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Correlation Analysis of the Hyoid Bone Position in Relation to the Cranial Base, Mandible and Cervical Part of Vertebra with Particular Reference to Bimaxillary Relations / Teleroentgenogram Analysis

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Original paper
SUMMARY
Introduction: The relationship among the orofacial system and the rest of the body ,both in functional and anatomical terms was the subject of numerous scientific studies. The optimum position of the bone structures of orofacial system provides performance of intact vital functions, such as breathing or swallowing. Hyoid bone represents a link between the head and neck. Although located in the neck, hyoid bone due to its brachial origin belongs to the visceral skeleton. **The purpose of the research:** a) To determine the position of the hyoid bone, in relation to the cranial base, mandible and cervical part of the vertebra; b) To determine the linear measures of hyoid bone and its constituents and c) to Identify on the profile teleroengen image, whether there are differences in the position of hyoid bone depending on the saggital maxillo-mandibular relationship. **The examinees and methods**: 30 profile teleroengen images of patients aged 17-18 years of both sexes were used for this study. To study the position of hyoid bone depending on the saggital maxillo-mandibular relationship respondents were divided into groups based on the ANB-angle values. The first group is ortognat patients with ANB-angle values, from 1 to 4°. The second group included patients with distal jaw relationship, that is, whose values of ANB-angle were greater than / or 5°. The third group consists of patients with ANB-angle value of 0 or negative. **Results and Conclusion:** The position of hyoid bone is not constant, but depends on the maxillo-mandibular anterior posterior relationships. Length of hyoid bones and greater horns of hyoid bone differs with respect to the sagittal malocclusion. In relation to the cranial base and maxillary bones flat position of the hyoid bone is highly correlated. A positive correlation was found with relation to the cervical vertebra, while the dependence is determined in relation to the steep mandibular plane.
Key words: the hyoid bone position, cranial base, mandible, bimaxillary relations, teleroentgenogram anylysis

1. INTRODUCTION

The relationship among the orofacial system and the rest of the body is both in functional and anatomical terms and the subject of numerous scientific studies. The optimum position of the bone structures of orofacial system provides performance of intact vital functions such as breathing or swallowing.

Hyoid bone represents a link between the head and neck. Although located in the neck, hyoid bone because of its brachial origin belongs to the visceral skeleton (1). This bone is over stilohyoid ligament (ligamentum stylohyoideum) stilohyoid muscle (musculus stylohyoideus) and last digastric abdominal muscle (posterior venter musculi digastrici) related to the base of the skull, through geniohyoid muscle (musculus geniohyoideus) milohyoid muscle (musculus mylohyoideus) and anterior digastric muscle belly (venter anterior musculi digastrici) is related to the lower jaw. In addition, the connection exist with the up-

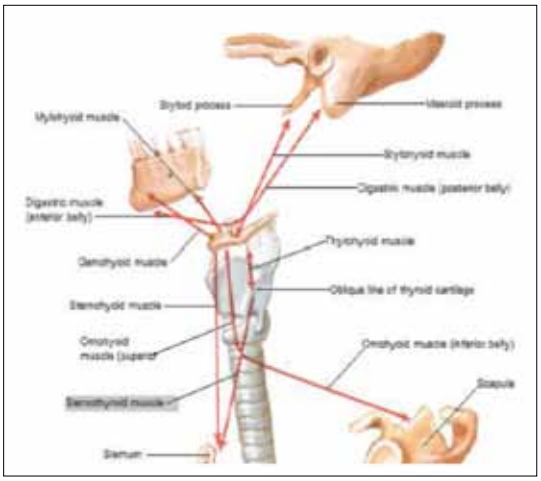

Figure 1. Correlation of hyoid bone with other anatomical structures (2)

per mediastinum (musculus musculus sternohyoideus et thyreohyoideus), paddle (omohyoideus musculus), and the thyroid cartilage larynx (ligamentum thyreohyoideum). Over fascia cervicalis may result in connection with the cervical vertebrae. In addition hyoid oblique muscles are involved in the construction of the language (chondroglossus et musculus musculus hyoglossus).

