Anatomic Variations of Mandibular Condyles in Brazilian Specimens

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Abstract

Objective To describe the morphological characteristics and asymmetries between the left and right mandibular condyles in Brazilian cadaveric specimens.

Material and Methods Thirty-two jaws were placed on a rigid support for image acquisition of the frontal and lateral views. The shapes of the mandibular condyles were classified, and measurements of the distance between the anatomical landmarks in the lateral and frontal views were performed.

Results Mandibular length and width were not different between the right and left sides. Regarding the shapes of the mandibular condyles, the rounded type was the most frequent, followed by marked medial slope; flattened; overhanging lateral and medial slopes; downward flattening of both slopes and their merger in a single, extensive surface; and deformity and marked lateral slope with flaring and flattening. Asymmetry between the left and right mandibular condyles was present in 40% of the specimens.

Conclusion The anatomy of mandibular condyles varies greatly, and this knowledge can avoid misdiagnosis by image examination of the anatomic variations.

Keywords
- mandibular condyle
- jaw
- anatomic variation
- temporomandibular joint

Introduction

The only freely movable articulation in the skull is the temporomandibular joint (TMJ). The TMJ has peculiar characteristics, such as the presence of fibrocartilage on the articular surfaces and the achievement of complex and synchronous movements between the mandibular condyles and the right and left temporal bones.[1] As part of the TMJ structure, the mandibular condyle plays an important role as the primary center of growth in the jaw, and it serves as the pivot end of the rotation of the jaw in the skull.[2] Its surface morphology and bone density correlate with the pathogenesis of mandibular asymmetry and bilateral imbalanced occlusal force. Also, these characteristics play a key role in the stability of long-term treatment results after orthodontic and orthognatic treatments.[3]

Variations in the normal morphology of the mandibular condyle occur due to age, gender, ethnicity, facial type, occlusal force, functional load, and malocclusion, and can also occur between the right and left sides.[4] Morphometric analyses of the structure of the mandibular condyle and of the condylar process are routinely evaluated by anatomists, radiologists, surgeons and clinicians, and are important for the diagnosis and surgical approaches in the clinical practice.

Previous studies have categorized mandibular condyles into four basic types: flattened, convex, angled, and rounded, in a series of studies on human jaws from a large collection of dry skeletons.[5–7] However, another study has determined eight typical mandibular condyle shapes in 100 crania from male and female subjects in a study about TMJ and occlusion.[8]

Several temporomandibular joint disorders (TMDs), such as hyperplasia, hypoplasia, bifid mandibular condyle, osteoarthritis, and tumors of the TMJ are characterized by morphological changes of the mandibular condyle and have been studied with various imaging modalities.[9] Hence, it is

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necessary to have a thorough understanding of the anatomy and of the morphology of the TMJ to ensure that a normal variant can be distinguished from an abnormal condition.[9]

Understanding the morphological patterns among different populations is particularly important, since variations in different ethnicities have important implications in medicine, plastic surgery, oral/maxillofacial surgery, and genetics. Therefore, the aim of the present study was to describe the morphological characteristics and asymmetries between the left and right mandibular condyles in Brazilian cadaveric specimens.

Material and Methods

The present study was performed at the Human Anatomy Laboratories of the Biological Sciences Institute of the Universidade Federal de Minas Gerais (UFMG), located in the state of Minas Gerais, Brazil. Thirty-two jaws were included in the study. The jaws belonged to mature specimens, but their exact age and gender are unknown. The inclusion criterion was to have the right and left mandibular condyles preserved. The bones were placed on a rigid support, 30 cm away from the digital camera for image acquisition of the frontal and lateral views. All of the photographs were taken by the same examiner. The shapes of the mandibular condyles were determined according to the following previous classification: (1) rounded; (2) flattened, overhanging lateral and medial slopes; (3) marked lateral slope with flaring and flattening; (4) marked medial slope; (5) downward flattening of both slopes and their merger in a single, extensive surface; (6) thin mandibular condyle with backward flattening; (7) triangular flaring of the lateral slope corresponding to a distinct bone crest rising vertically along the anterior wall of the mandibular condyle; and (8) a more or less marked depression in the posterior wall.[8]

