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Correlation of the gonial angle with condylar measurements on dry mandible: a morphometric study for clinical-surgical and physiotherapeutic practices

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SUMMARY

The aim of this study was to establish morphometrically a correlation of gonial angle size with condylar measures on Brazilian mandibles. For this purpose, we analyzed 220 mandibles. The measurements obtained were: length, in millimeters (mm), of each mandibular condyle (left/right), on two planes: anteroposterior and mesolateral; and gonial angle, in degrees (A°), on each side of the mandible. Data were analyzed using the Kolmogorov-Smirnov test, Pearson's test and the Mann-Whitney unpaired test, considering differences with $p<0.05$ as significant. The morphometric correlation of the parameters analyzed in the mandibles showed a statistically significant positive Pearson correlation. Our results support a multifactorial model of structural variations of the condyle and angle of the mandible, and these factors determine the morphological characteristics of the mandible. In addition, we suggest that they should be considered in clinical-surgical evaluations and be remembered during the procedures used for physiotherapy.

Key words: Gross Anatomy – Mandible – Condyle – Gonial angle – Morphometry

INTRODUCTION

Craniofacial skeletal development depends on controlled proteolytic processes in extracellular matrices mediated by elements of the large family of matrix metalloproteases and their physiological inhibitors, the tissue inhibitors of metalloproteases (Chin and Werb, 1997; Olsen et al., 2000).

The mandible is a paired bone that develops within the mandibular arch, embedding teeth and forming an articulation of the jaw with the cranium: the temporomandibular joint (TMJ) (Glasstone, 1971; Ramaesh and Bard, 2003). This bone is originated from pri-

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mary intramembranous ossification in the fibrous mesenchymal tissue around the Meckel cartilage. Growth of the mandibular body and condyle appears during week 7 after fertilization (Lee et al., 2001). Before 1 year of age the mandible is less developed than the maxilla in the sagittal dimension. In the meantime, it undergoes major subsequent growth increments in the following years (Farkas et al., 1992), specially during years 7 and 15 of development (Lux et al., 2004).

Several studies have been carried out stressing mandibular morphology or morphometry in regard to biomechanics and masticatory and occlusive functions (Spyrides et al., 1992; Kieser, 1999; Brandão et al., 2001; He, 2004; Al-Hiyasat and Abu-Alhaija, 2004), using mandibular measurements as a vehicle to explore and develop new statistical methods and techniques (Martin, 1936; Morant et al., 1936) or to perform comparative studies of sexual dimorphism in many animals and in humans (Wood, 1976; 1985; Wood et al., 1991; Humphrey, 1999). A relatively large body of information is available concerning the spatial development and developmental changes that occur in the facial bones, together with aspects linked to conservative or surgical treatment (Awofala, 1985; Vale et al., 1994; Guedes et al., 2001; Schendel and Linck, 2004), as well as some reported variations in human mandibular morphology and morphometrics (Lee and Choi, 1961; Murphy, 1957; Aitchison, 1964; Aitchison, 1965; Landín and Ayala, 1985; Chang and Lee, 1990), and even surgical and morphological analyses (Swennen et al., 2004). However, few data have been found in the literature that specifically establish morphometric correlations between a condyle and an angle in a human mandible. Therefore, the aim of the present study was to analyze condyle morphology on two morphometric planes and to verify the correlation with the angle value in dry mandibles from a Brazilian population.

MATERIAL AND METHODS

The protocol for the present research project was approved by a suitable Ethics Committee for human research and the work was carried out under the provisions of the Helsinki declaration in 1995 (as revised in Edinburgh, 2000). The guidelines for our internal review board were met for the observations made here. We used 220 dry mandibles from the collection of five universities in the city of Rio de Janeiro.

Morphometric parameters

To study mandibular morphology, direct measurements were taken from dry mandibles. Linear measurements of mandibular condyles were made with a digital pachymeter (mm). To measure the gonial angle (A°) a goniometer was used. All measurements were performed by the authors.

The length measurements of each mandibular condyle (left/right) obtained in millimeters (mm) on two planes were:

a) Antero-posterior (Fig. 1) — left: LAPP / right: RAPP

b) Mesolateral (Fig. 2) — left: LMLP / right: RMLP

The angular measurements obtained in degrees (A°) were: left mandibular angle (LMA) and right mandibular angle (RMA) (Fig. 3).

