Morphometric analysis of the mandibular condyle of hyperdivergent individuals with class II and class III skeletal patterns

Análise morfométrica do côndilo mandibular de indivíduos hiperdivergentes com padrões esqueléticos de classe II e classe III

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ABSTRACT
Introduction: To compare the condyle morphology of individuals with hyperdivergent skeletal patterns in Class ii and Class iii skeletal patterns. Methods**:** Multislice Computed Tomography examinations of 41 individuals (82 temporomandibular joints), aged 18 to 42, with an accentuated vertical growth pattern, of whom 21 had a Class ii skeletal pattern and 20, a Class iii skeletal pattern were evaluated retrospectively. The following measurements were taken: width (d1), thickness (d2), horizontal angle (a1), and anterior angle (a2) of the condyle. The normality of data distribution was verified by means of descriptive statistics, graphical analysis, and the Shapiro-Wilk test. The Student's-*t* test was used to compare the measurements between the groups tested. The Pearson Correlation was used to identify correlations among quantitative measurements. A 5% level of significance was used for all tests. Results**:** There was statistically significant difference between groups for the four measurements analyzed ($P < 0.05$). D1 and d2 values were lower for hyperdivergent individuals with a Class ii skeletal pattern. A1 was higher for hyperdivergent individuals with a Class ii skeletal pattern, and a2, higher for hyperdivergent individuals with a Class III skeletal pattern. Conclusions: Hyperdivergent individuals with a class ii pattern have a condyle with a smaller thickness and width, than individuals with a class iii pattern, and these characteristics should be considered when planning the orthodontic and orthognathic treatments.

Keywords: temporomandibular joint, mandibular condyle, tomography, cephalometry, Maxillofacial Development.

RESUMO
Introdução: comparar a morfologia do côndilo de indivíduos com padrões esqueléticos hiper divergentes nas classes II e III. Métodos: exames de tomografia computorizada multislice de 41 indivíduos (82 articulações temporomandibulares), com idades compreendidas entre 18 e 42 anos, com um padrão de crescimento vertical acentuado, dos quais 21 tinham um padrão esquelético de classe ii e 20, um padrão esquelético de classe iii foram avaliados retrospectivamente. Foram feitas as seguintes medições: largura (d1), espessura (d2), ângulo horizontal (a1), e ângulo anterior (a2) do côndilo. A normalidade da distribuição dos dados foi verificada por meio de estatística descritiva, análise gráfica, e o teste shapiro-wilk. O teste-t do aluno foi utilizado para comparar as medições entre os grupos testados. A correlação pérola foi utilizada para identificar correlações entre as medições quantitativas. Foi utilizado um nível de 5% de significância para todos os testes. Resultados: houve diferença estatisticamente significativa entre os grupos para as quatro medições analisadas ($p < 0,05$). Os valores D1 e d2 foram mais baixos para indivíduos hiper divergentes com um padrão esquelético de classe II. A1 foi superior para indivíduos hiper divergentes com um padrão esquelético de classe ii, e a2, superior para indivíduos hiper divergentes com um padrão esquelético de classe iii. Conclusões: os indivíduos hiper divergentes com um padrão classe ii têm um côndilo com menor espessura e largura do que os indivíduos com um padrão classe iii, e estas características devem ser consideradas no planeamento dos tratamentos ortodônticos e ortográficos.

Palavras-chave: articulação temporomandibular, côndilo mandibular, tomografia, Cefalometria, desenvolvimento maxilofacial.

1 INTRODUCTION

The relationship between different growth patterns and the morphological characteristics of the temporomandibular joint (TMJ) have frequently been the objects of investigation [1-6]. It is now known that there is a relationship between condylar morphology and temporomandibular dysfunction [7-10].

Individuals with a hyperdivergent skeletal pattern tend to have smaller condyles when compared with those with the hypodivergent pattern [4, 11, 12]. Individuals with a Class III skeletal pattern have larger condylar dimensions, as well as smaller horizontal angulation of the condyle than individuals with a Class II skeletal pattern [2, 3, 5, 13, 14]. In addition, greater condylar decentralization in the mandibular fossa, in the sagittal view, was observed in the Class II group [15, 16].

Mandibular condyles with smaller width and thickness [8, 10], and with an accentuated anteromedial angulation [7] are more likely to have joint disc displacement [8, 10]. It is also known that there is a strong relationship between the condylar axis and idiopathic condylar resorption [9]. An anatomical profile that predisposes to disc displacement indicates the need for special occlusal and orthofunctional care in patients with these characteristics, in order to prevent disruption within the internal aspects of the TMJ [17]. In addition, the mandibular condyle plays a fundamental role in the long-term outcomes in terms of stability after orthodontic and orthognathic treatments [3].

