Hyoid bone position in relation to Mandibular rotation

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Abstract

Aims This retrospective cephalometric study was designed to evaluate and correlate the hyoid bone position and angulations in two groups of subjects exhibiting vertical and horizontal mandibular rotation.

Material & method: Each group consisted of 50 subjects (25 males and 25 females) with skeletal class I pattern. Cephalometric data were obtained and four measurements were used to locate the hyoid bone in 3 aspects 1. Vertical, 2. Horizontal and 3. Angular. Thirteen angular and linear measurements were used to evaluate mandibular rotation and facial morphology.

Result: There were statistically significant differences in vertical position, horizontal distances and angulations of hyoid bone measurements between the vertical and horizontal group subject ($P<0.05$). These measurements were significantly correlated with mandibular rotation angles.

Conclusion: In vertical mandibular rotation group subjects, the hyoid bone showed to be more inferior and posterior position with downward inclination. While in horizontal mandibular rotation group subjects, the hyoid bone was more superior and anterior position with relatively upward angulations.

Keywords: Hyoid bone, Mandibular rotation.

Introduction

Changes in hyoid bone position are related to changes in mandibular position[1, 2, 3,4,5,6] and that the hyoid bone adapts to anteroposterior changes in head position [7]. Studies of hyoid relationships to the facial skeleton and the cervical column have indicated, that the hyo - cervical relationship is more stable than the relationship of the hyoid to the skull and mandible [1, 2, 8, 9,], but Licciardello et al [10] reported a highly significant decrease of a distance between mandibular, vertebral column and hyoid bone in skeletal class III subjects treated with chin cup and dilaire mask therapy. Other studies [11, 12] have shown that changes in hyoid bone position are coordinated in both upward and downward rotation of the mandibular position and changes in head and cervical posture when provided longitudinal studies of denture wearers.

The hyoid bone is a unique structure in man in that, unlike all other bones of the head and neck, it has no bony articulation but provides attachment for muscles, ligaments and fascia of the pharynx, mandible and cranium [8]. Brodi [13] considered that the hyoid bone is an important part of postural apparatus of the head and jaws. While Licciardello et al [10] concluded in their study that the function of the hyoid bone could point out as an (organ of respiration), since the variation of its position, as a sign of new muscular equilibrium, should help

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to maintain the patency of the upper airway. Hyoid bone developed from the second and third branchial arches. The posterior portion of the tongue also develops from these two arches [14]. The variation in position of the tongue in the mouth is a major factor in changing the shape and position of dental arches [15]. Wick wire[16] and Behltelf et al [17] have shown, however that the tongue can adapt to a new situations as reflected in a downward and backward positions of the hyoid bone.

Ismail[18] and Haralabakis[19] studied the position of the hyoid bone in relation to the skeletal classification in open bite patients and concluded that the hyoid bone was positioned differently according the skeletal class.

Abdul Rahman[20] studied the hyoid bone position in different skeletal classes among Iraqi population using cephalometric measurements described by Sassounis archial method of analysis in 1955. The result concluded that the position of hyoid bone varies considerably in skeletal classes and is affected by the posterior vertical facial height rather than the anterior vertical facial height.

The position of the hyoid bone relation to the cranial base and mandible has been of interest especially as an indicator of tongue posture and function. Milne et al[21] said that the tongue, hyoid and the mandible appear to work as an integrated unit. Hoffman and Hoffman[22] believed that hyoid bone was important in tongue position in that most of the extrinsic muscles of tongue are attached to it and it also helps to maintain the pharyngeal airway which is essential to life, Behlfelt[17] and Battagel[23] confirm this finding.

Studies of alterations in mandibular morphology and position in relation to hyoid bone position have been reported by Graber[24] and McNamara[25] subsequent to orthopedic chin - cup therapy. These studies have indicated that is a distal or clockwise facial rotation with the mandible moving relatively posteriorly and inferiorly. Hyoid position also tended to move slightly posteriorly but was primarily displaced in an inferior direction. Licciardello et al[10] reported a similar result when he evaluated the changes in hyoid bone position after skeletal class III therapy with chin cup and delaire face mask treatment.