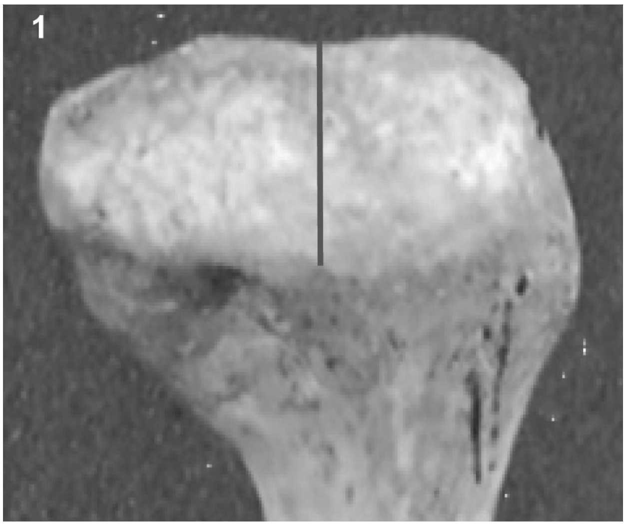

Figure 1. Measurement position of mandibular condyle on antero-posterior plane. Superior view.

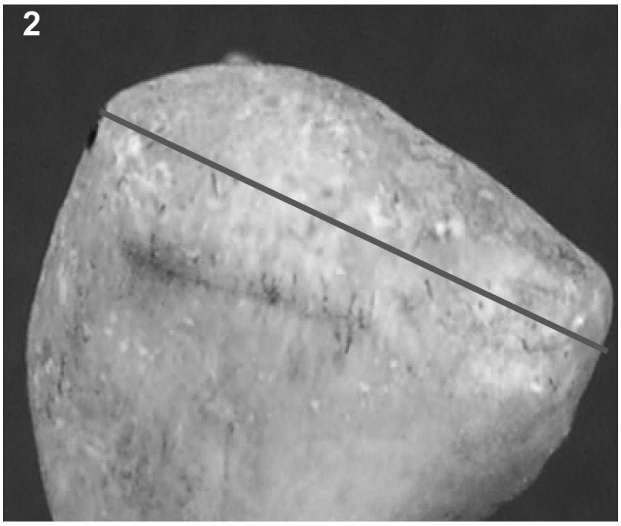

Figure 2. Measurement position of mandibular condyle on mesolateral plane. Superior view.

Criterion for the exclusion of a sample

All children's and elderly persons' mandibles as well as unilaterally or bilaterally damaged mandibles were excluded.

In all samples, the presence of the right and left condyle was considered indispensable for us to be absolutely sure that the specimens studied belonged to the same original mandible, so that the statistics would afford reliable results. Variables such as age, sex and race were not considered.

Statistical analysis

Graph Prism software was used in the statistical evaluation of the measurement results. From these measurements, means and standard deviations (means±SD) were calculated. The data were analyzed using the Kolmogorov-Smirnov test to check Gaussian distribution; by Pearson's test to analyze correlations, and by the Mann-Whitney unpaired "t" test to quantify the differences among groups, considering differences with $p<0.05$ as significant (Mandarim-de-Lacerda, 1999; Arango, 2001).

