Rev. Odont. UNESP, São Paulo
12(1/2):143-152, 1983.

HYOID BONE'S CEPHALOMETRIC POSITIONAL STUDY IN NORMAL OCCLUSION AND IN MALOCCLUSION PATIENTS

Carlos Augusto Aranha N. GALVÃO*

ABSTRACT: The hyoid bone plays an important role in the physiology of the tongue, whose deviations may cause severe malocclusions. This study tries to show, by cephalometric roentgenograms, the position of this bone in connection with some skull structures in those patients with a normal occlusion and in those who present malocclusion problems. The patients were divided into groups from which 35 of them, young adult patients, were positioned in the control group because of their normal occlusion, and the others, 55 patients in the skeletal growth process were divided into three groups according to the respective malocclusion of each one, following Angle's classification. It was verified that the biggest linear measurements were those from young adults considered to be normal occlusion patients and the biggest angular ones were observed in the Class II malocclusion patients. The measurements related to the bony pharynx presented a relative stability in the position of this structure.

KEY-WORDS: Hyoid bone; cephalometrics; malocclusion.

INTRODUCTION

There is a general agreement in orthodontics about the responsability of the tongue functional devices such as the tongue thrust and the atypical swallowing, as being important aetiological factors of some types of the malocclusion deviations. These devices are related with an endless number of cases that relapse after the orthodontic treatment.

Notwithstanding the unusual remembrance of the hyoid bone by the orthodontists, it plays a relevant role in the oral physiology, in such a way that SICHER[17] calls it "the skeleton of the tongue".

Some statements exist which declare that alterations in the position of the hyoid bone may occur in those patients who suffer functional diseases of the tongue, which were already mentioned in the begining of this work. Although, these affirmations are in need of confirmation[19].

This bone is ownner of unique characteristics. It is derived from the second and third branchial arches, together with the posterior portion of the tongue. Its shape reminds us a horse-shoe and its projections encircle the larynx, just above the thyroid cartilage, at the level of the epiglottis. The hyoid is the only bone of the humam body which does not stablish any kind of bony articulations and it is kept in position by the action of muscles and ligaments attached on it. Two great muscle groups are inserted on it, the suprahyoid muscles — depressors of the mandible — and the infrahyoid muscles — depressors of the larynx.

The hyoid bone influences the tongue, the base of the skull, the thyroid cartilage, the mandible, the sternum, the scapula and the pharynx.

* Departamento de Clínica Infantil — Faculdade de Odontologia — UNESP — 16.100 — Araçatuba — SP.

Some authors[4, 7, 13, 14, 15] studied the morphology and the function of this bone and others[1, 2, 9, 10, 11, 12, 18, 19, 21], through cephalometric techniques, tried to stablish the position of the hyoid bone in relation to the structures of the skull and cervical vertebrae. Cinefluorograph was also used to determine both position and the physiology of the hyoid bone, what permited to obtain more informations in this research area[5, 6].

Since the reference points and the measurements techniques used in cephalometric analisys were different among each other and all of them were placed in skull reference points, BIBBY & PRESTON[3] proposed a new technique by using planes between the third cervical vertebra and the mandibular symphsis, known as the hyoid triangle.

The purpose of this paper is to find out the position of this bone in young adults sample through the cephalometric study. This sample was composed by patients with normal occlusion and by Angle's Class I, II and III malocclusion patients in the skeletal growth process.

The measurements used in this method evidence the linear vertical distance of the hyoid bone with the base of the skull, with the atlas vertebra, the posterior nasal spine, and the anterior portion of the mandible, which is represented by the mentalis point. Another objective of this study was to relate the hyoid bone with the bony pharynx and to stablish comparison between these structures by angular relations.

MATERIAL AND METHODS

Ninety profile roetgenograms from male and female patients of different ages were taken. The patients ranged between 11 to 18 years old, with different Classes of malocclusion and young adults whose average age was 20 years and 7 months old and whose occlusion were considered to be normal. The selection of the patients obeyed the following conditions: the molar key criterion and the cephalometric result of the measurement of the ANB angle. All Class I malocclusion patients had an ANB value between 0° and 4°, all Class II malocclusion patients had an amplitude of the ANB value higher than 4°, while those Class III malocclusion patients had an ANB value lower than 0°. The criterion for the selection of the patients who had a normal occlusion was the bilateral molar key, the absence of individual malpositions, the presence of all teeth, from the central incisor to the second molar, and the non previous orthodontic treatment.

