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*Research Article*

# Maxillomandibular Characteristics Related To Mandibular Asymmetry In Brazilian Adolescents With Different Sagittal Skeletal Patterns.

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## Abstract

**Objective:** evaluate maxillomandibular characteristics associated to mandibular asymmetries in brazilian adolescents who present different sagittal skeletal patterns using cone beam computed tomography (CBCT).
**Methods:** tomographic images of 210 patients were selected and divided into three groups of 70 individuals each (Class I; Class II; and Class III). The groups were subdivided into three categories according to the degree of the lateral chin (gnathion) deviation 1) relative symmetry; 2) moderate asymmetry; and 3) severe asymmetry. Three planes of reference were established in the CBCT images and several measures were taken to compare bilateral skeletal differences within asymmetry degrees for the different sagittal skeletal patterns.
**Results:** In the transverse plane, Gn-MSP and Go-MSP showed statistical differences, different from J-PSM (P>0,05). In the sagittal plane, Go-Coronal (dif) showed a significant difference in the severe asymmetry in Class III individuals. However, GoGn (dif) presented significant difference in the asymmetry for all the sagittal skeletal patterns. Evaluations on the vertical plane showed that CoGo (dif) was significantly different in Class I and II individuals with severe asymmetry, and in Class III individuals, for all mandibular asymmetries. When comparing Class I, II and III individuals regarding the different asymmetry intensities, it became evident that one sagittal plane measure, Go-Coronal (dif), and one vertical measure, J-Camper (dif) were significantly different in Class II and III sagittal skeletal patterns, respectively, in individuals with severe asymmetry.
**Conclusion:** lateral chin deviation was not the only skeletal alteration found in patients with asymmetry; there was variation of the bilateral differences among the degrees of asymmetry and sagittal skeletal patterns; bilateral differences of the maxilla position followed the mandibular ones only in the vertical direction and in Class II and III patients.

**Keywords** : *Facial Asymmetry, Cone-Beam Computed Tomography, Adolescent*

## INTRODUCTION

Asymmetry is relevant in the evaluation of smile and facial appearance [1-3]. Therefore, odontology has developed techniques to harmonize craniofacial structures between the right and left sides aiming at achieving a more pleasant facial aesthetics. However, it might not be always possible, as facial asymmetry may be the result of a disorganized growth of craniofacial structures trigged by genetic factors, congenital or acquired disorders, and idiopathic developmental delays [4].

The prevalence of asymmetry varies among the age groups, and few studies have been found regarding adolescents. Among those, Ramirez-Yañez et al. [5] reported 25% of mandibular asymmetry in adolescents and Garcia et al. [6] 21.8%. In adults, the prevalence may vary from 11% to 37% [7-11], and it might be over 50% if the method used is more accurate [5,12-14]. Such variability in the prevalence has been attributed to the difficulties in the standardization of the methodology to evaluate facial asymmetry; even though most authors agree that chin deviation is the most striking asymmetry [6,10,12,15].

As a consequence, more accurate techniques to evaluate facial asymmetry have been developed, being the most recent ones 3D image capture, such as sterophotogrammetry, laser scanning, and computerized tomography. However accurate [16-19], the first two ones evaluate only soft tissues. They also pose some difficulties to acquire the images when children

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and adolescents are concerned, as they demand a still facial expression and relaxed occlusion, and they do not identify the reference points precisely [12].

On the other hand, computerized tomography, mainly the cone beam computed tomography (CBCT), allows a thorough evaluation of skeletal and dental anatomical structures and soft tissue [20,21]. This image examination allows the possibility of locating and quantifying the asymmetries without distortion. It also provides real measurements 1:1 [22-24] and the image is taken using less radiation than medical computed tomography [25,26].

Therefore, considering the scarce number of studies on asymmetry in young patients, the aim of this study was to evaluate, using CBCT, the mandibular characteristics associated to mandibular asymmetries in adolescents with different sagittal skeletal patterns.

## MATERIALS AND METHODS

This study was approved by the ethics committee of the Brazilian Lutheran University (ULBRA, Canoas, RS, Brazil), report n° 4.310.478 in 03/09/2020.

This cross-sectional study is part of a larger project that evaluates the prevalence of mandibular asymmetries and their associations in individuals of different age groups [6]. CBCT images from 210 individuals were eligible, and the calculation of power for statistical tests showed that the number of individuals were enough ($\beta < 0.2$, using $\alpha = 0.05$).

