P value
H-FH pre-treatment	ClassI	69.21	3.72	.049
	ClassII	69.23	2.54	
	ClassIII	67.40	2.19	
H-SN pre-treatment	ClassI	83.97	3.60	.014
	ClassII	84.13	4.81	
	ClassIII	86.00	5.02	
H-MP pre-treatment	ClassI	5.68	2.28	.002
	ClassII	6.07	0.75	
	ClassIII	3.10	0.66	
H-POG pre-treatment	ClassI	40.99	2.96	<0.001
	ClassII	44.03	2.16	
	ClassIII	37.00	1.98	
H-C3 pre-treatment	ClassI	28.77	2.83	<0.001
	ClassII	26.77	5.21	
	ClassIII	33.50	6.27	
H-GO pre-treatment	ClassI	31.85	3.40	<0.001
	ClassII	26.97	2.80	
	ClassIII	38.00	4.22	

Statistically significant difference present between the Classes.

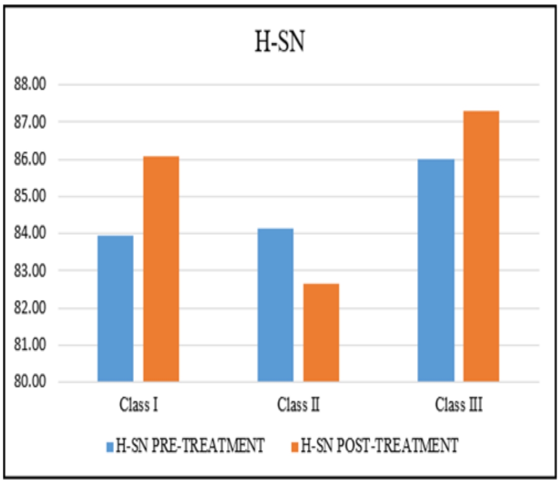
Table 5. Comparison of Linear parameters - post-treatment between the classes

Linear parameters - post-treatment	Group	Mean(mm)	SD	P value
H-FH post-treatment	ClassI	71.73	3.09	<0.001
	ClassII	67.60	2.78	
	ClassIII	71.00	3.05	
H-SN post-treatment	ClassI	86.10	3.35	.002
	ClassII	82.67	6.26	
	ClassIII	87.30	4.27	
H-MP post-treatment	ClassI	7.08	2.25	<0.001
	ClassII	5.10	2.63	
	ClassIII	4.00	1.82	
H-POG post-treatment	ClassI	42.40	3.00	<0.001
	ClassII	46.13	3.15	
	ClassIII	35.40	2.29	
H-C3 post-treatment	ClassI	26.68	3.18	<0.001
	ClassII	26.43	3.49	
	ClassIII	37.60	5.12	
H-GO post-treatment	ClassI	29.52	3.78	<0.001
	ClassII	26.07	2.60	
	ClassIII	40.67	4.07	

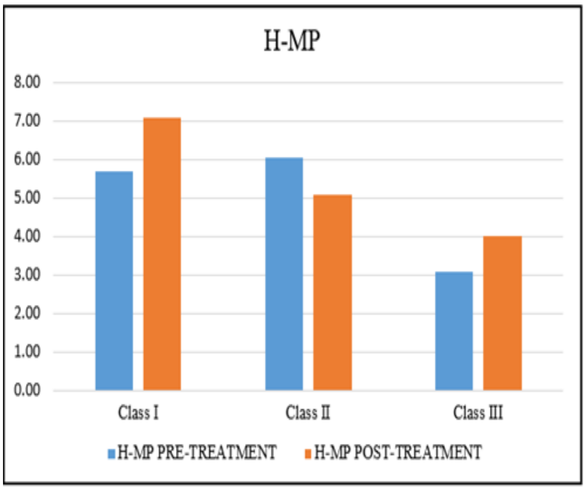
Statistically significant difference present between the Classes.



