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Radiographic studies of the hyoid bone and cervical spine in Angle Class I and Class II/2nd Division malocclusions

Estudos radiográficos do osso hioide e da coluna cervical nas maloclusões Classe I e Classe II/2ª Divisão de Angle

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Resumo

Introdução: Estudo interdisciplinar investigativo do complexo estomatognático-cervical, necessário para compreender a estrutura e a biomecânica do osso hioide e coluna cervical em participantes Classe I e II/2ª Divisão de Angle. **Objetivo:** Analisar a posição do osso hioide e da curvatura da coluna cervical nas radiografias em perfil de participantes com má oclusão Classes I e II/2ª Divisão de Angle. **Material e método:** A posição do osso hioide foi avaliada a partir de seu alinhamento com a vértebra cervical correspondente. A apresentação da curvatura da coluna cervical foi determinada a partir da proximidade com a quarta vértebra cervical. **Resultado:** Houve diferença estatística significativa na posição do osso hioide (p=0,027) entre as classes, que ficou situado em C3 na Classe I e mais abaixo, entre C3 e C5, na Classe II/2ª Divisão. A coluna cervical apresentou alterações em ambas as classes sem diferença estatística entre as mesmas (p=0,533), com aumento, retificação e inversão da curvatura. **Conclusão:** Neste estudo, o osso hioide apresentou posições distintas nas más oclusões estudadas, no entanto, a má postura da coluna cervical foi comum em ambas as classes.

Descritores: Má oclusão; radiografia; osso hioide; coluna cervical.

Abstract

Introduction: Interdisciplinary investigative study of the stomatognathic-cervical complex, necessary to understand the structure and biomechanics of the hyoid bone and cervical spine in Class I and II / 2nd Division participants. **Objective:** To analyze the position of the hyoid bone and the curvature of the cervical spine on lateral radiographs of participants with Class I and II/2nd Division Angle malocclusion. **Material and method:** We evaluated the position of the hyoid bone from its alignment with the corresponding cervical vertebra. The presentation of curvature of the cervical spine was evaluated from the fourth cervical vertebra. **Result:** There was a statistically significant difference in the position of the hyoid bone (p=0.027) between the classes, which was located at C3 in Class I and further down, between C3 and C5, in Class II/2nd Division. The cervical spine showed alterations in both classes, with an increase, rectification, and inversion of the curvature with no statistical difference between them (p=0.533). **Conclusion:** In this study, the hyoid bone showed different positions in the malocclusions studied, however, poor posture of the cervical spine was common in both classes.

Descriptors: Malocclusion; radiography; hyoid bone; cervical column.

INTRODUCTION

Understanding the etiology of pain conditions is essential to attenuate, eliminate or prevent its progression[1]. During orofacial therapies, the presence of discomfort and pain may be indicative of inadequate positioning of the structures of the stomatognathic system, particularly skeletal structures such as the hyoid bone that anchors the musculature of the tongue and cervical spine that articulates cranial movements. The craniomandibular system is widely studied in the scientific community and the interinfluence of its structures, one on the other, still generates discussions[2]. In comparative studies of Angle's Classes I and II/ 2nd Division, such as Nascimento et al.[3], it was observed that the participants of this last class, unlike the first, suffer significant impacts in the cervical region when the tongue muscles are overloaded by isometric suction exercises[3].

To determine the biomechanics of this impact, we first think about the bone structure, the hyoid bone, which, unlike other bones, is floating and related to a complex muscle chain: the hyoid musculature. It maintains a relationship with the larynx, influencing the adjustment of the dimensions of the air passage and with the pharynx, facilitating swallowing. Finally, together with the mandible, it is indirectly related to the craniocervical postural muscles, accompanying the cervical spine in its development and longitudinal growth[4-8].

