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Original Article

Morphometric analysis on the rami of dentate and edentate mandibles and the influence of the rami on edentulism, using the Image J software.

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ABSTRACT

Introduction:Sexual differentiation through examining the skeleton or separate bones, such as the mandible, can be done using a series of morphological and measurement parameters. However, presence or absence of teeth, sex, racial miscegenation and biomechanical adaptations of the masticatory system are factors that can alter the shape of the mandible and, consequently, its morphometry.Objective:To conduct morphometric analysis on the rami of dentate and edentate mandibles and the influence of the rami on edentulism. Materials and methods:100 dry adult mandibles were examined, of which 50 were male and 50 female. The mandibles were photographed using a camera that was attached to a static holder positioned at a distance of 20 cm from the object to be photographed. The images were digitalized and transferred to the Image J1.42qsoftware. This was used to measure the height of the coronoid process and the height and width of the mandibular rami.Results:There were significant differences in the morphometric measurements of the coronoid process height (CPH), ramus height (RH) and ramus width (RW) of the mandible in relation to sex, and also in relation to the age of the edentate and edentate mandibles. However, there were no significant differences in the CPH, RH and RW measurements, in relation to the presence or absence of teeth or between the right and left sides. Conclusion:Edentulism did not cause remodeling of the morphometric measurements of the CPH, RH and RW of the mandible, although these measurements were greater for the male sex.

Introduction

The mandible is the only mobile bone in the facial skeleton. It is considered to be the strongest bone in this region because it supportsocclusal masticatory forces and resists masticatory muscle action transmitted to the skull through the temporomandibular joint (TMJ) [1]. It has high bone density and does not disintegrate easily like other, more porous bones. Thus, it has become important in the forensic dentistry identification process [2].

The presence or absence of teeth, the individual's sex, the effect on muscle strength, ethnic characteristics and racial miscegenation are factors that can alter the shape of the mandible [3-6]. Some authors have reported that the periodontal ligament, which connects tooth roots to the alveolar process, stimulates modifications to the mandible starting from the fetal age [6,7].

Edentulism is also an important factor in these modifications. It has greater influence on the mandible outline than does the individual's sex, and also promotes reduction of the dimensions of the mandible and alterations to the position and anatomical relationships of the mental foramen [8]. This occurs because tooth extraction causes alveolar reabsorption that in some cases is so intense that the mental foramen becomes located at the level of the residual edge [9].

Differences between dentate and edentate mandibles were observed using anteroposterior and lateral radiographs in the study byMerrot et al [10].It was seen that the height of the symphysis and mandibular body decreased when there were no teeth. It can also be noted that different shapes and extents of the condyles can be generated through functional adaptations after tooth loss, since this gives rise to a new occlusal relationship between the maxillae, thereby stimulating condyle remodeling [11].

Many studies have been conducted on the morphometric data of the mandible [2,10,12-17].However, these studies have, in particular, highlighted the differences between female and male

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mandibles, rather than the differences between dentate and edentate mandibles. Therefore, the present study had the aim of performing morphometric analysis on the rami of dentate and edentate mandible and the influence of the rami on edentulism.

Materialsand Methods

Sample

100 dry mandibles were examined. These were available in the Anatomy Laboratories of the Federal University of Sergipe (UFS) and Tiradentes University(UNIT) in Aracaju, Sergipe, Brazil. Nineteen unidentified mandibles or mandibles presenting fragmentation of structures of importance for the measurements were excluded. The mean age was 54.72 years, with a range from 14 to 81 years; 41 mandibles (50.62%) were from females and 40 (49.38%) from males; and 32 (39.5%) were from edentate mandibles and 49 (60.49%) from dentate mandibles.

Morphometric evaluation

The rami of the mandibles were photographed bilaterally using a SONY DSWD-A100K camera, attached to a static holder and positioned at a standard distance of 20 cm from the object to be photographed. The images were digitalized and saved in JPEG (Joint Photographic Experts Group) format.

The morphometric variables evaluated were: coronoid process height (CPH), mandibular ramus height (RH) and mandibular ramus width (RW). The CPH was measured by tracing a line from the apex of the coronoid process to the mandibular angle (Figure1). The RH was measured from the highest point of the condylar process to the mandibular angle (Figure2). The RW corresponded to the smallest distance between the anterior and posterior margins of the mandibular ramus perpendicularly to height (Figure 3). All measurements were made by three dental students, at different times, using the Image J 1.42q software,which is public-domain software developed by the National Institute of Health (NIH) in the United States.