Tomographic images were obtained from a database of a dental diagnosis and planning centre (Compass3D®, Belo Horizonte, MG, Brazil), and images were randomly chosen in relation to sex and race of the individuals.

Inclusion criteria adopted: tomographic images should have been asked either with clinical justification, or if it was impossible to answer to the clinical needs using conventional radiographic techniques, guidelines from Sedentexct project [27]; individuals should be between 10 and 19 years old; images should have been generated in tomographic devices of the same brand (i-CAT®, Imaging Sciences International, Hatfield, Pa). Exclusion criteria: individuals who had undergone trauma and/or surgeries on the face; and craniofacial syndromes and anomalies.

CT scans were performed using the same equipment (i-CAT - Imaging Sciences International, Hatfield, Pa), adjusted for 120KvP, 3-8mA and exposition time of 20 seconds.

Patients were instructed to seat, occlude in maximum habitual intercuspation, and leave lips at rest. The head was positioned keeping the Frankfurt plane parallel to the ground and the median sagittal plane perpendicular to the ground.

CBCT images were exported in Digital Imaging and Communication in Medicine (DICOM) format using iCAT Vision®. DICOM files were sent to SimPlant Ortho Pro 2.0® software (Materialise Dental, Lueven, Belgium), and the location of the anatomic points were done by multi-planar reconstruction cuts, measurement scale of 0.01mm and 0.01°.

The sample was divided into three groups of 70 individuals each according to the sagittal skeletal pattern, Class I (between 0° and 4.5°); Class II (>4.5°); and Class III (<0°), as proposed by Tweed [28,29]. The groups were subdivided into three categories according to the degree of the lateral chin (gnathion) deviation in relation to the median sagittal plane: relative symmetry, patients who presented up to 2mm deviation; moderate asymmetry, patients who presented a deviation within 2mm and 4mm; and severe asymmetry, patients who presented a deviation greater than 4mm. These parameters were selected based on previous studies [5,13,30].

**Table I** shows the points and planes of reference used in this study. Three planes of reference were defined in CBCT images, and mandibular and maxillary measurements were grouped into transverse, sagittal and vertical planes. The sagittal plane was determined according to Damstra et al. [36]. **Table II** presents the measures used to evaluate bilateral differences of mandibular and maxillary components. Both tables can be seen in **Figure 1**.

**Figure 1.** Measures used to evaluate bilateral differences of mandibular and maxillary components: I) Gn-MSP, Go-MSP, J-MSP; II) ANB angle, Go-Coronal, GoGn, CoGo, Go-Camper and J-Camper.

