REVISTA DE ODONTOLOGIA DA UNESP
www.revodontolunesp.com.br
Original Article
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Angle Class II/2nd Division: is there an alignment?

Classe II/2ª Divisão de Angle: existe alinhamento?

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How to cite: Nascimento ALO, Rei F, Nagae MH. Angle Class II/2nd Division: is there an alignment? Rev Odontol UNESP. 2023;52:e20230001. https://doi.org/10.1590/1807-2577.00123

Resumo

Introdução: Estudo interdisciplinar investigativo do complexo cérvico-estomatognático, necessário para compreender a estrutura e a biomecânica desse sistema em participantes Classe I e II/2ª Divisão de Angle. **Objetivo:** Avaliar o alinhamento e a posição das estruturas crânio cervicais nas radiografias de participantes Classe I e II/2ª Divisão de Angle e sua relação funcional com o sistema estomatognático. **Material e método:** As imagens digitais Trans Oral e Perfil de participantes com maloclusão Classe I e II/2ª Divisão de Angle foram submetidas à medição linear e angular do crânio, mandíbula, Atlas e do Áxis através do *software Advantage Workstation 4.6 (AW4.6 ext. 04)*. **Resultado:** Houve diferença significativa nas medidas angulares de alinhamento vertical entre o Crânio, Áxis e a Mandíbula (p = <0,001), e da articulação esquerda entre o Atlas e o Áxis (AE: p = 0,011; AAE: p = 0,042). Das medidas lineares das distâncias entre o Atlas e o Áxis, a distância AOD apresentou estatística bastante próxima do nível de significância (p=0,0502), porém acima. Não houve diferença significativamente estatística nas demais medidas avaliadas. **Conclusão:** Neste estudo, o alinhamento entre as vértebras cervicais Atlas e Áxis e a mandíbula e os ângulos das articulações atlanto occipitais se mostraram alterados nos participantes Classe II/2ª Divisão de Angle. Não há diferença significativa no tamanho e distância do Atlas e do Áxis entre as Classes.

Descritores: Pesquisa interdisciplinar; má oclusão; radiografia; coluna cervical.

Abstract

Introduction: Interdisciplinary investigative study of the stomatognathic-cervical complex, necessary to understand the structure and biomechanics of this system in Angle Class I and II / 2nd Division participants. **Objective:** To evaluate alignment and position of cranial cervical structures on radiographs and their functional relationship with the stomatognathic system. **Material and method:** Trans Oral and Profile radiographs were submitted to biomechanical analysis, considered the linear and angular measurement of Atlas and Axis through the application included in the radiogram software. **Result:** We observed a significant difference in the angular measurements of vertical alignment between the Skull, Axis, and the Mandible (p = <0.001), and in the left joint between the Atlas and the Axis (AE: p = 0.011; SEA: p = 0.042). Among the linear measures of the distances between the Atlas and the Axis, the AOD distance presented statistics quite close to the level of significance (p = 0.0502), but above. There was no statistically significant difference in the other measures. **Conclusion:** In this study, the alignment between the Atlas and Axis cervical vertebrae and the mandible and angles of the atlanto-occipital joints are altered in Class II / 2nd Division participants. There is no difference in the size and distance of the Atlas and the Axis between the Classes.

Descriptors: Interdisciplinary research; malocclusion; radiography; cervical column.

INTRODUCTION

Investigations on the biomechanics of the craniomandibular system usually focus on the musculature or other structures[1] but do not interconnect the bone morphology of the cervical spine to the mandibular structure, which can be provided by X-ray[2].

Bones are part of the musculoskeletal system and are ruled by the principles of biomechanics[3,4]. The integration of the biomechanical components in the cervical spine is not always considered in clinical practice[5] since the assessments by health professionals usually consider individual cervical skull movements, starting from the musculature. However, from a more detailed perspective, these movements are not individual but shared by the muscles from bones and tendons to reach synergy and joint stability. This occurs because the musculoskeletal system is symmetrical and maintains its homeostasis in the coordination of many skull, cervical, and mandibular axes, and planes simultaneously[4].

The Axis works as a point of support that pierces the articulation from one side to the other, and the plane is perpendicular to this axis. The movements occur in the planes in a combination of muscle contractions over the bones, according to the arrangement of muscle fibers and tendon insertion[3]. The disposition of most of the muscle fibers in the stomatognathic system provides diagonal movements, that is, a vertical and a horizontal[3] component, facilitating rotations around an articulation and conveying efficiency and economy of energy[6].

