Original Article

Assessment of condyle-coronoid angle and gonial angle for gender determination: A digital panoramic study in Bagalkot population

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Abstract

Background: The determination of gender is of utmost importance for forensic science and medico-legal purposes. The mandibular bone may play a vital role in gender determination as it is the most dimorphic bone of the skull that is often recovered intact. In this respect, orthopantomograms are of great value in accurate age and sex estimation. The mandibular angles, especially the gonial angle is an important parameter of the craniofacial complex giving an indication about the vertical parameters and symmetry of the facial skeleton. The purpose of the current study was to evaluate the usefulness of mandibular gonial and coronoid-condyle angle measurements on digital panoramic images as an indicator for gender determination in the Bagalkot population.

Materials and Methods: A total of 200 panoramic images (100 males and 100 females) of Bagalkot district patients aged (18–58) yrs old were selected. Two mandibular parameters 1) gonial angle and 2) condyle-coronoid angle were analyzed using trophy DICOM 6.1.2.0, masterview 4.2.0. Two-way analysis of variance (ANOVA) test and Tukey's multiple post hoc procedures were used to compare the gender and two sides (left and right) with respect to gonial angle and condyle-coronoid angle.

Results: The analysis of the present study confirmed a statistically significant difference between the right and left sides of the gonial angle and condyle-coronoid angle in both genders. The mean comparison also shows a variation between males and females, based on gonial angle and condyle-coronoid values; females have statistically significant higher mean values than males. Based on the analysis, the present study concludes that this difference between males and females from both sides suggests that the gonial angle and condyle-coronoid angle help in gender determination.

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Conclusion: The results of the study show that greater mandibular angle aids in gender dimorphism and proves to be beneficial in gender estimation. Gonial angle and condyle-coronoid angle can be used to differentiate gender with high accuracy.

Keywords: Condyle-coronoid angle, digital panoramic images, gender determination, gonial angle

INTRODUCTION

Determination of gender in skeletal remains is an important part of archaeological and many medicolegal cases, especially when the bodies are damaged beyond recognition as in mass disasters.[1] Gender differences in bone pelvis and skull are well defined. After these two bones, it is the mandibular bone in humans that helps in identifying age, sex and race.[2] The mandibular bone, like other bones in the body, is affected by age, metabolic activity and hormonal changes.[3] The mandibular angle is actually the angle between the posterior border of the ramus mandible and the lower border of the mandibular bone.[4] The mandibular bone is the largest and strongest bone in the face with a horizontally curved, convex forward structure with two broad rami, which climb upwards at the end of the structure. The coronoid and condyloid appendages of the mandibular bone are considered suitable for study as this bone is the most durable facial skeleton and retains its shape better than do other bones.[5,6] The term 'Gonion' is derived from the Greek word 'ywvtx', i.e., angle.[7] It is a point in the extreme posterior portion of the inferior most region of the mandibular angle.[8]

Panoramic radiographs (OPG) are the most common extraoral radiographs that provide the maximum details with respect to hard tissue of maxilla and mandible and can be easily saved and stored in a database for years.[9] It is considered a gold standard of care for dental screening, diagnosis and treatment planning, it provides significant information about the dentition and supporting bone. Panoramic radiography is useful for measuring the gonial angle with accurate performance
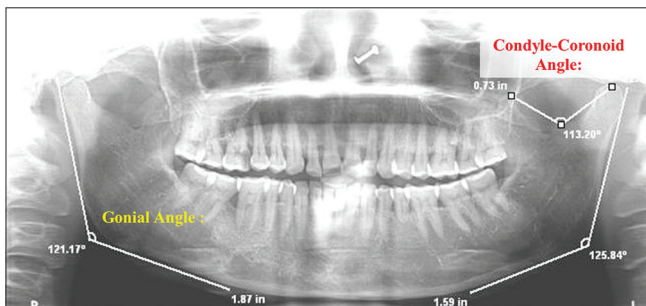
and also provides adequate information about both right and left sides.[10] The purpose of the present study was to measure the mandibular angles i.e., gonial angle and condyle-coronoid angle to assess their usefulness in gender determination.

MATERIALS AND METHODS

Digital panoramic radiographs of 200 patients were obtained (100 males and 100 females) with an age range of 18–58 years from department archives. As the present study was conducted on radiographs stored in the system, ethical clearance was not applicable. The inclusion criteria were: 1) High-quality digital images without any positioning errors.

2) Ideal orthopantomographs of completely dentate patients were selected.