Several authors have reported that individuals with accentuated vertical growth (hyperdivergent subjects) have smaller condylar dimensions. However, few TMJ morphometric studies have related the vertical growth pattern to the anteroposterior growth pattern [5, 11]. Therefore, this study was conducted to verify whether the anteroposterior growth pattern is related to the condylar measurements of hyperdivergent individuals.

2 MATERIALS AND METHODS

This retrospective study was approved by our institutional ethics committee. All images evaluated in this research were captured for the purpose of preoperative orthognathic planning. Our exclusion criteria were any degenerative alterations of the condyle, history of fracture, neoplasms, developmental abnormalities of the bone components of joints or systemic diseases potentially affecting joint morphology.

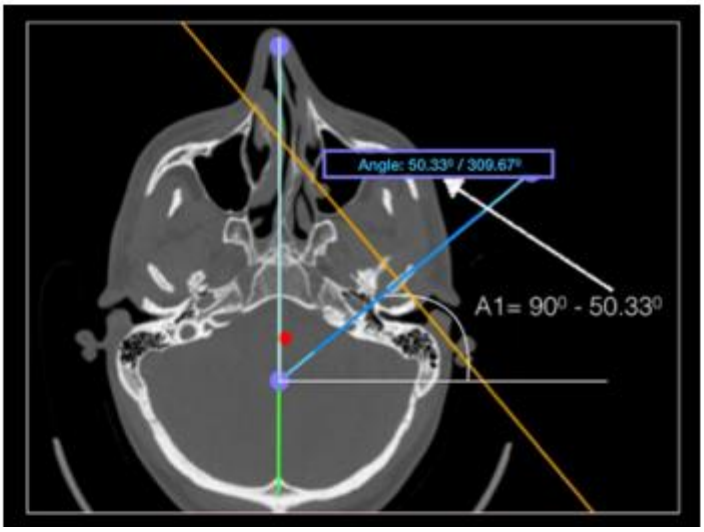
The sample of this observational cross-sectional retrospective study consisted of Multislice Computed Tomography examinations of 82 TMJs of patients of both genders, aged 18 to 42, hyperdivergent, of whom 21 had a Class II skeletal pattern and 20, a Class III skeletal pattern. The classification of skeletal pattern – Class II and Class III – of the individuals included was defined by digital lateral cephalometric radiographs, using point A, nasion (N), point B, ANB angle measurement of Steiner's analysis (Class II ANB>4^0 or Class III ANB<0^0). The vertical growth pattern was defined by the angle of the Frankfort mandibular plane (FMA) of Tweed's analysis and by the GoGn-SN angle of Steiner's analysis (FMA>29^0 and GoGn-SN>36^0).

During image acquisition, they remained in occlusion, without swallowing, in a supine position, with the Median Sagittal Plane (PSM) and Frankfurt Horizontal Plane (PHF) perpendicular to the horizontal plane. The images were acquired using a 512x512 matrix, with a FOV (field of view / field of view) covering the size of the patient's head, Gantry Tilt at 0^0, slice thickness of 0.6 mm and interval of 0.2 mm between slices.

Tomographic images were evaluated by using the OsiriX Lite® software tools, and measurements were performed in a low light environment on an Apple® Mac Book Pro, considering two linear and two angular measurements, as described below:

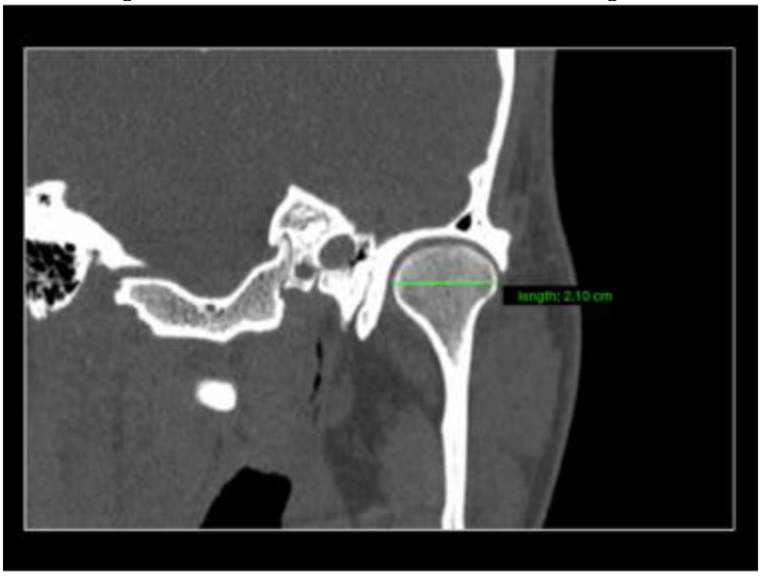
- A1 (horizontal angle) - angle formed by the extension of the major condylar axis with the coronal plane, established in the axial image. To obtain this angle, the median sagittal plane was established, the angle formed between the extension of the major condylar axis and this plane was measured, and then the value found was subtracted from 90º (Fig 1);

Figure 1. Illustration of the method for obtaining A1.