Through such a mechanism, the skull functions circularly, dissolving its weight over the cervical spine through rotations, inclinations, or flexoextensions, for or against the force of gravity, respectively, in a combination of muscle actions[3]. Along with the neck, the skull performs important movements in its joints, but not broadly. These are small individual movements that gain amplitude by adding up, forming a biomechanical and economic intelligent chain where each part influences and is influenced by the others[7].

(Due to its close joint relationship with) The first cervical vertebra – Atlas (C1) – moves along with the skull on the second cervical vertebra – Axis (C2)[4]. Skull and Atlas form an atlantooccipital articulation that allows movements of bending and extension, that is, lowering and raising the head in the frontal plane. The Axis, in turn, articulates with the Atlas, forming an atlantoaxial articulation, and has a vertical extension called the odontoid process, which works as a pivot for the skull and the Atlas to make rotation movements in the cross-sectional plane[4].

According to the dental pattern of malocclusions, these movements might be compensated. In the case of Angle Class II/2nd Division, for example, the central axis – the skull – is limited to a small mandible or a large jaw and a cervical spine that might be straightened, altering the biomechanics of the region.

Analyzing the stomatognathic and/or cervical problems of skeletal muscle origin correctly requires understanding that such biomechanics, especially the bone parts composing this system, might be explained by the morphology observed through digital radiographic images.

Therefore, this study aims to analyze the presentation, alignment, and position of the cervical skull structures through X-rays, as well as their functional relationship with the stomatognathic system in Angle Class I and Class II/2nd Division individuals.

METHOD

This is a quantitative, prospective study carried out at the Services of Dentistry, Radiology, and Speech Therapy in the Faculty of Medical Sciences, State University of Campinas-CEPRE / FCM/ UNICAMP. Approved by the Research Ethics Committee for Human Beings, protocol 39597414,2.0000,5404. All participants (or their caretakers) signed an Informed Consent Form.

Sample

Considering the specific features of the studied population, the sample was selected by convenience, thus representing non-probabilistic research, composed of 70 participants, both male and female, aged between 18 and 59 years old, out of which 39 belonged to the Angle Class I and 31 to the Angle Class II/2nd Division, corresponding to the control group and study group, respectively.

Inclusion Criteria

- Healthy participants with all dental elements, Class I molar relationship (without skeletal compromise), and molar relationship of Angle Class II/2nd Division (with retrognathism).

Exclusion Criteria

- Participants with postural deviations; syndrome, chronic systemic disease, trauma, or skeletal malformation; dental agenesis, dental prosthesis carriers, and/or with Temporomandibular Dysfunction.

Occlusal Analysis

The analysis was carried out by a dental surgeon specialized in radiology, using the following ANGLE classification: Class I with mesiodistal mandible relationship, upper incisor teeth overlapping a third of the height of the crown of lower incisor teeth, upper and lower first molars with the mesiobuccal cusp of the upper molar in occlusion in the buccal groove of the lower molar. Class II/2nd Division with the presence of mandibular retrognathism and/or jaw prognathism, distal occlusion of the lower first molar relative to the upper first molar, and vertical overjet between the upper incisor teeth and lower.

Radiography

All digital X-rays were carried out at the Radiology Service, School of Medical Sciences, University of Campinas (UNICAMP), by a single technician supervised by a specialist physician in radiology Fabiano Reis. The participants were instructed on the technical aspects of the procedure (position, respiration, and start of exposition)[2].

We used Cross-sectional Lateral and Anteroposterior (AP) views by observing the topographic reference points that indicate the patient's correct position concerning the regular anatomy of the cervical spine region: Mastoid Process, Angle of the Mandible or Gonion, Thyroid Cartilage ("Adam's apple"), and Seventh Cervical Vertebra (C7).

The radiology tests for the cervical spine were performed in the orthostatic position (standing) to show the alignment and stability of the ligaments and the natural curvature of the spine, in addition to their linear and angle measurements. The participants were positioned with their arms at their sides.

The participants were protected against radiation by minimizing the exposition of their radiosensitive tissues (thyroid, parathyroid, breast, testicles, and ovaries), in addition to the use of specific exposition factors and avoidance of repetitions.

The following precautions were taken:

- Careful communication, safety, manipulation, and patient comfort;
- Instruction on the adequate position for each test and the need to hold their breath during the tests;
- Search for the ideal imaging quality under the shortest exposition time possible.