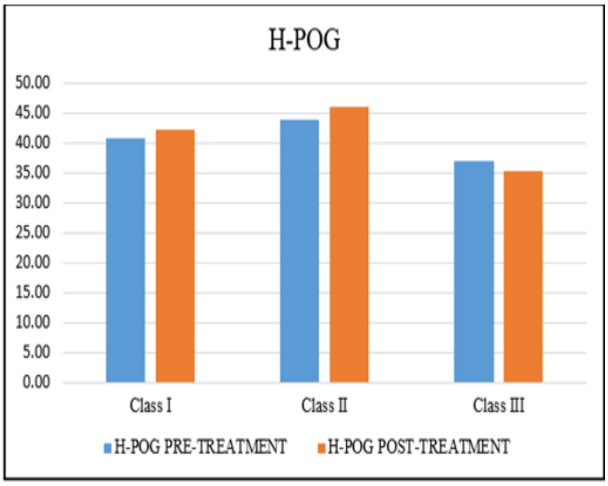
Graph 6. Comparison of pre and post-treatment H-FH distance



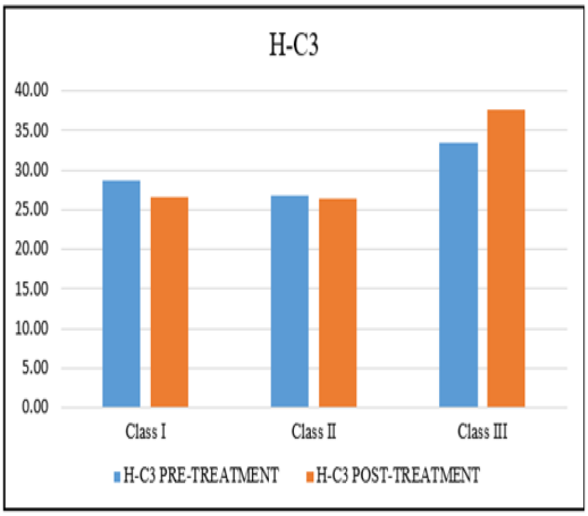
Graph 7. Comparison of pre and post-treatment H-SN distance



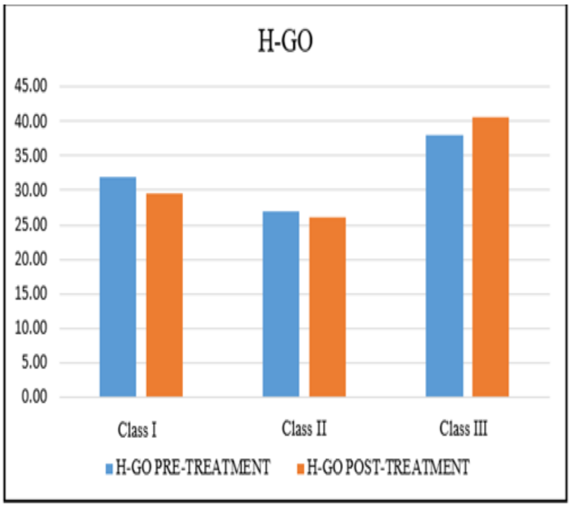
Graph 8. Comparison of pre and post-treatment H-MP distance



Graph 9. Comparison of pre and post-treatment H-Pog distance



Graph 10. Comparison of pre and post-treatment H-C3 distance



Graph 11. Comparison of pre and post-treatment H-Go distance

Table 6. Comparison of Airway - pre-treatment between the classes

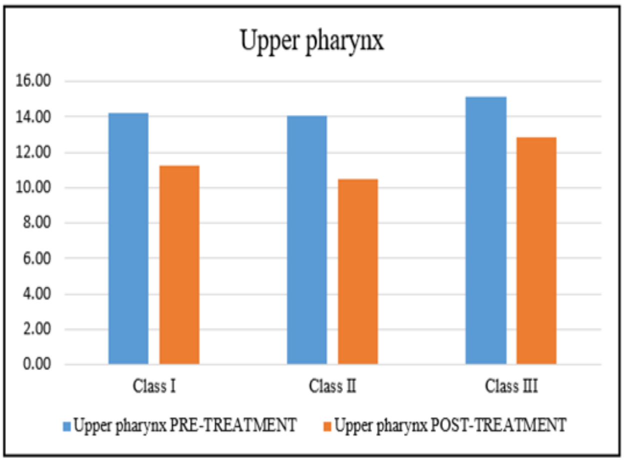
Airway - pre-treatment	Group	Mean(mm)	SD	P value
Upper pharynx pre-treatment	ClassI	14.23	1.92	.008
	ClassII	14.06	1.67	
	ClassIII	15.00	1.84	
Lower pharynx pre-treatment	ClassI	10.93	1.62	.011
	ClassII	10.67	1.74	
	ClassIII	11.00	2.07	

