ORIGINAL ARTICLE

KOREA. J. ORTHOD. 1996. 26(6) : 677-689

A LONGITUDINAL POSITIONAL CHANGES OF HYOID BONE IN KOREANS WITH NORMAL OCCLUSION

Hyo-Sang Park, D.D.S., M.S.D.

The positional changes of the hyoid bone over entire growth period were studied by cephalometric method in order to determine the average position and average growth changes of the hyoid bone in koreans with normal occlusion. The materials included cephalometric radiographs obtained on twenty six males and twenty two females over the period from 8.7 years to 16.7 years of age in average.

The results of this study might be summarized as follows;

- The mean value and standard deviation of each measurement were obtained in each age and gender.
- The hyoid bone tended to positioned forwardly in female at the age of 12.7, 14.7, and 16.7 years of age as compared with male.
- The hyoid bone positioned more downwardly in male than in female

keyword : the hyoid bone, growth, changes

The hyoid bone is suspended by musculature and ligaments that are attached to structures above and below it. Therefore the position of hyoid bone might be determined by these muscles

In early 40's Negus[17] stated that as face grows, the mandible is carried downward and forward, accordingly the tongue and the hyoid bone are carried in the same direction, and he also postulated that the position of hyoid bone is influenced by the position of head.

After that, many investigators studied the position of hyoid bone relative to craniofacial structure[1,3,4,9,13], the movement of the hyoid bone during cyclic jaw movement and deglutition by using cineradiographic[16,21], eletromyographic, and videofluorographic method.[19,29]

※ The present research has been conducted by the Bisa Research Grant of Keimyung University in 1995

Nevertheless, the longitudinal serial study of the positional change of the hyoid bone was rare in western country and especially absent in koreans.

The purpose of this study was to determine the changes in the position of the hyoid bone over entire growth period in koreans with normal occlusion.

MATERIALS and METHODS

The materials for this study consisted of 48 longitudinal cephalometric series(26 males, 22 females) obtained from the files of the department of orthodontics, school of dentistry, Kyungpook national university. The cephalometric radiographs were taken at two year time intervals over entire growth period(8.7, 10.7, 12.7, 14.7, 16.7 years old). The materials were selected in terms of normal occlusion, normal facial profile, and proper positioning of patient to natural head position at the first taking of

Table 1. Cephalometric landmarks used in this study

1. S(Sella): the center of the sella turcica
2. Na(Nasion): the most anterior point of the frontonasal suture
3. Or(Orbitale): the lowermost point of the lower margin of the bony orbit
4. Po(Porion): the most superior point of the external auditory meatus
5. ANS(Anterior nasal spine) : the most anterior point on the bony hard palate
6. PNS(Posterior nasal spine): the most posterior point on the bony hard palate
7. A(Subspinale): the most posterior point on the curvature from the anterior nasal spine to the crest of the maxillary alveolar process
8. UIT(Upper incisal tip): the incisal tip of the maxillary central incisor
9. LIT(Lower incisal tip): the incisal tip of the mandibular central incisor
10. UMMC(Upper molar mesial cusp tip): the mesial cusp tip of the maxillary first molar
11. LMMC(Lower molar mesial groove): the mesiobuccal groove of the mandibular first molar
12. Pog(Pogonion): the most anterior point on the contour of chin
13. Me(Menton): the most inferior point on the symphyseal outline
14. Go(Gonion): a bony point by bisecting line of angle that formed by ramal plane and mandibular plane
15. RGn(Retrognathion): the most inferior, posterior point on the mandibular symphysis
16. APH(Anterior point of hyoid): the most superior, anterior point on the body of the hyoid bone
17. PPH(Posterior point of Hyoid): the most posterior point of the hyoid bone
18. C3: the point at the most inferior anterior position on the third vertebrae
19. AD1: intersection of adenoid contour with a line from PNS to basion (the most postero-inferior point of the clivus)
20. AD2: intersection of adenoid contour with a line from PNS to the midpoint of the sella-basion line
21. OP(Odontoid point): the most postero-inferior point on the 2nd cervical vertebrae
22. CP(Cervical point): the most postero-inferior point on the 4th cervical vertebrae
23. AA: the most anterior point on the body of the atlas vertebrae seen on the lateral cephalometric radiograph

radiographs.

Films were traced on tracing paper by superimposing serial cephalometric radiographs for improving accuracy. If both sides of image were not coincided, the midpoint was selected for tracing. Cephalometric landmarks(Fig. 1 and Table 1) were inputted into personal computer by pointing the landmarks, by utilizing the analysis program, angular and linear measurements were calculated the nearest 0.01 degrees, 0.01 mm respectively.

In order to determine the angular relationships of the hyoid bone to reference line, angular measurements(Fig. 2) were measured. To determine the anteroposterior positional change of hyoid bone, horizontal measurements(Fig. 3) were calculated. And to estimate the vertical growth change of hyoid bone, vertical measurements(Fig. 4) were measured. Measurements of hyoid triangle(Fig. 5) were measured in order to compare this method to other method using cranial reference line in terms of efficiency to determining the position of hyoid bone. Two measurements for cervical angulation(Fig. 6) were measured to understand the effect of cervical vertebral angulation to the position of the hyoid.

The arithmetic mean(M), standard deviation(S.D.), and standard error(S.E.) were calculated. Differences of variables between males and females were tested for statistical significance with Student's t test at each age.