Description of Cervical Spine Images

1. Cross-sectional View (CS) – C1 and C2: The parts were aligned from the participant's mid-sagittal plane. The head was adjusted so that, with the mouth open, the line on the lower margin from the upper incisors to the base of the skull (mastoid tip) was perpendicular to the table and/or to the Image Receiver (IR) or angular to the Central Radius (CR). Care was taken that there was no rotation of the head or chest and that the mouth was fully open during exposure. Breathing was suspended at the technician's command for image taking. It was instructed to open the mouth only with the movement of the mandible. The tongue remained at lower rest to prevent its shadow from overlapping C1 and C2.

2. Profile View: Alignment of the cervical spine: The mid-coronal plane and the external acoustic meatus (EAM). The participants lowered their shoulders, relaxed them, and stretched the chin a little forward to prevent the mandible from overlapping the upper vertebrae.

   For total expiration, breath was held to maximize the slump of the shoulders.

Analysis of X-rays

The digital X-rays were performed and analyzed on the Advantage Workstation 4.6 software (AW4.6 ext. 04) by applying the IHE Portable Data for Imaging-2010/ GE Medical Systems for Visor DICOM Centricity /Windows NT2000 SP4 and Windows XP SP2/ Pentium III processor of 700 MHz/ 128 MB of memory. The following bone structures were studied: Atlas, Axis, and Skull (Figure 1). The biomechanics analysis of the cross-sectional and profile images considered the linear (assessed in millimeters) and angular (assessed in degrees) measures of the bones based on the study variable (Table 1 and Figure 2) using the software contained in the Digital Radiography.

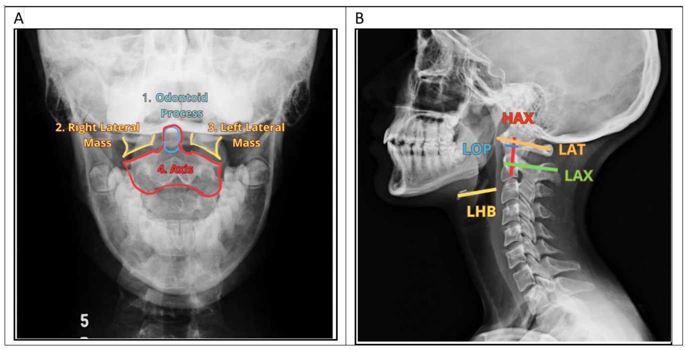

Figure 1. Bone structures studied: (A) Transoral Image: 1. Axis Odontoid Process; 2. Right Lateral Mass of the Atlas; 3. Left Lateral Mass of the Atlas; 4. Axis; (B) Profile Image: LAT=Body of the Atlas Bone; HAX=Axis Bone height; LAX=Axis Bone Length; LHB=Hyoid Bone. LHB=Length of the Head of the Odontoid Process.

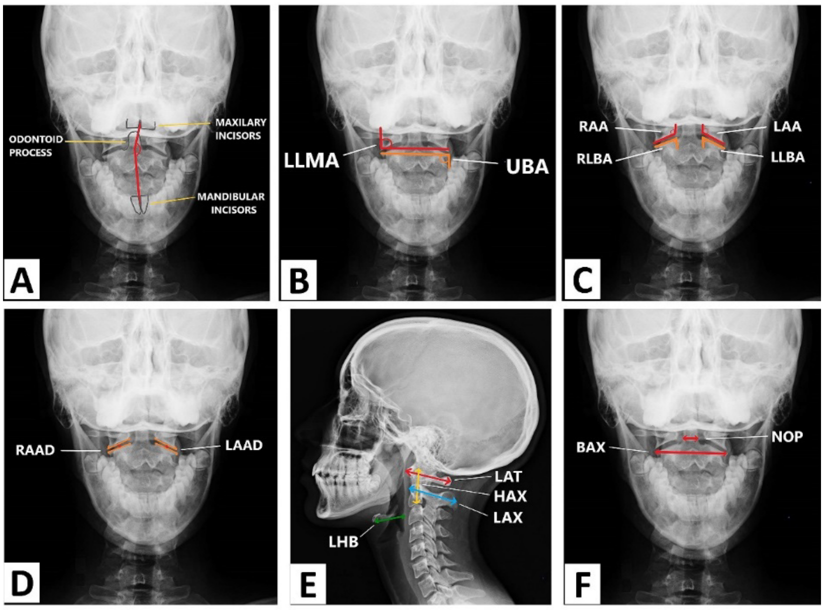

Figure 2. Linear and angle study of the cervical spine. (A) Craniomandibular-Cervical Alignment; (B) Angle between the Lateral Atlas Masses (LLMA) and the Angle of the Upper Base of the Axis (UBA); (C) Lower Atlas Internal Joint Angle (RAA/LAA) and Upper Axis Angle (RLBA/LLBA); (D) Mean distance between the Atlas and the right axis (RAAD) and Mean distance between the Atlas and the left axis (LAAD); (E) Linear measurement of the Atlas and Axis, profile; (F) Linear measurement of the axis (NOP= neck/head, BAX= upper base of axis).