Gonzalez and Galindo[26] concluded that the position of the hyoid bone is very important in the position of the head in which that the anteroposterior position of the hyoid bone presented with posterior position of the head, vertical growth, posterior rotation of the mandible when they were applied the hyoid triangle and cervical vertebrae analysis to a sample of 51 patients with hemifacial microsomia.

Tallgren and solow[27] concluded that in the older age groups the mandibular inclination, the anterior facial heights and the sagittal jaw relation were, on average larger than in the young age group, the mean vertical distance from the hyoid bone to the upper face, the mandible and the cervical column were greater in the older age groups. While the position of the hyoid in relation to the cervical column showed less variability than the hyoid relation ship to the maxilla and the mandible, also the study indicated that a large hyo-mandibular distance is associated with a large mandibular inclination. Kaduk et al[28] compared in his retrospective cephalometric long term study, the hyoid bone position in cleft lip and palate patients with orthodontic patient with no cleft. The result concluded that with increasing age of the patients, the skull growth pattern changed from vertical to horizontal growth, hyoid

bone position differed significantly and was found to be more caudal and anterior.

The position and inclination of the hyoid bone in relation to the mandibular rotation does not seem to have been studied systematically. The purpose of the present study was to:

1- Investigate the relationships of hyoid bone position and inclination with mandibular rotation in Iraqi adult sample (by location of the hyoid bone in three different aspects: vertical, horizontal and angular).

2- Correlate the hyoid position with both vertical and horizontal rotation of the mandible.

Material and Methods

176 cephalometric radiographs of pre- treated Iraqi individuals aged 18 - 25 years with skeletal class I were traced and analyzed according to the ANB angle[29]. Records were taken from the files Supplied with each radiograph in Orthodontic Department in Dentistry College, Baghdad University. Subject with gross facial asymmetry, facial abnormality, under orthodontic treatment, or any poor quality of radiograph was excluded.

Then the previous sample were divided into two groups according to the posterior facial height and anterior facial height ratio (PFH / AFH ratio) [30, 31], subjects in which the ratio (PFH / AFH) is under 62 % was expressed as a vertical growth pattern (Group V). Subjects in whom the ratio (PFH / AFH) is Greater than 65 % was expressed as horizontal vector (group Z). So that the final sample size of the two groups was comprised of 100 subjects, each group was consisted of 50 subjects (25 males and 25 females).

Cephalometric measurements

Four cephalometric measurements were used to evaluate the position of the hyoid bone, and thirteen measurements to evaluate the mandibular rotation and facial morphology.

A. **Hyoid bone measurement** Figure (1): according to stepovich[32]

1- SL line: it is a vertical distance from (S) point to the intersection of the hyoid plane (HG) at the point (L).

2- SLG (angle of hyoid bone) it is formed by the line connecting (S) point and the registrations point (L) on the hyoid bone with the hyoid plane (HG). (L) Point is a registration point at which a perpendicular from SN at S intersects the hyoid plane.

3- LH: it is a horizontal distance from the registration point (L) to a point H on the hyoid bone to locate the hyoid bone anteriorly. If point L was to the left of point H, a positive figure was recorded; if it was to the right a negative figure was recorded.

4- d : it is a horizontal distance from the most anterior point of hyoid bone (H) to the most anterior point of Atlas vertebra: to locate the posterior position of the hyoid bone[33].

B. **Measurements of mandibular rotation**[34, 35] Figure (1)

1- Saddle (NS Ar) ,2- Articular (S ArGo) 3- Gonial angle (ArGoMe), 4- Upper gonial angle (NGOAr), 5-Lower gonial angle (NGOMe), 6- SNMeGO(This angle gives the inclination of the

mandible relative to the cranial base), and 7- Y-axis (NSGn : the anterior or posterior rotation of the mandible is characterized by closing or opening of this angle)

C. **Linear measurements** [29, 36] vertical facial dimensions were recorded.

1- AFH: represents the anterior facial Height it measured vertically from N point to Me point.