Due to the above mentioned different contacts with the surrounding bones, hyoid bone is a real link between the different structures of the cervical and mandibular areas (3), and the movers muscles that attach to this bone has a central role in lowering the lower jaw, that is, in opening the mouth. So by suprahyoid muscle contraction comes to rise of hyoid bone, larynx and pharynx if the jaw is fixed, and if the muscle is fixed by infrahyoid comes to lowering of hyoid bone and retreat back the lower jaw, which allows you to open your mouth. The optimum position of the cranio-cervical structures is a prerequisite for performing various vital functions such as breathing or swallowing. Dysfunction of any structure in cranio-cervical region can lead to disorders, which can manifest itself in other structures of the cranio-cervical region. To what extent will a disorder manifested depends on a lot on the individual ability of individuals to adapt to the disturbance occurred (4).

2. THE PURPOSE OF THE RESEARCH:

Determine the position hyoid bone in relation to the cranial base, mandible and cervical part of the vertebra.

Determine the linear measures of hyoid bone and its constituents.

Determine the by the profile teleroengen image whether there are differences in the position of hyoid bone depending on the saggital maxillo-mandibular relationship.

3. THE EXAMINEES AND METHODS

30 profile teleroengen records of patients aged 17-18 years of both sexes were used for this study.

S	Sella	Mid contour of sella turcica
Se		The center hole of sella turcica
N	Nasion	Point where connects internazal with nasofrontal suture
A	Subspinale	Point with the largest premaxilla concavity
B	Supramentale	Point with greatest chin profile chin concavity
C3		The most inferior and most anterior point of the third cervical vertebra
RGn	Retrognation	The most distal point of the mandible symphysis
H_1	Hioid 1	The most anterior and most superior point of the hyoid bone body
H_2	Hioid 2	Most distal point of the hyoid bone greater horn
H_3	Hioid 3	The most superior point at the junction of the hyoid bone body and greater horn
SnA	Spina nasalis anterior	Top of the anterior nasal spine
SnP	Spina nasalis posterior	Top of the posterior nasal spine
Go	gonion	Most lower and most distal point in the region of the mandible ramus
Gn	gnation	The lowest point of the chin in the medial plane
Me	menton	Lowest point where are merged the shadow of the chin and the lower border of the mandible
Or	Orbitale	The lowest point of the lower edge of the orbit
Po	porion	The highest point of acusticus meatus externus
ii	Incision inferius	Top of the lower incisor crown
is	Incision superius	Top of the crown of labial upper central incisor
iia		Top of the labial apex of the lower incisors
isa		Top of the apex of the upper central labial incisor
Cd	Condilion	highest point of the mandible ramus
Pg	Pogonion	The most prominent point of the chin
Ar	Articulare	Cross-section of the shadow of caput mandibulae to the body of occipital bone

Table 1. Cephalometric points

SN	The basic plane of the skull base front part
NSe	Length of anterior cranial base
NA	Line maxillary prognathism
NB	Line of mandibular prognathism
SnA-SnP	Palatal plane
Go-Gn Go-Me	Mandibular plane
Po-Or	Frankfurt Horizontal
ii-iia	Shaft of the most labial lower incisors
Is-isa	Shaft of the labial upper central incisor
C_3H1	The line connecting the most inferior anterior point of the third cervical vertebra and the anterior most superior point of the hyoid bone body
H_1RGn	The line connecting the most superior anterior point of the hyoid bone body and retrognation
RGn C_3	The line that connects retrognation and most inferior anterior point of the third cervical vertebra
SH_1	The line that connects sella turcica and most superior anterior point of the hyoid bone body
NH_1	The line connecting the nasion and the most superior anterior point of the hyoid bone body
H_1-H_2	Length of the hyoid bone
H_2-H_3	Length of the hyoid bone greater horn
H_1-H_3	Length of hyoid bone body

Table. 2. Cephalometric lines

From the study were excluded subjects with any form of cerebral palsy, muscular dystrophy or any diagnosed syndrome, whose clinical picture can affect the position of the maxilla or mandible in the sagittal, transverse or vertical direction. Also, from the study were excluded the patients who were in orthodontic treatment, or patients who are carrying a mobile or fixed orthodontic appliance.