To assess the dimensions of the mandibular condyles, measurements of the distance between the anatomic landmarks in the lateral and frontal views of the mandibular condyles were performed (►**Fig. 1**). For this purpose, the following definitions were considered according to Schlueter et al (2008).[10]:

- **M** (medial mandibular condyle surface): most medial point of the mandibular condyle on the frontal view.
- **L** (lateral mandibular condyle surface): most lateral point of the mandibular condyle on the frontal view.
- **A** (anterior mandibular condyle surface): most anterior point of the mandibular condyle on the lateral view.
- **P** (posterior mandibular condyle surface): most posterior point of the mandibular condyle on the lateral view.
- **M-L** (mandibular condyle width): the distance between the M and L landmarks, corresponding to the largest dimension of the mandibular condyle on the frontal view.
- **A-P** (mandibular condyle length): the distance between the A and P landmarks, corresponding to the largest dimension of the mandibular condyle on the lateral view.

Image analyses were performed using the ImageJ software (National Institutes of Health, Bethesda, MD, USA) and all of the data were analyzed using Microsoft Excel (Microsoft Corporation, Redmond, WA, USA) and GraphPad Prism 5 (GraphPad Software, La Jolla, CA, USA). The means ± standard error of the mean (SEM) for each group were calculated and compared. Statistical significance was evaluated using the unpaired Student *t*-test. Values of $p \leq 0.05$ were considered significant.

Results

No Differences between the Anteroposterior and Mediolateral Measurements of the Right and Left Mandibular Condyles

The mandibular condyle length (A-P dimension) and width (M-L dimension) were not different between the right and left sides. The minimum and maximum values, means, and SEM are shown in ►**Table 1**.

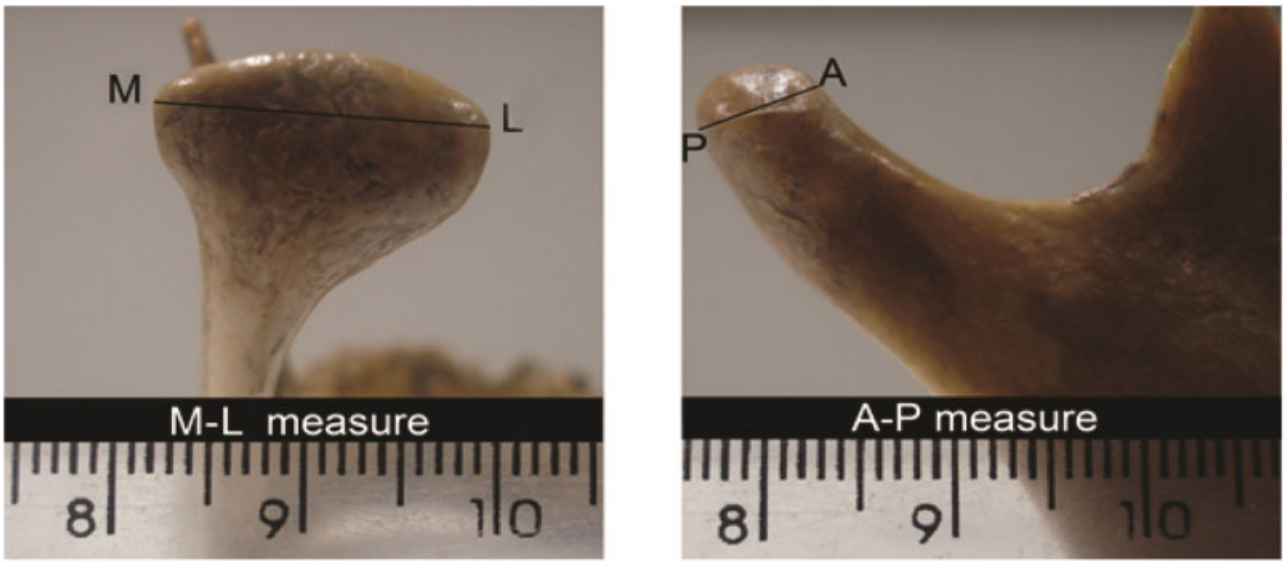

Fig. 1 Mediolateral and anteroposterior measurements of the mandibular condyle surfaces. The left panel shows the mediolateral measurement in the frontal view, and the right panel shows the anteroposterior measurement in the lateral view. Abbreviations: A-P, anteroposterior; M-L, mediolateral.