Table 1. Research variables: Cranio-Cervical Angle and Linear Measurements

Variable	Description	p-value
ALIGNMENT ANGLE	*Frontal angle between the Axis-Atlas and Axis-Mandible lines*	<0.001 *
Angle	***Vertical Angles between the Atlanto-Axial Joints on transoral X-ray (in degrees)***	
RLBA	Articular angle of the Upper Right Lateral Base of the Axis	0.998
LLBA	Articular angle of the Upper Left Lateral Base of the Axis	0.184
RAA	Right Articular Angle of the Atlas	0.664
LAA	Left Articular Angle of the Atlas	0.011*
LLMA	**Angle between the Lateral Atlas Masses**	0.826
UBA	Upper Angle of the Base of the Axis	0.051*
RIGHT ANGLE	Angle of the Right Atlanto-axial Joint	0.820
LEFT ANGLE	Angle of the Left Atlanto-axial Joint	0.042*
Length	***Length of the Atlas, the Axis and the Hyoid bones on Cross-sectional and Profile Views (mm)***	
Cross-sectional (CS)		
RBLM	*Length of the* Lower Right Base of the Lateral Mass of the Atlas	0.710
LBLM	*Length of the* Lower Left Base of the Lateral Mass of the Atlas	0.831
BAX	*Length of the* Upper Base of the Axis	0.82
NOP	*Length of the* Neck of the Odontoid Process	0.675
Profile *(mm)*		
LAT	Length of the Atlas Body	0.703
LAX	Length of the Axis Body	0.794
HAX	Height of the Axis Body	0.354
LOP	*Length of the* Head of the Odontoid Process	0.420
LHB	Length of the Hyoid Bone	
Distance	***Distances between the Atlas(C1) and the Axis(C2) on Cross-sectional X -ray (mm)***	
RAAD	Average Distance between the Atlas and the Axis on the right	0.167
LAAD	Average Distance between the Atlas and the Axis on the left	0.09
MRAA	Medial Distance of the Right Atlanto-Axial Joint	0,628
LRAA	Lateral Distance of the Right Atlanto-Axial Joint	0.190
MLAA	Medial Distance of the left Atlanto-Axial Joint	0.791
LLAA	Lateral Distance of the left Atlanto-Axial Joint	0.269
RAO	Average distance between the Atlas and the Odontoid Process on the right	0.0502*
LAO	Average distance between the Atlas and the Odontoid Process on the left	0.132

*A p-value less than or equal to 0.05 indicates that the difference is statistically significant.

Statistical Analysis

The statistical methods used herein tested the hypothesis that the cervical spine of the Angle Class I and Class II/2nd division individuals presented different structural and dynamic features. Considering that the samples were unpaired, that is, the two groups included different individuals, the t-test (parametric test) and Mann-Whitney test (non-parametric)[8] were applied. The student-t test was applied to verify the existence of significant differences between the mean of the two groups.

RESULT

Profile of the examined sample

The results show a homogenous relative distribution of the participants in the sample by sex between the classes. Nevertheless, women predominated in the research.

The participants were aged between 18 and 59 years old with heights between 1.49 m and 1.82 m. The Angle Class I individuals were slightly older than those of the Class II/2nd Division, at an average age of 34 and 30 years old, respectively. As to height, both classes presented remarkably close summary measurements (minimum, median, mean, maximum, and standard deviation), indicating no marked difference between distributions. This is a positive aspect since the size of the bones is influenced by the participant's height and otherwise the results could have been influenced by different height measures by class, thus causing a selection bias.

Vertical Alignment between the Cervical Vertebrae (Axis) Atlas (Skull/Jaw) and Mandible

The U Mann-Whitney test and boxplots were applied to analyze the variable related to the vertical alignment of the skull (reference point: midline of the upper incisor teeth), second cervical vertebra, Axis (reference point: midline), and mandible (reference point: midline of the lower incisor teeth) in the research participants, according to the occlusal Angle Classes I and II/2nd Division[8]. Figure 3 shows that the test was significant (p-value< 0.05), indicating that the null hypothesis was rejected. In addition, there is a statistically significant difference between the Angle Classes I and II/2nd Division.

