Original Article

Hyoid bone position in subjects with different vertical jaw dysplasias

Ashok Kumar Jena[a]; Ritu Duggal[b]

ABSTRACT

Objective: To test the hypothesis that there is no difference in hyoid bone position among subjects with different vertical jaw dysplasias.

Materials and Methods: Seventy-one North Indian adult male and female subjects in the age range of 15 to 25 years were selected for the study. Based on the vertical growth pattern of the face, subjects were divided into Group I (n = 24; subjects in whom both Frankfort mandibular plane angle [FMA] and basal plane angle measured 20 to 25 degrees), Group II (n = 17; subjects in whom both FMA and basal plane angle measured <15 degrees), and Group III (n = 30; subjects in whom both FMA and basal plane angle measured >30 degrees). Lateral cephalograms with the mandible in rest position were traced and analyzed manually for evaluation of hyoid bone position.

Results: The anteroposterior position of the hyoid bone was significantly forward in subjects with short face syndrome compared with normal subjects ($P < .05$) and subjects with long face syndrome ($P < .001$). The vertical position of the hyoid bone was comparable among subjects with different vertical jaw dysplasias. The axial inclination of the hyoid bone was more oblique in subjects with long face syndrome than in those with short face syndrome ($P < .01$).

Conclusion: The anteroposterior position of the hyoid bone was more forward in subjects with short face syndrome. The vertical position of the hyoid bone was comparable among subjects with different vertical jaw dysplasias. The axial inclination of the hyoid bone closely followed the axial inclination of the mandible. (*Angle Orthod.* 2011;81:81–85.)

KEY WORDS: Hyoid bone position; Vertical jaw dysplasia

INTRODUCTION

In subjects with severe vertical jaw dysplasia, orthognathic surgery involving the mandible often is required to improve occlusion, esthetics, and function. The positions of the hyoid bone and the tongue also are changed, with consequent narrowing of the pharyngeal airway space.[1] The position of the hyoid bone is influenced by the position of the tongue, thus affecting the pharyngeal airway space.[2] Narrowing of the pharyngeal space might be a factor in obstructive sleep apnea.[3] The correlation between hyoid bone position and the vertical growth pattern of the face is controversial. Opdebeeck and associates[4] compared the position of the hyoid bone in subjects 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. So it is necessary to determine whether any difference is evident in hyoid bone position among patients with different vertical jaw dysplasia.

MATERIALS AND METHODS

Subjects for this study were selected from patients who attended the Orthodontic Clinic, Division of Orthodontics, Centre for Dental Education and Research, All India Institute of Medical Sciences, India. A total of 71 North Indian adult male and female patients in the age range of 15 to 25 years were selected for the study. The type of molar relationship and the sagittal jaw relationship were not considered when subjects were selected for the study. Subjects who had any anomaly of cervical vertebra, a history of any orthodontic treat-

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ment, anterior and posterior open bite and crossbite, mouth breathing, and tongue thrusting were excluded from the study.

All subjects were divided into three groups (Groups I, II, and III), based on their vertical facial growth pattern. Group I included 24 subjects (M = 10, F = 14), Group II included 17 subjects (M = 9, F = 8), and Group III included 30 subjects (M = 13, F = 17). Types of vertical facial growth pattern among study subjects were evaluated on the basis of the Frankfort mandibular plane angle (FMA) and the basal plane angle. Subjects in whom both FMA and basal plane angle measured 20 to 25 degrees were included in Group I; subjects in whom both FMA and basal plane angle measured <15 degrees were included in Group II; and those in whom both FMA and basal plane angle measured >30 degrees were included in Group III.

After subjects had been selected for the study, they were tested to obtain the final lateral cephalogram that was used for evaluation of hyoid bone position. During exposure of final cephalograms, subjects were guided to stand still with the mandible in relaxed position to ensure that no strain or change in head posture occurred while the head was fixed in the cephalostat. Subjects were especially advised not to swallow during exposure of the radiograph. All lateral cephalograms were exposed in the same cephalostat with similar exposure parameters.