For the cephalometric roentgenograms the patients were instructed to maintain the column in an erect position while the head was positioned according to the horizontal plane of Frankfort by the use of a collimator connected to the x-ray machine's head stock. They were told to keep a slight occlusion of the teeth, not contracting the mandible too much and not executing tongue pression. The remainder procedure followed the usual techniques.

The cephalogram (Fig. 1) was traced by hand using acetate paper over the films in which, besides the routine anatomical design, were determined the following points, lines and angles (Fig. 2):

Reference points - Point S (sella turcica); point N (nasion); Point A; Point B; Point ANS (anterior nasal spine); Point PNS (posterior nasal spine); Point M (mentalis); Point AA (the most anterior limit of the atlas vertebra); Point H (hyoidale, the most anterior point on the body of the hyoid bone. It corresponds to the vertex of the anterior triangle of the radiograph image). Lines - Line S-N; Line ANS = PNS (palatal plane); Line H-M; Line H-AA; Line AA-PNS; Line S-H and Line PNS-H.
Angles — ANB; SN.H; SN.AA; M.H.AA; S.H.PNS and S.H.M.

For the linear measurements it was used a decimillimeter precision caliper and for the registration of the angular measurements it was used a transferrer with a half degree approximation. All measurements were done by the same person for three times to limit the degree of error. All measurements were repeated after an interval of one week. The elimination of the measurements errors were done by the standard deviation of the three measurements and its arithmetical means.

The cephalograms were divided into four groups:

1. Control group (CG) - Formed by 35 normal occlusion patients;
2. Group I (G I) - Constituted by 21 Class I malocclusion patients;
3. Group II (G II) — Constituted by 20 Class II division 1 malocclusion patients;
4. Group III (G III) - Formed by 14 subjects with Angle's Class III malocclusion;

The following cephalometric measurements were made:

1. H-M : the distance from the hyoid bone and the chin;
2. S-AA : the distance from the sella turcica to the atlas vertebra;
3. AA-PNS : the distance between the atlas vertebra and the posterior nasal spine;
4. S-H : the distance between the sella turcica at the sphenoid bone and the hyoid bone;
5. PNS-H : the distance between the posterior nasal spine and the hyoid bone;
6. AA-H : the distance between the atlas vertebra and the hyoid bone;
7. ANB : the angular relationship among the apical bases;
8. SN.H : the relationship between the base of the skull and the hyoid bone;
9. SN.AA : the relationship between the base of the skull and the atlas vertebra ;
10. M.H.AA : the relationship among the hyoid bone and the chin and the atlas vertebra;
11. SH.PNS : the relationship among the hyoid bone, the sella turcica and the posterior nasal spine;
12. S.H.M : the relationship among the hyoid bone, the sella turcica and the mandible.

RESULTS

The results of this cephalometric positional study are inserted on Table 1. The means were all submited to the statistical variance analysis, in order to verify the differences among the experimental groups.

DISCUSSION

The methods for determing the position of the hyoid bone through cephalometric radiographs are variable. Some authors like KING[12] used just linear measurements, others used linear and angular measurements [2,3,9,18,19]. INGERVALL *et alii* [11] just made comparisons with mandible while INGERVALL [10] determined comparisons of the hyoid bone position with the morphology of the human face and dental arches.

According to GRABER[8] the relationship of the hyoid bone with the mandible is dependent on the individual skeletal types. Such affirmation explains the divergent results between some investigations which find positive correlations between certain hyoid bone position and mandibular morphology measurements, while others find no correlations at all.

Some investigators affirm that the hyoid bone assumes variable positions from a person to another and that differences in it may also occur in a same sample of patients after a short space of time[19].

The measurements between the hyoid bone and some cranial points relatively distant may determine results in which slight alterations in the points and in the reference planes result in large variations, even that these differences are just apparent ones.

TABLE 1 — Arithmetical means and the respective standard deviations of the linear and angular measurements, as well as the statistical significance between the differences (F).