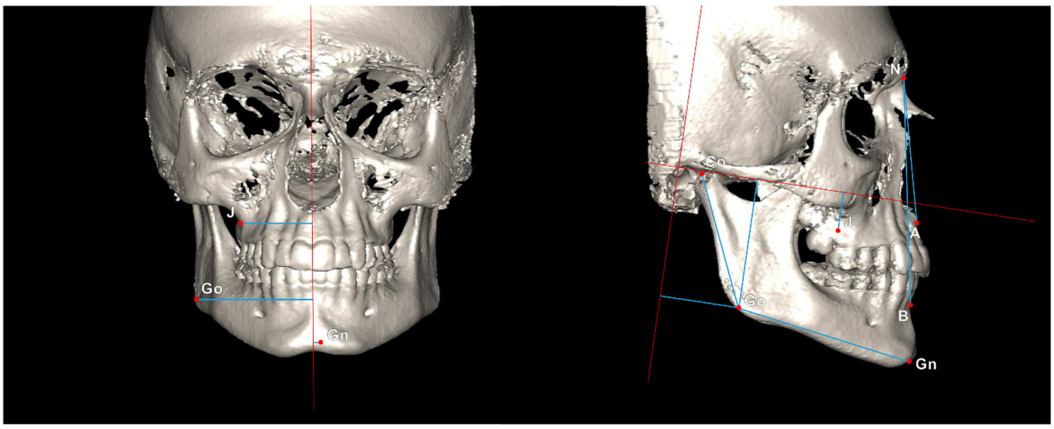

**Table 1.** Description of the anatomical points and reference planes used in this study.

| Point/Plane | Abbreviation | Definition |
|---|---|---|
| Anatomical porion | Po | The highest point of the external auditory meatus |
| Orbital | Or | The lowest point of the infra-orbital margin |
| Anterior Nasal Spine | ANS | Point located in the extremity of the anterior nasal spine |
| Basion | Ba | Midpoint on the anterior margin of the occipital foramen |
| Sella | S | Central point of the sella turcica |
| Nasion | N | The most anterior and medium point of the nasofrontal suture |
| Subspinal | A | The deepest anterior point in the concavity of the anterior maxilla |
| Supramandibular | B | Point located in the deepest concavity of the anterior portion of the mandibular symphisis |
| Gnathion | Gn | The lowest point of the anterior margin of the lower jaw |
| Jugal | J | Point in the intersection of the jaw tuberosity margin with the zygomatic pillar |
| Gonion | Go | The lowest and most posterior point of the gonial angle outline |
| Condyle | Co | The most superior and anterior point of the mandibular condyle |
| Frankfurt plane | Frankfurt | The plane passes through the right and left anatomical porion and the left orbital point (PoR, PoL – OrL) |
| Median Sagittal Plane | MSP | It refers to the intersection of Nasion and Basion points, perpendicular to the Frankfurt Plane. Used to evaluate transverse changes |
| Coronal Plane | Coronal | The plane passes through the right and left anatomical porion and it is perpendicular to Frankfurt Plane. Used to evaluate changes in the Sagittal direction |
| Camper Plane | Camper | The plane passes through the right and left anatomical porion and through the anterior nasal spine (ANS). Used to evaluate changes in the vertical direction |

**Table 2.** Measures used to evaluate bilateral differences of mandibular and maxillary components.

| | Variable | Measure | Definition |
|---|---|---|---|
| TRANSVERSE | Gn-MSP | Distance between the gnathion and the median sagittal plane | Mandibular asymmetry (Lateral deviation of the menton) |
| | Go-MSP | Distance beween the gonion and the median sagittal plane taken from the contralateral and deviated sides | Transverse position of the jugal (maxilla) |
| | J-MSP | Distance between the jugal point and the median sagittal plane taken from the contralateral and deviated sides | Transverse position of the jugal (maxilla) |
| | Go-MSP/dif | Difference in the distance of the gonion to the sagittal plane between the contralateral and deviated sides | Bilateral difference in the position of the gonion in the transverse plane |
| | J-MSP/dif | Difference in the distance of the jugal point to the sagittal plane between the contralateral and deviated sides | Bilateral difference in the position of the jugal point in the transverse plane |
| SAGITAL | ANB angle | Angle formed in the intersection of NA and NB lines | Sagittal relation of the jaws |
| | Go-Coronal | Distance from the gonion to the coronal plane taken from the contralateral and deviated sides | Sagittal position of the gonion |
| | GoGn | Distance from the gonion to the gnathion taken from the contralateral and deviated sides | Length of the mandible body |
| | Go-Coronal/dif | Difference in the distance of the gonion to the coronal plane between the contralateral and deviated side | Bilateral difference in the position of the gonion in the sagittal plane |
| | GoGn/dif | Difference in the distance of the gonion to the gnathion between the contralateral and deviated sides | Bilateral difference of the length of the mandible body |

| | | | |
|---|---|---|---|
| VERTICAL | CoGo | Distance from the condylion to the gonion taken from the contralateral and deviated sides | Height of the mandibular rami |
| | Go-Camper | Distance from the gonion to the camper plane taken from contralateral and deviated sides | Vertical position of the gonion |
| | J-Camper | Distance from the jugal point to the camper plane taken from the contralateral and deviated sides | Vertical position of the jugal |
| | CoGo/dif | Difference in the distance from condylion to the gonion between the contralateral and deviated sides | Bilateral difference of the height of the mandibular rami |
| | Go-Camper/dif | Difference in the distance from the gonion to the camper plane between the contralateral and deviated sides | Bilateral difference of the gonion in the vertical plane |
| | J-Camper/dif | Difference in the distance from the jugal point to the camper plane between the contralateral and deviated sides | Bilateral difference of the jugal point in the vertical plane |

/dif = difference: value obtained in the contralateral side deducted from the deviated side