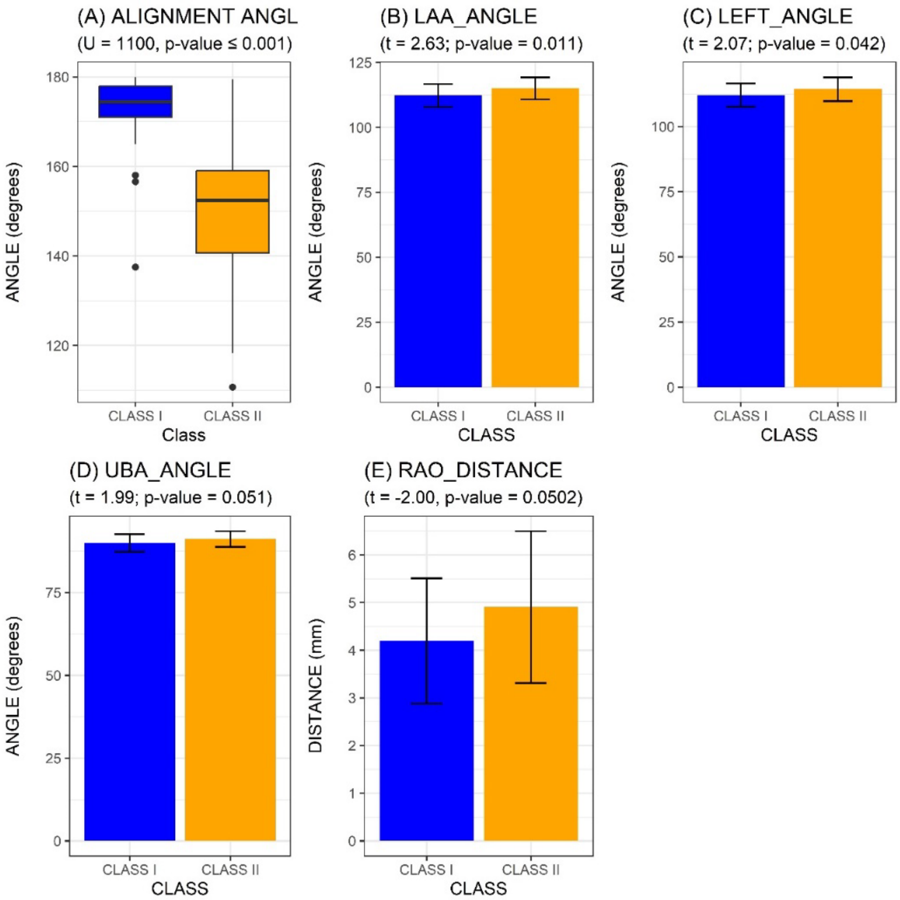

Figure 3. Angles and Distances: (A) Skull, Axis, and Mandible alignment; (B) Left Joint Angle of the Atlas. (C) Left Atlantoaxial Angle; (D) Upper angle of the base of the axis; (E) Mean distance between the Atlas and Odontoid Process on the right .

Angles

The results for the variables related to the Joint Angles of the Atlas and Axis Bones, Atlantooccipital Articulation, and the Atlas and Axis Bones with the Vertical Line (Frontal angle between the Axis-Atlas and Axis-Mandible lines) indicate no significant difference between the means of Classes I and II, at a 95% confidence level. Table 1 shows that most of the p-values of the variable were above 0.05, indicating that the hypothesis that the means of the groups were equal cannot be rejected, which suggests no statistically significant difference between Classes I and II. However, this was not the scenario for two cases: LAA ANGLE, belonging to the group of the Joint Angles variable of the Atlas and Axis Bones, and LEFT ANGLE, belonging to the group of the Atlantooccipital Articulation Angles variable, for which the t-test resulted in a p-value below 0.05, allowing to reject the null hypothesis of equality of means between the groups. In this case, there is a significant difference between Classes I and II, that is, between the control and study groups (Figure 3, B and C). It is worth highlighting that for the UBA ANGLE, the t-test resulted in a borderline p-value (p = 0.051), indicating that the null hypothesis of equality of means between the groups cannot be rejected (Figure 3D).