All horizontal, vertical, and angular measurements used in this study

Measurements on angular relation of the hyoid bone(Fig. 2)

1. HP-FH; angle formed by the long axis of the hyoid bone and the FH plane
2. HP-PP; angle formed by the long axis of the hyoid bone and the palatal plane
3. HP-OP; angle formed by the long axis of the hyoid bone and the occlusal plane
4. HP-MP; angle between the hyoid plane and the

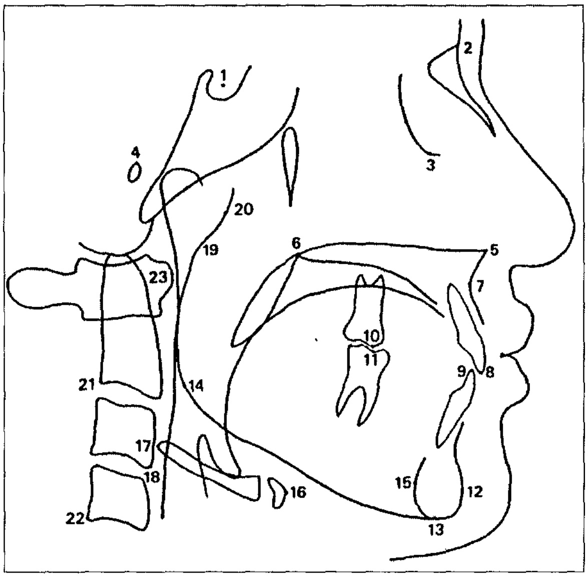

Fig. 1. Cephalometric landmarks

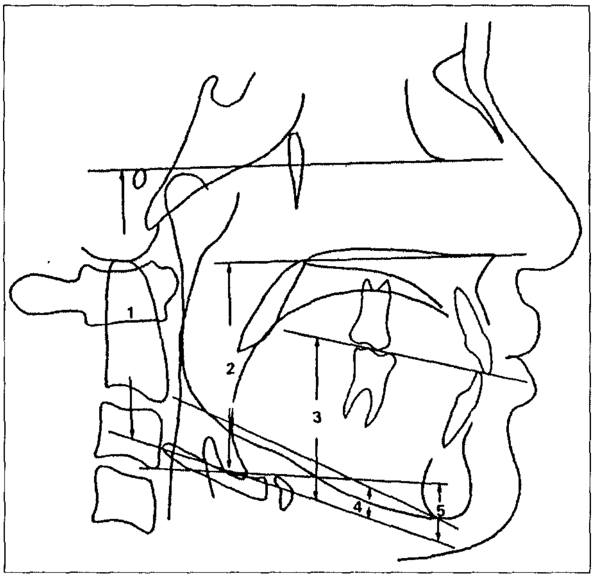

Fig. 2. Measurements on angular relationship of the hyoid bone to reference lines.

mandibular plane

5. HP-C3RGn; angle between the hyoid plane and C3RGn plane

Measurements on horizontal relation of APH(Fig. 3)
1. S-APH; horizontal distance between vertical projection of S and APH on FH plane
2. A-APH; horizontal distance between vertical projection of A and APH on FH plane
3. RGn-APH; horizontal distance between vertical projection of RGn and APH on FH plane
4. Pog-APH; horizontal distance between vertical projection of Pog and APH on FH plane
5. C3-APH; horizontal distance between vertical projection of C3 and APH on FH plane
6. AA-APH; horizontal distance between vertical projection of AA and APH on FH plane

Measurement on vertical relation of the hyoid bone(Fig. 4)

1. FH-APH; distance of APH to FH plane
2. FH-PPH; distance of PPH to FH plane
3. RGn-APH; vertical distance between RGn and APH
4. C3-APH; vertical distance between C3 and APH

Measurements on hyoid triangle(Fig. 5)
1. C3-RGn: distance between C3 and RGn
2. C3-APH; distance between C3 and APH
3. RGn-APH; distance between RGn and APH
4. APH-APH'; distance of APH to the C3RGn plane

Measurements on airway and cervical angulation (Fig. 6)
1. NSL/OPT; angle between nasion-sella line and the posterior tangent to the odontoid process of the second cervical vertebrae
2. NSL/CVT; angle between nasion-sella line and cervical vertebrae tangent to the odontoid process (Linder-Aronson and Henrikson 73)
3. AA-PNS; distance between AA and PNS
4. AD1-PNS; distance between AD1 and PNS
5. AD2-PNS; distance between AD2 and PNS

FINDINGS

Mean, standard deviation, and standard error of each item were shown in table 2.

Measurements of angular relationships of the hyoid plane to reference line showed no significant differences between males and females at each age groups.

Measurements of anteroposterior relationships of

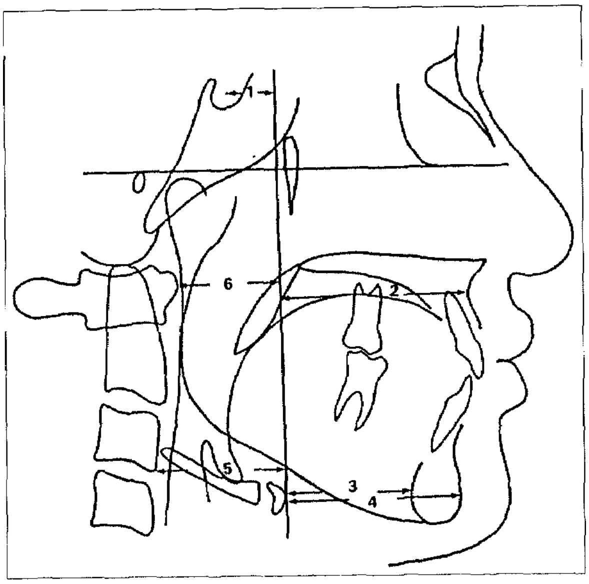

Fig. 3. Measurements on horizontal relationship of the hyoid bone to reference points

