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Assessment of mandibular ramus for sex determination: Retrospective study

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ABSTRACT

Background: The determination of sex is as a keystone in the identification. The skull is considered the second-best mark of gender determination. However in cases where a complete dry skull is not found, the mandible may play an important role in gender estimation as it is the most dimorphic, largest, and strongest bone of the skull. Studies showed cone beam computed tomography (CBCT) found better than traditional methods. The using of CBCT device can obtain undistorted and good-quality 3D images with a low radiation dose.In this study, it was purposed to measure the morphometric parameters of the 3D mandible models in the Central Anatolian Turkish population and to evaluate the effectiveness of measurements in gender determination.
Method: The study was consisted of 70 individuals (35 males, 35 females; mean age 24,69 ± 2,85 years). Linear parameters were measured in mm using the mouse-driven method. The measurements were recorded from the both of right and left side. Acquired measurements between groups were evaluated with Student t-test.
Results: In the present study five different parameters of mandible were measured and mean values were determined. It was found that all variable of mandibular ramus on CBCT models showed a statistically significant difference among the sex ($p < 0.05$).
Conclusions: Mandibular ramus measurements can be useful tool for sex determination. These results propose that the mandible describes sexual dimorphism in the modern adult Central Anatolian Turkish population. However further studies with larger populations are needed to reveal this relation.

1. Background

The determination of sex is as a keystone of identification while serving as an important aspect of forensic anthropology and in medico-legal examinations. The prime goal of identification is the determination of sex; followed by age, stature, ethnic population estimation and which are sex-dependent.[1,2]

Using a complete skeleton, gender analysis and estimation are done with almost 90 to 100% accuracy in defining morphologic features for gender determination.[3] On the other hand, it can be difficult to analyse for determination of identity when incomplete or fragmentary bones and bodies are severely damaged, such as in the case of a mass disaster[4]

After the pelvis, the skull is noted as the second-best mark for gender identification.[5] However, in cases where a complete dry skull is not found, the mandible may play an important role in gender determination as it is the largest, most rigid and dimorphic bone of the skull. It sensitive during young people's development and holds many dimorphic characteristics that could be applied for the gender estimation.[6] At the same time, the relative growth (size, lengths, force, and angulation) of the mastication muscles are known to effect the mandibular ramus dimorphism, as the masticatory forces implemented are distinct for sex.[3]

Humphrey et al.[7] reported that changes in the mandibular bone were appropriate for sexual dimorphism and could be used for gender determination. The mandibular condylar and ramus are greatest morphological modification, and these areas reflect the differences between the sexes.[4] It is necessary to find the dependable differential analytical methods for the dimorphic part of bones. Researchers used morphological, measured, and molecular parameters.[5] Morphological parameters are visual and observable. On the other hand, metric parameters are reliable, reproducible, and based on bone fragment measurements.[6] In recent studies, skeletal measurements have been viewed as useful in detecting gender features. Therefore, it is necessary to find the dependable discriminatory analytical methods for dimorphic fragment bones.

Mandibular characteristics, such as the gonial angle, ramus length and breadth, and other morphologic measurements have been reported. At the same time, the reliability of these measurements has caused discussion among researchers. The dimorphic features of some parameters used in other studies on jaws were inconsistent in the literature.[5]

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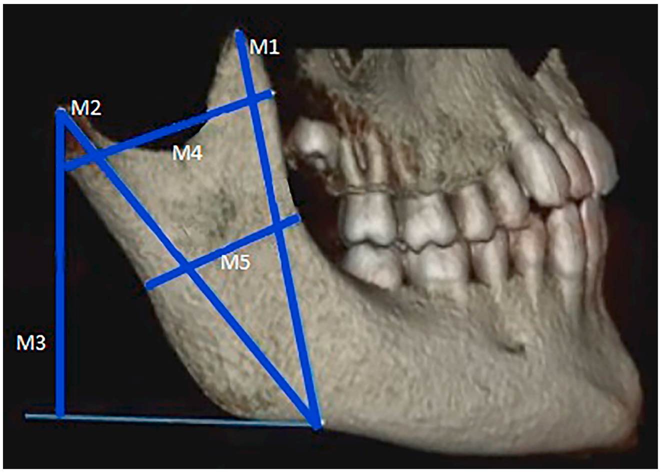

Fig. 1. Mandibular ramus measurements (M1, M2, M3, M4, M5).

Besides, it is well known that skeletal features vary between distinct populations. For this reason, each population requires a self-specific criterion for gender assessment.

