Evaluation of the position of the hyoid bone in relation to vertical facial development

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Evaluation of the position of the hyoid bone in relation to vertical facial development and comparative evaluation of the relation of this position with the dentofacial system was made on 25 patients with hyperdivergent vertical growth, 25 patients with hypodivergent vertical growth, and 25 patients with normal vertical facial development. SN-Go-Gn, Gonion, ANS-PNS/Go-Gn angles and S-Go, N-Me, S-Go/N-Me measurements from lateral cephalometric films were used as identification parameters. Seven horizontal, five vertical and five angular cephalometric measurements were made in order to determine the position of the hyoid bone. SN plane was used as the reference plane. Results were evaluated through "t" test. No significant relation was found between hyoid bone position and gender. When gender distinction was disregarded, and the group with normal facial development was compared with the hyperdivergent group, statistically significant differences were observed for CVT-H distance in horizontal measurements and for H-SN, H-F, H-PD, H-OD distances in vertical measurements. When the group with normal facial development was compared with the hypodivergent group, only the horizontal measurement Pg-H was statistically significant. The hyoid bone location in the hyperdivergent group was in a more of a posterior and superior position. The hyoid bone location in the hypodivergent group was not changed vertically, however, it had more of a posterior placement with the increase of Pg-H distance.

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INTRODUCTION

Orthodontics has begun to broaden the content to include the study and position of anatomical structures adjacent to the oral region. The position of the hyoid bone has great importance in this respect.[1,12] It affects the muscles, ligaments and fascia attached to it.[2] Previous studies have reported a close relationship of the hyoid bone to both adjacent bony structures as well as vertical facial development.[1,4,5,10,12,13,20] Unlike all other bones of the head and neck, the hyoid bone has no bony articulations. It is connected with pharynx, mandible and cranium through only muscles and ligaments.[5] The position of the hyoid contributes greatly to mouth breathing and abnormal swallowing habits. Since it also helps determine facial type, it can be a factor in prognosis and post-treatment stability of orthodontic intervention.[4,5,8,9,11,14,23,26]

It has previously been stated that there was a relationship between mandibular positional changes and the position of the hyoid bone.[1,9,14,26]

Adamidis and Syropoulos[1,2] were first to question the possible effect of mouth breathing on mandibular position and consequently on hyoid bone position. They further drew attention to the role played by the suprahyoid muscles and the influence on the direction of mandibular growth. They finally determined that the position of the hyoid bone in relation to the cervical column, however, showed less variability than the relation to the maxilla and mandible.

The role of the hyoid bone on stability and, therefore effectiveness of the breathing tract has been emphasized as well as the effect on the form and function of the tongue.[9,24]

The aim of this study was to evaluate and compare the position of the hyoid bone and the relationship with the jaws and face, in individuals with different vertical growth patterns.

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MATERIALS AND METHODS

This study was conducted on cephalometric radiographs of 75 patients consisting of 3 categories of vertical development. In the selection criteria for the three types of vertical development: SN-GoGn, gonial, ANS-PNS/Go-Gn angles, S-Go, N-Me distances, and S-Go/N-Me (Jarabak ratio)[15] were used as defining measurements (Table I).

The hyper-divergent vertical development group with 15 girls and 10 boys; the hypo-divergent vertical development group with 14 girls and 11 boys, and finally the normal vertical development group with 14 girls and 11 boys. All patients had a Class I molar relationship.

The ages of the patients are shown in Table I. Patient selection criteria were:

1. No previous orthodontic treatment;
2. Comfortable nose breathing;
3. Normal swallowing pattern;
4. No visual or hearing disability;
5. No scar tissues around the head neck area

During the lateral cephalometric radiographs special care was taken that no change in head posture or muscle strain occurred when fixing the head in the cephalostat. The patients were instructed not to swallow.

Seventeen (17) measurements were used to determine the horizontal, vertical, and angular orientation of the hyoid bone in the craniofacial complex. SN plane was used as the reference plane (Figures 1 to 5). Comparisons were based on t-tests.