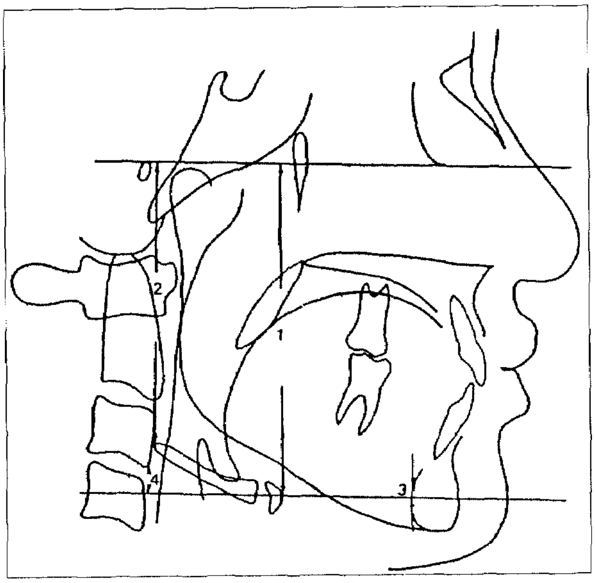

Fig. 4. Measurements on vertical relationship of the hyoid bone to reference points.

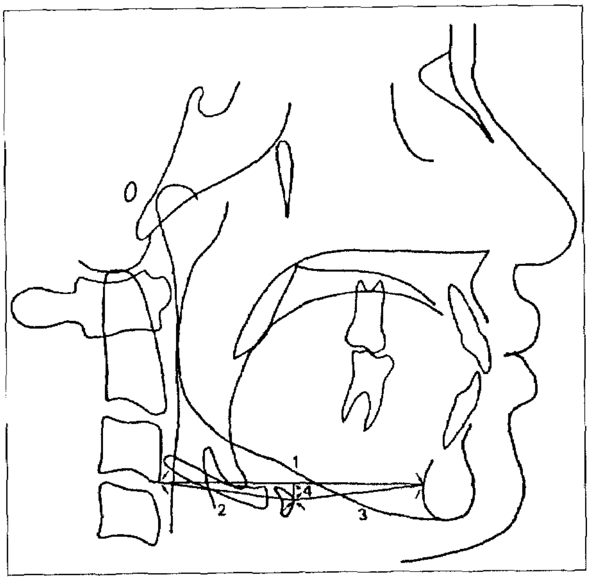

Fig. 5. Measurements on the hyoid triangle

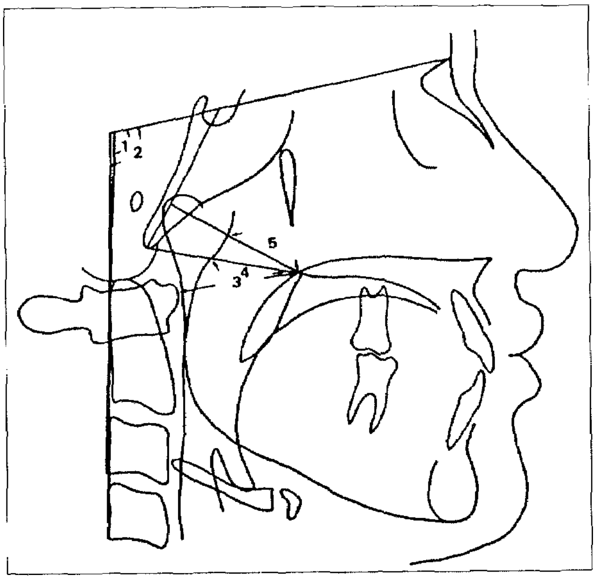

Fig. 6. Measurements on airway and cervical angulation

APH to other landmarks were as follows:

Significant differences between male and female were observed in the linear measurements of RGn-AHP, Pog-AHP in 12.7 age group and C3-AHP in 14.5, 16.5 age groups.

In the items of which measured to estimate the vertical position of the hyoid bone, the FH-AHP and RGn-AHP showed significant differences between male and female in each group except 8.7 age group. The FH-PHP and AHP-C3 of males were long as compared with that of females in 12.7, 14.7, and 16.7 age group.

Measurements in the hyoid triangle yielded the following information:

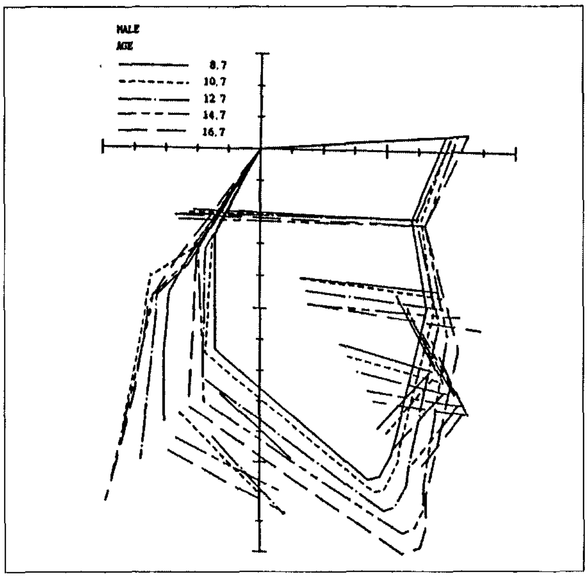

Fig. 7. Average growth change of the position of the hyoid bone from 8.7 to 18.7 years of age in male.