Linear measurements

ANB	Groups		H-M	S-AA	AA-PNS	S-H	PNS-H	AA-H
2.11	CG	X̄	47.53	52.96	34.54	112.61	66.81	65.79
± 2.38		SD	± 4.64	± 4.93	± 4.10	± 10.88	± 8.19	± 8,87
2.19	GI	X̄	42.69	49,14	32.52	103.95	60.49	60.85
±1.18		SD	± 7.36	± 5.31	± 3.84	± 10.29	± 8.32	± 8.34
6.45	GII	X̄	39,82	47,84	33,24	102.07	59.73	59.74
±1.26		SD	± 7.07	± 5.07	± 4.92	± 11,66	± 8.05	± 8.75
-5.73	GIII	X̄	46.76	48.93	32.00	110.36	65.97	69.18
±2.63		SD	± 6.16	± 5.20	± 4.06	± 10,40	± 8.14	± 10.15
—	F	—	7.48*	5.16*	1.55	5.02*	4.45*	4.10*

Angular measurement

ANB	Groups		SN.H	SN.AA	M.H.AA	S.H.PNS	S.H.M.
2.11	CG	X̄	91.08	110.64	114.60	14.55	99.21
±2.38		SD	± 3.65	± 4.87	± 8.46	± 4.03	± 5.85
2.19	GI	X̄	90.21	111.11	121.85	13.95	103.76
±1.18		SD	± 5.05	± 4.92	± 13.79	± 2.73	± 11.77
6,45	GII	X̄	91.52	112.80	124.10	15.65	106.52
±1.26		SD	± 2.84	± 5.36	± 10.44	± 4.16	± 9.49
-5.73	GIII	X̄	85.00	108.46	122.42	10.23	107.26
±2.63		SD	± 4.58	± 3.88	± 10,25	± 4.55	± 9.27
—	F	—	8.13*	2.04	4.20*	5.27*	4.02*

* — Significance at the level of 5%; F limit ≃ 2.37

FIG. 1 — Cephalogram used in this study.

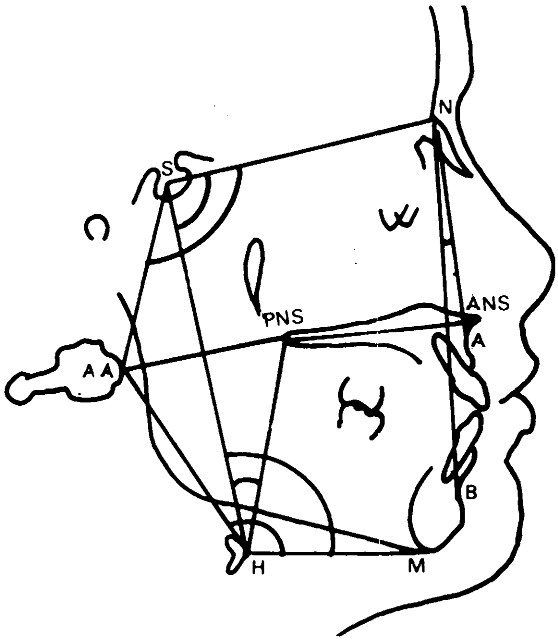

FIG. 2 — Points, lines and angles that composed the cephalometric landmarks used in the determination of the hyoid bone position, according to the author's method.

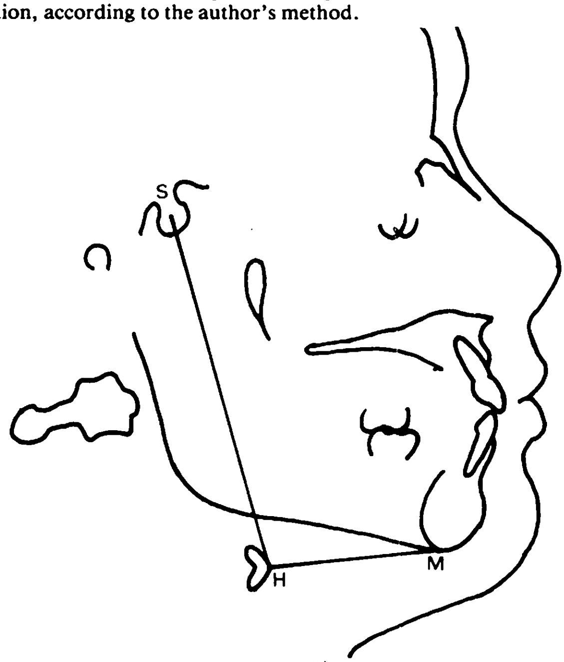

FIG. 3 — A schematic cephalogram showing the mean position of the hyoid bone in relation to the base of the skull and the chin in Class I malocclusion patients (G I).