Comparisons and correlations between the groups were performed using the SPSS software, version 19.0, and the significance level was set at 95% ($p<0.05$). All values were presented as the mean ± standard deviation. Data normality was evaluated by means of the Shapiro-Wilk test. The means between the groups were then compared using analysis of variance (ANOVA) and Tukey's test. A correlation test was then applied (Pearson or Spearman).

Results

The measurements on the morphometric variables of CPH and RH were similar to each other, whereas they differed with regard to RW (Table 1). Moreover, the reliability analysis on the morphometric measurements between the observers showed a Cronbach alpha value of 0.953,which should be considered excellent, according toMaroco, Garcia-Marques [18].

The multivariate analysis (Table 2) verified the set of measurements (CPH mean, RH mean and RW mean). A significant difference can be seen between the male and female sexes ($p<0.001$) with a mean effect dimension of 0.106 and power of 0.95.The interaction between sex and teeth showed a significant effect ($p=0.091$)with a small dimension effectof 0.042.In analyzing the variable of side, no significant effect was observed ($p=0.41$),nor were there any interactions between sex and side ($p=1$); side and teeth ($p=0.92$) orsex, side and teeth ($p=1$).

The results obtained from comparing the sexes (Table 3) showed that male mandibles presented mean values greater than those of females, for the three variablesanalyzed. The maleCPHmean was 60.5 ± 5.9,while the female CPHmean was 56.5± 6.3 ($p<0.0001$),thus showing a mean difference of 4.2 ± 1 and 95% CI of 2.2 to 6.2.The mean male RH was 61.7 ± 6.3 and the female RH was 58.1± 7.2 ($p<0.001$), resulting in a mean difference of 4.1 ± 1.1 and 95% CI of 2.0 to 6.3.The mean maleRW was 32.4 ± 4.2, while the female RW was 30.6± 3.6 ($p= 0.002$), with a difference of 2.0 ± 0.6 and 95% CI of 0.7 to 3.3. Also inTable 3, it can be seen that there was no significant different in relation to the mean ages of the male and female mandibles ($p> 0.05$).

The values obtained from analysis on the edentate and dentate mandibles (Table 4)did not present any significant differences regarding the three variables analyzed ($p> 0.05$). In contrast, the ages of the edentate mandibles were significantly greater ($p= 0.007$)than those of the dentate mandibles.

InTable 5, it can be seen that there were no significant differences in the mean valuesforCPH, RH and RWbetween the right and left sides of the mandibles analyzed.