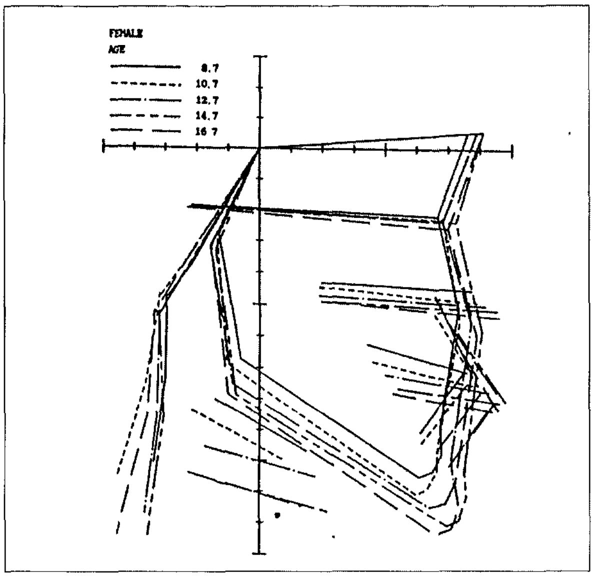

Fig. 8. Change of the position of the hyoid bone from 8.7 to 18 7 years and in female

In 8.7 age group, there was no differences between male and female. But the distance from the mostanterior point of hyoid bone (AHP) to the C3-RGn plane of male was greater than that of female in 10.7, 12.7, 14.7, and 16.7 age groups. The distance from C3 to AHP of male was greater than that of female in 12.7, 14.7, and 16.7 age groups, it meant that the hyoid bone of male positioned forwardly compared to female. The distance from APH to RGn of male was shorter than that of female only in 12.7 age group.

In concerned of measurement of cervical angulation, there were no significant differences between male and female in all age group.

In measurement for estimating airway patency, the AA-PNS of male was shorter than that of female in 8.7, 10.7, and 12.7 age group. Other measurements did not show any significant differences between male and female.

DISCUSSION

The hyoid bone develops from the second and third branchial arches. The hyoid has close relation to posterior portion of tongue developmentally. The hyoid bone also has direct relationship to surrounding structure by suprahyoid and infrahyoid muscle but no bony articulation.

Mainland[15)] pointed out that the role of the hyoid bone was the platform that can be stabilized by one set of muscles so that other muscles can act from it. Therefore, the hyoid bone may be changed in position in relation to the growth change of surrounding bony structure.

It is very difficult to study the positional change of hyoid bone during growth because of instability of the position of the hyoid bone during taking the cephalometrics. Even if a same operator takes two radiographs of same patients, same time, the position of the hyoid is different from each other.

Stepvovich[26)] noted that he could evaluate the movement of the head by measuring the deviation of the Frankfort plane against the film edge. The inability to control the tilt of the head might be the biggest reason why the position of the hyoid bone could not be duplicated from film to film in the same individual. If head movement could be stabilized, this error could be eliminated. Greenfield and his associates[9)] pointed out that the inaccuracy of cephalostatic ear rod in assessing for postural recordings of the head and neck. Winnberg et. al.[29)] also noted the importance of head posture in studies

Table 2. Mean values of measurements at each age

	Age 8.7						
	Male			Female			Probability
	M	SD	SE	M	SD	SE	
Angular measurement							
HP-FH	25.89	8.22	1.61	23.56	5.36	1.14	
HP-PP	-26.27	8.57	1.68	-23.07	5.08	1.08	
HP-OP	-13.82	8.24	1.62	-11.66	5.94	1.27	
HP-MP	5.21	7.70	1.51	7.28	6.71	1.43	
HP-C3RGn	-20.27	9.04	1.77	-17.98	6.89	1.47	
Horizontal measurement							
S-APH	16.81	6.38	1.25	15.61	5.19	1.11	
A-APH	44.10	5.43	1.07	46.86	4.25	0.91	
RGn-APH	24.37	5.44	1.07	26.69	4.89	1.04	
Pog-APH	37.79	6.22	1.22	39.56	4.98	1.06	
C3-APH	30.83	2.30	0.45	31.01	2.08	0.44	
AA-APH	27.52	4.99	0.98	28.09	4.39	0.94	
Vertical measurement							
FH-APH	77.50	5.00	0.98	74.24	6.85	1.46	
FH-PPH	62.12	5.15	1.01	59.80	6.86	1.46	
RGn-APH	3.81	3.55	0.70	1.48	4.83	1.03	
C3-APH	9.00	4.60	0.90	6.94	2.35	0.50	
Hyoid triangle							
C3-RGn	55.67	6.33	1.24	58.15	5.59	1.19	
C3-APH	32.45	1.99	0.39	31.86	2.05	0.44	
RGn-APH	24.93	5.35	1.05	27.11	5.10	1.09	
APH-APH'	5.97	3.14	0.62	4.43	2.25	0.48	
Airway and cervical angulation							
NSL/OPT	94.18	8.01	1.57	94.23	5.97	1.27	
NSL/CVT	96.55	7.81	1.53	97.53	5.78	1.23	
AA-PNS	28.51	3.33	0.65	30.78	2.70	0.58	p=0.014
AD1-PNS	14.18	2.87	0.56	14.53	3.37	0.72	
AD2-PNS	18.77	4.24	0.83	19.06	4.57	0.97	

of mandibular and hyoid movements. In this study, author selected the materials which had appropriate FH plane arrangement against film edge and the number of samples was quite large, therefore the methodological error might be quite small.

There were several methods to investigate the positional change of hyoid bone. First of all, many investigators have used a cephalometric method, it was very popular and cheaper than any other methods. After cinefluorography had been introduced to investigate the hyoid bone movement pattern[21], Miotti[16] used cineradiograph for studying the hyoid bone movement before and after surgical correction. Pancherz et. al.[19] also studied dynamic hyoid movement by using the videofluographic study. But the methods using lateral cephalometric, is very easy to perform, and very easily understand by other readers, and have been used by many orthodontists. Therefore, author determined to utilize the cephalometric method.