Many previous studies have used various methods to evaluate hyoid bone position.[5–9] All of these studies used cranial structures to define reference planes from which hyoid bone position was measured. Cranial reference planes are relatively far from the hyoid bone. Thus a small variation in the position or inclination of the reference planes would result in much greater apparent variation in hyoid bone position. However, in this study, a new method was used to evaluate hyoid bone position with the use of reference planes adjacent to the hyoid bone. Cephalometric landmarks and reference planes used for evaluation of hyoid bone position are shown in Figure 1.

Sella perpendicular (Sper) and PTR perpendicular (PTRper) planes were used as vertical reference planes, and the C_3C horizontal (C_3Chor) plane was used as the horizontal reference plane for evaluation of anteroposterior and vertical positions of the hyoid bone, respectively. The perpendicular distances from H-point to PTRper plane (H-PTRper distance) and from H-point to Sper plane (H-Sper distance) were used to evaluate the anteroposterior position of hyoid bone, whereas the perpendicular distances from H-point to C_3Chor plane (H-C_3Chor distance) and from G-point to C_3Chor plane (G-C_3Chor distance) were used to evaluate the vertical position of the hyoid bone. The angle between H-axis and PTRper plane

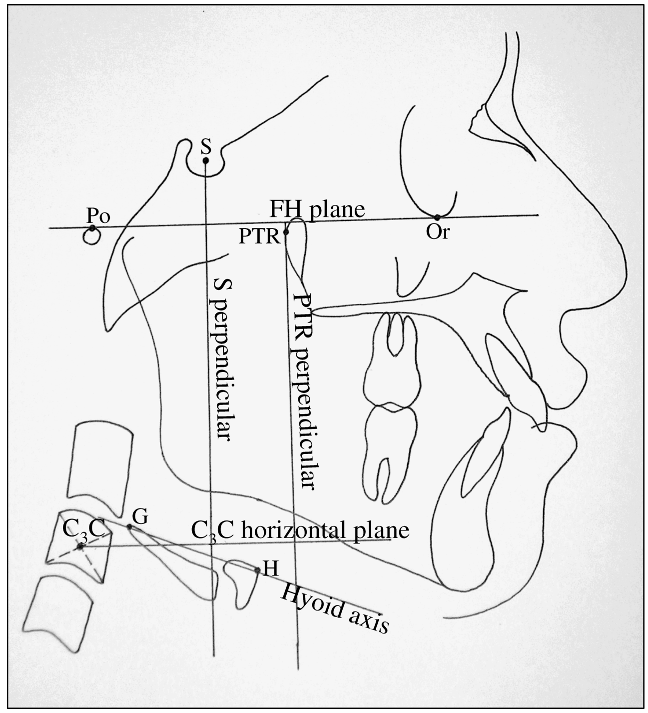

Figure 1. Cephalometric landmarks used for evaluation of hyoid bone position. Sella (S): Geometric center of the pituitary fossa located by visual inspection. Orbitale (Or): The lowest point on the inferior rim of the orbit. Porion (Po): The most superiorly positioned point of the external auditory meatus. Pterygoid vertical reference (PTR): The most posterior point on the distal radiographic outline of the pterygomaxillary fissure. Center of third cervical vertebra (C_3C): The intersection point of diagonal lines drawn between the anteroinferior and posterosuperior corners and between the anterosuperior and posteroinferior corners of the third cervical vertebra. Hyoidale (H): The most superior anterior point on the body of the hyoid bone. G-point (G): The most posterior point of the greater horn of the hyoid bone. Cephalometric reference planes were used for the evaluation of hyoid bone position. Frankfort horizontal plane (FH-plane): The horizontal plane that joins Po and Or. Sella perpendicular (Sper): The perpendicular line drawn on the FH-plane at S. PTR perpendicular (PTRper): The perpendicular plane drawn on the FH-plane at PTR. C_3C horizontal (C_3Chor): The horizontal plane perpendicular to the Sper at C_3C. Hyoid axis (Haxis): The line that connects points H and G.

(Haxis-PTRper angle) and the angle between hyoid axis and C_3C horizontal plane (Haxis-C_3Chor angle) were considered as angular parameters for evaluating the axial inclination of hyoid bone. All linear and angular parameters are shown in Figure 2.

All cephalograms were traced and analyzed manually by the first investigator. All parameters were measured thrice, and the mean was considered for statistical analysis.