Statistically significant difference present between the Classes.

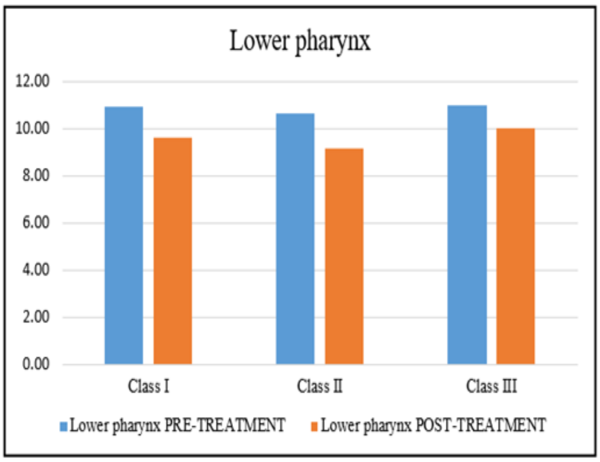
Table 7. Comparison of Airway - post-treatment between the classes

Airway - post-treatment	Group	Mean	SD	P value
Upper pharynx post-treatment	ClassI	11.25	1.58	.014
	ClassII	10.49	1.22	
	ClassIII	12.88	1.70	
Lower pharynx post-treatment	ClassI	9.63	1.17	<0.001
	ClassII	9.17	1.34	
	ClassIII	10.02	1.17	

Statistically significant difference present between the Classes.



Graph 11. Comparison of pre and post-treatment upper pharyngeal space



Graph 12. Comparison of pre and post-treatment lower pharyngeal space

DISCUSSION

The etiology of malocclusion is believed to be multifactorial, since the airway is assumed to play a role in dentofacial development, several studies tried to correlate patients with normal naso-respiratory functions with different malocclusions and airway dimensions. From the late 1800s until now, the relationship between pharyngeal structures and dentofacial pattern has been intensively researched. Early research was mostly based on observational estimates, mainly because of insufficient medical instrumentation. However, the opinions that have arisen from these limited conditions are still being discussed.[21]

Radiographic assessment of the nasopharyngeal airway and hyoid bone position can be performed with great accuracy and reproducibility when carried out under well-defined conditions and cephalostatic fixation of the head. The methods for determining the position of the hyoid bone through cephalometric radiographs are variable. Some authors like King[22] used just linear measurements, others used linear and angular measurements. During orthodontic diagnosis and treatment planning an evaluation of the patient's nasal respiratory function can offer valuable information. It is therefore desirable to find a simple method of assessing the nasal and nasopharyngeal airway, as a complement to the clinical examination.[23,24]

In this study, changes in position and orientation of hyoid bone and pharyngeal airway size after orthodontic treatment was evaluated in various malocclusions where lateral cephalogram taken with natural head position. The statistically different values of the linear and angular measurements findings show that hyoid bone is more inferiorly and posteriorly placed in Class I malocclusion, posteriorly and superiorly placed in class II and anteriorly and inferiorly placed in Class III malocclusion. The findings are similar to Galvao[5], Allhaija and Al-Khateeb[17] and Erdinc et al[26].