Twenty (20) randomly selected lateral cephalometric radiographs were retraced and re-measured one month later to estimate the error that might occur in their measurement and tracing. The error for each parameter was calculated based on Dahlberg's[16] formula.

After the method error for each parameter had been determined, 95% confidence limits of the real method error were calculated.

As shown in Table III the greatest method error was made in the N-H value (1.12mm), while the lowest method error was made in the CVT-H value (0.4mm).

RESULTS

There was no significant difference in the orientation of the hyoid bone between males and females. When gender distinction was disregarded and the group with normal facial development was compared with the hyperdivergent group, statistically significant differences were observed for CVT-H, H-SN, H-FH, H-PD, H-OD distances. When the group with normal facial development was compared with the hypodivergent group, only the horizontal measurement Pg-H was statistically significant (Table IV).

Table I. Age distribution of the patients

Groups	N	Girls	Boys
Normal Vertical Development	25	11.97±2.12	12.85±1.93
Hyperdivergent Development	25	9.98±0.78	10.28±0.84
Hypodivergent Development	25	13.60±5.87	11.98±2.11

Table II. Descriptive measurements of anomalies

	Normal Vertical Development			Hypo-Divergent Development		Hyper-Divergent Development	
	N	$\bar{X}$	σ	$\bar{X}$	σ	$\bar{X}$	σ
Measurements							
Angular							
SN-Go-Gn	25	32.35	2.06	27.16	4.02	40.10	3.35
Gonion	25	124.85	5.71	122.54	4.31	128.00	17.81
ANS-PNS/Go-Gn	25	24.68	3.31	19.64	4.32	32.58	3.97
LINEAR							
S-Go	25	76.72	6.88	77.36	6.85	67.46	5.01
N-Me	25	117.00	7.97	113.12	6.76	114.62	7.95
S-Go/N-Me	25	62.17	3.81	67.92	4.02	58.42	2.64

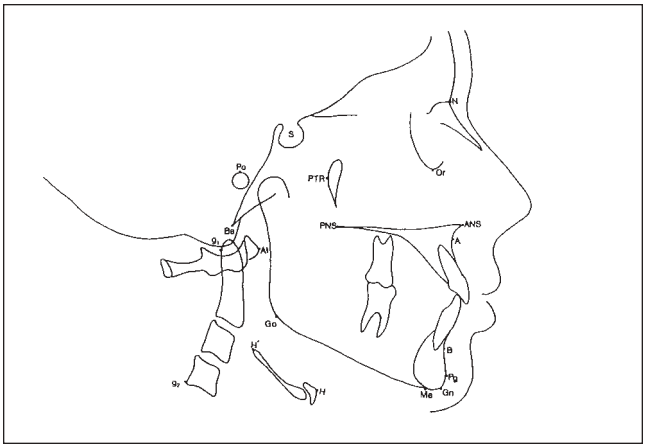

Figure 1. Cephalometric points

N: Nasion
S: Sella
A
B
Go: Gonion
Gn: Gnathion,
H: The most anterior point on the hyoid bone
H¹: The most posterior point on the hyoid bone
At: The most anterior point of the Atlas
Pg: Pogonion
PTR: The outer and most posterior point of the pterygomaxiller fissur
g_1: The odontoid process of the second cervical vertebra
g_2: The most posterior-inferior point of the 4th cervical vertebra
Or: Orbita
ANS: Spina nasalis anterior
PNS: Spina nasalis posterior
Ba: Basion
Me: Menton
Po: Porion

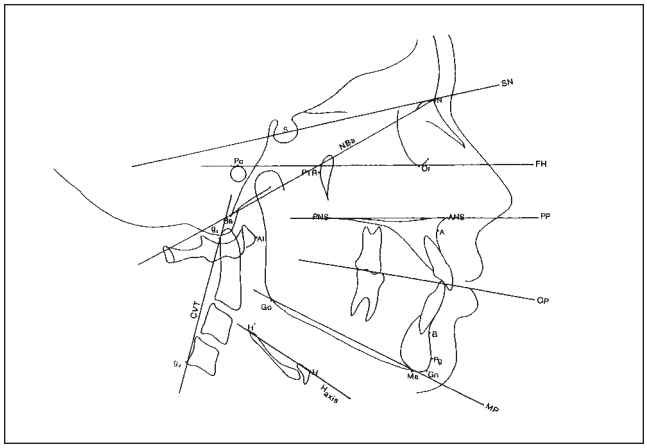

Figure 2. Cephalometric planes
SN: Sella-Nasion plane
CVT: A line through g_1 to g_2
FH: Franfurt horizontal plane
PP: Palatal plane
MP: Mandibular plane
OP: Okluzal plane
NaBa: Nasion-Basion plane
H_{axis}: The long axis of the hyoid bone