To study the position of hyoid bone depending on the saggital maxillo-mandibular relationship respondents were divided into

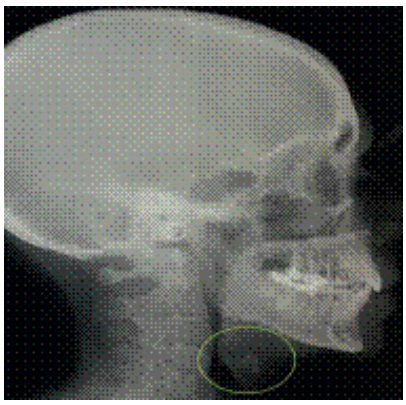

Figure 2. Profile teleroengen image

groups based on the ANB-angle values. The first group is ortognat patients with ANB-angle values from 1 to 4°. The second group included patients with distal jaw relationship, that is, whose values ANB-angle is greater than/ or 5°. The third group consists of patients with ANB-angle value of 0 or negative.

For the analysis of teleroengen profile images was used the computer software AX-Ceph, which is specially designed and adapted to this type of research.

Analysis of profile teleroengen images took place as follows:

- Preparation of x-ray image for computer analysis.
- Input of cephalometric points positions.
- Measurement of angles and linear measures.

For the analysis teleroengen profile image the following cephalometric points will be used,

Figure 3. Cephalometric points

which are shown in the Table 1 and Figure 3.

For the analysis of the teleroengen profile image will be used following cephalometric lines, resulting by combination of these cephalometric points, which are shown in Table 3.

N-Se	Length of anterior cranial pit
N-Me	The front face height
S-Go	Posterior height
H_1-H_2	Length of the hyoid bone
H_2-H_3	Length hyoid bone greater horns
H_1-H_3	Length of hyoid bone body
H_1-C_3	Distance of hyoid bones body from vertebrae
H1-RGn	Distance of hyoid bone body from the mandible
C_3-RGn	Distance between the vertebra and mandible
S-H_1	Distance from the hyoid bones body and Sella turcica
PP-H_1	Distance of hyoid bone body from the maxillary plane
MP-H_1	Distance of hyoid bone body from the mandibular plane
H_1-tangenta C_3-Rgn	The height of the triangle H1-C3-RGn
SnA- SnP / tangenta iz A	The length of the upper jaw body
Tangent mandible/ iz Pg	The length of the lower jaw body
Tangent rami mandible iz Cd	Length of lower jaw ramus

Table 3. The linear measurement

For the calculation of linear measure as a basic measure will use the value of NSE expressed in mm, and whose value will be presented for comparison with the value 1.

Linear measures that will be used in the study are shown in Table 3 and in Figures 4, 5 and 6.