Figure 1. Coronoid process height

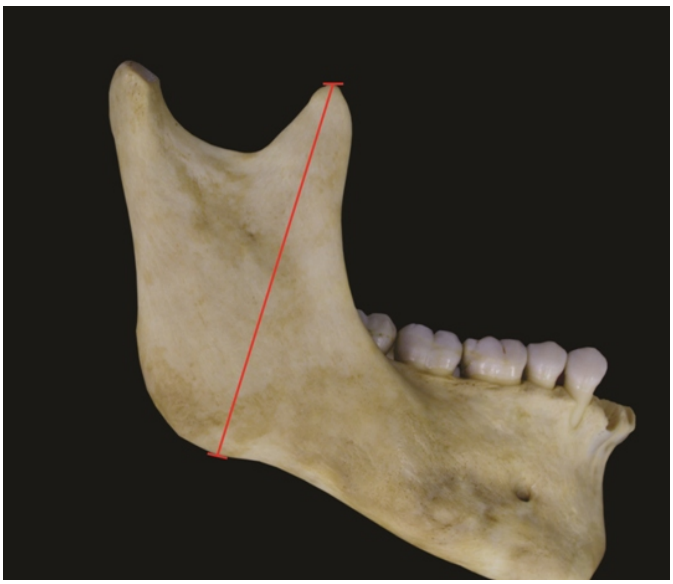

Figure 2. Mandibular ramus height

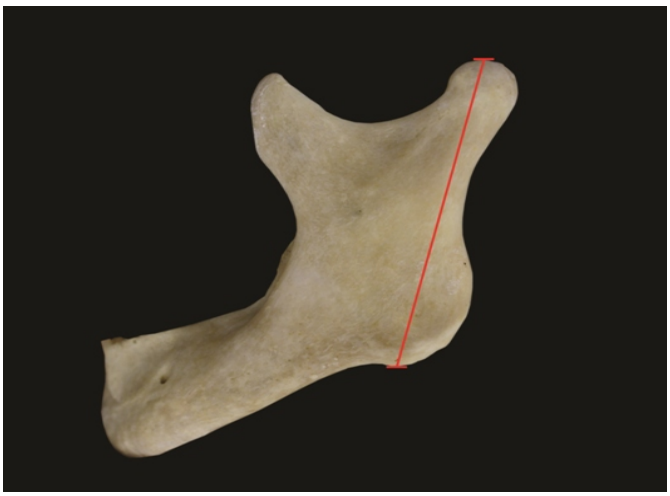

Figure 3. Mandibular ramus width

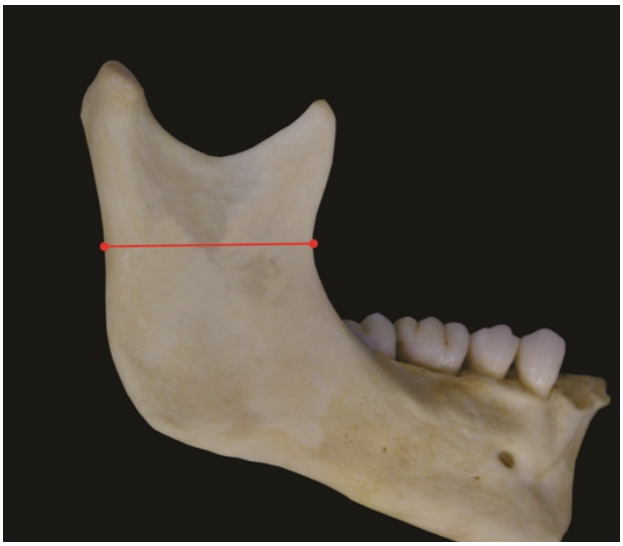

Table 1. Morphometric data on the dry mandibles evaluated

Variable	M ± SD	Minimum	Maximum
CPH1	55.7 ± 6.5	40.6	70.6
CPH2	59.7 ± 6.4	44.8	77.4
CPH3	60 ± 7.5	43.3	77.9
CPHmean	**58.5 ± 6.4**	**43.2**	**75.1**
RH1	55.7 ± 7.0	40.5	72.7
RH2	59.1 ± 7.5	42.2	80.4
RH3	64.7 ± 7.7	47.5	85.9
RHmean	**59.8 ± 7.0**	**45.8**	**79.1**
RW1	30.4 ± 4.3	20.7	44.5
RW2	31.4 ± 4.1	21.9	42.4
RW3	32.6 ± 4.3	22.4	44.4
RWmean	**31.5 ± 4.0**	**21.8**	**42.6**

M =arithmetic mean; SD =standard deviation; CPH1 to CPH3 =morphometric measurements on the coronoid process height made by three different evaluators; RH1 to RH3 =morphometric measurements on the mandibular ramus height made by three different evaluators; RW1 to RW3 =morphometric measurements on the mandibular ramus width made by three different evaluators; CPHmean =mean value of the coronoid process height found by the evaluators; RHmean =mean value of the mandibular ramus height found by the evaluators; RWmean =mean value of the mandibular ramus width found by the evaluators.

Table 2. Multivariate analysis on CPH, RH and RW (MANCOVA)

Variables	Multivariate statisticalanalysis[a]	p	PartialETA[b]	Power
Age	0.021	0.36	0.02	0.29
Sex	0.106	0.001	0.106	0.954
Side	0.019	0.41	0.019	0.26
Teeth	0.056	0.0334	0.056	0.694
Sex vs. Side	0	0.998	0	0.052
Sex vs. Teeth	0.042	0.091	0.042	0.549
Side vs. Teeth	0.003	0.917	0.003	0.081
Sex vs. Side vs. Teeth	0	0.996	0	0.054

Dependent variables = CPH MEAN, RH MEAN and RW MEAN; fixed factors = sex, side and teeth; covariable = age; sex vs. side = interaction between sex and side; sex vs. teeth = interaction between sex and dental status; side vs. teeth = interaction between side and dental status; sex vs. side vs. teeth = interaction between sex, side and dental status. a= Pillai's trace; b = effect dimension.

Table 3.Comparison of mean values for CPH, RH and RW in relation to age and sex.

Variable	Male (40)	Female (82)	p
Age	55.8 ± 16.8	57.1± 17.0	0.61
CPH mean	60.5 ± 5.9	56.5± 6.3	0.0001
RH mean	61.7 ± 6.3	58.1± 7.2	0.001
RW mean	32.4 ± 4.2	30.6± 3.6	0.005

Values expressed as means and standard deviations
ttest for independent data
p significance level.