Statistical Method

A master file was made and data were statistically analyzed on a computer with the Statistical Package for the Social Sciences (SPSS) software (SPSS Inc,

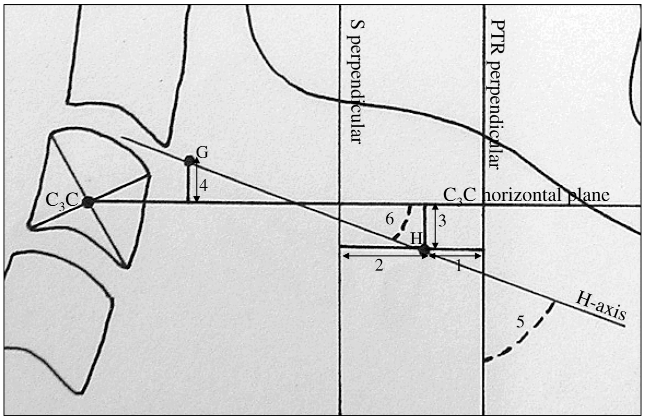

Figure 2. Linear and angular parameters used for the evaluation of hyoid bone position. 1: H-PTRper distance; 2: H-Sper distances; 3: H-C_3Chor distance; 4: G-C_3Chor distance; 5: Haxis-PTRper angle; and 6: Haxis-C_3Chor angle.

Chicago, Ill). A data file was created under dBase and was converted into a microstat file. Data were subjected to descriptive analysis for mean, range, and standard deviation of all variables. One-way ANOVA was used for analysis of variance, and a post hoc test (Bonferroni) was used for multiple comparisons. $P \leq .05$ was considered the level of statistical significance.

RESULTS

Mean age, FMA, and basal plane angle among the three groups of subjects are shown in Table 1. The mean age of subjects in Groups I, II, and III was 17.42 ± 2.08 years, 18.29 ± 2.97 years, and 16.93 ± 2.55 years, respectively. No statistically significant difference in mean age was noted among subjects in the three groups. The mean FMA in subjects from Groups I, II, and III was 22.92 ± 1.86 degrees, 12.59 ± 3.08 degrees, and 33.33 ± 4.08 degrees, respectively. The mean basal plane angle in subjects from Groups I, II, and III was 21.04 ± 2.72 degrees, 12.41 ± 3.97 degrees, and 32.77 ± 4.98 degrees, respectively. The results for all cephalometric measurements are shown in Table 2 and in Figure 3.

The anteroposterior position of the hyoid bone was evaluated from the H-PTRper distance and the H-Sper distance. When the position of the H-point was anterior to the PTRper and Sper planes, values for the perpendicular distances were considered as positive; values were considered as negative when the position of the H-point was posterior to the reference planes. The mean H-PTRper distance and H-Sper distance among the three groups of subjects were statistically highly significant ($P < .001$). The anteroposterior position of the hyoid bone in Group II subjects was significantly forward compared with subjects in Group I ($P < .05$) and Group III ($P < .001$). However, the anteroposterior position of the hyoid bone in subjects from Group I was comparable with that in subjects from Group III. Thus the anteroposterior position of the hyoid bone was significantly different among subjects with different vertical jaw dysplasias.

Table 1. Mean Age, FMA, and Basal Plane Angle Among Three Groups of Subjects[a]

	Group I (n = 24) Mean ± SD	Group II (n = 17) Mean ± SD	Group III (n = 30) Mean ± SD
Age, years	17.42 ± 2.08	18.29 ± 2.97	16.93 ± 2.55
FMA, degrees	22.92 ± 1.86	12.59 ± 3.08	33.33 ± 4.08
Basal plane angle, degrees	21.04 ± 2.72	12.41 ± 3.97	32.77 ± 4.98

[a] FMA indicates Frankfort mandibular plane angle; SD, standard deviation.

The vertical position of the hyoid bone was determined from H-C_3Chor and G-C_3Chor distances. When the positions of the H-point and the G-point were superior to the C_3C horizontal plane, values for the H-C_3Chor and G-C_3Chor distances were considered as positive; when the positions of the H-point and the G-point were inferior to the C_3C horizontal plane, values for the H-C_3Chor and G-C_3Chor distance were considered as negative. The mean vertical distance from H-point to C_3C horizontal plane was least in Group II subjects but was comparable with that in subjects in Groups I and III, and was not significant at a statistical level ($P = .108$). The mean G-C_3Chor distance was also comparable among subjects in the three groups ($P = .448$). Thus the results of the present study show that the vertical position of the hyoid bone was not affected by the nature of vertical growth of the face.