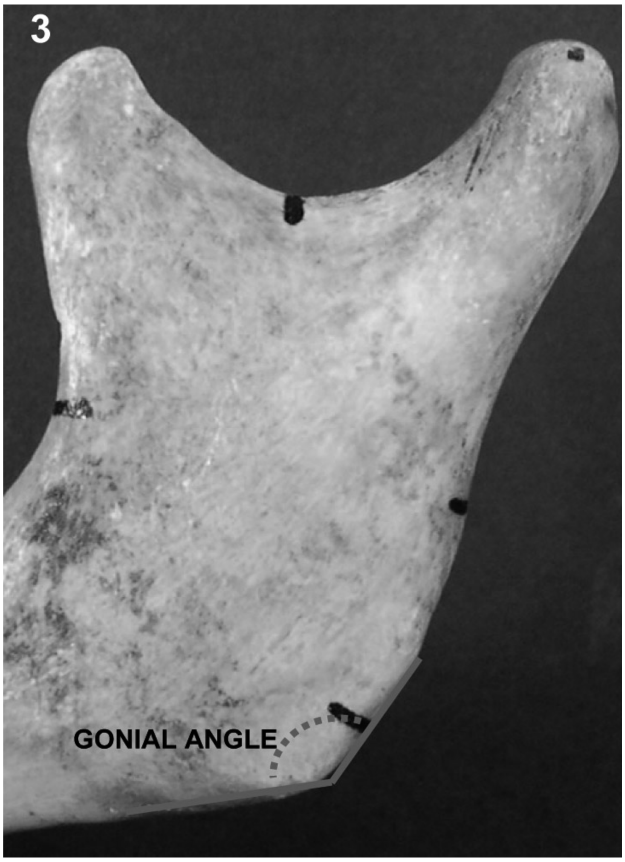

Figure 3. Measurement position of mandibular gonial angle. Superior view. Profile view of lateral side.

RESULTS

The linear and angular morphometric data analyzed on the left and right sides of the mandible are shown respectively in tables 1 and 2. All group samplings were evenly distributed according to Gaussian curvature.

Table 1. Data obtained on left side mandibles.

	Range	Mean	SD
LMA	106 / 145	128.25°	±6.56
LAPP	5.04 / 13.71	8.41mm	±1.25
LMLP	10.99 / 25.04	18.98 mm	±2.43

Table 2. Data obtained on right side mandibles.

	Range	Mean	SD
RMA	110 / 146	127.68°	±6.09
RAPP	12.09 / 25.10	8.64mm	±1.47
RMLP	4.40 / 12.99	19.15mm	±2.34

The morphometric correlation of the parameters analyzed on the left side (Table 3) and on the right side (Table 4) of the mandibles showed a positive Pearson correlation that was statistically significant.

The compared average measurements of the groups on the left and right sides are shown in Tables 5 and 6, respectively.

Table 3. Data correlated on left side mandibles.

	r	r^2	Conf Int (95%)	P value
LMA X LMLP	-0.3944	0.1556	-0.5006 to -0.2765	0.0001*
LMA X LAPP	-0.2127	0.0452	-0.3356 to -0.08272	0.0015*
LMLP X LAPP	0.2012	0.0405	0.0707 to 0.3248	0.0027*

* Significant

Table 4. Data correlated on right side mandibles.

	r	r^2	Conf Int (95%)	P value
RMA X RMLP	-0.3274	0.1072	-0.4406 to -0.2039	0.0001*
RMA X RAPP	-0.1947	0.03792	-0.3188 to -0.06407	0.0037*
RMLP X RAPP	0.2441	0.05956	0.1155 to 0.3646	0.0003*

* Significant

Table 5. Comparison of data among the average measurements on left side mandible groups.

	Mean difference	Conf Int (95%)	P value
LMA X LMLP	-119.84	-120.73 to -118.96	0.0001*
LMA X LAPP	-109.27	-110.20 to -108.34	0.0001*
LMLP X LAPP	-10.572	-10.934 to -10.210	0.0001*

* Significant

Table 6. Comparison of data among the average measurements on right side mandible groups.

	Mean difference	Conf Int (95%)	P value
RMA X RMLP	-108.54	-109.40 to -107.67	0.0001*
RMA X RAPP	-119.04	-119.87 to -118.21	0.0001*
RMLP X RAPP	-10.505	-10.871 to -10.138	0.0001*

* Significant

DISCUSSION

Cells may feel mechanical changes and can make alterations and adaptations in the structure of the tissues and their functions. Mechanical stimuli govern processes such as cellular division and differentiation and determine the form of the tissues (Benjamin and Hillen, 2003). Thus, alterations in any of the components of the masticatory system cause reactions and adaptations in the others, and this may lead to a functional unbalance in the system, affecting TMJ function and other craniomandibular structures involved in the mastication (Vasconcellos, 1991).

The condyle has an irregular cylindrical shape due to a slight tilting of the mandible neck: the part between the condyle and the branch. The articulation surface of the condyle progresses upwards and anteriorly and has two variables. Grieve (1994) obtained data in which the mesolateral dimension of the condylar process measured approximately 15-20 mm and the antero-posterior dimension measured 8-10 mm and the medial pole was generally more prominent than the lateral one.