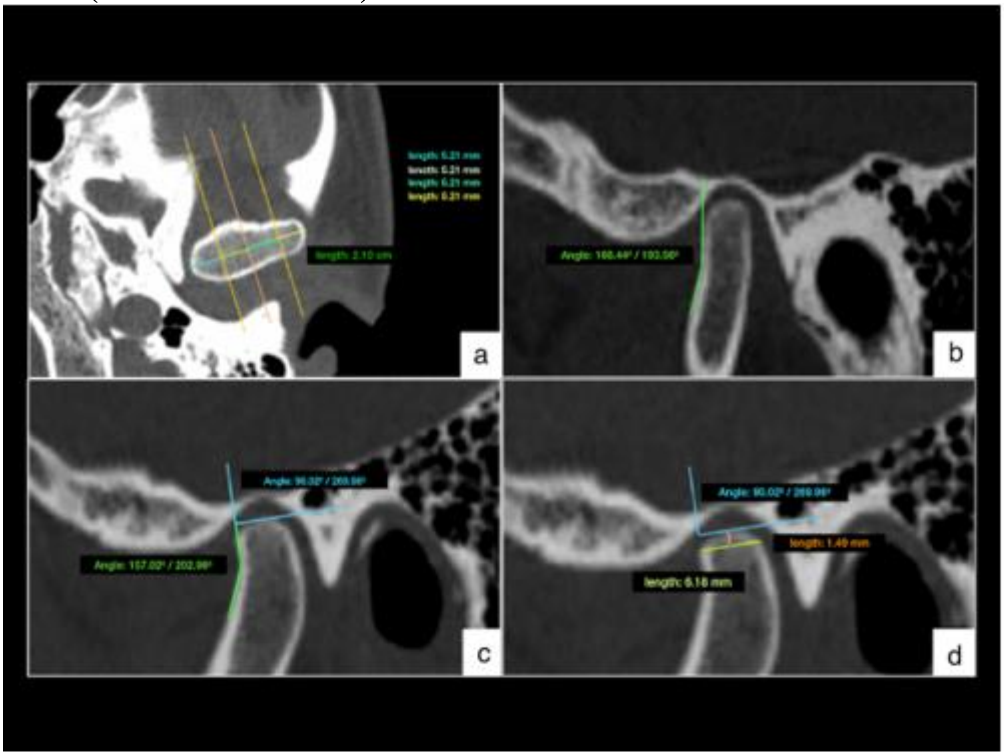
- D1 (width) - distance, in millimeters, between medial and lateral poles of the mandible, from cortex to cortex, obtained at the central coronal slice (Fig 2);

Figure 2. Illustration of the method for obtaining D1.



- A2 (anterior angle) - angle formed between the head and neck of the mandible, measured in the parasagittal plane and on the anterior surface, at three distinct points: in the center of the condyle (A2C), in its medial half (A2M), and in its lateral half (A2L). The A2 value corresponded to the average of A2C, A2M, and A2L. (Fig 3a,b);
- D2 (thickness) - distance, in millimeters, between anterior and posterior limits of the condyle, from cortex to cortex, obtained in parasagittal slices and at three distinct points: in the center of the condyle (D2C), in its medial half (D2M), and in its lateral half (D2L). This measurement was taken 1.5 mm below the tangent to the upper contour of the condyle. This tangent is perpendicular to the line that forms the A2 angle. The D2 value corresponded to the average of D2C, D2M, and D2L (Fig 3a,c,d) [8].

Figure 3. Illustration of the method for obtaining A2 and D2. (A) Axial plane of the mandible head, showing its division into four equal parts, in which A2 and D2 were measured; (B) Parasagittal section, showing A2 measurement (mandible head anterior angle); (C) and (D) Parasagittal sections, showing the method for obtaining D2 measurement (mandible head thickness).



In order to perform the inter- and intra-examiner agreement tests, 40% of the samples were evaluated by two pre-calibrated examiners (PhD in Oral and Maxillofacial Radiology) who analyzed each of the samples at two different times, with a two-week interval between evaluations. After obtaining a excellent agreement (ICC≥0,94), measured by the intraclass correlation coefficient, and consequent validation of the method, a single examiner evaluated all images of the study.

The database elaboration and descriptive analysis were performed using the R software (version 3.5.0, R Foundation for Statistical Computing, Vienna, Austria). Categorical variables were expressed as frequencies and percentages, and continuous variables were expressed as average and standard deviation. The normality of data distribution was verified by using descriptive statistics, graphical analysis, and the Shapiro-Wilk test. After verifying normal distribution, the Student's-*t* test was used to compare the measurements between the groups tested. In order to identify correlations among quantitative measurements, the Pearson Correlation was used. A 5% level of significance was used for all tests.

