Original Article

Comparison of the Changes in Hyoid Bone Position in Subjects with Normodivergent and Hyperdivergent Growth Patterns: A Cephalometric Study

Abstract

Objective: The aim of this study is to test the hypothesis that there is no difference in hyoid bone position among individuals with different growth patterns before and after treatment. **Materials and Methods:** Pre- and post-treatment lateral cephalogram of forty Class I adults in the age group of 20–27 years were grouped. All the cases were treated with the first premolar extraction in all quadrants. Based on the growth pattern of the face, individuals were divided into: (1) Group 1 (n = 20): Normodivergent, i.e., FH/MP angle smaller than 30.5° (20 patients). (2) Group 2 (n = 20): Hyperdivergent, i.e., FH/MP angle larger than 30.5° (20 patients). Lateral cephalograms were traced and analyzed manually for evaluation of hyoid bone position. Patients in both groups were treated with preadjusted appliances. Pre- and post-treatment lateral cephalograms were traced, and variables were compared using paired *t*-test, and the relationship between dentofacial variables, growth pattern, and the hyoid bone position was analyzed using Karl Pearson's correlation coefficient method. The changes of hyoid position after treatment were compared using *t*-test. **Results:** The data were analyzed by Kolmogorov–Smirnov and paired *t*-test. Karl Pearson's correlation coefficient test was performed to determine whether there was an association between the changes of hyoid and growth pattern. Following retraction of incisors, statistically significant correlation was observed in the pre- and post-treatment values of dentofacial structures and hyoid bone, but no significant correlation was found in position of the hyoid bone in the normodivergent and hyperdivergent groups. In both the groups, hyoid bone moved in an inferior and posterior direction after orthodontic treatment. **Conclusion:** No change was seen in position of the hyoid bone in normodivergent and hyperdivergent groups.

Keywords: *Hyoid bone, hyperdivergent, normodivergent*

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Introduction

Brodie[1] points out that as man assumed an upright posture, the head had to be balanced on the vertebral column. This was attained by equal anterior and posterior muscle tension relative to the occipital condyles. In the accomplishment of this delicate cranial balance and posture, the hyoid bone plays an important and active part. According to Gray,[2] the omohyoid muscles are concerned, "especially in prolonged inspiratory efforts, since by tensing the lower part of the cervical fascia it lessens the inward suction of the soft parts which would otherwise compress the great vessels and the lung apices." 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.

In general, considerations of the cervicofacial skeleton, the hyoid bone tends to be overlooked or given scant attention. However, it is a unique structure in man in that, unlike all other bones of the head and neck, it has no bony articulations. There are two major groups of muscles – the suprahyoid and the infrahyoid attached to this bone. These muscles rely on the hyoid bone for their actions and have certain very important functions. The digastric muscles increase the anteroposterior dimension and the oropharynx during deglutition while the posterior belly of the digastric and the stylohyoid muscle act to prevent regurgitation of food after swallowing. The suprahyoid muscles depress the mandible by contracting against a fixed

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hyoid platform, the absence of which may seriously impair mandibular opening.

Several studies have reported significant relationship between pharyngeal structures and both dentofacial and craniofacial structures.[3,4] Numerous researchers reported the interaction between pharyngeal dimensions and various sagittal and vertical facial growth patterns at varying degrees.[5,6] Skeletal features such as retrusion of the maxilla and mandible and vertical maxillary excess in hyperdivergent patients may lead to narrower anteroposterior dimensions of the airway.[7]

Sagittal facial growth is seen as downward and forward growth.[8,9] A study indicated that vertical growth of condyles is lesser than vertical growth of facial sutures and alveolar processes, resulting in backward mandibular rotation and bite opening. On the contrary, if vertical growth of condyles is greater than vertical growth of facial sutures and molar areas, forward mandibular rotation and bite closing are seen. Therefore, the ultimate vector of mandibular growth is a consequence of the competition between horizontal and vertical growth.[10] An interaction occurs between respiratory function and the maxillary and mandibular growth pattern.[11]

The correlation between hyoid bone position and the vertical growth pattern of the face is controversial. Opdebeeck *et al*.[12] compared the position of the hyoid bone in individuals with short face and long face syndrome and noted movement of the hyoid bone in concert with movement of the mandible, tongue, pharynx, and cervical spine. Thus, the positions of the hyoid bone and the tongue can be considered as indicators of pharyngeal airway passage. Hence, it is necessary to determine whether any difference is evident in the hyoid bone position among patients with different growth patterns. To investigate this assumption, the main aim of this study was to compare changes in position of the hyoid bone in healthy Class I individuals with two different growth patterns (Group I: Normodivergent and Group II: Hyperdivergent). For this purpose, the null hypothesis assumed was that no significant differences were present in the hyoid bone position of Class I individuals with different growth patterns. Furthermore, the pre- and post-treatment dentofacial parameters in normodivergent and hyperdivergent group were compared.