Exclusion criteria: Patients with a history of extraction, fracture, developmental disturbances or any other

Table 1: Comparison of gender (male and female) and two sides (left and right) with respect to Gonial angle by two way ANOVA

Sources of variation	Degrees of freedom	Sum of squares	Mean sum of squares	F	P
Main effects					
Gender	1	1083.17	1083.17	19.5112	0.0001*
Sides	1	1.50	1.50	0.0270	0.8698
2-way interactions					
Gender × Sides	1	0.97	0.97	0.0176	0.8947
Error	196	10881.02	55.52		
Total	199	11966.66			

*$P<0.05$

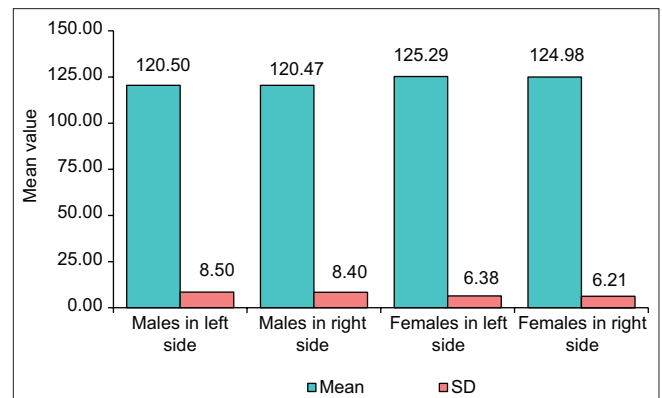**Figure 1:** Measurements of mandibular angles on orthopantomograph

Figure 2: Comparison of gender (male and female) and two sides (left and right) with respect to Gonial angle

Table 2: Pairwise comparison of gender (male and female) and two sides (left and right) with respect to Gonial angle by Tukey's multiple *post hoc* procedures

Interaction	Males in the left side	Males in the right side	Females in the left side	Females in the right side
Mean	120.50	120.47	125.29	124.98
SD	8.50	8.40	6.38	6.21
Males in the left side	-			
Males in the right side	P=0.9999	-		
Females in the left side	P=0.0071*	P=0.0066*	-	
Females in the right side	P=0.0140*	P=0.0131*	P=0.9967	-

*P<0.05

Table 3: Comparison of gender (male and female) and two sides (left and right) with respect to Condyle-Coronoid angle by two way ANOVA

Sources of variation	Degrees of freedom	Sum of squares	Mean sum of squares	F	P
Main effects					
Gender	1	1006.57	1006.57	11.7518	0.0007*
Sides	1	2.06	2.06	0.0240	0.8770
2-way interactions					
Gender × Sides	1	1.68	1.68	0.0196	0.8887
Error	196	16787.82	85.65		
Total	199	17798.13			

*P<0.05

Figure 3: Comparison of gender (male and female) and two sides (left and right) with respect to Condyle-Coronoid angle

mandibular pathologies leading to variation in the size of the mandible were excluded from the study.

The gonial angle was drawn with a tangent to the lower border of the mandible and another line tangent to the distal border of the ascending ramus and the condyle on both the sides then the gonial angle was measured at the point of intersection of the plane tangential to the lower border of the mandible and to the distal border of the ascending ramus and condyle. The angle between the condyle and coronoid process was formed by the intersection between the two lines drawn from the condyle and coronion meeting at the deepest point on the mandibular notch as shown in Figure 1. The two parameters were measured using the mouse-driven method by moving the mouse and drawing lines and were analyzed using trophy DICOM 6.1.2.0 masterview 4.2.0. Two-way ANOVA test and tukey's multiple post hoc procedures were used to compare the gender and two sides (left and right) with respect to gonial angle and condyle-coronoid angle. The data were analyzed using SPSS 20 software.