The integration of biomechanical knowledge of the cervical spine and the hyoid-mandibular system is neglected in clinical practice. Health professionals, according to their training, tend to consider isolated craniocervical-mandibular structures in their assessments, ignoring the perception of the whole[9,10]. In this context, malocclusion can influence muscle actions and alter skeletal positioning, generating compensation. In Class II/2nd Division, for example, the skull is limited between a small mandible or a large maxilla and a cervical spine that may be straightened. But, what happens in Class I that shows proportionality in these structures? Is the position of the hyoid bone and cervical spine compensated for in these classes? Studying these questions can clarify these biomechanics.

Through Digital Radiography, which demonstrates the characteristics of the bone framework[11] in which muscles and tendons are inserted, we will study the craniocervical biodynamics, in particular the position of the hyoid bone in relation to the cervical spine and the curvature of the cervical spine in Class I and Angle Class II/2nd Division.

METHOD

This is a quantitative, prospective study performed by the Center for Studies and Research in Rehabilitation Dr. Gabriel Porto, Faculty of Medical Sciences, State University of Campinas-CEPRE / FCM/ UNICAMP. Approved by the Research Ethics Committee-CEP/ FCM / UNICAMP under number 39597414.2.0000.5404. Participants signed the Informed Consent Form.

Sample

We chose the patients undergoing dental treatment by convenience, inviting them to participate in the research. They were submitted to anamnesis and selected according to the criteria below to compose the sample.

- *Inclusion Criteria*: Healthy participants with all dental elements; with **Class I molar relationship** (without skeletal involvement) and **Class II/Division 2 Angle molar relationship** (retrognathic).

- Exclusion Criteria: tooth agenesis, dental prosthesis, temporomandibular disorder, syndromes, systemic or chronic disease, orthostatic difficulty, in order to eliminate morphological or functional alterations that could influence the craniocervical structures or make radiography difficult.

The sample consisted of 70 participants, both genders, between 18 and 59 years old – 39 from Class I and 31 from Class II / Angle's 2nd Division, corresponding to the control group and the study group respectively.

- **Occlusal Analysis**: performed by a dental surgeon, according to the Angle classification:
- **Class I**: Mesiodistal relationship of the mandible, maxillary incisor teeth overlapping one-third of the height of the crown of the mandibular incisor teeth, maxillary and mandibular first molars with mesiobuccal cusp of the maxillary molar in occlusion in the buccal groove of the mandibular molar.
- **Class II/2nd Division**: with mandibular retrognathism or maxillary prognathism, distal occlusion of the mandibular first molar in relation to the maxillary first molar, and overbite between the maxillary and mandibular incisors.

X-ray

The radiographs were performed by the same technical professional, supervised by the radiologist Fabiano Reis.

Device parameters used in this protocol: Fixed RX equipment, with table and stand. Manufacturer: Siemens, Model: Polymat Plus S, vacuum tube, oil-cooled, with rotating anode. Focus: fine and coarse. RX tube capacity: 40-150Kv; from 1 to 400 mAs; from 125 to 500 mA.

Communication and safety precautions were taken during the exams, and metallic props that could interfere with the procedure were removed. The lateral cervical spine routine[11] was performed in the orthostatic position to demonstrate alignment, ligament stability, and the natural curvature of the spine. Each participant kept their arms at their sides, depressed their shoulders, relaxed them, and extended their chin forward to prevent mandibular overlap in the upper vertebrae.

After a full exhalation, the participants held their breath maximizing the depression of the shoulders. The technician, after confirming the correct positioning (alignment of the middle coronal plane and MAE) and visualization of the vertebrae on the high-resolution monitor, fired the beam cannon, calibrated at 50 kV penetration and 0.8 mAs, with an incidence of X-rays, R.C.: perpendicular, directed to C4-C5; D.F.F.: 1.5 cm; on the side of the neck, 80 cm away, obtaining a simple radiographic image in the lateral view, in a standardized size of 24 cm × 30 cm.