To study the position hyoid bone

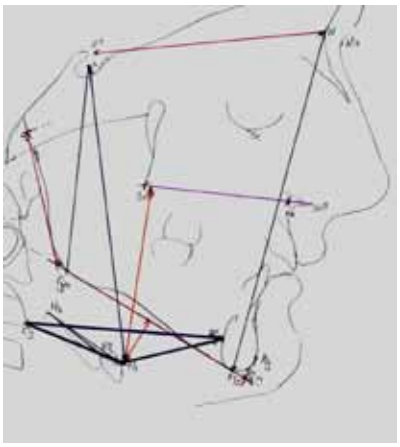

Figure 4. Linear measure

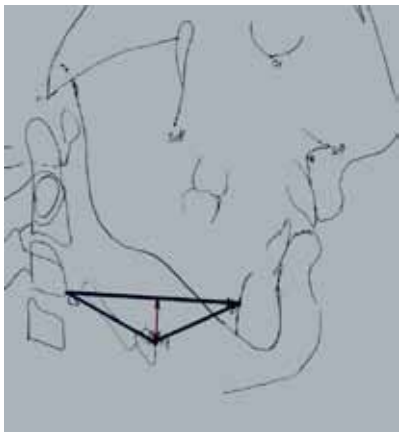

Figure 5. The height of the triangle H1-C3-RG

Figure 6. Linear measures of hyoid bone

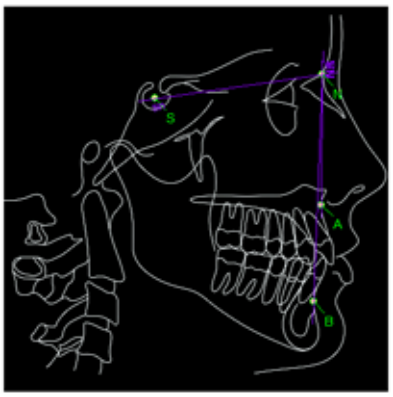

Figure 7. ANB-angle

depending on the saggital maxillo-mandibular relationship subjects will be divided into groups based on the ANB-angle values. The first group is ortognat patients with ANB-angle values from 1 to 4°. The second group included patients with distal jaw relationship, that is, whose values ANB-angle greater than/or 5°. The third group consists of patients with ANB-angle value of 0 or negative.

Angular measures that will be

SNA	The angle of the anterior-posterior position of the upper jaw relative to the skull base
SNB	The angle the anterior-posterior position of the lower jaw in relation to the base of the skull
ANB	Angle, which shows the anterior-posterior relationship of the upper and lower jaw
C_3HRGn	The angles, which describe the relationship of hyoid bone body with the body of the lower jaw and third cervical vertebrae
$H_1RGn\ C_3$	
$RGnC_3H_1$	
SNH_1	The angle of the hyoid bone body position in relation to the base of the skull
$H_1H_3H_2$	The angle of hyoid bone inclination
H_1H_2- SN	The angle of hyoid bone position in relation to the base of the skull
H_1H_2- PP	The angle of hyoid bone position in relation to the palatal plane
H_1H_2- MP	The angle of hyoid bone position in relation to the mandibular plane
H_1H_2-FP	The angle of hyoid bone position in relation to the Frankfurt horizontal
NSAr+SArGo+ArGoGn	Bjork's summary angle for assessment the type of growth

Table 4. Angular cephalometric measurements

I group ANB-angle from 1° to 4°		II group > 4°		III group< 1°		Total
girls	boys	girls	boys	girls	boys	
9	7	6	4	1	3	30

Table 5. Research subjects

used in the study are shown in Table 4 and in Figures 8 and 9.

3.1. Statistical analysis

From the data, which will be obtained in the survey will be formed a computer database using Microsoft® Excel 2007, which will be used for descriptive statistical analysis.

It will use the following methods of statistical analysis:

- Percentages and rates,
- Mean,
- Standard deviation,
- Correlation analysis.

4. RESULTS

In the study participated 30 patients who were divided into three groups considering the size of ANB-angle.