RESULTS

The results of this study show that there are significant differences in the mandibular angle between both genders. There were statistically significant mean differences with the two sides (left and right) in males and females in respect to gonial angle [Tables 1 and 2, and Figure 2] and also condyle-coronoid angle when measured on both right and left sides in males and females, showed
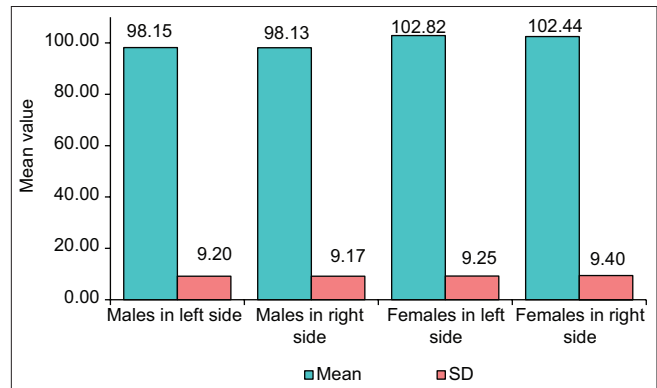
significant mean differences with $P < 0.05$ [Tables 3 and 4, and Figure 3]. The gonial angle was found to be more statistically significant in females in comparison to males and similarly, the condyle-coronoid angle was found to be higher in females than males which shows it can be used as a significant parameter in determining gender.

DISCUSSION

Sex determination in an unidentified skeleton may be extremely complicated, especially in cases of explosions warfare and other mass disasters because of skeletal fragmentation.[11] Identification of skeletal remains holds prime importance in forensic medicine and anthropology, especially in crime investigations. The mandible and its variations in age, sex and race will help surgeons, physicians, anthropologists to give correct interpretations for the results of diagnostic procedures in living.[12]

Skeletal components most often investigated for gender determination are the pelvis and skull with mandible used to analyze sexual dimorphism in fragmented bones.[13] The mandible is the largest, strongest, and the most movable part of the skull, and its identification is important in medico-legal cases and anthropological work.[14]

Mandibular condyle and ramus are the most sexually dimorphic as they are associated with the greatest morphological changes in size and remodeling during growth.[15]

Table 4: Pairwise comparison of gender (male and female) and two sides (left and right) with respect to Condyle-Coronoid angle by Tukey's multiple *post hoc* procedures

Interaction	Males in the left side	Males in the right side	Females in the left side	Females in the right side
Mean	98.15	98.13	102.82	102.44
SD	9.20	9.17	9.25	9.40
Males in the left side	-			
Males in the right side	P=0.9999			
Females in the left side	P=0.0312*	P=0.0549		
Females in the right side	P=0.0207*	P=0.0924	P=0.9968	-

*$P<0.05$

The gonial angle plays an important role in growth pattern prediction and estimating age and also for evaluating the symmetry of the facial skeleton.[16,17]

Panoramic radiographs are routinely used for the diagnosis of oral diseases. The main advantages of the panoramic image are its broad coverage, low patient radiation dose and short time required for image acquisition.[13] Several studies have reported that panoramic radiographs are reproducible and accurate for the linear and angular measurements on the mandible. Larheim and Svanaes have found that the gonial angle assessed from a panoramic radiograph was almost identical to that measured on a dried mandible.[18]

In the present study, the mandibular angles were found to be higher in females than males. Statistically significant differences were found in comparing both rights and left sides of the mandible with gonial angles.

The condyle-coronoid angles also were found to be higher in females than males on comparing both right and left sides. Our results are in accordance with the studies done by Farahani *et al*.[2] and Abuhijleh *et al*.[19] who studied the gonial angles, and found that the gonial angles were significantly higher in females than males.

The condyle-coronoid angle is not studied widely, in the present study we found the measurements were significantly higher in females than males and can be used as an effective tool in gender determination. The reason for this difference could be attributed to the stages of mandibular development, developmental status, growth rates, and duration.[3] There are various factors that may influence the mandibular morphology like masticatory forces, occlusal forces, dietary habits and hormonal changes. Few studies have shown the role of hormonal differences in this distinct differentiation. Two factors, such as gender hormonal differences that affect bone metabolism or masticatory muscles might be responsible for this difference in the gonial angles.[9] The present study confirmed a significant difference between right and left gonial angle and condyle-coronoid angles in both genders, which proved the intrinsic nature of the irregularity of the human mandible.

In the present study, the gonial angle was found to be 120.47 on the right side and 120.5 on the left side, and in females the right side was found to be 124.98 and the left side 125.29, whereas the condyle-coronoid angle were found to be 98.13 (right), 98.15 (left) side in males and 102.44 (right), 102.82 (left) in females which are similar results found in a study done by Saikiran C H *et al*.[20] who found gonial angles to be higher in females than males on both right and left sides.

CONCLUSION

In the present study, a statistically significant difference was observed between the gonial angles and condyle-coronoid angle measured between males and females using panoramic radiographs. Both gonial angle and condyle-coronoid angles showed high sexual dimorphism and can prove to be highly beneficial in gender determination.

Conflicts of interest
There are no conflicts of interest.

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