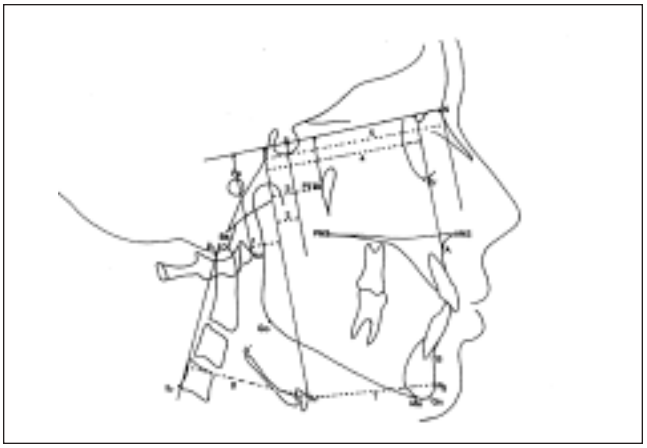

Figure 3. Horizontal measurements
1-At-H
2-S-H
3-PTR-H
4-A-H
5-N-H
6-C VT-H
7-Pg-H

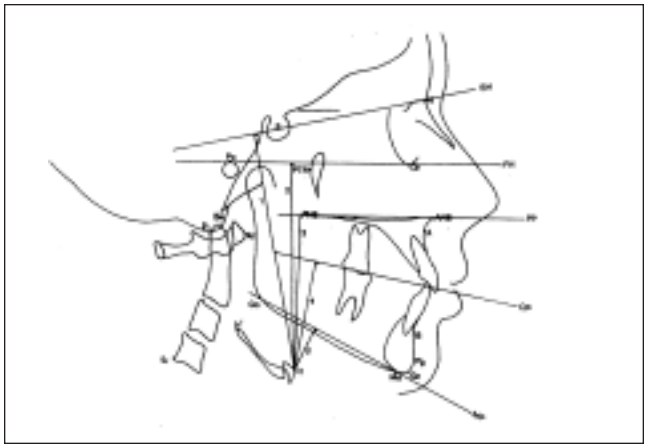

Figure 4. Vertical measurements
1-H-SN
2-H-FH
3-H-PP
4-H-OP
5-H-MP

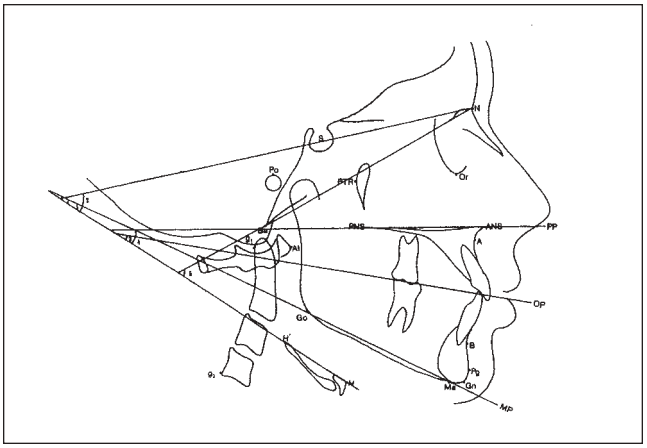

Figure 5. Angular measurements
1-H_{axis}-MP
2-H_{axis}-SN
3-H_{axis}-OP
4-H_{axis}-PP
5-H_{axis}-NaBa

DISCUSSION

It has been stated that the stability of the position of the hyoid bone, in all Angle classifications, depended on the direction of facial growth of the mandible.[9]