2- PFH: represents the posterior facial height it measured vertically from S point to point Go.

3- LFH: represents the Lower facial height it measured vertically from ANS point to Me point.

D. **Facial angles**[34, 37] SNA, SNB, and ANB to determine the skeletal pattern of the selected sample.

Angular measurements were made with an accuracy of 0.5degrees, and linear measurements were made with an accuracy of 0.5 mm.

Statistical analysis

Two weeks after the first measurements, 20 radiographs were selected randomly, and their hyoid bone dimensions with all other cephalometric measurements used in the study were measured by the same investigator. A paired t test was applied to the first and second measurements, and no significant differences were found between the first and the second radiographic readings at (5%) probability level.

The data were statistically analyzed using SPSS version 14 with simple descriptive statistics (mean, standard deviation, upper and lower limits). t-test was applied to detect the statistically significant difference in the mean values of different measurements between the two examined groups (vertical and horizontal) and between genders.

Pearson correlation coefficient was done to detect the significance of the hyoid bone measurements and other cephalometric measurements in vertical and horizontal groups.

Results

Hyoid bone position

Table (1) showed the descriptive statistics of the measurement of the hyoid bone in both vertical and horizontal groups with the t- test. It is found that the vertical distance of the hyoid bone position (SL) is significantly larger at the level of 0.05 in vertical group than that in horizontal (110.24 103.42 respectively) that means the hyoid is displayed more inferiority in vertical group .

Angle of hyoid bone inclination also demonstrated in this table represented by SLG angle in which it becomes closed in vertical group while it opens in horizontal group (61.18 , 68.4 respectively) this difference was significant at a level of 0.05. This means that hyoid bone was relatively inclined more downward in vertical group than in horizontal.

An Anteroposterior change in position of the hyoid bone was indicated by two measurements. In vertical group, the anterior position of the hyoid bone represented by the LH distance showed a significant decrease than that in horizontal group at a level of 0.05 (2.17 , 8.43 respectively) which means that the L point is moving more forward indicating a relatively posterior displacement of the hyoid bone .

The posterior position of the hyoid bone represented by (d) distance shows significant difference at the level of

0.05 between vertical and horizontal group subjects, though this distance was smaller in the former group than in the latter (25.21 ,33.027 respectively) .

Although the mean values of the hyoid bone measurements were higher in male sample than that in females, but these were statistically not significant at 0.05 levels. Therefore, the comparison of hyoid bone measurements between genders was disregarded and considered with a total sample.

Angular and linear measurements

The descriptive statistics of all angler and linear measurements in both vertical and horizontal groups are shown in table (2) with the t- test.

The mandibular rotation angles (NSAr, SArGo, ArGoMe, NGOMe, SNMeGO and y-axis) were higher in vertical growth pattern group than that in horizontal group. These differences were statistically significant at the level of 0.05. NSAr and NGOAr showed no significant differences between the two examined groups.

Angles of sagittal jaw relation ship were significantly smaller in vertical group than that in horizontal group although the difference between two angles were statistically not significant between vertical and horizontal groups (ANB : 2.1, 2.2 respectively) indicated more retruded facial pattern in vertical group subjects since they exhibited smaller values of SNA , SNB angles (78.57, 76.41 respectively)

The mean values of the vertical linear measurement between the vertical and the horizontal group were displayed in this table. It showed that the AFH and LFH were higher in vertical group than that in horizontal, while in horizontal group the PFH was higher than that in vertical group (87.26, 77.08 respectively). These differences were statistically significant at a level of 0.05.

Correlations

Pearson correlation analysis of hyoid bone position in relation to other variables among vertical and horizontal group subjects were displayed in table (3) and (4) respectively.

The vertical distance of the hyoid bone (SL) was positively and significantly correlated, in vertical group subjects; with all mandibular rotation angles (except the NGOAr angle).A similar correlation of SL vertical distance has been found in horizontal group subjects but with y-axis only.