Measurement of the Distances between Atlas and Axis Bones

As to the variable related to the linear distances between Atlas (C1) and Axis (C2) in the Cross-sectional X-ray, Table 1 shows that all p-values were above 0.05, indicating that the hypothesis that the means of the groups were equal cannot be rejected, which suggests no statistically significant difference between Classes I and II, at a 95% confidence level.

For the RAO DISTANCE, the t-test resulted in a p-value of 0.0502, which is remarkably close to the 5% significance level, but, indicating that the null hypothesis of equal means between the groups cannot be rejected. In this case, the chart of the confidence interval helps visualize the small intersection (Figure 3E).

Dimensions of the Atlas and Axis Bones

The results of the variable related to the length of the Atlas and Axis bones in the cross-sectional and profile X-rays (Table 1) show that all p-values were above 0.05, indicating that the hypothesis that the means of the groups were equal cannot be rejected, which suggests no statistically significant difference between Classes I and II.

DISCUSSION

Considering the morphological nature of this study, we were concerned with the correlation between the height and size of the participants' cervical spine bones, whose disproportion could interfere with the results. However, the sample showed to be well-balanced regarding these elements.

Mandible, Mouth Opening, Dental Midline, and Asymmetries

Mandibular asymmetry was initially observed with most of the Class II individuals showing lateral deviation (Figure 3A). Asymmetry might result from several situations related to malocclusion and/or TMJ.

For Gomes, Brandão[9], mandibular movements are complex combinations of muscle activities that enable stomatognathic functions with articular freedom linked to the stability and symmetry of temporomandibular joints.

Mongini[10] mentions that the muscle dynamic balance and synchronism of the structures of the stomatognathic system promote its correct and smooth functioning since the TMJ has several compensatory defense mechanisms that might be started upon morphological and/or functional interferences to preserve its balance throughout the functional adaptation. Therefore, craniomandibular disorders derive from the extrapolation in the reaction capacity or TMJ compensation in maintaining balance under the intensity and constancy of forces originating from occlusal disharmony and neuromuscular disorders.

For Bianchini et al.[11], the asymmetry found in dental-skeletal problems is worsened by posture and stomatognathic functions that are altered in the maintenance and continuation of neuromuscular disorders, oral functional habits, and chewing patterns, which result from muscle changes that characterize hypofunction or hyperfunction.

Unilateral chewing might also cause or be a consequence of alteration in the muscular function generated by the asymmetrical activity of mandibular muscles in swallowing and chewing[12]. In this case, there is greater muscle strength on the working side of the orofacial and masticatory muscles than on the balancing side, where muscles are elongated and have lowered tone, with discrepancy compromising the whole stomatognathic system.

Cheney[13] describes that the mandible might be asymmetrical and deviate from its centric position due to variations in the structures of support and functional asymmetries caused by dental malocclusion, constricted upper arch, and improper restorations, among others. Such factors might cause deep structural asymmetry and hamper the return of the mandible to its original centric position. For Fricton, Schiffman[14], the alteration in the mandibular position might promote changes in the biomechanical balance, myofascial trigger point installation, and intra-joint structures, in addition to a decrease in intra-joint space and disk displacement.

Limitation of the mouth opening is another common alteration of the TMJ. Torres et al.[15] mentions that the limitations in mouth opening are associated with several pathologies that promote disorders in the temporary temporomandibular articulation or those of progressive and degenerative nature, demonstrating that early diagnosis, treatment, and timely monitoring might minimize the after-effects and incapacities. Thereby, analyzing the maximum inter-incisor distance might reveal the limitation of mouth opening in disorders that involve temporomandibular articulation and interfere with oral motricity and stomatognathic functions with mouth opening[11]. Therefore, it is worth considering the regular amplitude of mouth opening since its reduction is associated with the presence of pain, internal TMJ derangements, or disorders of the masticatory muscles [11].

According to Dimitroulis[16], such disorders alter the mandibular function and its movements, interfering with daily life activities, speech, and nutrition. The muscles especially influence the analysis of maximum active inter-incisor distance since orofacial and cervical myofunctional disorders might limit mouth opening[17] because the skull muscles that stabilize the mandible enable or hamper the movements of opening, closure, and laterality[14].

Tosato, Biosotto-Gonzalez[18] report that the reduction of the amplitude of the mandibular movement and its lateralization was associated with the tension in masticatory musculature and cervical alteration. Such a finding can be corroborated in the results of pain treatments that promote muscular relaxation and mouth opening, in addition to the easing of the restriction of mandibular movements and midline deviation since the reduction in painful symptomatology improves the mandibular function[19].