In adults, the mandibular condyles are about twice as wide on the frontal plane as on the sagittal plane, thus forming a large articular area (Grieve, 1994; Smith et al., 1997). In our study, the left and the right mesolateral planes were also twice the size of the left and right antero-posterior planes, confirming the results of Grieve (1994) and Smith et al. (1997). However, our measurements revealed a variation in the sizes of both planes.

The condyle is made up of a spongy bone covered by a layer of thick fibrocartilaginous tissue, mainly formed by collagen and a small amount of elastic fibers. This cover is thicker in areas that have to work harder, giving them physical and biological attributes that are appropriate for receiving heavier loads during mastication (Nunes-Jr et al., 2005). The cartilage of the mandibular condyle acts as an important center for the endochondral growth of the mandible during embrionary morphogenesis (Inoue et al., 2002). Traumas to this region may cause a delay in development, facial malformation and, consequently, mechanical damage to the articular surface (Oztan et al., 2004).

Regarding the mandibular angle, studying a Chinese population Xie and Ainamo (2004) found an average value of 122.4° in the young population and 122.8° among the elderly. Our data differ from theirs and this angle measured 128.25° on the left side and 127.68° on the right side. The variation found may be due to the ethnic group, the different morphometric technique used, or also to specific aspects such as the biomechanics and physiology characterising and differentiating the groups of people studied.

The action of muscle strength and the stiffness of the mandibular bone tissue may influence malformation of the mandible (Chen et al., 2000). According to Tencate (1998), the muscles involved in mastication are classically the masseter, the medial pterigoid, the lateral pterigoid and the temporal muscles. In functional terms, other groups of muscles are involved in the process of mastication, such as the post-cervical group, which plays a role as a stabilizer of the basis of the cranium, and the infra-hyoid group, which stabilizes the hyoid bone, thus allowing the milo-hyoid muscle and the anterior venter of the digastric muscle to influence mandibular position. However, the most important forces in mandibular malformation, mainly as regards opening the mouth, are generated by the lateral pterigoid muscles (Hylander, 1984).

Vasconcellos (1978) reported the damage on masticatory muscles due to dysfunction as well as direct damage to the articulation and malfunctions in mimic and posterior cervical muscles. For Tencate (1998), the role of the muscles in stabilization should not be overestimated since during mastication the strain used in the articulation is not only heavy but also changes constantly.

According to Newton's 3rd law, "all ordained movements come from a stable basis, provided by the articulations of the body which act as a support at the moment when the strain acts around them, resisting the movements with a strain equal or opposed to the movement strain". The temporomandibular joint (TMJ) is an operational unit formed by the right and left joint complexes, and since the mandible is a single bone the joints on each side are coordinated so as to act in all movements (Sicher and Dubrul, 1977).

The mandible should be considered as a curved beam subject to bilateral and unilateral strengths, and it seems reasonable to wonder whether this shape and structural appropriateness would influence the development of malformations or morphofunctional unbalances during the process of growth of the mandible biarticular complex as a consequence of the action of forces generated due to a masticatory defect or any other mechanism that might unilaterally or bilaterally overload the growing mandible with uneven intensity.

Thus, our results support a multifactorial model of structural variation in the shape and size of the condyles among people and between the right and the left sides in the same person, which can be explained through the genetic pattern, by the action of biomechanical forces, and by biochemical alterations of the extracellular matrix components of the bone tissue with age, such as collagens type I and II, which act mechanically, and collagens IX and XI, which act as regulators, causing the reshaping of the mandible bone-joint components, and dramatically influencing the tissues morphological characteristics. Other issues such as bone maceration and the anatomic site studied should also be considered as interference factors.

Several studies have shown that mandible position and morphology have a direct influence in occlusion of the teeth and in TMJ functional ability. This joint represents a constant worry for several specialists (medico-dental and surgical-clinical) attempting to understand its biomechanical and functional behavior in activities such as mastication, speech, occlusion, and other functions that involve the mouth in its 1500 to 2000 daily movements (Hoppenfeld, 1998).

Thus, study of the inherent morphology of the mandible is of great relevance for interactions among specialists in dentistry and physiotherapy aiming at a more efficient rehabilitation of patients with temporomandibular dysfunctions.

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