Further more, the (SL) distance in both groups has highest significant correlation with facial heights (AFH, LFH and PFH) at the level of 0.01 in both vertical and horizontal groups.

The angle of hyoid bone position (SLG) in the two examined groups has no significant correlation with all variables except with the anterior position of the hyoid bone (LH) in which it shows strong and significant correlation at a level of 0.01. This correlation indicates that a smaller angle of hyoid bone is associated with relatively posterior position of it and vise versa.

The anteroposterior position of the hyoid bone which is represented by the horizontal distance (LH) anteriorly and (d) distance posteriorly showed that the (LH) distance has a strong and significant correlation with AFH and LFH in vertical group and with LFH only in horizontal group subjects. The posterior distance (d) has significant correlation with SArGO and NGOMe angles in vertical group, while it has no significant correlation with all variables in horizontal group subjects.

Discussion

The significant differences in the position and angulations of hyoid bone

were found in vertical group and horizontal group subjects who possessed skeletal class I jaw relationship can be summarized as fallows: In subjects who exhibited vertical growth pattern , the displacement of the hyoid bone was inferiorly with a down ward angulations of it (since it shows higher value of SL vertical distance and small value of SLG angle) (table1), this is associated by the movement of the L point more anteriorly giving an indication of posterior position of the hyoid bone . This come in agreement with Tallgren and sollow[27] who stated that, on the average, a large distance from the hyoid bone to the mandible is seen in subjects with a large inclination of the mandible. The significant differences of the posterior distance of the hyoid position between vertical and horizontal groups represented by the (d) distance may agreed with Licciardello et al[10] who found that an inferior hyoid bone position is associated with a decrease of a distance between mandibular, vertebral column and hyoid bone. While it comes in contrary of the findings of Takag etal[1], Fromm[m2], and Bibby and preston[8] who studied the hyoid relationships to facial skeleton and the cervical column and indicated that the hyo- cervical relation ship is more stable than the relation of the hyoid to the skull and mandible, also Graber[3] considered that the measurements from the vertebral column to hyoid bone as unreliable measurements and was disregarded. Kumar[9] confirm these findings.

Angles of mandibular rotation show their highest values in vertical group subjects (table2) indicated a back ward rotation of the mandible which comes in accordance with Tallgren and Sollow [27]and adamidis[33] who stated that the hyoid position is coordinated with facial structure. Also , the significant correlation of the vertical position of the hyoid bone with mandibular rotation angles, AFH and LFH (Table 4) confirm this findings as indicated by Tallgren and solow[27] who reported that there are certain connection of a back ward mandibular rotation with an increased in facial heights. Also, the reduced SNA, ANB mean values indicated more retruded facial morphology which comes in coordination with a back ward rotation of the mandible.

All these give an indication that in vertical group subjects, the hyoid bone is positioned more posterio-inferiorly which is associated with back ward rotation of the facial complex and the mandible. This come in agreement with Graber[3, 24, 25] who indicated that the posterior inferior, (i.e. clock wise) rotation of facial complex particularly the mandible is followed by the similar pattern of the hyoid bone apparatus. This can be explained on the bases that as the mandible is moved posteriorly relative to other craniofacial structures, the tongue and the hyoid bone are literally "carried" with it. Also Graber[3] claimed that with increased posterior movement of the mandible there is an increased movement of the hyoid bone in an inferior direction.

On the other hand, subjects who exhibited horizontal growth pattern, the vertical distant of the hyoid bone (SL) was reduced (table 1) with more back ward movement of the (L) point (indicating a more anterior position of the point H of the hyoid bone), and the (SLG) angle is relatively larger than that in vertical growth pattern gives and indication of a more superio-anterior position of the hyoid bone with an upward inclination. This comes in accordance with the findings of Stepovich[32]. Further more the angles of mandibular rotation were reduced in this group (Table 2) with an increased mean value of SNA, SNB

angles in that of the vertical group. Also the AFH and LFH show their lowest values and the PFH showed its highest value in this group gives an indication of more forward rotation of the mandible as come in agreement with Tallgren and Sollow[27]. Also , the significant correlation of the mandibular inclination angle (Y-axis) and the LFH with the vertical position of the hyoid bone (table 3) supports this connection of the forward mandibular rotation and the decrease in facial heights as agreed by Tallgren and Sollow[27] who indicated that backward mandibular rotation is connected with an increase in facial heights.