Studies of both dry bones and radiographs were used for measurements.[6] New techniques are improving in the field of medical scanning all the time. At present, computer-assisted work methodologies becoming a developing trend in forensic science. In the literature, studies showed developed accuracy, repeatability, and reliability of cone beam computed tomography (CBCT) over traditional methods. These methods do not require invasive processing,[8,9] whereas the CBCT imaging device can obtain undistorted three-dimensional (3D) images of good quality with a low radiation dose,[10] which ensures exact localization and description of bone structures with a specific CBCT software. The studies of mandibular ramus morphology utilize CBCT measurements for the determination of sex.

The purpose of our study is to assess the usefulness of mandibular ramus in gender determination on the Central Anatolian Turkish population three-dimensional (3D) mandible models.

2. Materials and methods

The study was consisted of 70 individuals (35 males, 35 females; mean age 24,69 ± 2,85 years). This retrospective study was performed using CBCT images acquired from patients who chosen to a variety of dental complaints and needed to viewed with CBCT. The mandible CBCT data were provided stored in the system from the faculty of dentistry, Kırıkkale University. The research plan was confirmed by the administration of the Faculty of Dentistry. The study was carried out at the Department of Oral and Maxillofacial Radiology in accordance with the guidelines of the Helsinki Declaration.

Exclusion criteria were: non-Turkish origin; pathological changes in mandible, fractures, bone tumors, systemic diseases affecting bone metabolism; growth disorders; severe osteoporosis, missing teeth, cleft lip or palate. The collected data were accessible only to the researcher. Moreover, the observer examined only the radiographs and was blinded to any other patient data in the radiographic examination procedure.

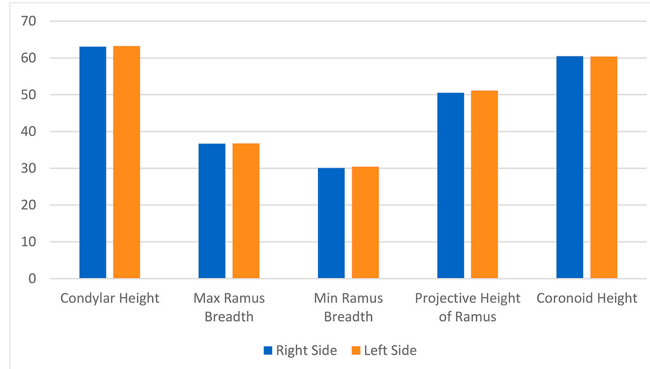

Fig. 2. Mean measurements in right and left side.

The CBCT images were taken using the i-CAT system (Imaging Sciences International, Hatfield, PA) studied at 120 kVp and 7 mA with an exposure time of 40 s and a voxel size of 200 mm. The CBCT data of the mandible was reconstructed three-dimensional images using the Invivo software (Anatomage, San Jose, California, USA). CBCT images were obtained with the patients seated. The head position was kept in the midsagittal plane perpendicular to the horizontal plane. During the examination, the patients were at rest for maximum intercuspidation.

Mandibular ramus linear parameters were measured by using mouse-driven method (moving the mouse and drawing lines using selected marks on the CBCT image) in mm (Fig. 1). The patients' informations recorded their dates of birth and genders. Mandibular measurements were defined in Table 1. After 2 weeks, the measurements were reevaluated at 10% of the total sample.

Data were analyzed using the Statistical Package for Social Sciences (SPSS), version 20. Student t-test was used for statistical comparisons between the right and left sides. The discriminant function analysis was carried out to find out whether the values can be used for genders determination.

3. Results

The Dahlberg Error and t-test showed no statistically significant difference between the first and second examinations (Dahlberg = 0.09 and t-test, $p = 0.665$). Student's t-test results of mandibular measurements for right and left sides are shown in Fig. 2. It was found that right and left sides measurements showed no statistically significant difference.

70 patients with an age range of 18–29 years (35 females, mean age, 23.23 ± 3.44; 35 males, men age, 23.29 ± 3.08 and overall mean age for both sexes was 24.69 ± 2.85 years).

In the present study five different parameters of mandible were measured and mean values were determined. All five mandibular ramus measurements for both sexes are shown in Table 2. It was found that all variable of mandibular ramus on CBCT models showed a statistically significant difference between the genders ($p < 0.05$) (Table 2).

The condylar height mean was determined as 66,65 ± 6,51 mm in males and 59,98 ± 5,36 mm in females, which was significant

Table 1
Description of the variables on the mandible.

Measurements	Abbreviation	Definition
Coronoid height	**M1**	Distance from the most superior point on the coronoid to the lowest point of the mandible
Condil height	**M2**	Distance from the most superior point on the mandibular condyle to the most lowest point of the mandible
Mandibular ramus height	**M3**	The projected distance between the highest point of the mandibular condyle and the intersection of lines the posterior and underside planes of the mandible.
Maximum ramus breadth	**M4**	Distance between most anterior and line connecting most posterior part of condyle and angle of mandible.
Minimum ramus breadth	**M5**	Distance between smallest anterior to posterior of ramus

Table 2
Descriptive statistics.