The vertical dimension of the face is important because of the role it plays on the diagnosis and the etiology of an orthodontic anomaly. There is a relationship between vertical growth of the condyles and vertical growth of the maxilla and the mandible. If the growth of posterior structures and mandible exceeds the vertical growth of the condyles, open bite with hyperdivergent facial characteristics is observed. If, on the other hand, mandibular growth is less than the vertical growth of the condyles, deep bite and hypodivergent facial type is detected. Abnormal facial type results from disproportionate growth of these structures.[15-18]

The SN-GoGn, gonial, ANS-PNS/Go-Gn angles and S-Go, N-Me, S-Go/N-Me distances measured in this study were used only to define the anomalies. Since the purpose of this study was to evaluate the position of the

Table III. Error of the method (Sm) and 95% confidence limits

DESCRIPTIVE MEASUREMENTS	Sm	UPPER CONFIDENCE LIMIT	LOWER CONFIDENCE LIMIT
Sn-Go-Gn	0.82	0.62	1.18
Gonion	0.90	0.68	1.29
ANS-PNS/Go-Gn	0.60	0.45	0.86
S-Go	0.60	0.45	0.86
N-Me	0.59	0.45	0.85
S-Go/N-Me	0.81	0.61	1.16
HYOID BONE MEASUREMENTS			
HORIZONTAL			
At-H	0.81	0.61	1.16
S-H	0.78	0.59	1.12
Pg-H	0.37	0.28	0.53
A-H	1.04	0.79	1.50
N-H	1.12	0.85	1.61
PTR-H	0.89	0.68	1.28
CVT-H	0.40	0.09	0.57
VERTICAL			
H-SN	0.53	0.40	0.76
H-PH	0.53	0.40	0.76
H-PP	0.57	0.43	0.82
H-MP	0.51	0.39	0.73
H-OP	0.74	0.56	1.07
ANGULAR			
H_{axis}-NaBa	0.81	0.61	1.16
H_{axis}-PP	0.75	0.57	1.08
H_{axis}-MP	0.66	0.50	0.95
H_{axis}-OP	0.68	0.52	0.96
H_{axis}-SN	0.65	0.49	0.93

hyoid bone, these values would not be mentioned in the discussion.

Andersen[3] studied the vertical position of the hyoid bone in 34 patients with anterior open bite and 40 individuals with normal occlusion. No sex differentiation was made for both groups.

Subtelny and Sakuda[22] also studied the position of the hyoid bone in 25 open bite patients and 30 individuals with normal occlusion. Again, no sex differentiation was made.

Biby and Preston[5] analyzed the position of the hyoid bone in a sample of 28 males and 26 females with Class I malocclusion and a mean age of 12.5 and 13 years using a triangle named "the hyoid triangle". No sexual dimorphism or significant differences in hyoid bone position were found.

In this study, just like along the lines of above-mentioned research, no significant differences in hyoid bone position were found between males and females.

While some studies used the natural head and neck position while obtaining the cephalometric films[9,12,16] others used a cephalostat to fix the head in position[5,13] The present study used the latter approach of fixing the head on the cephalostat. The fact that the radiographs were not taken in the natural head and the neck position should be taken into consideration in discussing the results.

Stepovich[21] showed the difficulty encountered in measuring the position of the hyoid bone on a day-to-day or even minute-to-minute basis. He stated that the fluctuations in the position of the hyoid bone should be prevented in order to obtain the correct measurements. As stated previously, during our study in order to minimize any movement, we fixed the head of the patient on the cephalostat.

Graber[9] used the SN plane as the reference plane in a study of 30 hyoid bone positions. Uzel *et al*.[25] stated that the position of the hyoid bone correlated with the vertical position of the mandibular basal structure, but that this change did not reflect the vertical relationship. They also mentioned that, although not a statistically significant find, in hypodivergent facial types the hyoid bone was closer to the mandible while in hyperdivergent cases, it was lower.

Gunnar and Ceylan[12] stated that the position of the hyoid bone was not greatly affected by vertical facial development.