Conclusion

For the vertical and horizontal growth subjects the hyoid bone position was studied in three different aspects; (1) vertical, (2) angular and (3) anteroposterior. The result was concluded as fallows;

1- The vertical, angular and anteroposterior position of the hyoid bone is significantly different in vertical group than that in horizontal group subjects.
2- In both groups (vertical and horizontal) the vertical position of the hyoid bone (SL) distance was the only hyoid measurements that correlated significantly with mandibular rotation angles rather than other hyoid bone measurements
3- The hyoid bone position is coordinated with mandibular rotation:

In vertical group pattern, Subjects possessed back ward rotation of the facial complex and particularly the mandible, the position of the hyoid bone is posterio inferiorly with downward angulations.

In horizontal group subjects, the position of the hyoid bone is antero superiorly with relatively upward inclination, which is associated with forward rotation of the mandible Figure (2).

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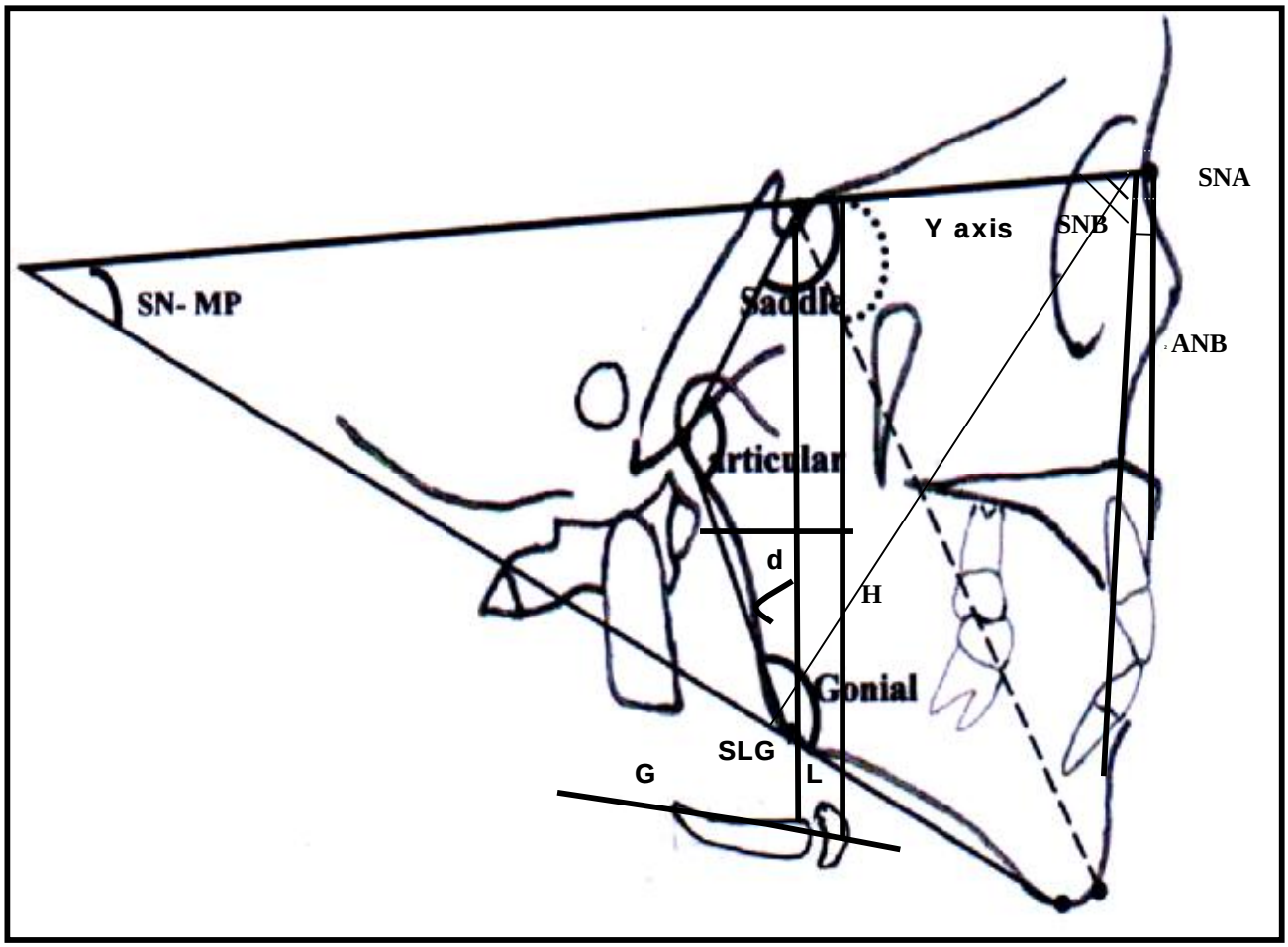