Materials and Methods

Pre- and post-treatment lateral cephalogram: of forty, Class I adults in age group of 20–27 years were grouped. All the cases were treated with the first premolar extractions in all quadrants. Based on the growth pattern of the face, patients were divided into:

1. Group I (n = 20): Normodivergent, i.e., FH/MP angle smaller than 30.5°
2. Group II (n = 20): Hyperdivergent, i.e., FH/MP angle larger than 30.5°.

Pre- and post-lateral cephalograms were traced and analyzed manually for evaluation of hyoid bone position and variables were compared. Individuals in both groups were treated with preadjusted appliances. The inclusion criteria included: Skeletal Class I, Class I molar, canine, and premolar relationship; well-aligned arches with no or minimal crowding; increased UL-E line, LL-E line, U1/SN, and L1/M P value greater than standard deviation (SD) above the mean. Maximum anchorage and maximal retraction of anterior teeth, no obvious hyperplasia of tonsils or adenoids on cephalograms, no history of previous orthodontic/orthopedic treatment or any cleft lip/palate, patients with chronic mouth breathing, permanent snoring and tonsillectomy, or adenoidectomy were excluded from the study.

All patients were treated with 0.022 × 0.028 inch preadjusted appliances. All pre- and post-treatment cephalograms were taken from the same machine by the same operator. Hyoid bone position was evaluated. The cephalometric landmarks and analyses [Table 1 and Figures 1, 2] were based on

Table 1: Cephalometric Landmarks and Measurements

Variable	Definition
Landmarks	
C3	The most anteroinferior point of the third vertebra
H	The most superior and anterior point of hyoid bone
RGN	The most protrusive point of retrognathion
H1	Foot point of perpendicular line from RGN to C3
Hyoid position	
HRGN, mm	Distance between H and RGN
HH1, mm	Distance between H and H1
C3H, mm	Distance between C3 and H
SH, mm	Distance between S and H
Dentofacial measurements	
ANB, degrees	Angle between point A and B at nasion
FH/MP, degrees	Angle between the mandibular plane and the FH plane
U1/FH, degrees	Angle between the FH plane and long axis of upper incisors
L1/MP, degrees	Angle between the mandibular plane and long axis of lower incisors
UL-E line, mm	Horizontal distance from the most protrusive point of upper lip to E line
LL-E line, mm	Horizontal distance from the most protrusive point of lower lip to E line
U1FHp, mm	Horizontal distance from the tip of the upper incisor crown to constructed FH plane vertical
L1FHp, mm	Horizontal distance from the tip of the lower incisor crown to constructed FH plane vertical
U6FHp, mm	Horizontal distance from the distal point of the upper first molar crown to constructed FH plane vertical
L6FHp, mm	Horizontal distance from the distal point of the lower first molar crown to constructed FH plane vertical

the methods described previously by Lowe *et al*.,[13] Liu *et al*.,[14] and Zhong *et al*.[15] Two serial cephalograms from each individual were traced by the same investigator.

Statistical analysis

All statistical analyses were performed with software package SPSS (for Windows 7, version 16.0, SPSS). Data were expressed as the mean and SD. Kolmogorov–Smirnov test was applied to pre- and post-operative measurements and showed a normally distributed population. Therefore, pre- versus post-treatment values were analyzed with paired *t*-test. The changes of hyoid position before and after treatment were compared using Kolmogorov–Smirnov and paired *t*-test. Karl Pearson's correlation coefficient test was performed to determine whether there was an association between the changes of hyoid measurements and those of dentofacial structures.

Results

No statistically significant differences were observed in the retraction distance of the upper and lower lips and the tip of upper and lower incisor, ANB angle, FH/MP angle, and the hyoid bone position between the normodivergent and hyperdivergent groups after the treatment as shown in Table 2. However, Tables 2 and 3, Graph 1 and 2 show statistically significant changes in the pre and post operative values of Groups I and II for dentofacial parameters and change in position of hyoid bone respectively. Table 4 and