During last two decades many authors studied the positional change of hyoid bone. Some investigators observed the growth changes of hyoid bone position throughout growth period[2,6,11,26], others investigated the difference of the position of hyoid bone according

	Age 10.7						
	Male			Female			Probability
	M	SD	SE	M	SD	SE	
Angular measurement							
HP-FH	27.18	8.40	1.65	23.69	6.65	1.42	
HP-PP	-27.12	7.39	1.45	-23.35	6.08	1.30	
HP-OP	-16.58	7.85	1.54	-13.54	6.79	1.45	
HP-MP	3.22	7.72	1.51	5.96	7.94	1.69	
HP-C3RGn	-23.57	7.73	1.52	-20.57	7.24	1.54	
Horizontal measurement							
S-APH	15.45	7.90	1.55	14.71	6.70	1.43	
A-APH	47.29	6.11	1.20	49.41	6.14	1.31	
RGn-APH	27.77	5.25	1.03	30.33	4.64	0.99	
Pog-APH	41.51	5.33	1.04	43.33	4.41	0.94	
C3-APH	30.83	2.53	0.50	31.18	2.09	0.45	
AA-APH	26.44	6.43	1.26	27.45	5.64	1.20	
Vertical measurement							
FH-APH	82.81	4.40	0.86	78.70	3.72	0.79	p=0.001
FH-PPH	66.35	4.70	0.92	63.71	5.00	1.07	
RGn-APH	5.95	3.35	0.66	3.20	3.66	0.78	p=0.009
C3-APH	9.58	5.55	1.09	6.47	3.45	0.74	
Hyoid triangle							
C3-RGn	58.91	5.57	1.09	61.73	5.34	1.14	
C3-APH	32.71	2.88	0.56	32.03	2.03	0.43	
RGn-APH	28.62	5.02	0.98	30.73	4.48	0.96	
APH-APH′	7.61	3.72	0.73	4.95	2.59	0.55	p=0.007
Airway and cervical angulation							
NSL/OPT	95.38	8.70	1.71	96.93	8.01	1.71	
NSL/CVT	98.50	7.99	1.57	100.17	7.96	1.70	
AA-PNS	28.89	2.88	0.57	31.60	2.89	0.62	p=0.007
AD1-PNS	15.16	2.57	0.50	15.75	2.71	0.58	
AD2-PNS	20.38	2.35	0.46	20.49	3.75	0.80	

to the skeletal pattern of patients[18], and others studied positional change of hyoid bone following the orthognathic surgery.[14,20,27]

But the longitudinal serial study of the positional change of the hyoid bone was scant.

Bibby and Preston[3,4] used the hyoid triangle to evaluate the position of the hyoid bone. But he could not find out the differences in the position of the hyoid bone between habitual tongue-thrusting or mouth breathing and normal patient. In this study the items among the hyoid triangle showed similar findings with other measurements. It might be useful measure to evaluate the position of the hyoid bone. But small change in the position of the hyoid bone can be undetectable by this method, because the position of the hyoid bone can be influenced by many factors during taking the cephalometric radiographs. It is very important to develope the trustful method to evaluate the position of the hyoid bone

In terms of the angular relation of hyoid bone, there were no differences between male and female. The angle between long axis of hyoid bone and FH plane showed the tendency of decreasing with the progress of growth. The downward growth of cervical vertebrae exceeds downward growth of mandible, therefore, the angle of hyoid bone relative to FH plane

	Age 12.7						
	Male			Female			Probability
	M	SD	SE	M	SD	SE	
Angular measurement							
HP-FH	24.54	8.03	1.58	22.44	5.60	1.19	
HP-PP	-24.53	6.93	1.36	-21.88	5.22	1.11	
HP-OP	-14.82	7.07	1.39	-13.20	5.70	1.21	
HP-MP	4.59	7.82	1.53	6.20	6.36	1.36	
HP-C3RGn	-21.72	7.47	1.46	-20.17	5.87	1.25	
Horizontal measurement							
S-APH	16.02	6.86	1.35	13.62	5.83	1.24	
A-APH	48.69	5.49	1.08	52.00	5.21	1.11	p=0.038
RGn-APH	29.37	5.18	1.02	33.42	4.62	0.98	p=0.002
Pog-APH	43.82	5.72	1.12	46.99	4.70	1.0	p=0.043
C3-APH	33.91	3.15	0.62	32.76	2.47	0.53	
AA-APH	27.85	5.24	1.03	27.36	4.64	0.99	
Vertical measurement							
FH-APH	90.32	6.24	1.22	84.31	6.25	1.33	p=0.002
FH-PPH	74.09	5.21	1.02	69.58	6.74	1.44	p=0.012
RGn-APH	8.31	4.60	0.90	4.36	5.14	1.10	p=0.007
C3-APH	11.26	5.80	1.14	7.01	0.78	3.64	p=0.004
Hyoid triangle							
C3-RGn	63.59	6.87	1.35	66.40	5.75	1.23	
C3-APH	36.19	3.09	0.61	33.69	2.33	0.50	p=0.003
RGn-APH	30.86	5.14	1.01	34.11	4.41	0.94	p=0.024
APH-APH′	9.61	4.36	0.85	5.91	3.34	0.71	p=0.0012
Airway and cervical angulation							
NSL/OPT	97.58	6.46	1.27	97.75	5.51	1.17	
NSL/CVT	99.63	6.23	1.22	101.55	5.90	1.26	
AA-PNS	30.50	3.77	0.74	33.03	3.41	0.73	p=0.019
AD1-PNS	17.02	3.31	0.65	16.88	2.47	0.53	
AD2-PNS	21.84	3.59	0.70	21.44	3.16	0.67	

decreased at 12.7 years of age in female and 14.7 years of age in male, thereafter the angle was maintained.