A satisfactory TMJ functioning reflects on the correct alignment of the dental midline, which is a vertical layout between the upper and lower incisors that must coincide in the mouth opening and its occlusion, determined by the mandibular centric relationship and the first dental contact between the midline of upper incisors and the midline of lower incisors. For Suguino et al.[20], the upper and lower dental midlines should coincide with each other and with the facial midline. When this does not occur, it is essential to define which midline is asymmetrical regarding the facial midline – jaw, mandibular, or both – and both the direction and magnitude of the discrepancy[20].

Higley[21] mentions that there are more mandibular than jaw asymmetries, considering that the jaw is fixed to the skull and easily follows the facial line, except in cases of bone malformations, while the mandible is mobile and susceptible to deviations generated by the lateral force, which might change the arch configuration. In this case, the mandible deviates and alters the midline to allow dental occlusion[21].

However, the assessment of the TMJ based on the dental midline might not describe the true position of this system for referring to an apparent direction. Tendon muscle compensations might disguise the true structural position by not scanning the alignment with the cervical spine, which can only be seen through specific tests, such as radiography. In this case, it is worth complementing the apparent assessment of the dental midline with a structural assessment, that is, a radiological assessment, and an analysis of the cervical skull posture. Thereby, the origin of the asymmetry might be biomechanical, that compensates for the morphology.

Vertical Alignment of the Mandible, Skull, and Cervical Spine

Our research showed significant differences in the skull-mandibular-cervical alignment (Figures 2A and 3A). For the transoral X-ray, the participants were instructed to maintain maximum mouth opening, that is, with the isometric movement of the hyoid muscles (to lower the mandible) and cervical (to stabilize the head) to visualize the Atlas and Axis. The articulation of the skull (jaw = upper incisors teeth) was observed through the upper cervical spine (Axis) and mandible (lower incisors teeth) and the vertical postural alignment occurring from the sagittal plane, which divides the human body equally between the right and left sides[4,6]. The cross-checking of these analyses revealed the most reliable position of the vertical alignment of the mandible, skull, and cervical spine since the muscles, although not shown in these images, determine the relative bone position by traction.

Dental alignment is important for maxilla-mandibular symmetrical functioning during chewing and speech. In turn, postural alignment is fundamental for a satisfactory movement of the head and shoulders since the pivot fit supports the skull in C1 and rotates the C2, allowing a 60º rotation to the right and the left, with balanced cervical movements and without the muscular overload of the suboccipital and sternocleidomastoid muscles.

The rotation of the skull occurs in the cross-sectional plane and the longitudinal axis[4], where muscular effort is lower than bending, extension, and inclination, being favored by the vertical rotation axis in the center of the odontoid process[4], where agonist and antagonist forces combine and support the head. In the orthostatic posture, the skull this movement is not heavier if turned to the right or the left.

Unlike other movements (bending, extension, and inclination) that have one component against gravity and one for, with antagonist muscles having a greater effort to stop the movements of the agonist and retaining the weight of the skull, the C1 rotation on the C2 occurs in the horizontal plane. However, due to the features of these vertebrae, the movement is not fully horizontal but helicoidal[4].

The lower surfaces of the Atlas and upper surfaces of the Axis have a cylindrical and convex shape in the anteroposterior part of their sides, which makes the first vertebrae "descend" in a vertical direction when rotating forward or backward and "ascend" in a vertical direction when returning to its initial position, which is higher[4].

When the musculature is balanced, the mandibular descend movement is performed in the frontal plane, in the vertical direction, generating no lateral compensation. However, our research showed that the Angle Class II/2nd Division cannot maintain such a balance (Figure 3A). The effort of the hyoid muscles to keep the mouth open through the mandible descend generates a fixed point in the movement, with the two temporomandibular joints along with the condyles separated from the mandibular fossa and the joint capsules and ligaments tensed. Such an overload is compensated for in the mobile points, skull, and Atlas, which rotate due to the asymmetrical contraction of the suboccipital muscles as a response to the muscular tension installed. In this scenario, the transoral X-ray reveals a lateral mass of the Atlas that is more advanced than the other, in addition to the upper incisor teeth being lateralized regarding the odontoid process, demonstrating the rotation (Figure 2A).