- Angle h1h3h2/ hyoid bone inclination
- Mean value of h1h3h2 -angle was 157.5 min–122 max 180 SD 20.278888
- Mean hyoid bone inclination for class I 162.2143
- Mean hyoid bone inclination for class II 149.75
- Mean hyoid bone inclination for class III 137
- High correlation with:
- <H1H3:PP–0.719515454
- <H1H3:MP–0.714731772
- <H1H3:FP -0.717035631

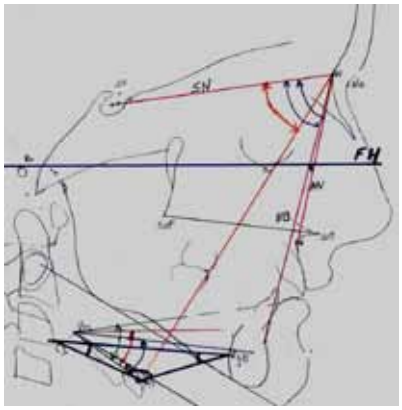

Figure 8. Angular cephalometric measures

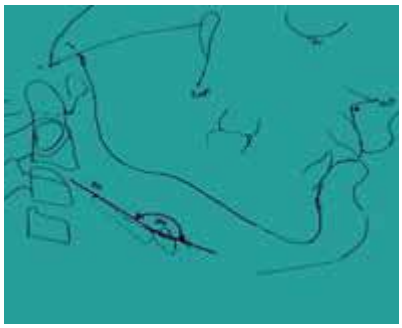

Figure 9. Hyoid bone inclination

- ΔH_1H_2H3–0.87658266
- IP:H1H2 – maxilla–0.892861019
- IP:H1H2 – mandible–0.875687118

We can see that this angle correlates highly with the maxillary plane, mandibular plane, and the position of the incisors in relation to hyoid bone. There are significant differences in the inclination of hyoid bone in relation to makilomandibular relations in anterior and posterior direction.

- Hyoid bone length H1-H2
- Mean value 33.75min 29 max 37
- SD 2.97361345
- Mean value for class I 33.857
- Mean value for class II 35.75
- Mean value for class III 29
- High correlation with:
- Maxilla length 0.779277696
- NSe – length of anterior cranial base 0.732660303
- Distance of hyoid bone body from vertebrae 0.818102434

In patients from group II is the longest length of the hyoid bone. Interesting is the correlation with the length of the anterior cranial base and the length of the maxilla.

- Length of hyoid bone body
- Mean value 8.225 min 6 max 10.25 SD 1.335675027
- Mean value for class I 8.5357
- Mean value for class II 8.25
- Mean value for class III

We did not find significant correlations with other structures.

- Length of hyoid bone greater horns
- Mean value 26.2 min 22.5 max 30 SD 2.201009869
- Mean vale for class I 25.857
- Mean vale for class II 28.5
- Mean vale for class III 24
- High correlation with: ΔSNH1 0.815994936
- ***Angle H1H2/SN*** – Angle of hyoid bone position in relation to skull base
- Mean angle value 33.95 min 24 max 51 SD 10.6287085
- Mean angle value for class I 34.57
- Mean angle value for class II 36.75
- Mean angle value for class III 24
- High correlation with:
- H1H2:PP 0.940556591
- H1H2:MP 0.830133678
- IP:H1H2 – maxilla 0.738949768

We can conclude that hyoid bone somehow maintains a static and dynamic balance of the skull and neck, as the hyoid bones axes compared to the flat cranial base showed significant interdependence in relation to the palatal plane, as well as in relation to the mandibular plane at different maxilla-mandible relations.

Angle H1H2/PP **Angle of hy-**

oid bone position in relation to palatinal plane

- Mean angle value 25.15 min 12 max 48 SD 11.83227695
- Mean angle value for class I 24.357
- Mean angle value for class II 31
- Mean angle value for class III 19
- High correlation with:
- H 1 H 2 / S N 0.940556591
- H 1 H 2 : M P 0.852225772
- H 1 H 2 : F P 0.930661406
- IP:H1H2 – maxilla 0.860342007
- IP:H1H2 – mandible 0.768543969

These findings also speak in favor that position of hyoid bone depends on maxilla mandible relations. Incisor inclination was also significantly conditioned by the position of hyoid bone.