Table 1 Mandibular condyle length (anteroposterior dimension) and width (mediolateral dimension)

Column Statistics	Mediolateral right cm ($n = 32$)	Mediolateral left cm ($n = 32$)	Anteroposterior right cm ($n = 32$)	Anteroposterior Left cm ($n = 32$)
Minimum	0.88	0.89	0.36	0.31
Maximum	1.35	1.37	0.90	0.94
Mean	1.10	1.09	0.50	0.45
Standard error	0.02	0.02	0.02	0.02

Mandibular condyle length (anteroposterior dimension) and width (mediolateral dimension) Minimum and maximum values, mean and standard error of mean of the right and left mandibular condyle dimensions.

Shapes of the Mandibular Condyles

Regarding the shapes of the mandibular condyles, the following types were observed: (1) rounded; (2) flattened, overhanging lateral and medial slopes; (3) marked lateral slope with flaring and flattening; (4) marked medial slope; (5) downward flattening of both slopes and their merger in a single, extensive surface (►**Fig. 2A**). Moreover, some mandibular condyles with deformities were detected (►**Fig. 2B**).

The most frequent type was type 1 (rounded), followed by type 4 (marked medial slope), type 2 (flattened, overhanging lateral and medial slopes), type 5 (downward flattening of both slopes and their merger in a single, extensive surface), and type 3 (deformity and marked lateral slope with flaring and flattening) (►**Table 2**).

Asymmetry between the Right and Left Sides

Furthermore, the frequency of asymmetry between the left and right mandibular condyles of the same jaw was analyzed, and 60% showed bilateral symmetry, while 40% demonstrated asymmetry (►**Fig. 3**).

Table 2 Frequency of mandibular condyle shapes

Mandibular condyle shapes according to Mongini (1977)	Number of mandibular condyles	Percentage (%)
1 — rounded	23	36
2 — flattened, overhanging lateral and medial slopes	9	14
3 — marked lateral slope with flaring and flattening	2	3
4 — marked medial slope	19	30
5 — downward flattening of both slopes and their merger in a single, extensive surface	7	11
6 — deformities	4	6
Total	64	100

Discussion

Morphological and morphometric methods are the two basic tools to study skull anatomy. Variations in mandibular