Radiographic Analysis

The study of the hyoid bone and the cervical spine was performed directly in Arya, which is the image storage software, in this way:

a) Position (height) of the hyoid bone (Figure 1): a tangent line was drawn anterior to the hyoid body. A line perpendicular to this was drawn at the mid-height of the body until reaching the cervical vertebra aligned with the bone in the radiographic image. The identification of this vertebra determined the height of the hyoid bone. The physiological reference for the height of the hyoid bone is the third cervical vertebra, C3.

b) Curvature of the cervical spine (Figure 2) – measurement of the depth of the cervical spine using the Penning method[12]: A tangent line was drawn from the posterosuperior margin of the second cervical vertebra to the posteroinferior point of the body of the seventh cervical vertebra. At the midpoint of the body of the fourth cervical vertebra, a line perpendicular to the tangent described above was drawn, measuring its extension. The normal distance is 10 +/- 2mm;

rectified cervical curvature is considered when measuring less than 08mm; inversion, values expressed in negative numbers (<1); and increased cervical lordosis, values greater than 12mm.

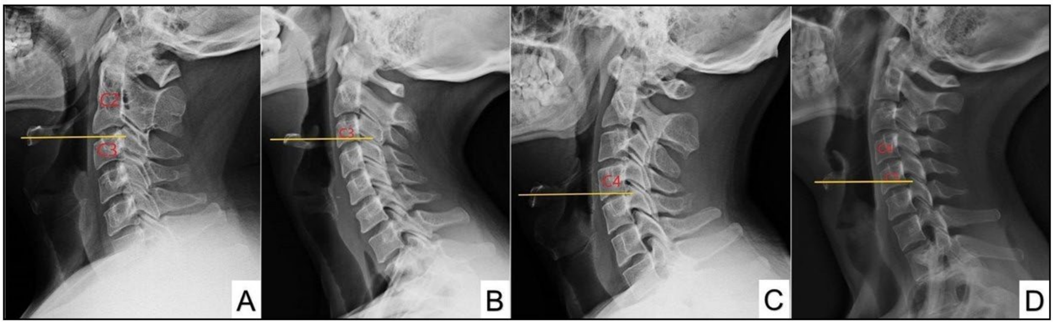

Figure 1. Height of the hyoid bone. A: in C2 and C3; B: in C3; C; in C4; D: in C5.

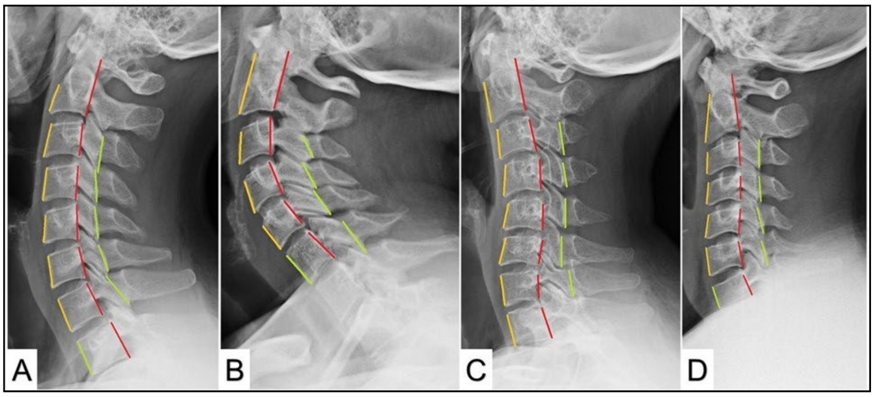

Figure 2. Cervical Spine. A: Normal; B: Increased Cervical Lordosis; C: Rectification; D: Inversion.

Statistical Analysis

The data structure in ".csv" format spreadsheets were analyzed in the software R version 3.6.0, Copyright (C) 2019 "The R Foundation for Statistical Computing", considering the variables of the position of the hyoid bone in relation to the cervical spine (C2, C2-C3, C3, C3-C4, C4, C4-C5, C5) and cervical spine curvature (normal, lordosis increase, rectification, inversion) in the classes.