The asymmetry between the bilateral cephalometric points was measured by the difference (dif) between the contralateral side and the side of the mandibular deviation. Gnathion displacement in relation to the median sagittal plane was measured in absolute values, regardless of the displaced side. Three dental professionals performed the tomographic measurements, being the error determined by the intraclass correlation coefficient (ICC), intraobserver and interobserver. The three professionals evaluated 10% of the tomographic measurements in two different moments, with an interval of two weeks between evaluations. ICC, intraobserver and interobserver, was of > 0.90 for both measurements, showing that the method was highly reliable.
SPSS® version 20.0 (IBM, Chicago, IL, USA) was used to the Statistical Analysis. Kruskal-Wallis non-parametric test was used to verify possible differences between Class I, II and II patients in relation to the different intensities of the mandibular asymmetry, p≤0,05.

## RESULTS

**Table III** shows the distribution of the sample according sex (frequency), age (standard deviation and amplitude), ANB angle, and gnathion deviation (absolute values) for each sagittal skeletal pattern.
**Table IV** presents the analysis of the differences between the contralateral side and the side of the mandibular deviation, for each group in relation to sagittal skeletal pattern. It is necessary to highlight that the differences with a negative value mean that the side of the displacement presented a larger average dimension than the contralateral side.
In the transverse plane (**Table IV**), only Gn-MSP and Go-MSP showed statistical differences (P>0,005). For Gn-MSP, there were significant differences for three degrees of mandibular asymmetry in Class I, II and III, while to Go-MSP, only in Class II and III, and severe asymmetry for Class I. Class II individuals with severe asymmetry presented the higher averages, and the presence of the negative sign suggests the largest distance of Go-MSP on the side of the deviation.
In the sagittal plane, Go-Coronal (dif) showed a significant difference in the severe asymmetry in Class III individuals. However, GoGn (dif) presented significant difference in the asymmetry for all the sagittal skeletal patterns.
Evaluations on the vertical plane showed that CoGo (dif) was significantly different in Class I and II individuals with severe asymmetry, and in Class III individuals, for all mandibular asymmetries. Go-Camper (dif) presented statistical difference in Class I and II individuals, in the three mandibular asymmetry degrees. However, J-Camper (dif) was significantly different in Class II individuals, for all the degrees of mandibular asymmetry; whereas in Class I individuals the significant difference was just found for severe asymmetry, without difference for Class III.
When comparing Class I, II and III individuals regarding the different asymmetry intensities (**Table V**), it became evident that one sagittal plane measure, Go-Coronal (dif), and one vertical measure, J-Camper (dif) were significantly different in Class II and III sagittal skeletal patterns, respectively, in individuals with severe asymmetry.

**Table 3.** Characteristics of the sample regarding sex, age, ANB angle and gnathion deviation for each sagittal skeletal pattern (n=210)

| Sagittal skeletal relationship | | | | |
|---|---|---|---|---|
| **Variable** | **Class I (n=70)** | **Class II (n=70)** | **Class III (n=70)** | **Total** |
| Sex: n (%)<br>Male<br>Female | <br>32 (45.2%)<br>38 (54.8%) | <br>30 (43.5%)<br>40 (56.5%) | <br>24 (34.3%)<br>46 (65.7%) | <br>86 (41.8%)<br>124 (59.2%) |
| Age:<br>average +- SD<br>amplitude (min/max) | <br>13.6 +-2.7;<br>(10/19) | <br>13.1+-2.5;<br>(10/19) | <br>14.6+-3.0;<br>(10/19) | <br>13.7+-2.7;<br>(10/19) |
| ANB (°)<br>average +- SD<br>amplitude (min/max) | <br>2.6+-1.2<br>(0.0/4.5) | <br>6.0+-1.3<br>(4.5/11.4) | <br>-1.6+-1.4<br>(-6.1/0.0) | <br>2.8+-2.9<br>(-6.1/11.4) |
| Gn-MSP (mm)<br>average +- SD<br>amplitude (min/max) | <br>1.0+-2.6<br>(-5.3/10.5) | <br>0.3+-2.0<br>(-5.8/6.4) | <br>0.9+-2.7<br>(-10.4/10.1) | <br>0.8+-2.5<br>(-10.4/10.5) |

**Table 4.** Comparison of the skeletal components involved with the distinct degrees of mandibular asymmetry for each of the sagittal skeletal patterns.