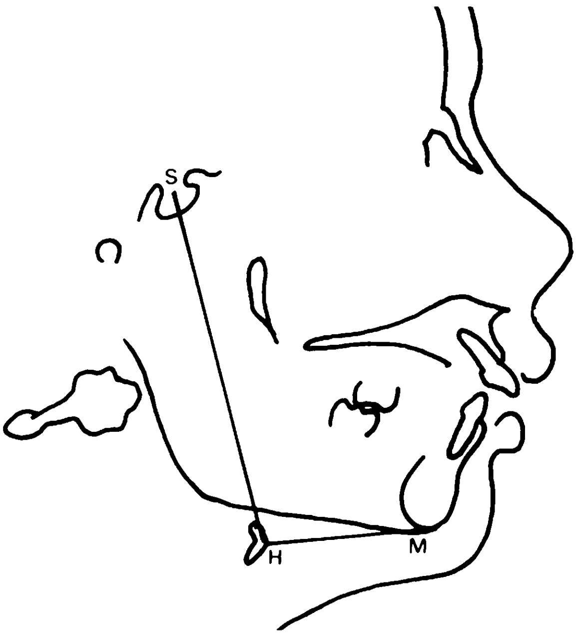

FIG. 4 — A schematic cephalogram showing a Class II malocclusion patient from the G II, in which is seen the mean position of the hyoid bone. Note the bigger proximity of the hyoid bone with the lower board of the mandible.

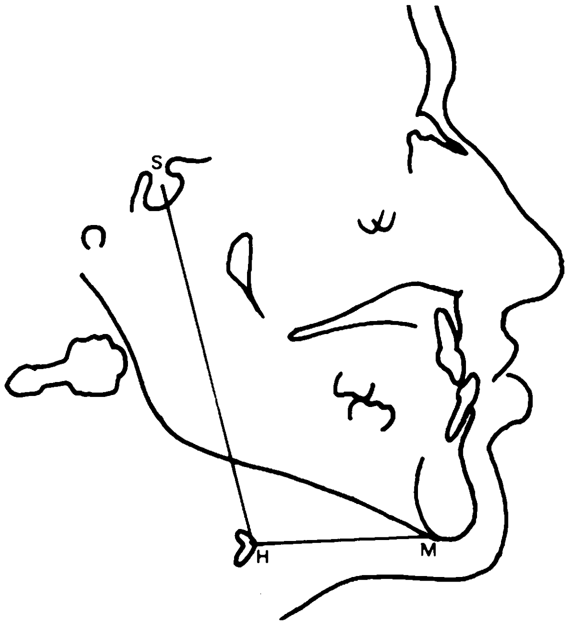

FIG. 5 — A schematic cephalogram of a Class III malocclusion patient, in which it is possible to observe the increased distance from the hyoid bone in relation to the mandibular plane.

That's why BIBBY & PRESTON[3] established relations between the hyoid bone and the reference points C_3 and RGn, which are situated in the cervical vertebra and mandibular symphysis, respectively.

In my opinion, the use of mobile structures like these authors did, could determine incorrections on the final results concerning the real position of the hyoid bone. In this paper, I looked for a method which used points situated in the base of the cranium, in the naso-maxillary process and the atlas vertebra.

By the use of this method I suggest that it is possible to get more informations because of the aid fixed structures as well as mobile structures in their relationship.

The results presented in this paper show that the linear measurements, except only one exception of the rule, presented significantly different values in the several experimental groups, in which the control group (CG) had the greatest means. As this group is formed by young adults, it reflects the fact that these subjects had reached their maximum craniofacial growth, what seems to be obvious.

