Use of non-metric characteristics of mandible in sex determination

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Abstract

Aims and Objectives: Mandible is the strongest, largest, hardest, and most durable bone of the skull which plays a paramount role in forensic study due to its ability to maintain its shape and contour better than other bones and exhibiting a greater degree of sexual dimorphism. To study the non-metric characteristics of mandible such as the variations of shape of chin, inferior border of mandible, and shape of coronoid process helps to distinguish between males and females.

Materials and Methods: The material for this study comprised 90 dry adult human mandibles of known sex which was obtained from Department of Anatomy. The peculiar features that allowed us to differentiate among the sexes was contour of the inferior border of mandible, shape of the chin and shape of coronoid process bilaterally.

Results: Male mandibles showed rocker-shaped predominantly (58.9%), whereas about (41.1%) of female mandibles exhibited a straight inferior border of the mandible. The shape of the chin in most of the males was bilobate (45.5%), square (43.6%), whereas female mandible had pointed chin (71.4%). Shapes of coronoid process observed were hook in (27.8%), rounded (31.1%), and triangular (41.1%) with $P < 0.05$ which indicated statistical significance.

Conclusion: The non-metric analysis of mandible could be used for sex determination.

Introduction

In forensic investigation identifying the human remains is thought to be a first step and is crucial for further analysis. The sex determination of human skeleton is usually the initial step in the identification method as future ways for age and stature estimation area of sex-dependent. The authenticity of sex determination depends on the fullness of the remnants, and therefore, the degree of sexual dimorphism inherent within the population. Once the entire adult skeleton is out there for analysis sex will be determined up to 100% accuracy, but in cases of fragmented bones which are usually found in mass disasters, obtaining 100% accuracy in sex determination is difficult and it largely depends on the available fragmented bones of skeleton.

As noted from the earlier studies, the most dimorphic and easily distinguish portion of skeleton among sexes after pelvis is skull, which has an accuracy rate up to 92%. On the other hand, cases where bones of the skull are not found intact, then sex determination using mandible may play a vital role, as it is the most durable, largest, strongest, and dimorphic bone of skull.

Mandible is very durable part of skull bone due to the dense layer of compact bone which can be observed in it, and because of this it tends to maintain its shape and contour well for a longer duration when compare to any other bones. The shape and size of mandible reflect the dimorphism characteristics. Female bones are generally smaller and less robust than male bones.

This characteristic feature of mandible helps in sex and age determination in medico-legal cases. In anthropological excavations, the morphometric features of the mandible aid to determine the sex, age, food habits and race of the population and also helps to understand the cave dweller/human evolution. As masticatory forces exerted are diverse for males and females the relative development such as strength, size, and angulation of the muscles of mastication is experienced to have a push on the expression of mandibular dimorphism. The shape of the mandible can vary according to the different lifestyles and chewing habits. Therefore, the morphological characteristics of the mandible vary among different ethnic groups. There are several causes of differences in the shape of the mandible between the sexes. The shape and size of the mandible appear to differ
between the sexes from the development of the deciduous tooth. Furthermore, the size of the masticatory muscles and mandible appear to differ between males and females before birth.\(^\text{[10]}\) The size of the ramus differs between males and females according to the stage of mandibular development and muscle growth.\(^\text{[10,11]}\) Furthermore, the mandible has different rate of growth in males and females.\(^\text{[12,13]}\) Because puberty occurs earlier in females than in males, sexual differences may manifest themselves in the skull and jaws of females earlier than in the later and longer maturing males.\(^\text{[14]}\) For the determination of males and females mandible, many attempts have been made with help of metric standards.\(^\text{[14-17]}\) However, metric methods have their disadvantages by their requirement of a complete mandible. Using non-metric methods, Bass\(^\text{[18]}\) found that the shape of the chin could be used to distinguish between males and females. In addition, Loth and Henneberg\(^\text{[19]}\) in his reported cases showed that there is a large difference in the flexure of the ramal posterior border during male and female Africans that can be used to differentiate the sexes with 99% reliability. In addition, it was reported that there are discrete differences in the gonial flaring of the mandible between the sexes.\(^\text{[20]}\)

In this study, we investigated the criteria that can be used to differentiate between males and females by using the non-metric characteristics of mandible such as different variations of contour of inferior border of mandible, shape of the chin and different variations in shape of coronoid process in mandibles.

### Materials and Methods

This study was undertaken on 90 dry adult, complete, undamaged human mandibles of known sex from the collection of Anatomy department. Out of 90 mandibles, 53 were of males and 37 of females and were examined for the variations shape of inferior border, shape of the chin and shape of coronoid process of both the left and right sides of the mandible. The shape of the chin was classified according to the thickness of the mandible in front of and beneath the chin, the profile of the chin according to amount of protrusion of the chin observed from the side, the contour of inferior border of the mandible was classified according to the depth of the antegonial notch, variations in the shape of the coronoid process in right and left sides of adult bones of both sexes were noted and tabulated.