RESULT

In the characterization of the sample, there was a homogeneous distribution of participants and a slight predominance of females in both classes.

Class I had 25 (58.14%) female participants and 14 (51.85%) male participants, while Class 2 had 18 (41.86%) female participants and 13 (48.15%) male participants, totaling 39 (55.71%). %) participants in Class I and 31 (44.29%) participants in Class II.

Class I was slightly older than Angle's Class II/2nd Division. The age of the participants had a mean of 34.44 years (standard deviation of 13.74) in Class I and a mean of 30.26 years (standard deviation of 13.03) in Class II.

Figures 3 and 4 point out the categorical variables related to the hyoid bone and C4, tested to verify the independence between the Classes, p>0.05 values mean that the Class does not influence the investigated variables. This occurred for the Cervical Spine variable, but not for the

Hyoid Bone, that is, the fact that they were Class I or Class II/2nd Division participants interfered with the results.

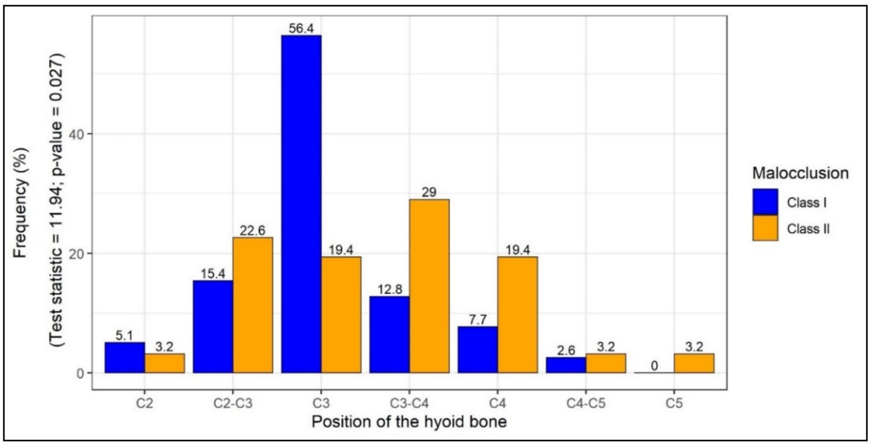

Figure 3. Distribution of the participants' Hyoid Bone position.

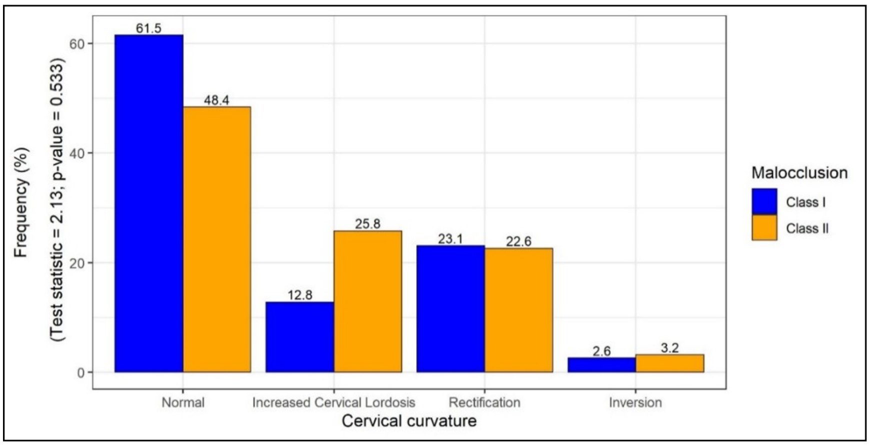

Figure 4. Distribution of cervical curvature in the participants, according to C4.

DISCUSSION

The sample was balanced by gender and age. The gender factor did not affect the position of the hyoid bone or the cervical curvature. We identified that the age group studied presented changes in cervical curvature in both classes.