The axial inclination of the hyoid bone was determined from the Haxis-PTRper angle and the Haxis-C_3Chor angle. With clockwise axial inclination of the hyoid bone, the values for these angles were considered as positive; the values for these angles were considered as negative when anticlockwise axial inclination of the hyoid bone was evident. The mean Haxis-PTRper angle and Haxis-C_3Chor angle among subjects in the three groups were high and were statistically significant ($P < .01$). The axial inclination of the hyoid bone in subjects from Group II was significantly less than in subjects from Group III ($P < .01$) and Group I ($P < .05$). However, the axial inclination of the hyoid bone was comparable among subjects in Groups I and III. Thus the present study showed that the axial inclination of the hyoid bone was different in subjects with different vertical growth patterns of the face.

DISCUSSION

The position of the hyoid bone was most anterior in subjects with short face syndrome and was most pos-

Table 2. Cephalometric Linear and Angular Parameters Among Three Groups of Subjects[a]

Parameters	Group I (n = 24) Mean ± SD	Group I (n = 24) 95% CI for Mean	Group II (n = 17) Mean ± SD	Group II (n = 17) 95% CI for Mean	Group III (n = 30) Mean ± SD	Group III (n = 30) 95% CI for Mean	*P* Value	Intergroup Comparison I Vs II	Intergroup Comparison I Vs III	Intergroup Comparison II Vs III
H-PTRper distance, mm	−2.32 ± 5.02	−4.44 ± −0.20	3.57 ± 5.79	0.58 ± 6.55	−5.24 ± 7.30	−7.96 ± −2.51	.000	*	NS	***
H-Sper distance, mm	14.24 ± 5.36	11.98 ± 16.51	20.49 ± .36	17.73 ± 23.25	10.60 ± 8.18	7.54 ± 13.65	.000	*	NS	***
H-C_3Chor distance, mm	−18.93 ± 9.14	−22.79 ± −15.07	−13.37 ± 8.15	−17.56 ± −9.18	−16.75 ± 7.35	−19.50 ± −14.00	.108	NS	NS	NS
G-C_3Chor distance, mm	−5.54 ± 8.73	−9.22 ± −1.85	−4.81 ± 8.11	−8.98 ± −0.64	−2.91 ± 6.75	−5.43 ± −0.39	.448	NS	NS	NS
Haxis-PTRper angle, degrees	68.58 ± 7.48	65.42 ± 71.75	75.47 ± 9.57	70.55 ± 80.39	67.23 ± 7.87	64.29 ± 70.17	.005	*	NS	**
Haxis-C_3Chor angle, degrees	21.42 ± 7.48	18.25 ± 24.58	13.94 ± 9.39	9.11 ± 18.77	23.10 ± 7.92	20.14 ± 26.06	.002	*	NS	**

[a] NS indicates nonsignificant.
* $P < .05$; ** $P < .01$; *** $P < .001$.

terior in subjects with long face syndrome. The anteroposterior position of the hyoid bone followed the anteroposterior position of the chin. When the mandible was rotated in an upward and forward direction, the suprahyoid muscles pulled the hyoid bone to move into a more anterior position, and when the mandible was rotated in a downward and backward direction, the hyoid bone tended to move posteriorly.[10] In the present study, the position of the hyoid bone in subjects with long face syndrome was backward as compared with that in subjects with normal vertical facial growth. Haralabakis, Toutountzakis, and Yiagtzis[9] 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 like the cervical spine, pharynx, and mandibular plane. This observation supported the concept that the hyoid bone moved in conjunction with adjacent anatomic