The measurement of the line which represents the distance H-M, pointed out the smallest mean in the Angle's Class II malocclusion patient's group, what probably might be due to the most retruded position of the lower jaw in these subjects.

The results from the measurements of the atlas vertebra and the posterior nasal spine (AA-PNS) are confirmed by the results of the angular measurement SN.AA, suggesting that the openning of the bony pharynx at the level of that vertebra is relatively constant as it was formely observed[3]. That's why the means themselves did not present significant differences in the studied groups.

The length of the line S-H was measured for establishing the vertical distance between the base of the skull and the hyoid bone, the smallest values for these measurements were found in group II, that is, in that group of patients with Angle's Class II malocclusion, as well as the measurements of AA-S and AA-H.

The linear measurement PNS-H, presented the minor means in group II. This result confirms what was exposed for the previous measurements and permits to conclude that the hyoid bone is situated a little bit upward or close to the inferior base of the mandible in those Class II subjects. This result contradicts GRANT's findings, who concluded that there were no differences in the position of this bone in the three classes of malocclusions. It is not on me to stablish a detailed discussion of such results because it is concerned with a non published work mentioned another author[19]. The results of this paper demonstrate that the group of Angle's Class III malocclusion had a more depressed position of the hyoid bone, that is to say, it is more distant to the board of the mandible. That's sufficiently clear and coherent since the vertical characteristics between these two classes of malocclusion are usually antagonic among themselves.

In G II, the measurement of the H-M distance was also the smallest one among all the other measurements, suggesting the smallest size of the body of the mandible or its distal position, what must contribute to justify the result of the PNS-H measurement.

The line AA-H is the exception on the rule of the measurements done. It was the only measurement in which the group presented Class III malocclusion patients who presented the biggest means ($\bar{X} = 69.18$ mm ± 10.15), what passed over, even in a small proportion, the control group that is composed by young adults subjects. That is because the hyoid bone is probably situated somewhat more downward, that is, more distant from the mandibular plane. This, in other words, means the inverse condition to what it was observed in the patients from G II, whose measurement, as well as the PNS-H, suggested the higher position or the most proximity of the hyoid bone to that plane. In spite the biggest dimensions of the AA-H measure in the G III, the vertical measurement S-H was not the biggest on this group, but in the CG it was. This can be apparently paradoxical and this phenomenon may probably occur because in the patients from the G III, the distance S-AA is considerably smaller. In other words, if we consider the triangle S.AA. H, both in CG and in G III, then, in the first one, the sides S-AA and S-H are bigger and the AA-H side smaller; and in the group of the patients with mandibular prognathism, the triangle formed by the union of these lines will have the S-H and AA-H sides bigger and S-AA smaller.

The angular measurement showed to be significantly different in the experimental groups with one exception. Although, in this case, the biggest mean values were found in G II's patients whose were all Angle's Class II malocclusions subjects, except the angular measuremente S.H.M in G III.

The measurements which represent the relationship between the atlas vertebra and the base of the skull, do not present different significant results, both in normal patients and in remmant groups with malocclusion persons. By this we can confirm the stability of the bony pharnyx position in relation to these structures, what was observed through the linear measurements of the distance between the points AA and PNS which were already discussed. By the way, the constatation of this was also observed by BIBBY & PRESTON[3].

The relationship between the hyoid bone and the anterior base of the skull (SN.H), pointed out values by which it was evidenced that those patients from group II presented the greatest means than all the other experimental groups. It is caused because of their distocclusion, associated with a little distance of the H-M line, whick is representative of the position of the hyoid bone in linear relation to the mentalis point.

The angulation SN.AA showed to be bigger in the group II, although, without statistical significance. As it was commented in the AA-PNS linear measurement, the position of the bony pharynx stays clearly characterized.

The amplitude of the angle M.H.AA, that represents the relation of the hyoid bone with the atlas vertebra and the chin, also shows that group II is the owner of the biggest observed mean ($\bar{X}$ = 124.10° ± 10.44), because of the smallest size of the length of the lines S-H and H-M.