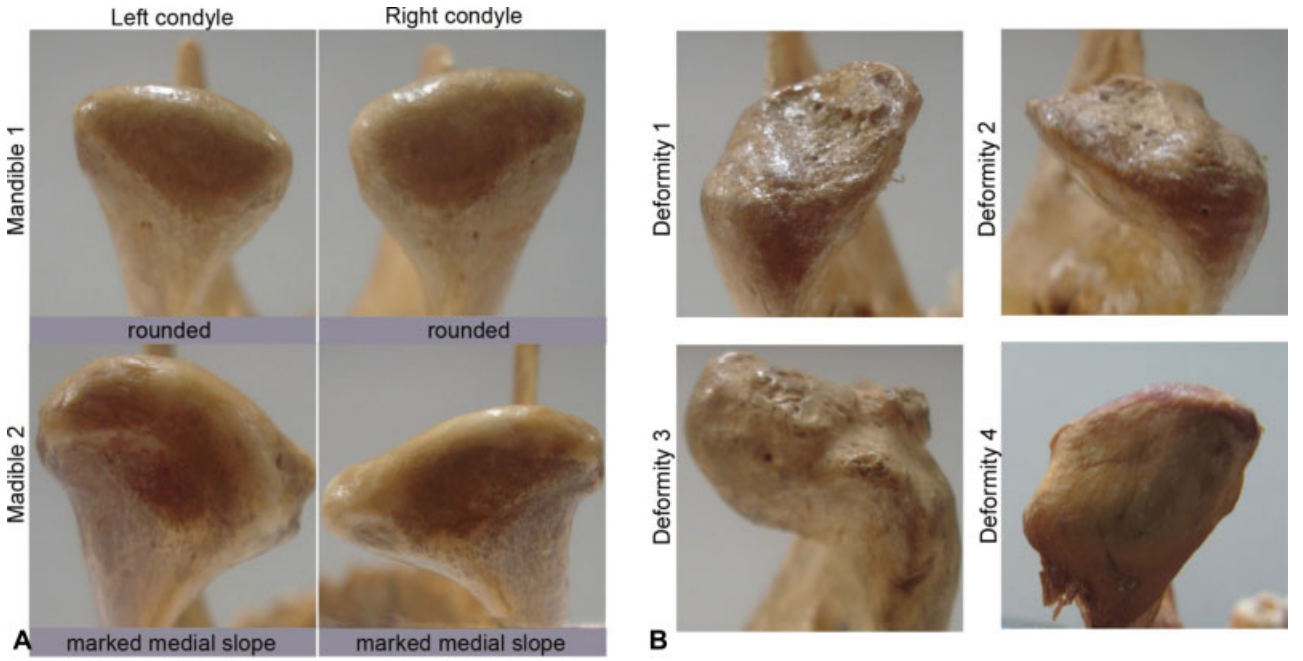

Fig. 2 Mandibular condyle shapes and asymmetry between the right and left sides. (**A**) Representative images of mandibular condyle shapes showing symmetry between the right and left sides in jaws 1 and 2; (**B**) Representative images of deformity in some mandibular condyles.

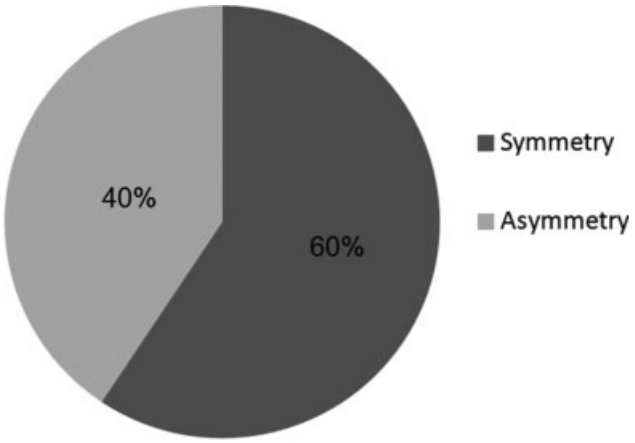

Fig. 3 Frequency of symmetry and asymmetry between right and left mandibular condyles.

morphology occur due to several factors and understanding the morphological patterns among different populations has important implications in dental practice. The present study aimed to describe the morphological characteristics and asymmetries between the left and right mandibular condyles in Brazilian cadaveric specimens.

Previous studies have measured the dimensions of the mandibular condyles in coronal and lateral views through a delimitation of the most prominent medial and lateral points. According to gender, the range of measures in the mediolateral (M-L) dimensions was between 2.02 and 2.21 cm in males and between 1.84 and 2.06 cm in females, while the anteroposterior (A-P) measurements ranged between 0.8 and 1.0 cm in males and between 0.78 and 0.98 cm in females.[5] In the present work, the mandibular condyle length (A-P) and width (M-L) had a lower average (1.1 and 0.48 cm, respectively). However, the gender and the age of the specimens could not be obtained. No difference was detected between the right and left sides, as previously observed.[10–12]

Regarding the evaluation of the morphology, many studies have described different methods for classification of the different types of mandibular condyles. According to Mongini's classification, the rounded mandibular condyle was the most frequent type observed here, followed by the marked medial slope.[8] These findings are in line with other studies.[7,11,12] The flattened with overhanging lateral and medial slopes shape was the third most frequent in this work. This type was the second most frequent elsewhere[7,12], which shows it is a common type of anatomic variation of mandibular condyles. In the present study, a few deformities were also found, which may be associated with traumas, developmental defects, and tumors, such as osteoma, osteochondroma and osteosarcoma.[9] Unfortunately, it was not possible to obtain information regarding the gender, age, and clinical data of the analyzed specimens, which is a limitation of the present study.

However, in the literature, only a few publications have described left-right asymmetries and anatomic variants of the TMJ in cadaveric specimens. The present work has shown that 60% of the jaws have bilateral symmetry in Brazilian specimens, which is in line with a previous study that has also found more similarities than dissimilarities in the size and in the form of the mandibular condyles.[10,13]

Conclusion

The appearance of the mandibular condyles varies greatly among different age groups and individuals, and it is important to know the possible morphological types and frequencies to avoid misdiagnosis of pathologies by image examination of an anatomic variation. Hence, these data are relevant for the clinical practice in the Brazilian population and can improve the diagnosis, prognosis, and mechanism-based therapy.

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