Table 4. Comparison of mean values for CPH, RH and RW in relation to age and edentate and dentate mandibles

Variable	Edentate (32)	Dentate (49)	p
Age	60.9 ± 5.4	53.6 ± 17.3	0.007
CPH mean	58.85 ± 7.32	58.23 ± 5.7	0.57
RH mean	69.82 ± 7.33	59.2 ± 6.69	0.15
RW mean	30.99 ± 4.55	31.79 ± 3.62	0.24

Values expressed as means and standard deviations
ttest for independent data
p significance level.

Table 5.Comparison of mean values for CPH, RH and RW in relation to age and side.

Variable	Right side(81)	Left Side(81)	p
CPH mean	58.7 ± 6.4	58.2 ± 6.4	0.65
RH mean	59.8 ± 6.9	59.9 ± 7.1	0.93
RW mean	31.2 ± 4.0	31.7 ± 4.1	0.38

Values expressed as means and standard deviations
ttest for independent data
p significance level.

Discussion

Edentulism is considered to be an important generator of mandibular alterations. The present study found that the RH values were greater in edentate mandibles than in dentate mandibles. Huumonen et al. [19] analyzed the relationship between tooth loss and mandibular structural shape and found that edentulous individuals presented a significantly larger gonial angle than did those with teeth, as well as presenting smaller condylar process height, on both sides.

In evaluating 106 radiographs in anteroposterior and lateral views, on patients with edentate and dentate mandibles, Merrot et al.[10]did not find any significant differences in relation to mandibular ramus height and width between the groups analyzed. However,Raustia et al. [20] evaluated mandibles by means of computed tomography and observed that edentate mandibles were smaller than dentate mandibles, and also presented a thinner mandibular body and condyle process. According toPorto et al. [11]absence of teeth can also interfere with the condyle position in relation to the cranium, through drawing the condyle towards the anterior region of mandibular fossa.

Chrcanovic, Abreu, Custódio [8] reported that edentulism generated specific alterations to mandibular shape, and therefore had greater influence on mandibular shape than did sexual dimorphism. According to Ural et al. [16] and Soikkonen, Ainamo, Xie [3]female edentate mandibles have smaller height of the upper edge than that of male edentate mandibles. This may be linked to bone osteopenia, which would further compromise the edge height.

However, Kingsmill, Boyde [21] reported that regardless of the presence of teeth or of the patient's sex, the mandible presents great variance in size and shape. The present study found more significant differences in CPH, RH and RW measurements of mandibles between male and female sex than between dentate and edentate mandibles. This is concordant with the data fromSaini et al. [22]who found that condyle process height, mandibular ramus width and, especially, coronoid process height presented a high degree of sexual dimorphism, with precision of 71.4%. According toHuumonen et al. [19]the ramus and condyle heights were significantly smaller on both sides of edentate mandibles than in dentate individuals. Moreover, the mandibular ramus height was greater on both sides in males than in females. The changes to mandibular morphology consequent to tooth loss comprised widening of the gonial angle and shortening of the ramus and condylar process heights. These results highlight the importance of rehabilitation of the masticatory system in order to maintain good functioning of the masticatory muscles for as long as possible.

Kharoshah et al. [15] performed computed tomography on Egyptian mandibles and observed that the height and width of male mandibular rami were greater than those of female mandibular rami. They also affirmed that the width can be used to identify individuals' sex. However, Franklin et al. [2]stated that coronoid process height was a better discriminator for sex in three out of five South African populations, and that the mandibularramus was an important indicator for sexual dimorphism [4].

It was found in the present study that the age of the edentate mandibles was greater than that of the dentate mandibles. Subramaniam, Naidu [23]reported that there was a significant correlation between mandibular growth and skeletal maturity. Thus, evaluation of skeletal maturity would provide a more valid basis than chronological age for grouping individuals. Tanveer, Sharieff [24]stated that age favored alterations to the ramus, condyle and mandibular angle. However, Soikkonen, Ainamo, Xie [3]did not identify any maxillary alterations between age groups.

Corroborating the data of Hutchinson, L'abbé, Oettlé [25]no significant difference was found in the mean values of the variables analyzed, between the right and left sides of the mandibles in the present study.

Conclusion

The analysis of the present study showed that the measurements made by the evaluators had good reproducibility and reliability. CPH, RH and RW measurements were statistically greater in male than in female individuals. There was no statistically significant difference in the variables analyzed between dentate and edentate mandibles, although it was observed that CPH and RH were greater in edentate mandibles, while RW was greater in dentate mandibles. Furthermore, the morphometric variables analyzed did not show any significant differences between the right and left sides of the mandible. It was also found that the ages of the edentate mandibles were significantly greater than those of the dentate mandibles. Therefore, edentulism did not cause significant remodeling of the morphometric variables analyzed.

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