The angular relationship of the hyoid bone and the base of the skull and posterior nasal spine (S.H.PNS), once more demonstrate that the biggest mean belong to G II. This big value must occur for the same reasons exposed in the previous measurement, that is, the smallest length of the distance between the point sella and the hyoid, and between it and the chin (M), by the measurements of the lines S-H and H-M, respectively.

The angle S.H.M evidences the relationship among the hyoid, the sella turcica and the mentalis point (Figs. 3,4,5) and is considered the only exception of the angular measures; in this case, the patients with Class III malocclusion, from G III, presented the biggest means. Probably this is a consequence of the increased obliquity of the body of the mandible, what by itself is a morphological characteristic of the mandibular prognathism. Though it was not the biggest mean obtained, the distance of the hyoid bone to the chin (H-M) showed to own an elevate value ($\bar{X}$ = 46.76 mm ± 6.16), just a little bit smaller than in the control group, whose values were $\bar{X}$ = 47.53 mm ± 4.64, what according to what I understand, may contribute for the opening of this angle.

As I could analyse before, the distance AA-H was the unique measurement in this group that overpassed the means of the control group patients. In this type of malocclusion the hyoid bone is positioned downward and more distant to the inferior board of the lower jaw. In view of this, only the biggest antero posterior inclination of the mandible could explain the biggest openning of this Class III individuals, in satisfactory terms.

In this work, it is a tentative to promote the discussions about some linear and angular relations in spite of the difficult task it represents to stablish cephalometric measures as other authors[3,10] have done. The selection of the experimental groups obeyed the criterion used by INGERVALL *et alii* [11], because these investigators also used young adult groups and Class I patients, whose age indicated to be in the growth phase. This selection did not follow all the criteria they suggested because of some few modifications. There was no discrimination about the sex since BIBBY & PRESTON[3] demonstrated that there is not any sexual dimorphism in a similar study.

Besides the use of a method without cranial reference points[9,18,19] I also prefered to make use of the line S-N which is representative of the anterior base of the skull because of its routinary use in the cephalometric tracings and effortless localization and stability of the involved structures.

In a previous discussion, the hyoid bone was said to play an important role in the physiology of the swallowing. The swallowing reflex repeats itself approximately twice a minute while one is awake and once a minute while one is asleep[20]. The perioral muscular forces and tongue pressure on incisor teeth have been evaluated by POSEN[16] and it has been reported to be from 600 to 2,500 grams and the pressure from this swallowing builts up a total force from 6,000 to 12,000 pounds in a 24 hour period[20].

If these forces are not well equilibrated and improperly directed it will not be difficult to any one imagine the results of them on the occlusion of the teeth.

CONCLUSIONS

According to the proposed method of the author, the linear and angular measurements used to determine the position of the hyoid bone were done on the cephalograms, in order to permit the conclusion of the following statements:

1. Except for the measure of the line AA-H, that represents the bony pharynx position, all the other linear measurements were bigger in the control group which was composed by elements considered to have a normal occlusion of the teeth, and the differences that were obtained were significant;

2. Except for the measure S.H.M, all the other angular measurements were bigger in G II than in the remmant groups and the differences were significant;

3. The distance AA-PNS and the angle S.N.AA, which establish the relationship of the bony pharynx to the other structures, did not show significant differences in all experimental groups, what proves a certain stability;

4. Class III malocclusion patients and the biggest measurementes for the distance between the atlas vertebra and the hyoid bone (AA-H) and for the angular relation of this bone to the base of the skull and the chin (S.H.M), being the differences significant at the level of 5%.

GALVÃO, C.A.A.N. — Estudo cefalométrico da posição do osso hióide em pacientes com oclusão normal e portadores de maloclusão. **Rev. Odont. UNESP**, São Paulo, 12(1/2):143-152, 1983.

RESUMO: O osso hióide desempenha um papel importante na fisiologia da língua, cujos desvios podem ocasionar severas maloclusões. Este trabalho procura mostrar, através de radiografias cefalométricas, a posição deste osso em relação a algumas estruturas do crânio. Foram estudados, por intermédio de cefalogramas laterais, 90 pacientes, sendo 35 adultos jovens com oclusão normal e 55 pacientes em fase de crescimento portadores de maloclusões. Destes, 21 eram portadores de Classe I, 20 portadores de Classe II, divisão 1 e 14 portadores de Classe III. Verificou-se que, de modo geral, as maiores medidas lineares foram obtidas nos pacientes com oclusão normal e as medidas angulares, com uma única exceção, foram observadas nos pacientes com maloclusão de Classe II. O faringe ósseo mostrou possuir certa estabilidade na sua posição.