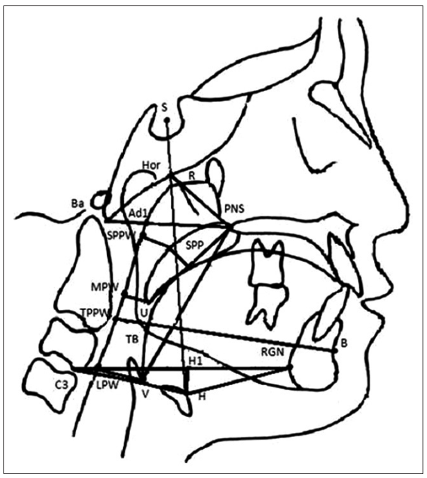


Figure 1: The cephalometric landmarks and analyses of pharyngeal airway

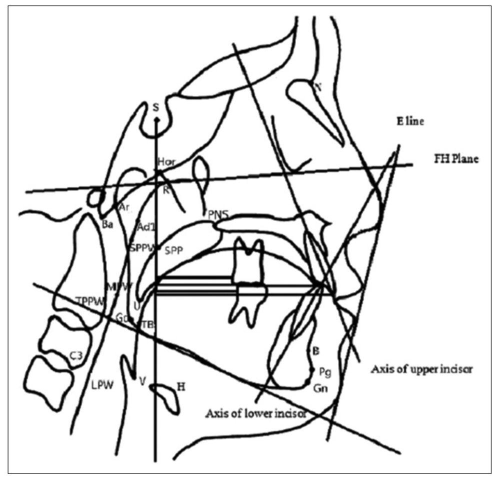


Figure 2: The cephalometric landmarks and analyses of dentofacial complex

Table 2: Comparison of the changes in dentofacial parameters preoperatively and postoperatively in Groups I and II

Variables	Group I Normodivergent (*n*=20)		Group II Hyperdivergent (*n*=20)		*t*	*P*
	Mean	SD	Mean	SD		
ANB (°)	0.41	0.09	0.39	0.09	0.5108	0.6157
FH/MP (°)	0.80	0.28	0.56	0.20	2.1868	0.0422*
U1/FH (°)	15.34	0.59	15.56	1.28	−0.4929	0.6280
L1/MP (°)	4.99	0.73	5.45	0.90	−1.2528	0.2263
UL-E line (mm)	3.33	1.10	3.36	0.98	−0.0622	0.9511
LL-E line (mm)	3.28	0.47	2.96	0.56	1.3915	0.1810
U1FHp (mm)	6.20	0.48	5.93	0.81	0.9078	0.3760
L1FHp (mm)	5.07	0.95	4.68	1.72	0.6281	0.5378
U6FHp (mm)	0.98	0.54	1.12	0.42	−0.6441	0.5276
L6FHp (mm)	0.42	0.40	0.51	0.22	−0.6286	0.5375

*$P<0.05$. SD – Standard deviation

Table 3: Comparison of the changes in position of hyoid bone preoperatively and postoperatively in Groups I and II

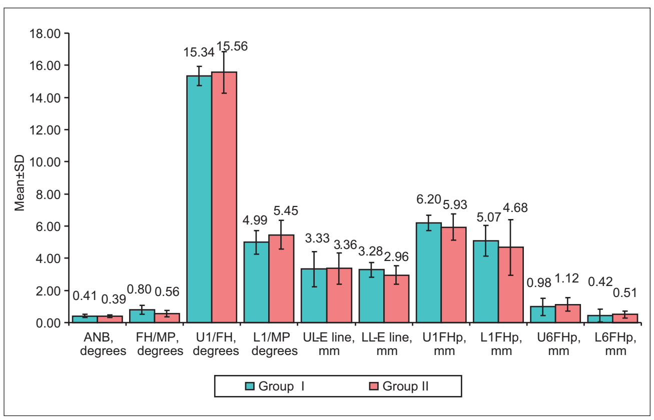
Variables	Time points	Group I (*n*=20)		Group II (*n*=20)		*t*	*P*
		Mean	SD	Mean	SD		
HRGN (mm)	Changes	0.41	0.18	0.33	0.15	1.0639	0.3015
C3H (mm)	Changes	0.86	0.38	1.18	0.83	−1.1070	0.2829
HH1 (mm)	hanges	0.35	0.11	0.30	0.30	0.4986	0.6241
SH (mm)	Changes	0.76	0.46	0.54	0.28	1.2924	0.2126