Table (1) Hyoid bone measurements in vertical and horizontal group subjects with t-test

Variable	Type	Mean	S. D.	t-test	Sig	Minimum	Maximum
SL	v	110.42	9.83			90	127
	z	103.42	7.50	4.003	S	90	118
SLG	v	61.18	6.55			36	69
	z	68.4	6.88	_5.376	S	36	69
LH	v	2.1728	9.51			-12.2	27.8
	z	8.4328	10.31	_3.156	S	-23.6	16.2
d	v	25.2182	3.40			18.07	41
	z	33.0276	5.32	_2.027	S	24.9	40.7

S: significant at 0.05 levels

Table (2) Descriptive statistics of all measurements for Vertical and Horizontal group subjects with t-test

Variables	type	Mean	S.D.	t-test	Sig	Minimum	Maximum
SNA	v	78.575	4.91	-3.536	S	66.9	91.9
	z	81.826	4.26			71.8	90.3
SNB	v	76.4189	4.49	-3.864	S	68.4	87
	z	79.604	3.72			72.6	89.1
ANB	v	2.152	4.37	-0.103	NS	-9.7	10.5
	z	2.228	2.82			-3.4	9.2
NSAr	V	124.0138	6.88	1.010	NS	107.7	138.1
	z	122.776	5.27			109.2	133.4
SArGo	v	145.3977	8.81	2.151	S	128.7	164
	z	142.102	6.30			130	156
ArGoMe	v	133.0062	7.15	5.636	S	121.2	158.1
	z	125.272	6.56			110.4	141.5
NGoAr	v	51.43973	5.08	-0.179	NS	39.9	62.8
	z	51.602	3.94			39.9	58.6
NGoMe	v	81.55438	5.56	7.126	S	70.8	100.2
	z	73.67	5.50			62.8	85.5
SNMGo	v	42.41353	4.60	12.828	S	33.6	59.4
	z	30.156	4.95			18.2	42.2
Y-axis	v	71.33911	4.05	4.979	S	64	80.7
	z	67.52	3.61			58	76.2
PFH	v	77.0828	5.73	-7.894	S	67.1	88
	z	87.262	7.09			75.7	103
AFH	v	129.1582	9.86	2.678	S	111.5	147.7
	z	124.172	8.72			109.2	145.6
LFH	v	73.68748	8.28	2.497	S	59	89.1
	z	69.926	6.70			58.1	86.3

S: significant at 0.05 level NS: not significant

Table (3) Correlations between Hyoid bone measurements and other variables in Vertical group subjects