Opedbeeck et. al.[18] found that the angle of the hyoid plane relative to SN plane was larger in the long face syndrome than short face syndrome. He said that it was result of the downward rotation of the mandible in concert with the hyoid bone, the cervical spine, and pharynx. Bench[2] observed that the downward growth of cervical vertebrae was quite faster in preschool children, thereafter the rate of descending was decreased. But the growth of cervical vertebrae was still larger than that of chin. He also stated that the hyoid bone behavior was more closely related with vertebral growth than with the chin behavior. As noted earlier, the angles of the hyoid bone relative to FH plane and mandibular plane were diminished according the progress of the growth. It may be result of the more downward growth of the cervical vertebrae rather than that of the chin.

In the previous study, it was noted that the hyoid was positioned more forwardly in class III group than class I group[1]. Koh and Cha[12] also observed that the position and angulation of the hyoid bone changed after treatment of the functional class III patients. Pim valk et. al.[20] demonstrated that the hyoid bone rotated

	Age 14.7						
	Male			Female			Probability
	M	SD	SE	M	SD	SE	
Angular measurement							
HP-FH	22.70	7.84	1.54	21.32	6.00	1.28	
HP-PP	-23.14	7.41	1.45	-20.99	5.66	1.21	
HP-OP	-15.12	7.90	1.55	-13.63	5.86	1.25	
HP-MP	5.18	8.16	1.60	5.81	6.43	1.37	
HP-C3RGn	22.59	8.76	1.72	19.56	5.56	1.19	
Horizontal measurement							
S-APH	21.69	6.87	1.35	15.19	5.41	1.15	
A-APH	51.61	5.93	1.16	52.21	4.27	0.91	
RGn-APH	33.74	6.08	1.19	35.10	4.31	0.92	
Pog-APH	48.71	6.40	1.25	49.28	4.55	0.97	
C3-APH	37.46	3.71	0.73	34.67	2.70	0.58	p=0.005
AA-APH	28.27	6.89	1.35	28.74	5.20	1.11	
Vertical measurement							
FH-APH	98.43	7.29	1.43	88.89	4.77	1.02	p=0.000
FH-PPH	81.82	6.15	1.21	74.37	4.66	0.99	p=0.000
RGn-APH	11.12	5.45	1.07	5.65	3.53	0.75	p=0.000
C3-APH	11.05	5.54	1.09	7.79	4.24	0.90	p=0.029
Hyoid triangle							
C3-RGn	71.46	7.88	1.55	69.98	4.93	1.05	
C3-APH	39.46	3.33	0.65	35.77	2.77	0.59	p=0.000
RGn-APH	35.95	5.94	1.16	35.73	4.16	0.89	
APH-APH′	11.04	4.54	0.89	6.70	2.95	0.63	p=0.000
Airway and cervical angulation							
NSL/OPT	99.80	7.48	1.47	96.97	5.71	1.22	
NSL/CVT	103.37	7.03	1.38	101.65	5.75	1.23	
AA-PNS	32.26	3.99	0.78	33.50	3.23	0.69	
AD1-PNS	18.95	3.04	0.60	19.79	3.56	0.76	
AD2-PNS	23.84	3.34	0.66	23.69	3.66	0.78	

anteriorly in mandibular advancement surgery group and the hyoid bone rotated posteriorly in mandibular set back group. But LaBanc and Epker[14] observed that the anterior rotation of hyoid bone during mandibular advancement surgery returned original position after retention. It may speculate that the position of the hyoid bone could be determined by the position and interrelationships of surrounding tissues.

Graber[8] found that the hyoid bone moved slightly posteriorly but was primarily displaced in inferior direction during the orthopedic chin cup therapy. He said the inferior movement of the hyoid bone resulted from the growth. But the positional alteration exceeded in amount what might have been expected by growth alone. He also noted that the inferior directional change of the hyoid bone during growth period suggested the stability and patency of the pharyngeal airway was a primary factor in hyoid positioning. King[11] observed that the distance between the hyoid bone and the cervical vertebrae was constant until puberty when the hyoid bone moved forward slightly. In this study, the hyoid bone showed quite constant relationship with the cervical vertebrae and the items showing the airway patency showed little change during growth period. It is quite consistent with King[11]'s observation. Kuroda et. al.[13]