| | | | **Relative symmetry** | | **Moderate asymmetry** | | **Severe asymmetry** | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **Measure** | **Average** | **SD** | **Average** | **SD** | **Average** | **SD** | **p** |
| Class I | Transverse | Gn-MSP | -0.06 | -0.06 | -0.06 | 0.56 | 6.74 | 2.05 | 0.000** |
| | | Go-MSP (dif) | 0.06 | 0.06 | 0.06 | 2.36 | -1.78 | 2.59 | 0.015* |
| | | J-MSP (dif) | 0.13 | 0.13 | 0.13 | 1.04 | -0.62 | 1.54 | 0.142NS |
| | Sagital | Go-Coronal (dif) | -0.21 | 2.35 | 0.12 | 2.69 | 1.91 | 3.55 | 0.068NS |
| | | GoGn(dif) | 0.05 | 1.86 | 0.59 | 2.04 | 2.52 | 1.90 | 0.000** |
| | Vertical | CoGo (dif) | -0.42 | 2.31 | 0.45 | 1.74 | 3.34 | 3.58 | 0.000** |
| | | Go-Camper (dif) | -0.40 | 2.11 | 0.56 | 2.44 | 2.34 | 3.36 | 0.000** |
| | | J-Camper (dif) | -0.12 | 1.43 | 0.10 | 1.66 | 1.73 | 1.58 | 0.000** |
| Class II | Transverse | Gn-MSP | -0.33 | 1.49 | 2.64 | 0.55 | 5.58 | 0.97 | 0.000** |
| | | Go-MSP (dif) | 0.37 | 2.22 | -1.28 | 2.09 | -3.87 | 2.49 | 0.001** |
| | | J-MSP (dif) | 0.08 | 0.95 | -0.56 | 1.30 | -1.69 | 2.57 | 0.056NS |
| | Sagittal | Go-Coronal (dif) | 0.33 | 2.27 | -0.41 | 2.25 | -3.92 | 7.09 | 0.204NS |
| | | GoGn(dif) | -0.38 | 2.03 | 0.57 | 1.94 | 4.41 | 4.04 | 0.032* |
| | Vertical | CoGo (dif) | -0.61 | 2.21 | -0.06 | 2.46 | 8.74 | 10.24 | 0.040* |
| | | Go-Camper (dif) | -0.68 | 2.01 | 0.11 | 2.05 | 7.10 | 8.04 | 0.010** |
| | | J-Camper (dif) | -0.53 | 1.24 | 0.36 | 1.34 | 3.79 | 2.64 | 0.000** |
| Class III | Transverse | Gn-MSP | -0.16 | 2.14 | 2.95 | 0.60 | 7.02 | 2.19 | 0.000** |
| | | Go-MSP (dif) | 0.51 | 2.43 | -1.87 | 2.00 | -2.96 | 2.27 | 0.001** |
| | | J-MSP (dif) | 0.06 | 1.05 | 0.09 | 1.33 | -0.52 | 1.17 | 0.507NS |
| | Sagittal | Go-Coronal (dif) | -0.13 | 2.38 | 1.26 | 2.85 | 5.83 | 3.74 | 0.004** |
| | | GoGn(dif) | -0.18 | 2.04 | -0.33 | 2.07 | 3.45 | 1.35 | 0.015* |
| | Vertical | Go-Camper (dif) | -1.10 | 2.42 | 0.64 | 1.35 | 2.30 | 2.20 | 0.000** |
| | | J-Camper (dif) | -0.70 | 1.95 | 0.20 | 2.07 | -0.45 | 2.34 | 0.491NS |
| | | | -0.21 | 1.44 | 0.45 | 1.34 | 0.05 | 0.86 | 0.350NS |

§ Kruskal-Wallis test to identify intergroup differences.