Haralabakis *et al*.[13] compared anterior open bites and normal occlusions and found that in both females and males the hyoid bone was positioned more backwards in the open bite group.

Opdebeeck *et al*.[14] observed that the hyoid bone moved "in concert" with neighboring anatomical structures and that in patients with long face syndrome the hyoid bone had a more of a posterior and superior position.

In this study, H-SN, H-FH, H-PP and H-OP vertical distances in the hyperdivergent group were found to be less when compared with the normal vertically developed group. Although not statistically significant, the H-MP distance also showed a decrease. The H-CVT horizontal distance showed a statistically significant decrease. These findings confirmed that the hyoid bone had a more of a posterior and a superior position in the hyperdivergent group.

Carlson and Lejion[6] have stated that the relation of the hyoid bone to the cervical vertebra was constant and that the inclination the hyoid bone and head to the horizontal plane did not change during life. However, Durzo and Brodie[8] have observed an increase of height in the cervical vertebrae during growth while the hyoid bone moved downwards. Meanwhile, the posterior cranial base and mandible were moving downward and farther from each other without changing the positional ratio of the hyoid bone. They have also stated that the anteroposterior position of the hyoid bone was more liable to change than the vertical relationship.

In this study, when the hyoid bone in patients with hypodivergent facial types was evaluated, there was no statistical significance in vertical direction, while the Pg-H distance showed statistical significance in horizontal direction. It can be stated that the hyoid bone had more of a posterior position in this group. This finding was supported by the non-significant increase in HPTR distances. The angular values in the hypodivergent group were also very close to the normal group.

Table IV. "t" test evaluation of differences betwen hyperdivergent-normal and hypodivergent-normal groups

	N	$\bar{X}$	σ	$\bar{X}$	σ	$\bar{X}$	σ	NORMAL TO HYPO-DIVERGENT	NORMAL TO HYPER-DIVERGENT
MEASUREMENTS									
HORIZONTAL									
At-H	25	20.16	5.78	22.62	16.59	18.56	6.46		
S-H	25	6.27	4.16	6.02	5.15	6.54	4.94		
Pg-H	25	45.25	5.49	49.68	5.59	42.88	4.63	**	
A-H	25	58.75	6.64	60.08	6.30	58.92	5.21		
N-H	25	68.93	7.45	70.44	7.00	69.06	7.50		
PTR-H	25	11.08	6.26	12.54	6.38	14.16	5.34		
CVT-H	25	47.95	4.72	47.95	5.74	44.42	3.85		**
VERTICAL									
H-SN	25	102.20	9.78	97.46	19.70	93.36	7.40		***
H-FH	25	79.87	8.07	77.60	7.90	71.84	6.76		***
H-PP	25	59.16	7.87	57.46	7.50	52.76	5.49		**
H-MP	25	17.79	15.18	15.20	5.88	12.40	4.75		
H-OP	25	40.10	6.23	39.42	5.57	35.16	8.35		*
ANGULAR									
H_{axis}-NaBa	25	50.60	4.72	47.95	5.74	44.42	3.85		
H_{axis}-PP	25	23.83	9.20	22.78	8.13	24.96	8.56		
H_{axis}-MP	25	8.29	5.46	7.32	4.34	9.08	6.09		
H_{axis}-OP	25	14.79	8.16	14.78	9.34	12.40	7.25		
H_{axis}-SN	25	31.37	8.52	31.48	8.23	33.32	7.85		

Adamidis and Syropoulos[2] and Tallgren and Solow[23,24] have observed that the position of the hyoid bone was effected by the inclination of the mandible and the cervical, cranifacial postural changes, and that the position of the hyoid bone and facial type were interrelated.

CONCLUSIONS

The hyoid bone has more of a superior and posterior position in the hyperdivergent group.

The hyoid bone has more of a posterior position in hypodivergent group.

The suprahyoid and infrahyold muscle groups are important for the function of the hyoid bone. When these muscles function harmoniously, the hyoid bone, in the proper development of the dentofacial structures, plays an important role.

More studies need to be conducted on different facial types to assess the role of the hyoid bone in vertical facial growth and development.

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