In this study, the hyoid bone moves inferiorly in ClassI and III cases compared to superiorly in Class II. The linear parameters for the hyoid bone's position (H-FH, H-SN, and H-MP) increases in these cases and the parameters (H-Pog) increases in ClassI and ClassII as the hyoid moves posteriorly and decreases in ClassIII as the bone moves anteriorly. The parameters (H-C3, H-Go) also increases and decreases in response to the hyoid bone's movement. The results of the angular measurements of hyoid bone failed to detect any significant differences among the three skeletal patterns. This was in agreement with results of a study by Chauhan et al.[27] which reported no difference in angular measurements of hyoid bone between Class I and Class II Div1 subjects. He evaluated the pharyngeal airway dimension, tongue and hyoid position in subjects with normal naso-respiratory functions having different dentofacial patterns of ClassI and Class II Division 1 patients which were selected randomly. Lateral head cephalograms were taken in normal head position within a lead foil attached to the tongue tip and a barium coating on the dorsal surface of tongue. The lateral cephalograms obtained were traced using lead acetate paper and measurements were taken. Different analyses were done for the pharyngeal airways, hyoid bone, and tongue.

Pharyngeal airway dimensions were seen to be the largest in skeletal Class III, followed by skeletal ClassI and skeletal Class II. These results are similar to the results of *Muto et al*[28], *Takemoto et al*[29], and *Martin et al*[30]. They established that the diameter of the pharyngeal airway was the highest in the mandibular prognathism, followed by the normognathic mandible, and the lowest in the retrognathic mandible. The mandible being positioned more anteriorly in prognathic patients results in a broader lower pharyngeal airway. Pharyngeal airway dimensions were greater in males compared to females, similar to the findings in the studies *by Samman et al*[31], *Guttal et al*[32], *and Martin et al*[30].

To find out the antero-posterior diameter of the pharyngeal airway space (PAS) at the level of the soft palate and base of the tongue was assessed in age-matched females with a normal mandible (n = 31), mandibular retrognathism (n = 30) or mandibular prognathism (n = 38) as study conducted by *Muto et al*[30] in 2008. All subjects were examined by lateral cephalometry. Measured variables were corrected with the use of appropriate regression equations to eliminate the effects of head posture on the PAS. The corrected data showed more clear-cut differences in the PAS among the three groups than did the measured data. Pharyngeal airway diameter was largest in the group with mandibular prognathism, followed by the normal mandible and mandibular retrognathism groups. These results indicate that the antero-posterior dimension of the PAS is affected by different skeletal patterns of the mandible.

The hyoid bone position had been examined in response to mandibular advancement in subjects with mild and moderate obstructive sleep apnea (OSA). Pairs of lateral cephalograms were taken, the first in the maximum intercuspation and the second in the most comfortable protrusion position. All the patients (13 females and 45 males) were Caucasians. The study which was conducted by *Battagel et al. 1999*[38] showed that in the protruded mandible the hyoid bone became closer to the mandibular plane and also displaced in more upward position.

The change in the position of the hyoid bone was examined by *Arslan et al. (2007)*[39] in patients with Hypohidrotic Ectodermal Dysplasia (HED), who exhibit the typical craniofacial features of Class III malocclusion, maxillary retrognathia, and deficiencies in the vertical, transversal, and sagittal growth of the jaws, in comparison to a control group. According to reports, the control group's hyoid bone was positioned more posteriorly than Class III.

The hyoid bone location in respect to the breathing pattern was evaluated cephalometrically by Ferraz et al. (2007)[40]. There were twenty-eight nasal breather samples and twenty-five oral breather samples in the study. The samples were all female. According to the study's findings, there were no statistically significant variations in the positions of the mandible, hyoid bone, and respiratory pattern. This means that the hyoid bone maintained a stable position independent of respiratory pattern which does not support present study.

The hyoid bone's resting position is very constant and is unaffected by habitual tongue-thrusting or mouth breathing, according to Bibby's (1984) [15] assessment of the position of the bone among mouth breathers and tongue-thrusters. For this reason, it can be used as a reference landmark in cephalometric analysis for orthodontic treatment purposes. The tongue and hyoid bone did not advance posteriorly with the mandible to the other craniofacial structures, according to Tourne[19], or else they would have invaded the important oropharyngeal and laryngeal niches. To mitigate this issue, the hyoid bone and related components are positioned inferiorly to prevent airway compromise. This implies that the pharyngeal airway's stability and patency are the main determinants of hyoid placement.