Even without a primary action in the rotation of the skull, the suprahyoid musculature intervenes in the movement since its insertion in the mastoid process – referring to the posterior digastric muscles – keeps the contraction started by the suboccipital due to the absence of antagonism toward stopping the movement (such as the bending of the elbow through the biceps brachii and the participative and opposite movement of the triceps brachii), but by adding elastic force. Kapandji[4] mentions that while a suboccipital muscle pulls the vertebra (C1 or C2) to one side, its contralateral is slowly distended to its limit, which leads the head to return to its neutral position.

Therefore, the key points are the bone and muscular proportion that favors the symmetry of the movements, which is important for the coordinated action between muscular contraction-relaxation and bone stabilization-fixation, Douglas[22].

Muscles act symmetrically when the bones in their base are also proportional. Class I is perfectly vertically aligned, showing that its rotation axis favors such a movement (Figure 3A), which does not occur in the Angle Class II/2nd Division. In Class II, there is a misalignment of the vertical angle formed by Atlas, Axis, and mandible, that might be part of your traits (Figure 3A). Such an asymmetry suggests that the muscle forces are not balanced; on the contrary, there is a lack of alignment between the muscle groups, with an overload of the synergists to stabilize the head and neck, as well as the agonists that work for the mandible to descend and keep the mouth open.

The electrographic studies of Nascimento et al.[23] found asymmetry in the suprahyoid muscular and occipital activities in Classes I and II/2nd Division during an isometric suction exercise. In this experiment, Class I recovered its symmetry, while Class II/2nd Division remained asymmetrical and with the presence of discomfort in the cervical region by overload. By associating such a result with the X-rays, we can see that the musculoskeletal system is already asymmetrical in this class. The cervical bone structure is an adequate size, but the bone mandibular/or jaw structure does not. The muscles inserted in these bones do not have an alternative rather than compensation work, that is, the asymmetry in the stomatognathic system of Angle Class II /2nd Division, especially in the lateral and rotation movements.

Angle and Linear Measurements

We measured the joint angles of the Atlas and Axis in the transoral X-ray. There was a significant difference in the left internal angle of the Atlas and the upper left angle of the Axis between the occlusal classes (Figures 3B, C, and D). The internal angle of the Atlas and the external angle of the Axis were larger for the Angle Class II/2nd Division, thus suggesting a posture compensation by the significant difference in the left atlantoaxial articulation (Figure 3C).

Joint angles are provided by musculoskeletal congruence. The atlantoaxial joints were expected to present symmetrical proportions of shape and inclination[4], which was not observed in the Angle Class II/2nd Division. Instead, there was a difference in inclination between the joint surfaces, reflecting on the articulation and appearing to activate the upper cervical spine differently from Class I. In turn, Class I presented symmetrical atlantoaxial joints between the lower side of the lateral masses of the Atlas, with the upper joint surfaces of the Axis, and the joint space.

There was a balance in the horizontal plane of the lower angles of the Atlas with vertical LLMA and the upper base of the Axis with vertical UBA (Table 1), enough to maintain homeostasis in the region and support the skull in both classes, thus suggesting that the anterior asymmetry was compensated in this plane.

Other Measurements

No significant difference was found in the measurements of the distances between the Atlas and the Axis (Table 1), although the LAAD and the RAO distances were close and remarkably close to this limit, respectively. There was also no significant difference either in the linear measurement of the right and left bases of the Atlas in the odontoid process or the Axis base in the cross-sectional X-ray between the classes. Neither in the size nor the height of the Atlas in the odontoid process of the profile X-rays. Likewise, no significant differences were found in the measurements of width and height for the first and second cervical vertebrae between the occlusal classes (Table 1). These results indicate that the bone structures of both classes are similar concerning the cervical spine, as well as that the structural adaptation of this bone segment regarding the size of the mandible/ jaw for the Angle Class II/2nd Division was conditioned to the musculature work.

CONCLUSION

Our results indicate that:

- The Angle Class II/2nd Division individuals have a different alignment between the cervical vertebrae C1 and C2 and the mandible compared with the Class I participants due to horizontal rotation compensation between the skull and the Axis;
- There is a significant difference between the angles of the atlantooccipital joints in the cross-sectional X-ray of the Angle Class II/2nd Division individuals concerning the regular reference standards in the literature, which might be related to muscular activity compensation;
- There is no difference in the size and distance of the C1 and C2 vertebrae between the classes, both in the cross-sectional X-rays and the profile images, demonstrating that the classes show similar cervical spines;
- The radiological image of the cervical spine can be used in the assessment of the stomatognathic system.

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CONFLICTS OF INTERESTS

The authors declare no conflicts of interest.

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Received: January 01, 2023
Accepted: May 17, 2023