UNITERMOS: Osso hióide; cefalometria; maloclusão.

GALVÃO, C.A.A.N. — Hyoid bone's cephalometric positional study in normal occlusion and in malocclusion patients. **Rev. Odont. UNESP**, São Paulo, 12(1/2):143-152, 1983.

REFERENCES

1. ANDERSEN, W.S. — The relation of the tongue thrust syndrome to maturation and other findings. *Am. J. Orthod.*, *49*: 261-275, 1963.
2. BENCH, R.W. — Growth of the cervical vertebrae as related to tongue, face, and denture behavior. *Am. J. Orthod.*, *49*: 183-214, 1963.
3. BIBBY, R.E. & PRESTON, C.B. — The hyoid triangle. *Am. J. Orthod.*, *80*: 92-97, 1981.
4. BRODIE, A.G. — Anatomy and physiology of the head and neck musculature. *Am. J. Orthod.*, *36*: 831-844, 1950.
5. CLEALL, J.F. & MILNE, I.M. — Cinefluorographic study of functional adaptation of the oropharyngeal structures. *Angle Orthod.*, *40*: 267-283, 1970.
6. CUOZZO, G.S. & BOWMAN, D.C. — Hyoid positioning during deglutition following forced positioning of the tongue. *Am. J. Orthod.*, *68*: 564-570, 1975.
7. DURZO, C.A. & BRODIE, A.G. — Growth behavior of the hyoid. *Angle Orthod.*, *32*: 193-204, 1962.
8. GRABER, L. — Hyoid changes following orthopedic treatment of mandibular prognathism. *Angle Orthod.*, *48*: 33, 1978.
9. GRANT, L.E. — *A radiographic study of the hyoid bone position in Angle's Class I, II and III malocclusions*. Kansas City, University of Kansas City, 1959. (Master's Thesis). Apud STEPOVICH, M.L., 1965.
10. INGERVALL, B. — Positional changes of mandible and hyoid bone relative to facial and dental arch morphology. A biometric investigation in children with postnormal occlusion (Angle Class II div. 1). *Acta odont. Scand.*,*28*: 867-894, 1970.
11. INGERVALL, B.; CARLSSON, G.E. & HELKIMO, M. — Change in location of hyoid bone with mandibular positions. *Acta odont. Scand.*, *28*: 337-361, 1970.
12. KING, E.W. — A roentgenographic study or pharyngeal growth. *Angle Orthod.*, *22*: 23-25, 1952.
13. LAST, R.J. — The muscles of the head and neck. *Internat. dent. J.*, *5*: 347, 1955. Apud STEPOVICH, M.L., 1965.
14. MAINLAND, D. — *Anatomy*. New York, Hoeber, 1945. p. 580.
15. PARSON, F.G. — Topography and morphology of the human hyoid. *J. Anat. Physiol.*, *43*: 279-290, 1909.
16. POSEN, A.L. — The influence of maximum perioral and tongue force on the incisor teeth. *Angle Orthod.*, *42*: 285-308, 1972.
17. SICHER, H. — *Oral anatomy*. St. Louis, Mosby, 1960. p. 65.
18. SMITH, J.L. — *A cephalometric radiographic study of the position of the hyoid bone in relation to the mandible in certain functional position*. Evanston, Northwestern University, 1956. (Master's Thesis). Apud STEPOVICH, M.L., 1965.
19. STEPOVICH, M.L. — A cephalometric positional study of the hyoid bone. *Am. J. Orthod.*, *51*: 882-900, 1965.
20. STRAUB, W.J. — Malfunction of the tongue. *Am. J. Orthod.*, *46*: 404-424, 1960.
21. THOMPSON, J.R. — A cephalometric study of the movements of the mandible. *J. am. dent. Ass.*, *28*: 750, 1941.

Recebido para publicação em 14.04.83.