- H1-C3 /Distance of hyoid bone body from vertebrae
- Mean value 37.65 min 30 max 45 SD 4.262563131
- Mean value for class I 38
- Mean value for class II 40.25
- Mean value for class III 30
- High correlation with:
- ANB 0.72009612
- NSe 0.801715542
- H1-H2 0.818102434

Distance of hyoid bones from the cervical part of the vertebra is not constant, but depends largely on maxilla mandible relationship and the length of the anterior cranial base, which speaks in favor of these results.

- H1/MP
- Mean value 18.2 min 9.25 max 25.5 SD 5.366821944
- Mean value for class I 19.821
- Mean value for class II 14
- Mean value for class III 9.25
- High correlation with:
- H1/PP 0.71738916
- S-H1 0.705548291
- H1: C3-RGn 0.857587138
- Angle RGnC3H1 0.793735748
- Angle C3H1RGn 0.825562851

Also these results speak in favor that the hyoid bone with right bears the name link of the head and neck. Position of hyoid bone depends on the bimaxillary relationship and the cervical spine.

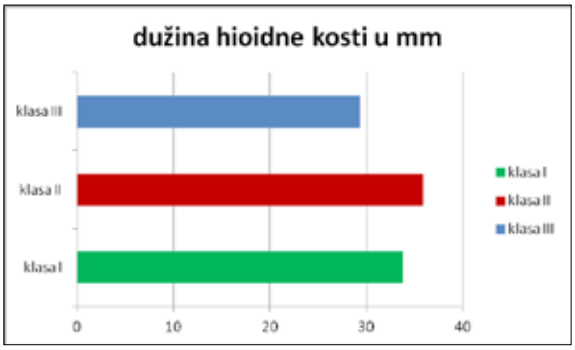

Chart 1. Length of hyoid bone i relation to ANB- angle

Chart 2. length of hyoid bone greater horns

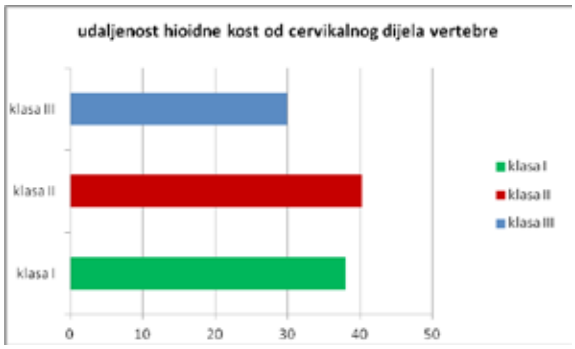

Chart 3. Distance of hyoid bone body from vertebrae

5. DISCUSSION

It is proved that the orofacial system affects the static and dynamic functions throughout the body, but has not yet been explained in detail the nature and interdependence of these relationships.

Broadbent (1931, 1937) with the discovery of lateral cephalometry investigated the sagittal and transverse topographical relationships between the lower jaw and the coronary suture, and temporo zygomatic pterigomaxillar suture of the human skull. These relations are constant from the first year of life until the end of life (5). Sprague (1943) found that the evolution of hyoid bones is closely associated with human orofacial functions (6). King (1952) studied the X-ray relations of hyoid bones with the neck part of the spine and found that the distance between hyoid bone and cervical spine is constant before puberty (7). Frankel (1963) described the connection between mouth breathing and irregular position of the tongue, where the imbalance between suprahyoid and infrahyoid muscles leading to dorsal-caudal position of the hyoid bone (8). Sloan et all (1967) found that the hyoid bone is placed somewhat more higher and ventrally in individuals with malocclusion of the second grade as opposed to the compared to persons with neutrooclusion to mandible (9). Grabber (1978) was followed in the treatment of subjects with under chin cap. After three years of therapy with under chin cap found that the hyoid bone was shifted posterior inferior relative to its initial position (10). their study found that there are gender differences in the position of hyoid bones, and that the position hyoid bones is stable and independent of orofacial dysfunction and function (11). Galvao (1983) in his research compare the position of the hyoid bones in subjects with different disgnatia, and found that the position of the hyoid bones differs (12).