Variable	SL	SLG	LH	d
SNA	-.037	-.031	-.180	.088
SNB	.008	.029	-.031	.112
ANB	-.059	-.075	-.203(*)	-.019
NSAr	-.069	.036	.048	-.376(**)
SArGo	.289(**)	-.099	.019	.306(**)
ArGoMe	.387(**)	.084	.126	.176
NGoAr	-.176	.143	.003	-.029
NGoMe	.461(**)	.002	.144	.224(*)
SNMGo	.411(**)	.015	.184	.187
Yaxis	.371(**)	-.042	.115	-.027
PFH	.312(**)	-.085	-.047	-.122
AFH	.897(**)	-.018	.284(**)	.042
LFH	.814(**)	.038	.326(**)	.059
SL	1	.073	.318(**)	.092
SLG	.073	1	.277(**)	.087
LH	100(**)	.277(**)	1	-.235(*)
d	100	100	100(*)	100

* Correlation is significant at the 0.05 level. ** Correlation is significant at the 0.01 level.

Table (4) Correlations between hyoid bone measurements and other variables in Horizontal group subjects

Variable	SL	SLG	LH	d
SNA	-.158	-.092	-.062	.081
SNB	-.144	.031	-.007	-.015
ANB	-.046	-.180	-.084	.143
NSAr	.023	.079	-.134	-.001
SArGo	.268	-.188	-.019	.013
ArGoMe	-.114	.166	.160	.072
NGoAr	-.109	.212	.156	.022
NGoMe	.227	.049	50	50
SNMGo	.213	.065	.043	.111
Yaxis	.536(**)	.044	.026	.105
PFH	.712(**)	-.026	.118	-.010
AFH	.924(**)	.104	.178	.036
LFH	.775(**)	.211	.281(*)	.069
SL	1	.223	.257	.042
SLG	.223	1	.460(**)	.266
LH	.257	.460(**)	1	-.163
d	.042	.266	-.163	1

** Correlation is significant at the 0.01 level.
* Correlation is significant at the 0.05 level.

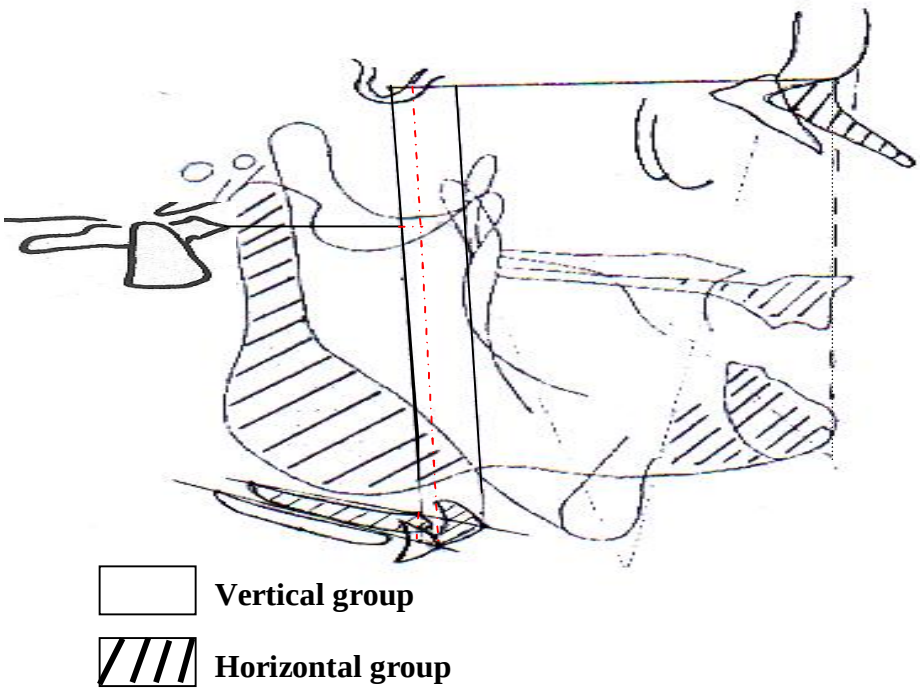

Figure (2) illustrates the hyoid bone position in vertical and horizontal mandibular rotation group subjects according to the result of the present study.