	Age 16.7						
	Male			Female			Probability
	M	SD	SE	M	SD	SE	
Angular measurement							
HP-FH	22.45	7.01	1.37	20.42	7.50	1.60	
HP-PP	-22.24	6.81	1.33	-20.51	7.68	1.64	
HP-OP	-15.73	6.75	1.32	-13.15	8.55	1.82	
HP-MP	4.56	7.48	1.47	6.28	8.67	1.85	
HP-C3RGn	23.15	7.91	1.55	-19.13	7.04	1.50	
Horizontal measurement							
S-APH	16.25	5.84	1.15	13.52	6.30	1.34	
A-APH	52.13	5.36	1.05	53.94	5.66	1.21	
RGn-APH	35.07	5.18	1.02	37.43	5.02	1.07	
Pog-APH	50.36	5.70	1.02	51.59	5.32	1.13	
C3-APH	38.94	3.30	0.65	34.87	2.30	0.49	p=0.000
AA-APH	28.84	6.06	1.19	27.26	5.37	1.14	
Vertical measurement							
FH-APH	103.16	6.19	1.21	88.99	4.66	0.99	p=0.000
FH-PPH	86.08	5.79	1.13	74.88	4.78	1.02	p=0.000
RGn-APH	13.09	4.71	0.92	5.07	4.27	0.91	p=0.000
C3-APH	12.09	5.69	1.12	6.73	3.66	0.78	p=0.000
Hyoid triangle							
C3-RGn	74.23	7.20	1.41	72.47	5.69	1.21	
C3-APH	41.19	2.93	0.57	35.69	2.27	0.48	p=0.000
RGn-APH	37.76	4.82	0.95	38.00	5.11	1.09	
APH-APH'	12.57	4.40	0.86	5.92	3.17	0.68	p=0.000
Airway and cervical angulation							
NSL/OPT	100.12	7.75	1.52	99.02	7.28	1.55	
NSL/CVT	104.00	7.00	1.37	103.41	7.13	1.52	
AA-PNS	32.75	4.26	0.84	33.85	2.96	0.63	
AD1-PNS	21.42	3.92	0.77	21.31	3.31	0.71	
AD2-PNS	24.71	3.86	0.76	24.75	3.24	0.69	

found that the position of the hyoid in relation to the mandible was constant in both lower protrusion group and upper protrusion group. But the increase of the distance between Pog and AHP was two times larger than that of the distance between C3 and AHP in this study.

Opdebeeck et. al.[18] stated that the vital necessity to maintain patency of the upper airway at the level of the base of the tongue may account for the downward rotation in the long face syndrome.

The airway patency would be primary factor that regulate the position of hyoid bone and major factor in limiting the amount of hyoid accommodation followed the change of position of the tongue. The position of the hyoid bone can be changed by change of surrounding environment somewhat, that is, the change of head posture, the change of tongue posture, surgical or orthopedic change of the position of mandible. Therefore the position of the hyoid bone might be determined by functional equilibrium of the surrounding tissue. It will be needed further investigation.

Adamidis and spyropoulous[1] observed that boys exhibited a greater distance between AHP and point A than girls in class I group, and Koh and Cha[12] observed no significant differences of the distance of the A-AHP between boys and girls. In this study in the group of 8.7 , 10.7, years old showed no significant differences between male and female, but thereafter, female showed a greater distance between AHP and point A.

Solow and Tallgren[24] pointed out the interrelationship between the craniocervical posture and dento-alveolar morphology. It may affect the positional change of hyoid bone. Hoffman and Hoffman[10] said that the hyoid was important in tongue position and also helped to maintain the pharyngeal airway. Gobeille and Bowman[7] observed the tongue crib make the hyoid move posteroinferiorly and noted that the tongue have close relationship with the hyoid bone in persons whom the hyoid bone was located near the mandibular plane. Cuozzo and Bowman[5] also observed that the tongue crib could displace the tip of the tongue posteroinferiorly, and this could be accomplished totally or partially by a similar displacement of the base of the tongue through a repositioning of the hyoid. Author didn't measure the position of tongue in this study, but it might have strong relationships with the position of the hyoid. Because the hyoid bone has direct relationship with the tongue by muscles. It can be postulated that the position of the hyoid bone can be determined by the functional equilibrium of surrounding muscles supported by surrounding skeletal system.

Solow and Tallgren[25] found that the craniocervical angulation showed most comprehensive correlation with craniofacial morphology. Thompson Ponick[28] confirmed these findings regarding the relationship between craniocervical angulation and craniofacial morphology. According to the hypothesis of soft tissue stretching by Solow and Kreiborg[23], in the case of adenoid obstruction of the nasopharyngeal airway, it can be predicted that the increased craniocervical angulation and changes in craniofacial morphology corresponding to this changed head posture. Solow and Greve[22] confirmed that the adenoid nasal obstruction could alter craniocervecal angulation. And the altered craniocervical angulation may influence the position and angulation of hyoid bone.

Durzo and Bordie[6] followed the mandibular deformity from 4.6 years to 26.8 years and found that the hyoid bone moved backwardly in compared with normal series. In their tracing, author can find that craniocervical angle increased and the mandible rotated clockwisely with the progress of the growth.

As noted earlier, in the hypothesis of soft tissue stretching, the changed craniocervical angulation can alter the craniofacial morphology. Conversely the mandibular deformity can alter the position of the hyoid and it can also alter the cranoicervical angulation for maintaining the airway patency.

Conclusively the position of the hyoid bone has dynamic relationship with surrounding tissue, for example, the craniocervical angulation, the growth of adenoid, the posture of the tongue, the growth of the cervical vertebra, and the chin. If any part of this dynamic functional equilibrium alter, it can affect the other remaining functional part of surrounding structure.

It will be needed further investigation that elucidates the dynamic functional relationships between the functional parts.

SUMMARY

A longitudinal growth study has been conducted on the positional changes of the hyoid bone.

The material included cephalometric radiographs obtained on twenty-six males and twenty-two females over the period from 8.7 years to 16.7 years of age in average.

The results of this study might be summarized as follows;

- The mean value and standard deviation of each measurement were obtained in each age and gender.
- The hyoid bone tended to positioned forwardly in female at the age of 12.7, 14.7, and 16.7 years of age as compared with male.
- The hyoid bone positioned more downwardly in male than in female.

Author Address

Hyo-Sang Park, D.D.S., M.S.D.

Department of Dentistry, School of Medicine,
Keimyung University,
194 Dong-San Dong, Junggu, Taegu, 700-310, Korea
Tel) 82-53-250-7806

Fax) 82-53-252-1605
E mail : hyosang@dsmc.or.Kr.
Dr. Hyo-Sang Park is a full time instructor at the Keimyung University, School of Medicine, Deparment of Dentistry, Taegu, Korea.