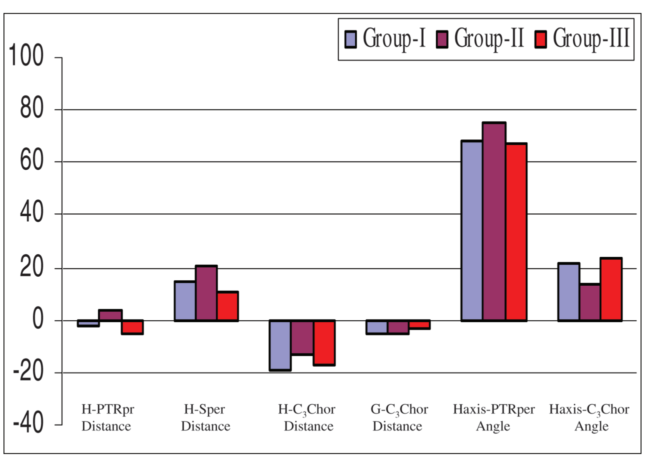

Figure 3. Comparison of cephalometric changes among three groups of subjects.

structures when rotating backward in patients with long face syndrome. However, in contrast to the previous study done by Opdebeeck et al,[4] the present study showed a significant difference in the anteroposterior position of the hyoid bone in subjects with different vertical jaw dysplasias when its position was evaluated from very near reference planes.

The vertical position of the hyoid bone in subjects with short face syndrome was slightly upward compared with that in subjects with long face syndrome and those with normal anterior face height. This could be the result of pull from the suprahyoid muscles, which occurred as the mandible was rotated in an upward and forward direction. In subjects with long face syndrome, the mandible was rotated in a downward and backward direction, resulting in slightly downward positioning of the hyoid bone. In subjects with enlarged tonsils, a more caudal position of hyoid bone was observed.[7] Ricketts suggested that the lower position of the hyoid bone in subjects with enlarged tonsils was intended to create an oral airway.[11] However, factors such as low tongue posture, narrow pharyngeal airway passage, and large craniocervical inclination could be considered as important determinants for low hyoid bone posture.[7]

The axial inclination of the hyoid bone was evaluated in relation to both vertical (PTRper) and horizontal (C_3C horizontal) reference planes. In subjects with short face syndrome, the axial position of the hyoid bone was more horizontal, whereas in those with long face syndrome, the axial position of the hyoid bone was more oblique. Opdebeeck et al[4] observed rotation of the mandible in concert with rotation of the hyoid bone. According to Opdebeeck et al,[4] a significantly large SN:hyoid plane angle was found in subjects with a high FMA with no significant difference between mandibular plane and hyoid plane angle. Thus the hyoid bone was involved in overall rotational movement of the movable parts of the craniofacial complex.[4] The more oblique axial position of the hyoid bone in subjects with high FMA and the more horizontal position of the hyoid bone in subjects with low FMA could be due to differences in tongue position. In subjects with counterclockwise rotation of the mandible, tongue position was posterior and superior against the palate, whereas in subjects with moderate clockwise rotation of the mandible, the tongue was positioned anteriorly, with the base of the tongue higher than normal at the level of the incisal edge; in extreme clockwise rotation of the mandible, the tongue was slightly retruded, with a very high tongue root position and with the tongue tip down in the mandible.[4] In subjects with high FMA, the cross section of the lower pharynx was reduced and the hyoid bone was closer to the cervical spine.[4] Encroachment of the vital pharyngeal space induced stretching of the cervical spine and hyperextension of the head. Thus the stretched cervical spine pulled the pharynx and the hyoid bone posteriorly and superiorly, while the tongue was rotated in the same direction, resulting in altered tongue position. Many previous studies reported a close association between inclination of the hyoid bone and mandibular inclination.[6,8,9] According to Haralabakis, Toutountzakis, and Yiagtzis, the hyoid bone moved in conjunction with adjacent anatomic structures, which were connected to the hyoid bone by muscles and ligaments.[9]

Thus the present study assumes that the pharyngeal airway passage would be more sufficient in subjects with short face syndrome than in those with long face syndrome. A mandibular setback procedure in subjects with long face syndrome could result in further narrowing of the pharyngeal airway passage and would lead to postsurgical obstructive sleep apnea. However, further study is required to evaluate the direct association between pharyngeal airway space and different vertical jaw dysplasias.

CONCLUSIONS

- The position of the hyoid bone in subjects with short face syndrome was more anterior than in subjects with long face syndrome.
- The vertical position of the hyoid bone was comparable among subjects with different vertical jaw dysplasias.
- The axial inclination of the hyoid bone closely followed the axial inclination of the mandible.

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