SD – Standard deviation

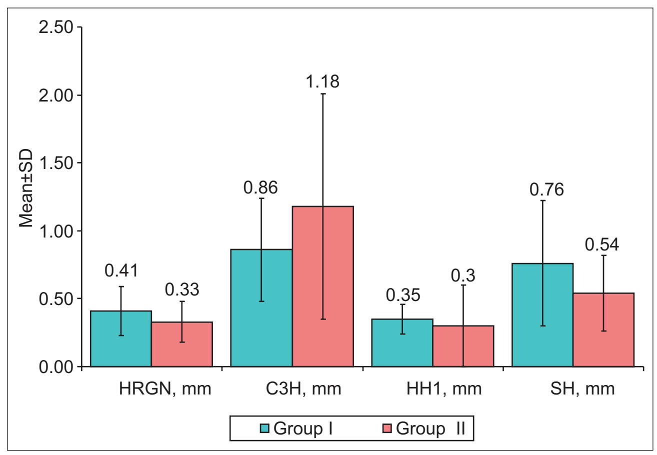
Table 4: Comparison of the changes in pretreatment and posttreatment values of dentofacial parameters by paired *t*-test (*n*=40)

Variables	Time	Mean	SD	Mean difference	SD difference	Percentage of change	Paired *t*	*P*
ANB (°)	Pretreatment	3.82	0.69	−0.40	0.09	−10.47	−20.8395	<0.001
	Posttreatment	4.22	0.67					
FH/MP (°)	Pretreatment	34.19	2.93	−0.68	0.27	−1.99	−11.3168	<0.001
	Posttreatment	34.87	2.98					
U1/FH (°)	Pretreatment	120.70	2.84	15.45	0.98	12.80	70.6550	<0.001
	Posttreatment	105.25	2.75					
L1/MP (°)	Pretreatment	97.42	3.41	5.22	0.83	5.36	28.0161	<0.001
	Posttreatment	92.20	3.49					
UL-E line (mm)	Pretreatment	2.76	0.74	3.35	1.02	121.47	14.7399	<0.001
	Posttreatment	−0.59	0.46					
LL-E line (mm)	Pretreatment	5.70	1.13	3.12	0.53	54.74	26.4886	<0.001
	Posttreatment	2.58	1.30					
U1FHp (mm)	Pretreatment	72.02	3.00	6.07	0.66	8.42	40.9749	<0.001
	Posttreatment	65.95	3.07					
L1FHp (mm)	Pretreatment	67.83	2.51	4.88	1.37	7.19	15.9592	<0.001
	Posttreatment	62.96	2.57					
U6FHp (mm)	Pretreatment	31.46	1.43	−1.05	0.48	−3.34	−9.8138	<0.001
	Posttreatment	32.51	1.43					
L6FHp (mm)	Pretreatment	32.34	2.41	−0.46	0.32	−1.44	−6.6013	<0.001
	Posttreatment	32.81	2.35					

SD – Standard deviation



Graph 1: Comparison of the changes in dentofacial parameters preoperatively and postoperatively in Groups I and II



Graph 2: Comparison of the changes in position of hyoid bone preoperatively and postoperatively in Groups I and II

Graph 3 show the pre and post treatment changes in the dentofacial parameters. After treatment, the hyoid bone tends to move in a posterior and inferior direction in both Groups (I and II), respectively. Table 5 and Graph 4 show the changes of the hyoid bone position after the treatment. The results displayed a significant decrease in C3H ($P < 0.001$) and SH ($P < 0.001$) whereas changes in HRGN and HH1 showed no significant differences. However, no significant changes in the position of hyoid bone were seen when both the groups were compared to each other.

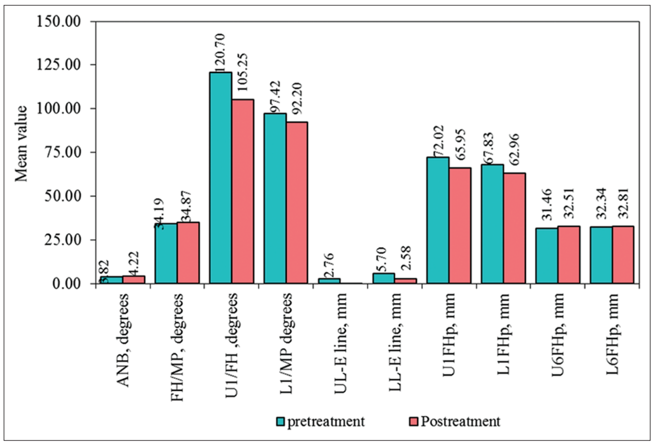
Discussion

Precise measurement of hyoid position by cephalometric means is considered difficult. Graber[16] states that slight variations in head position in the cephalostat, the postural position of the spine, and the state of function; all affect the position of the hyoid bone. However, he points out that within these limitations, definite conclusions concerning the normal hyoid position may be made. Stepovich[17] reports that when roentgenograms of the same person were taken at different time intervals; the hyoid bone was found to be positioned differently in each film. Ingervall *et al.*[18] believe that Stepovich exaggerates the lack of precision in recording the hyoid bone position, although they admit that the hyoid position will vary even under standard conditions. King[19] noted that the changes in head position lead to changes in the position of the hyoid bone in the same person. If the head is extended back, then the hyoid bone moves back; if the head is tipped forward, then the