REFERENCE

1. Adamidis, I. P. and spyropoulous, M. N. Hyoid bone position and orientation in class I and class III malocclusions. Am. J Orthod Dontofac orthop 101(4) : 308-312, 1992.
2. Bench, R. W. Growth of the cervical vertevrae as related to tongue, face, and denture behavior. Am J Orthod 49(3): 183-214, 1963.
3. Bibby, R. E. The hyoid bone position in mouth breathers and tongue thrusters, Am J Orthod 85(5): 431-433, 1984.
4. Bibby, R.E. and Preston, C.B. The hyoid triangle. Am J Orthod 80(1) : 92-98, 1981.
5. Cuozzo, G. S. and Bowman, D. C. Hyoid positioning during deglutition following forced positioning of the tongue. Am J Orthod 68(5): 564-570, 1975.
6. Durzo, C. A. and Brodie, A. G. Growth behavior of the hyoid bone. Angle Orthod 32(3): 193-204, 1962.
7. Gobeille, D. M. and Bowman, D. C. Hyoid and muscle changes following distal repositioning of the tongue, Am J Orthod 70(3): 282-289, 1976.
8. Graber, L. W. Hyoid changes following orthopedic treatment of the mandibular prognathism. Angle Orthod 48(1): 33-38, 1978.
9. Greenfield, B., Kraus, S., Lawrence, E., and Wolf, S. L. The influence of cephalostatic ear rods on the positions of the head and neck during postural recordings. Am J Orthod Dentofac Orthop 95(4): 312-318, 1989.
10. Hoffman, J. A. and Hoffman, R. L. Tongue- thrust and deglutition: some anatomical physiological, and neurological considerations, J Speech Hear Disord 35:105-120, 1965.
11. King, E. W. A roentgenographic study of pharyngeal growth, Angle Orthd 22(1): 23-37, 1952.
12. Koh, S. D. and Cha, K. S. A study on positional change of the hyoid bone before and after activator therapy in angle's Class III malocclusion patients. Korea J Orthod 24(4) : 827-839, 1994.
13. Kuroda, T., Nunota, E., Hanada, K. and et. al. A roentgenocephalometric study on the position of the hyoid bone. J Jap Ortho Soc 25(1): 31-38, 1966.
14. LaBanc, J. P. and Epker, B. N. Changes of the hyoid bone and tongue following advancement of the mandible. Oral Surg 57(4): 351-356, 1984.
15. Mainland, D. Anatomy. New York 1945 Paul B. Hoeber, Inc. p.580.
16. Miotti, A.M. Mandibula prognathism: a cineradiographic analysis of mandibular and hyoid bone movements before and after surgical correction. Am J Orthod 82(4): 310-317, 1982.
17. Negus. V. E. The mechanism of the Larynx. C. V. Mosby Co. St. Louis. cited from King, E. W. A roentgenographic study of pharyngeal growth, Angle Orthd 22(1): 23-37, 1952.
18. Opdebeeck, H., Bell, W.H., Eisenfeld, J., and Mishelerich, D. Comparative study between the SFS and LFS rotation as a possible morphogenetic mechanism. Am J Orhtod 74(5) : 509-521, 1978.
19. Pancherz, H., Winnberg, A., and Westesson, P. L. Masticatory muscle activity and hyoid bone behavior during cyclic jaw movements in man. A synchronized electromyographic and videofluorographic study. Am J Orthod 89(2): 122-131, 1986.
20. Pim Valk, J. W., Zonnenberg, A. J. J., Van Maanen, C. J., and Van Wonderen, O. G. T. The biomechanical effects of a sagittal split ramus osteotomy on the relationship of the mandible, the hyoid bone, and the cervical spine, Am J Orthod Dentofac Orthop 102(2): 99-108, 1992.
21. Sloan, R. F., Bench, R. W., Malick, J. F, and et. al. The applications of cephalometrics to cinefluoroscophy: Comparative analysis of hyoid movement patterns during deglutition in class I and class II orthodontic patients. Angle Orthod 37(1): 26-34, 1967.
22. Solow, B. Greve, E. Craniocervical angulation and nasal respiratory resistance In McNamara J.A.(editor): Naso-Respiratory function and Craniofacial growth, Ann Arbor. University of Michigan, Center for growth and development, pp87-119, 1979.
23. Solow, B. and S Kreiborg. Soft tissue stretching: A possible control factor in craniofacial morphogenesis. Scand J Dent Res 85: 505-507, 1977
24. Solow, B and Tallgren, A. Head posture and craniofacial morphology. Am J phys Anthrop 44 : 417-436, 1976
25. Solow, B. and Tallgren, A. Dentoalveolar morphology in relation to craniocervical posture. Angle Orthod 47(3): 157-164, 1977.
26. Stepovich, M. L. A cephalometric positional study of the hyoid bone, Am J Orthod 51(12): 882-900, 1965.
27. TaKagi, Y., Gamble, J.W., Proffit, W. R., and Christiansen, R.L. Postural change of the hyoid bone following osteotomy of the mandible, Oral Surg Oral Med Oral pathol 23(5): 688-702, 1967.
28. Thompson Posnick, B. Craniocervical angulation and morphologic variables in children: A cephalometric study. M.S.D. thesis, university of north carolina, chapel Hill, 1978
29. Winnberg, A., Pancherz, H., and Wetesson, P. L. Head

posture and hyomandibular function in man synchronized electromyographic and videofluorographic study of the open-close-clench cycle. Am J Orthod Dentofac Orthop 94(5): 393-404, 1988.

KOREA. J. ORTHOD. 1996 ; 26 : 677-689