Partly disagreeing with Nunes et al.[13] who suggest that changes in neck posture are frequent in adolescents, we had cases of poor neck posture, that is, increased lordosis, rectification, and inversion of the curvature among adults. The results also showed that the position of the hyoid bone was different between the classes. These variations indicated a change in the orthostatic biomechanics of the position of the hyoid and cervical spine under the skull, showing compensation in the interrelationships of the stomatognathic system since the curvature of the cervical spine and the height of the hyoid bone are a consequence of the function and stability of the craniomandibular system.

The physiological relationship of the position of the hyoid bone with the cervical vertebrae presented by the Class I participants (Figure 3) was considered a normal biomechanical relationship, because it was constant, while it appeared to be compensatory in Class II / 2nd Division, which presented the hyoid bone at various heights of the cervical spine (Figure 3), indicating intense muscular demand. A low hyoid bone suggests insufficiency of the suprahyoid muscles to keep it in the ideal position, allowing the infrahyoid muscles to pull it intensely in the distal direction. Among the causes of changes in bone position, Tourné[14] states that it is a protective mechanism, as the lower hyoid bone in relation to the mandible ensures constancy of the air diameter in the anteroposterior direction, which would cause the cervical spine to be straightened. Other mechanisms are possible. As a connecting structure, the hyoid bone can adjust itself by influencing the maintenance of horizontal gaze.

For Brodie[15], the cervical spine maintains the head erect due to the balance of the anteroposterior muscle action exerted on the atlanto-occipital joint and conducted by the hyoid bone in the interaction of the supra and infra hyoid muscle groups. For Rocabado Seaton[16], the craniovertebral joint will maintain its normal position and the temporomandibular joints will remain balanced concerning the skull, through the tension forces of the muscles on the bony part, that is, the maxilla and mandible, connected to the cervical spine and the hyoid bone.

However, excess infrahyoid muscle tension can lower the hyoid bone, retract the mandible and straighten the cervical spine, because the hyoid is anchored to the sternum and scapula[17], influencing the spine, which is why Rocabado Seaton[16] states that “the position of the hyoid bone depends more on the cervical curvature than on the craniocervical relationship itself”. Another mechanism for modifying the alignment of the hyoid bone with C3, or C3 and C4, may be the interference of swallowing by the apex of the curvature of the cervical spine in the increase in lordosis, which reduces the pharyngeal space by compression and makes the hyoid bone descend to the level C5[18].

As it has a unique connection for muscles, ligaments, and fascia of the pharynx, mandible, and skull[4], the descent of the hyoid bone ensures the air diameter and induces changes in the mandibular rest position and the cervical spine[17].

Kim et al.[19] mentioned that different situations, such as orthognathic surgery of the mandible, also influence the descent of the hyoid bone and cause a reduction in the diameter of the airways, which means that the position of the hyoid bone depends on the joint muscle function[4] as much as on the individual response.

In this study, even with greater oscillation in the hyoid position, we did not separate Angle's Class II/2nd Division types. Those with a larger mandible and smaller maxilla may not show changes in the position of the hyoid, as the chin becomes more anterior and the suprahyoid muscles are able to maintain their balanced proportion, whereas, in those participants who have a smaller mandible and larger or normal maxilla, the trajectory of the suprahyoid musculature would be closer to the hyoid bone and vertical, favoring the infrahyoid action. These considerations may justify a part of the class to present the bone at the level of C3-C4 and another part to oscillate (Figure 3).

An intraclass analysis is not seen in studies, which seek to compare the hyoid bone only in different classes. Tallgren, Solow[20], state that the relationship of the position of the hyoid bone varies according to the malocclusion, maxilla, and mandible, and not with the cervical spine.

Assessing the whole is important to identify interference from other regions. Parrine et al.[21], state that an altered dorsal kyphosis is correlated with malocclusion, and interferes with the hyoid bone because one of the infrahyoid muscles has a scapular insertion. Regardless of malocclusion, the cervical spine can present its conditions.