NS: not-significant; *significant p≤0,05; ** significant p≤0,01

**Table 5.** Comparison of the skeletal components involved with the distinct sagittal skeletal patterns for each degree of mandibular asymmetry.

| | | | Class I | | Class II | | Class III | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Average | SD | Average | SD | Average | SD | p |
| Relative symmetry | Transverse | Gn-MSP | -0.06 | 1.36 | -0.33 | 1.49 | -0.16 | 2.14 | 0.158NS |
| | | Go-MSP (dif) | 0.06 | 2.12 | 0.37 | 2.22 | 0.51 | 2.43 | 0.485 NS |
| | | J-MSP (dif) | 0.13 | 2.90 | 0.08 | 0.95 | 0.06 | 1.05 | 0.772 NS |
| | Sagital | Go-Coronal (dif) | -0.21 | 2.35 | 0.33 | 2.27 | -0.13 | 2.38 | 0.524 NS |
| | | GoGn(dif) | 0.05 | 1.86 | -0.38 | 2.03 | -0.18 | 2.04 | 0.391 NS |
| | Vertical | CoGo (dif) | -0.42 | 2.31 | -0.61 | 2.21 | -1.10 | 2.42 | 0.392 NS |
| | | Go-Camper (dif) | -0.40 | 2.11 | -0.68 | 2.01 | -0.70 | 1.95 | 0.909 NS |
| | | J-Camper (dif) | -0.12 | 1.43 | -0.53 | 1.24 | -0.21 | 1.44 | 0.066 NS |
| Moderate asymmetry | Transverse | Gn-MSP | 2.79 | 0.56 | 2.64 | 0.55 | 2.95 | 0.60 | 0.245 NS |
| | | Go-MSP (dif) | -0.53 | 2.36 | -1.28 | 2.09 | -1.87 | 2.00 | 0.222 NS |
| | | J-MSP (dif) | -0.30 | 1.04 | -0.56 | 1.30 | 0.09 | 1.33 | 0.190 NS |
| | Sagittal | Go-Coronal (dif) | 0.12 | 2.69 | -0.41 | 2.25 | 1.26 | 2.85 | 0.241 NS |
| | | GoGn(dif) | 0.59 | 2.04 | 0.57 | 1.94 | -0.33 | 2.07 | 0.332 NS |
| | Vertical | CoGo (dif) | 0.45 | 1.74 | -0.06 | 2.46 | 0.64 | 1.35 | 0.898 NS |
| | | Go-Camper (dif) | 0.56 | 2.44 | 0.11 | 2.05 | 0.20 | 2.07 | 0.736 NS |
| | | J-Camper (dif) | 0.10 | 1.66 | 0.36 | 1.34 | 0.45 | 1.34 | 0.785 NS |
| Severe asymmetry | Transverse | Gn-MSP | 6.74 | 2.05 | 5.58 | 0.97 | 7.02 | 2.19 | 0.469 NS |
| | | Go-MSP (dif) | -1.78 | 2.59 | -3.87 | 2.49 | -2.96 | 2.27 | 0.393 NS |
| | | J-MSP (dif) | -0.62 | 1.54 | -1.69 | 2.57 | -0.52 | 1.17 | 0.741 NS |
| | Sagittal | Go-Coronal (dif) | 1.91 | 3.55 | -3.92 | 7.09 | 5.83 | 3.74 | 0.034* |
| | | GoGn(dif) | 2.52 | 1.90 | 4.41 | 4.04 | 3.45 | 1.35 | 0.389 NS |
| | Vertical | CoGo (dif) | 3.34 | 3.58 | 8.74 | 10.24 | 2.30 | 2.20 | 0.584 NS |
| | | Go-Camper (dif) | 2.34 | 3.36 | 7.10 | 8.04 | -0.45 | 2.34 | 0.111 NS |
| | | J-Camper (dif) | 1.73 | 1.58 | 3.79 | 2.64 | 0.05 | 0.86 | 0.016* |

## DISCUSSION

The main finding of this study suggests that adolescents between 10 and 19 years old, regardless their sagittal skeletal pattern, present some degree of lateral gnathion displacement. Assuming that the asymmetry might influence significantly, and negatively, individuals' psychosocial characteristics and their quality of life [3,31,32], being important to establish which are the determinant factors for facial asymmetry, this finding is clinically relevant and points to the care that clinicians should take in making an appropriate and timely diagnosis in order to plan the approach to be adopted, whether compensatory orthodontics or a future surgical approach.

Therefore, the three-dimensional (CBCT) evaluation of the skeletal characteristics of adolescents, categorized according to different sagittal skeletal patterns, is a significant advance in this study. The findings revealed differences between maxillary and mandibular components that will influence in the degree of mandibular asymmetry in the three skeletal patterns (Table IV). However, the scarce number of studies on the subject regarding adolescents, and using only 3D images analysis, made the discussion of data difficult.