The non-metric items observed in this study is as follows:

1. The contour of inferior border of the mandible [Figure 1]: Straight/ rocker/ undulating
2. The shape of the chin [Figure 1]: Bilobate/square/pointed
3. Coronoid process of mandible [Figure 1]: Hooked, rounded and triangular.
   * Inclusion criteria: Well-formed mandible
   * Exclusion criteria: Fractured, deformed, bony growths of coronoid process (osteocondroma) were excluded from the study. Chi-square test was used to analyze the data obtained and \(P = 0.05\) was obtained which showed that this study was statistically significant.

### Results

Male mandibles showed rocker-shaped predominantly (58.9%), whereas about 41.1% of female mandibles exhibited a straight inferior border of the mandible. The shape of the chin in most of the males was bilobate (45.5%), square (43.6%), and pointed (10.9%), whereas female mandible had was either square (8.6%) or bilobated (20.0%) and pointed chin (71.4%). Shapes of coronoid process observed were hook in 27.8%, rounded (31.1%), and triangular (41.1%) with \(P < 0.05\) which indicated statistical significance.

### Discussion

Differentiating features among the genders and also the differences in ethnic groups can be done by observing the morphological characteristics of bone this plays an important role in the field of physical and forensic anthropology. Sound bone is difficult to obtain because the quality of bone deteriorates over time due to factors such as environment-induced erosion. In sex determination examination of the pelvic bone is the most accurate means, but this bone is rarely found intact. Skull is most easily distinguishing portion of the skeleton as a part of the skull mandible shares its own characteristics. The mandible is the strongest and largest bone in the human body and will be in the well-preserved state for a longer duration when compared to any other bone. Hence, mandibular characteristics are significantly useful for determining sex and race. The shape of the chin and the inferior border of the mandible had a different shape between males and females in this study.

The shape of the chin is used widely to distinguish between the sexes, because the male chin is usually bilobate/square, whereas the female chin is more pointed. Similar observations were made in this study; specifically, 90.7% of males had either a bilobate or square chin, whereas 72.2% of females had a pointed chin. However, while the shape of the chin is more distinctive in males than in females, sex determination based only on the shape of the chin is not sufficiently reliable.

The characteristic that was the most distinguishable between the sexes in this study was the shape of the inferior border of
mandible. The inferior borders of mandibles from males tended to be rocker shaped (58.9%), whereas inferior borders of mandibles from females tended to be straight (41.1%) but we did not encounter undulating form of inferior border of the mandible in this study [Table 1]. Therefore, the shape of the inferior border of the mandible may be used as a reliable index for sex determination. However, we believe that using only this characteristic is not sufficiently reliable for sex determination; instead, evaluating both the shape of the chin and the shape of the inferior border of mandible improve the precision of sex determination. When these two items were combined, 90.7% of male mandibles exhibited the characteristics of male mandibles (a bilobate or square chin and a rocker-shaped inferior border of the mandible), whereas 77.2% of females exhibited the characteristics of female mandibles (a pointed chin and a straight inferior border of the mandible [Table 2]. Few males (9.3%) had a pointed chin and a straight inferior border, which are characteristics of females, while 27.7% of the females exhibited mandibular characteristics that were characteristic of males [Table 3]. Therefore, the probability of assigning the incorrect sex to a mandible when examining both the shape of the chin and the shape of the inferior border of the mandible is very low. Moreover, the shape of the chin is the most distinctive characteristic in males, whereas the inferior border of the mandible is the most distinctive characteristic in females. Therefore, we can determine the sex using the following two-step approach. During the first step in determining sex based on the characteristics of the mandible, if the inferior border of the mandible is rocker shaped, it is likely to be the mandible of a male, but if the inferior border is straight, it is likely to be the mandible of a female; during the second step, if the chin of the mandible has a straight inferior border is bilobate/square, it is likely to be the mandible of a male, whereas pointed and straight is likely to be of female.

Shapes of coronoid process observed were triangular (41.1%), rounded (31.1%), and hook in 27.8% where triangular and hook shape had slight male predilection and triangular and rounded had slight more of female predilection [Table 4]. Isaac and Holla [21,22] reported a study of 157 mandibles incidence of hook-shaped was 27.4%, triangular (49%), and rounded type (23.6%). He found the incidence of the rounded type almost equal in male and female mandibles, triangular type slightly more in the females, while hook type more in the male mandibles. Comparing with Isaac and Holla the incidence of hook type was closely similar to the present study, but triangular and rounded shape incidence observed was more in males and so the findings did not coincide with the author.

**Conclusion**

The differences between the sexes and among ethnic groups the morphological characteristics of the mandible are determined by the environment and different growth patterns. Therefore, males and females can be distinguished based on the shapes of various parts of the mandible. We found that the simultaneous use of the shape of inferior border of the mandible and the shape of the chin is the best method of predicting sex with a rate of accuracy that is higher than 90% and the morphological variation of shapes of coronoid. The most commonly found shape of coronoid process was triangular shape. The incidence of triangular rounded and hook shape of the coronoid process were observed predominantly in the male bones compared to female bones. The above findings could be of substantial significance for the anatomist, anthropologist, and forensic researchers.

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