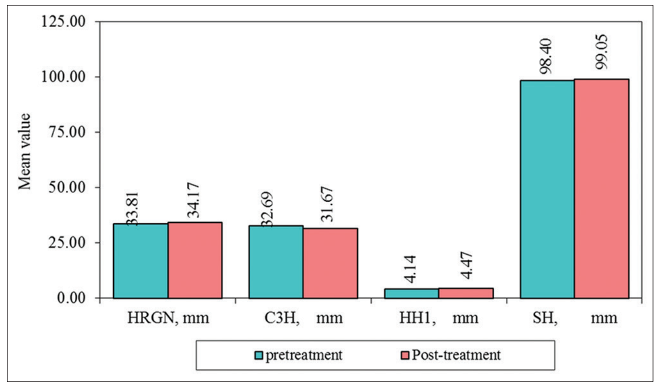
Table 5: Comparison of the changes in pretreatment and posttreatment values of the hyoid bone position by paired *t*-test (*n*=40)

Variables	Time	Mean	SD	Mean difference	SD difference	Percentage of change	Paired *t*	*P*
HRGN (mm)	Pretreatment	33.81	3.16	−0.37	0.17	−1.09	−9.9174	<0.001
	Posttreatment	34.17	3.15					
C3H (mm)	Pretreatment	32.69	1.38	1.02	0.65	3.12	7.0158	<0.001
	Posttreatment	31.67	1.42					
HH1 (mm)	Pretreatment	4.14	1.37	−0.33	0.22	−7.85	−6.6141	<0.001
	Posttreatment	4.47	1.33					
SH (mm)	Pretreatment	98.40	3.34	−0.65	0.39	−0.66	−7.5056	<0.001
	Posttreatment	99.05	3.18					

SD – Standard deviation



Graph 3: Comparison of changes in pre- and post-treatment values of dentofacial parameters



Graph 4: Comparison of the changes in pre- and post-treatment values of hyoid bone position

hyoid bone moves forward. Grant[20] studied the position of the hyoid bone in Class I, II, and III malocclusions. He concludes that the hyoid bone position is constant in all three classes and that the position of the hyoid bone is determined by the musculature and not by the occlusion of the teeth.

The possibility of some tie-up between the hyoid bone position and mandibular morphology led to a consideration of skeletal types which, according to Graber[16] and gives disparate results since some of the investigations find positive correlations between hyoid bone position and skeletal type while others find no correlation at all.[21]

In the present study, there was no significant difference found in the position of the hyoid bone in individuals with normodivergent and hyperdivergent growth patterns. In both groups, the hyoid bone is displaced in posterior and inferior direction. However, Haralabakis *et al*.[22] also found no difference in anteroposterior position of the hyoid bone in adult individuals with anterior open bite compared with individuals with normal bite when its position was evaluated from near reference structures such as the cervical spine, pharynx, and mandibular plane. This observation supported the concept that the hyoid bone moved in conjunction with adjacent anatomic structures when rotating backward in patients with long face syndrome. However, the previous study done by Opdebeeck *et al*.[12] also showed no significant difference in the anteroposterior position of the hyoid bone in individuals with different vertical jaw dysplasias when its position was evaluated from very near reference planes.

The hyoid position depends on the relative balance of muscle attachment from the base of the cranium bilaterally and the region of the mandibular symphysis. The inferior movement of the hyoid bone seen in the present study is consistent with the findings of other studies,[17,18] showing that this movement is an adaptation preventing an encroachment of the tongue into the pharyngeal airway.

The limitation of the current study is that two-dimensional imaging was used to evaluate three dimensional structures. However, there is a high correlation between lateral radiographs and three-dimensional magnetic resonance imaging scans.[23] Moreover, Miles *et al*.[24] reported a high reliability of cephalometric landmarks and measurements. Thus, cephalograms are still widely used. The other limitation of the present study was that the gender of the patient was not taken into consideration. Further studies should be aimed at long-term effects of orthodontic treatment on hyoid bone position with three-dimensional imaging.

Conclusion

The values of the dentofacial parameters and hyoid bone position showed no difference between the normodivergent (Group I) and hyperdivergent (Group II). However, in each group, the hyoid bone tends to move in a posterior and inferior direction.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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