Our results show that the majority of participants, with a slight predominance of class I, presented a normal cervical curvature, that is, gentle enough to dampen the action of gravity in the orthostatic position (Figure 4). Normal posture presents a balance between the forces acting on the human body, and bad posture results from negative effects, or phenomena, incidents on the axial skeleton to deviate it in the opposite direction and of equal intensity to the force that caused them, without returning to the initial position. This suggests that postural deviations result from structural differences and how individuals use these structures to perform and perpetuate a function.

For Nunes[22], the craniocervical-hyoid system is closely related and belongs to the larger system: the human body, whose parts are functionally coordinated with each other, and should be studied in full. In this aspect, Kapandji[17] says that the altered cervical curvature results from unbalanced muscle action. The intense and symmetrical contraction of the neck muscles causes an increase in cervical lordosis as they extend the head and cervical spine in such a way that they increase the curvature, which reduces their damping capacity. In the rectification, in turn, the cervical spine becomes rigid due to the simultaneous contraction of the prevertebral muscles, located immediately in front of the vertebral bodies, and the hyoid muscles, which act from the jaw block, verticalizing the curvature. The inversion occurs in a cervical spine when the head flexor muscles determine the flexion of the cervical spine on the thoracic spine in an antagonism-synergy relationship with the prevertebral muscles[17] (Figure 2).

For Rocabado Seaton[16], the presentation of the cervical curvature can influence the stability of the skull, and the opposite also occurs, as changes in the position of the skull affect the biomechanics of the Atlas, which is the first cervical vertebra (C1) causing compression or distension. Muscle tensions cause deformations and compensation in various directions due to the action of muscle chains. In compression, the space between the cervical vertebrae decreases with consequent shortening of the suboccipital muscles that need the flexibility to maintain the automatic positioning of the skull. Pain may occur, such as headaches of cervicogenic origin, due to compression of nerves and blood vessels, dysfunction of the mandibular and hyoid regions, and impairment of the anterior and posterior muscles of the neck[16]. The distension results from anterior cranial rotation (flexion), producing important alterations in the mandibular position and the contact of the dental pieces, such as occlusal instability, alterations in muscle patterns and trajectories, alterations in the centricity and dynamics of the temporomandibular joints (TMJs) and the hyoid bone[16].

In this cycle of interrelationships, Cárdenas et al.[23] states that the relationship between the cervical spine and the position of the skull is associated with the characteristics of each skeletal class, whose morphology would be anchored in the individual growth direction vector, causing changes in the airways, joint pain, changes in vertebral posture, for functions, as per the malocclusion. The skull, therefore, interferes with the cervical spine[16], in its upper and lower portions. In the upper region of the cervical spine, flexion and extension movements of the skull occur. In the lower part, cervical lordosis occurs, which changes according to the action of the muscles that move it in various directions. In this aspect, the increase in cervical lordosis can occur in association with cranium flexion, while the rectification of the cervical spine can occur with the extension of the cranium[16].

Several factors can be observed in the evaluation of the stomatognathic system. The deepening of the discussions on the cranial, mandibular, hyoid, and now cervical position, aims to support therapy in the different disorders caused by malocclusions since the functioning of the stomatognathic system is dependent on each of these parts, adapted to individual characteristics.

CONCLUSION

The malocclusion seems to influence the trajectory and action of the hyoid muscle, determining the distinct position of the hyoid bone in the malocclusions studied and the predominance of its oscillation in the majority of Angle Class II/2nd Division participants.

Both classes presented cases of increase, rectification, and inversion of the cervical spine, identified as poor posture in the region, unrelated to the type of malocclusion.

In this research, the biomechanical evaluation of the stomatognathic system through digital radiography was significant to understand part of the complex muscle function involved in Angle Class I and Class II/2nd Division malocclusions.

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CONFLICTS OF INTERESTS

The authors declare no conflicts of interest.

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