In the transverse plane, and according to the expected, Gn-MSP values were significantly different among the degrees of the asymmetries for all the sagittal groups. Other studies [10,13,30,33,34] corroborate this finding, confirming that chin deviation is a relevant morphological alteration to determine asymmetry, and influences on its perception. However, Sanders et al. [35] showed that despite the lateralization of the gnathion in relation to the sagittal plane, this finding alone was not significant, suggesting that there might have happened some compensation of the condylar position and/or vertical position of the glenoid fossa with a consequent adjustment of the laterality of the jaw.

The results also showed that there was lateral deviation not only of the gnathion, but also of other structures, which is in accordance to other authors [30,33,34,36,37]. The transverse location of the gonion showed a significant difference among the three mandibular asymmetry degrees for Class I, II and III adolescents, being the highest average registered for Class II with severe asymmetry. However, in Class I adolescents, only severe asymmetry showed a significant difference, suggesting that in cases with a more harmonious maxillomandibular relationship in the anteroposterior direction, only severe cases show a difference in the lateral position of the gonion.

In the anteroposterior direction, Go-Coronal measure presented significant difference only for Class III individuals with severe asymmetry. Primozic et al. [38] found the same results and they stated that the changes in Class III have the tendency to get worse along the growth and development of the individual, mainly during the pubertal growth peak, which results in severe deformity, both in frontal and sagittal directions. On the other hand, Oyasenik et al. [39] showed similar statistical data for both symmetric and asymmetric Class III individuals. Such differences might be attributed to methodological differences related to the type of the image, the measures, and/or age group. Still on the sagittal plane, regarding the mandibular body (GoGn), there was a significant statistical difference for all the skeletal patterns with severe asymmetry.

Regarding the vertical position of the gonion, Class I and II adolescents, for all different asymmetry degrees, presented bilateral difference in relation to camper's plane. Class II adolescents with severe asymmetry also presented greater bilateral difference in the vertical position of this point, which suggests that the gonion of the contralateral side is positioned lower than the side of the mandibular deviation in this group. According to Uesugi et al. [40] such striking differences in the three-dimensional positioning of the gonion point in asymmetric patients might be related to muscle imbalance in these individuals.

The analysis of the behaviour of Gn-MSP, Go-MSP and Go-Camper measures suggests that when adolescents present severe gnathion asymmetry, the gnathion deviation in relation to the median sagittal plane seems to be related to a spatial displacement of the contralateral gonion, which tends to move downward in the direction of the median sagittal plane, resulting in a counter-clockwise rotation of the mandible.

Further evaluations on the vertical plane showed that mandibular ramus height CoGo (dif) was significantly different in patients with severe asymmetry in all the classes and, in Class III patients, the difference was also significant in individuals with relative and moderate asymmetry. The highest average was also observed in Class II individuals with severe asymmetry, which is similar to the results of other studies that evaluated this measure in adults [20].

Regarding the maxillary components evaluated, the positioning of the jugal point showed no difference in the transverse direction. However, in the vertical direction, there was a significant difference in Class II individuals (all the asymmetries), and Class I individuals (severe asymmetry), but none in Class III individuals. These findings suggest that in the vertical direction, bilateral differences of the maxillary position (J) in Class II and III patients followed the mandibular ones (Go) (Table IV).

Bilateral maxillomandibular components presented some variability in the three sagittal patterns, and in relation to the degree of mandibular asymmetry. It suggests that the asymmetries, when present, behave differently and independently of the sagittal skeletal pattern. Therefore, these points are highly relevant to be observed when dentists are planning the treatment of their patients, mainly when the patients are in an active growth phase, which suggests the need of further studies in this age group.

## CONCLUSIONS

1. Chin displacement is not the only skeletal change present in patients with asymmetry, as other variables showed significant differences when compared to the different deviation degrees in different sagittal skeletal patterns.
2. Bilateral differences found among the different degrees of asymmetry and sagittal skeletal patterns varied. Class II individuals presented the greatest bilateral difference in the positioning of the transversal and vertical gonion, and in relation to the length of the mandibular body in the severe degree of the mandibular asymmetry.
3. Bilateral differences of the maxilla positioning followed the mandibular one only in the vertical direction and in Class II and III patients.

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### Conflicts of Interest

The authors declare no conflicts of interest.

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