In order to determine whether pharyngeal variables in cephalograms are more reliable than a single measurement of the most restricted area, Pae et al[41]. devised a study. Eighty pairs of supine and upright cephalograms were acquired; these were then divided into four groups based on the severity of OSA. The results showed that the pharynx lengthens as the position of the hyoid bone moves inferiorly, as the hyoid bone and epiglottis share a close anatomical relationship. The difference in upper airway length between patients in Class II and Class III can be explained by the hyoid bone position found in Class II and Class III in this study.

According to the functional matrix theory the supra hyoid muscles that attach to the mandible and the tongue causes the hyoid bone to be more anteriorly placed and hence changes the position of the bone in relation to ClassI patients. While in Class II the contracture of the supra hyoid muscles is lesser and the hence the hyoid is more posteriorly and superiorly placed. The role of the functional matrix theory can hence be described well with the correlation of the hyoid bone with the different skeletal malocclusion. Conversely, because of the adverse effects of the hyoid bone's position and orientation in different growth patterns, the functional matrix theory can be refuted on the same grounds. It states that because of the mandible's rotation, the hyoid bone's position and orientation should alter, but this isn't the case and as a result, provides statistically insignificant data, which defies the alternative explanation.

CONCLUSION

The purpose of this study was to evaluate changes in orientation and position of hyoid bone and pharyngeal airway space in various malocclusions. The hyoid bone plays a critical role in the function of the suprahyoid and infrahyoid muscle groups. Its contribution to the particular orientation and function of these muscle groups may be crucial for the establishment of particular jaw structural elements and tooth occlusion. Further investigation on different types of malocclusions, as well as other craniofacial anomalies, might be useful in clarifying the role of the hyoid bone in growth magnitude and direction, and in the influencing of mandibular growth through the control of the suprahyoid or infrahyoid muscles. Depending on the type of skeletal malocclusion, the hyoid bone has a variable position and orientation.The hyoid bone is more inferiorly and posteriorly positioned in ClassI malocclusion, posteriorly and superiorly placed in Class II malocclusion, and anteriorly and inferiorly placed in ClassIII malocclusion.

Limitation of our study is that, to reach a conclusive result, the vertical and transverse dimensions of the complex three-dimensional (3-D) anatomical structures must be assessed and correlated; however, in this investigation, two-dimensional (2-D) lateral cephalograms were used. Since we are comparing two cephalograms that were collected at various times, standardizing the magnification of the lateral cephalograms from pre- and post-treatment is necessary for this investigation to minimize the error.

To overcome this,with the development of three-dimensional computerized tomography (CT) scans, this diagnostic modality is advised for more accurate assessment of orthodontic patients for prospective evaluations of three-dimensional craniofacial structures, such as the pharynx, hyoid bone, and position of the tongue in relation to various facial types. Direct digitization of radiographs using a computer-controlled program significantly reduces the amount of effort required.With the use of accessible cephalometric tracing software, we can quickly and accurately evaluate cephalometric radiographs and create progress superimpositions.

Values obtained from present study suggested that maintaining the patency of the upper respiratory tract is one of the main functional factors controlling the movement of the hyoid bone in patients with different skeletal patterns. In the context of orthodontic treatment, the dimensional changes in the pharyngeal area were generally minor, and even the differences observed.

The upper and lower pharyngeal airways were assessed according to McNamara’s airways analysis. According to the results of the present study, ClassIII has the most pharyngeal space, followed by ClassI, and ClassII, which has the least. The oropharyngeal airway volumes of Class II patients were smaller when compared with ClassI and ClassIII patients. It was observed that mandibular position with respect to cranial base had an effect on the oropharyngeal airway volume.

For further study, to increase measurement precision and accuracy, lateral cephalogram digitization and cephalometric tracing software should be utilized. In order to achieve a definitive conclusion, it is recommended to increase the sample size and conduct the study in an extensive population to reach to a definite conclusion.

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