Variable	Female		Male				P value
	Mean	Standard deviation	Mean	Standard deviation	Wilks' Lambda	F	
Condylar height	59.98	5.36	66.65	6.51	0.751	20.925	0.000
Max ramus breadth	35.16	2.91	38.41	2.86	0.739	22.274	0.000
Min ramus breadth	28.97	2.88	31.68	2.89	0.808	15.004	0.000
Projective height of ramus	48.00	7.26	53.91	8.72	0.875	9.000	0.004
Coronoid height	57.57	5.30	63.54	5.11	0.743	21.83	0.000

Table 3
Linear discriminant function variables.

Variables	**Female**	**Male**
Condylar height	4.122	4.542
Max ramus breadth	3.441	3.764
Min ramus breadth	−0.173	−0.289
Projective height of ramus	−3.551	−3.858
Coronoid height	1.852	2.022
Constant	−150.377	−180.044

Table 4
Prediction accuracy.

True group	Predicted group		Total	% Accuracy
	Female	Male		
Female	25	10	35	73.5
Male	9	26	35	77.4

(P = 0.00). The mean value of maximum ramus width in females was 35,16 ± 2,91 mm, it was 66,65 ± 6,51 mm in males, which was significant (P = 0,00). The mean value of minimum ramus width in males and females was 31,68 ± 2,89 mm and 28,97 ± 2.88 mm respectively (P = 0.00). The mean value of projection height of the ramus in males and females was 53,91 ± 8,72 mm and 48,00 ± 7,36 mm respectively, and their standard deviations were and respectively, which was significant (P = 0.004). The coronoid height mean was determined as 63,54 ± 5,11 mm in males and 57,57 ± 5,30 mm in females, which was significant (P = 0.00) (Table 2).

Discriminant function analysis variables were obtained from Fischer exact test, and they were shown at Table 3.

Gender was accurately stated in 25 samples out of 35 female mandibular measurements with prediction accuracy rate of 73.5%, and 26 samples out pf 35 males mandibular measurement with an accuracy rate of 77.4% (Table 4).

4. Discussion

One of the important aspects of Forensic dentistry is the determination of the gender from remained jaws and dentition. Mandibles are used for measurements, as these bones remain largely intact bone with high degree of sexual dimorphic characteristics. In this study, it was purposed to measure the morphometric parameters of the 3D mandible models in the Central Anatolian Turkish population and to evaluate the effectiveness of measurements in gender determination.

The present study shows that there is a statistically significant correlation between the right and left measurements. The results indicated that all five parameters measured on mandibular ramus using 3D CBCT showed statistically significant diversity difference between gender. The rate of sexual dimorphism of the mandibular ramus was found to be high.

Our results were similar to those of other studies.[4,11,12] Although the results were statistically significant, the differences in the measurements values of the studies were observed and displayed variability between populations. These studies emphasized that mandibular bone showed sexual dimorphism, and the mandibular ramus was especially effective for the determination of sex.[4,12] However, the missing part of these studies is the use of panoramic radiography. The disadvantages of the ortopantomographs (OPG) method are magnification and geometric distortion which results in many mistakes. The vertical dimension as compared to the horizontal dimension showed that little changed. Therefore, measurements utilizing the OPG method are not reliable.

Another study[13] used the same parameters on dry mandible in North Indian population, and our results aligned, which supported the idea that the mandibular ramus was a strong sexual dimorphic bone. The reason that anatomical differences are a statistically significant distinction between male and female can be attributed to muscles and hormonal differences.

Studying Multidetector Computed Tomography (MDCT) images among Turkish population, similar parameters showed parallel results with our study.[14] The MDCT uses more than the amount of radiation given to the patient according to CBCT and is more expensive than our method.

One study showed that CBCT measurement results are very close to the anatomic truth; moreover intraobserver CBCT measurements were highly dependable.[15] Another study suggested the CBCT method could be used in anatomical structures that are difficult to measure by traditional techniques, and measurements can be made in living creature with this method.[16]

Our study limitation is the small sample size. Therefore, studies in different regions may provide different results.

5. Conclusion

The evaluation of the mandible, especially the ramus region, is an important parameter for gender determination in forensic medicine. Gender determination suggestions in future studies should be examined by using different parameters in larger sample groups and different age groups on ramus. Although ramus measurements distinct between males and females in each population, there is also a difference between measurements among societies. Therefore there is a need to develop standards specific to each population for accurate gender identification from skeletal remains. We believe that these studies results will assist surgeons dealing with the mandible and face region and radiologists for diagnosis.

Declaration of competing interest

No relationship/conditions/circumstances that present a potential conflict of interest.

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