Nobili and Adverse (1996) pointed to the body posture at various disgnatia. So people with distooclusion keep their head slightly forward, as opposed to people with mezioclusion, who hold head more to the back, and thus indirectly changing the position of the hyoid bone (13).

Tallgren (1987) found that the position of hyoid bone is in relation to the cervical spine quite stable,

but compared to the mandibular or maxillary plane (14). Behlfelt (1990) examined the position of the head, the position hyoid bones and the position of tongue in children with enlarged and normal tonsils. He found that children with enlarged tonsils have a lower position of hyoid bone and the vertical position of the tongue (14). Adamidis and Spyropoulus (1992) examined the differences in position between the hyoid bones of subjects from I and III class. They found that respondents with III class hyoid bone position and anterior to the opposite inclination relative to the mandibular plane (14). Harlabakis (1993) comparing the position of the hyoid bone in subjects with deep and open bite, concluded that there are differences in the direction of the anterior posterior position of hyoid bones, but there is a strong inclination of hyoid bone in relation to the palatal plane, but not in relation to the mandibular plane (14).

Trenouth and Timms (1999) described a positive correlation between the length of the mandible (measured from the points of Gon-Men) with the distance between the third cervical vertebra and hyoid bone (C3H) (15).

Kolias in 1999 I and II followed the changes in the position of hyoid bone by longitudinal study. It has been noted that with age comes to lowering of hyoid bone, which is more pronounced in men, while anterior posterior position remains stable. Tongue comes in the upright position (16,17).

Kaduk (2003) compare the position of hyoid bones in children with cleft and children without clefts. These are mainly determined by higher values in children with clefts. Position of hyoid bones in children with cleft is significantly more anterior and caudal, which is explained as a mechanism for adaptive closing of velopharingeal valves and swallowing (18). Similar findings were identified in the study in children with Pierre-Robin's syndrome (19,20).

Allhaija and Al-Khateeb (2005) found that there are differences in the position of hyoid bone with respect to the sagittal maxillo-mandibular relationships. They also found that there are sex differences in the position hyoid bone in class I and III, and that the position of the hyoid bones is significantly correlated with the ANB angle (21).

Juliano (2009) research the impact of mouth breathing by cephalometric and polysomnograhic methods. Thus it was established that children who breathe through the mouth tend to have retro positioned mandible relative to cranial base, strongly inclining occlusal base, set up more horizontal lower edge of the mandible, and the tall part of the cervical spine and placed nearer to hyoid bone (22).

Sun 2009 examined subjects whose occlusion was in the first class. Aim of this study was to determine whether there is a correlation between the position of the hyoid bone and incisor position in something larger incisors, that is, in which the clinical picture is manifested with the protrusion, and in which occurs with standard (rotated) position of the incisors. It was found that in subjects with dental protrusion hyoid bone is in anterior-superior position, unlike other groups of respondents (23).

Sierpinski 2009 has examined the position of hyoid bones in older subjects wearing complete dentures for at least five years and has been proven to reduce vertical dimensions, or the height of the bite affects the hyoid bone position change, which is down below and change the orofacial muscle activity (24).

This study has shown interesting relationships of hyoid bone with adjacent structures. But if we take into consideration that no account was taken of the vertical maxillary mandible relations, as well as the bimaxillary transverse relationships, this research would be good to extend to a larger number of subjects taking into account the vertical and transversal parameters.

6. CONCLUSION

Position of hyoid bone is not constant, but depends on the maxillo-mandibular anterior and posterior relationships. Length of hyoid bone and greater horns of hyoid bone differs with respect to the sagittal malocclusion. In relation to the cranial base and maxillary bones flat position hyoid is highly correlated. A positive correlation was found with relation to the cervical vertebra, while the dependence is determined in relation to the mandibular plane.

Conflict of interest: none declared.

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