3 RESULTS

Of the 54 Computed Tomography examinations, 41 examinations were used in the study, of which 21 were of individuals with a Class II skeletal pattern and 20, with a Class III skeletal pattern, totaling 82 TMJs.

There was a significant difference between Class II and Class III skeletal patterns in individuals with an accentuated vertical growth pattern, for all measurements studied (Table 1).

When assessing the horizontal angle of the condyle (A1), the Class II group had higher values (mean of 27.12º) than the Class III group (mean of 19.25º), with a high statistical significance ($P < 0.001$) (Table 1).

In all measurements performed to obtain the anterior angle of the condyle (A2), there was statistical difference between groups for A2L and A2C measurements ($P < 0.001$) and for the A2M measurement ($P = 0.004$). Likewise, when the mean between the angles (A2) was assessed, the values were significantly higher in the Class III group (165.33º) than in the Class II group (154.01º) ($P < 0.001$) (Table 1).

Relative to the condylar mediolateral width (D1), Class III individuals had a significantly higher mean value (20.21 mm), when compared with Class II individuals (16.83 mm) ($P < 0.001$) (Table 1).

In the condylar thickness (D2) evaluation, significant difference was observed for D2M values ($P < 0.05$), but there was no statistical difference for D2L ($P = 0.137$) and D2C ($P = 0.084$) values. However, the mean value of the condyle thickness was significantly lower in the Class II group (5.19 mm) than in the Class III group (5.58 mm) (Table 1).

Table 1. Comparison of linear and angular measurements, for hyperdivergent individuals with class II and class III skeletal patterns.

Measurements	Skeletal patterns				
	Class II		Class III		p-value
	Average	SD	Average	SD	
A1	27.12º	10.30º	19.25º	6.42º	< 0.001*
D1	16.83 mm	1.74 mm	20.21 mm	1.95 mm	< 0.001*
A2	154.01º	7.87º	165.33º	5.86º	< 0.001*
D2	5.19 mm	0.84 mm	5.58 mm	0.63 mm	0.021*

* Statistically significant
Legends: **A1** - horizontal angle / **D1** - condyle width / **A2** - anterior angle / **D2** - thickness

4 DISCUSSION

It is imperative to analyze the TMJ morphological characteristics when diagnosing and planning orthodontic and orthognathic treatments, since joint structures can cause instability in the result achieved [18]. Therefore, Computed Tomography examinations are the exam of choice to analyze this factor, due to the high quality of the images for assessing bone components [19, 20].

In this study, the condyle width was significantly smaller in hyperdivergent individuals with a Class II skeletal pattern, when compared with individuals with a Class III skeletal pattern, corroborating the findings of previous studies [3, 5, 11, 12, 13].

Krisjane et al. [2] and Hasebe et al. [11], found no statistically significant difference in the condyle thickness of individuals with Class II and Class III skeletal patterns. However, these authors performed the measurement in the sagittal plane at a single point, not considering that the condyle thickness can vary from medial to lateral point. We believe that the average thickness calculated using the values of measurements taken in three different segments, is more representative of the mandibular condyle thickness. This allowed us to affirm that hyperdivergent individuals with a Class II skeletal pattern had a sharper tapering condyle than individuals with a Class III pattern.

It is known that a condyle with lower volume, with limited thickness and/or width, is associated with joint disc displacement [8, 10]. Thus, it seems legitimate to state that joint disc displacement occurs more frequently in hyperdivergent individuals with a Class II skeletal pattern.

An accentuated horizontal angle and a lower anterior angle is also associated with joint disc displacement [7, 8], the morphology found in hyperdivergent individuals with a Class II pattern.

Kristensen et al. [9] found an association between higher horizontal angles and idiopathic condyle resorption ($p < 0.001$). Based on the results of the present study, it could be inferred that hyperdivergent individuals with a Class II skeletal pattern were more likely to have idiopathic mandible head resorption.

Fraga et al. [14] and Paknahad et al. [15] observed that individuals with a Class II skeletal pattern present the condyle positioned more anteriorly in the mandibular fossa, which may be associated with the lower anterior angle of the condyle. Therefore, it would be expected that individuals with a Class III skeletal pattern, with a greater anterior angle, would have the condyle positioned more centrally in the mandibular fossa.

5 CONCLUSION

The morphometric characteristics of the mandibular condyle are influenced to a greater extent by the anteroposterior skeletal pattern than by the vertical skeletal pattern. Hyperdivergent individuals with a class II pattern have a condyle with a smaller thickness and width, than individuals with a class III pattern, and these characteristics should be considered when planning the orthodontic and orthognathic treatments.

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