Original Article

A Novel Approach toward Mandibular Condyle Imaging and Quantification through Modified Reverse Panoramic Radiography for Determination of Gender

Shweta Dwivedy, Sunira Chandra, Akanksha Srivastava, Shruti Chandra, Pratikchhaya Shrestha, Richa Thakur

From the Department of Oral Medicine and Radiology, Saraswati Dental College, Lucknow, Uttar Pradesh, India

Abstract

Background: Mandible is the only movable bone of the skull which provides an arena for age and gender determination. A normal variation of the condylar morphology that occurs with age, gender, facial type, and functional load has been established by few authors. It is still the incompletely explored quarter in anthropology and forensic science for gender determination.

Aims: The aim of this study is to assess the reliability of mandibular anteroposterior condylar diameter for gender determination utilizing modified reverse panoramic radiographic technique.

Materials and Methods: Reverse panoramic radiograph of 60 healthy randomly selected individuals (30 males and 30 females) was taken between the age group of 25 to 45 years. Anteroposterior maximum diameter of both condyles (right and left) was recorded with Trophy Dicom Imaging software, and the values obtained were further subjected for statistical analysis.

Results: Average anteroposterior diameter of condyle in male and female was observed, i.e., 10.21533 ± 0.99595 and 9.401667 ± 1.048026 mm, respectively, which was statistically significant.

Conclusion: Although the present study is a pilot study, we can conclude that maximum anteroposterior diameter of the mandibular condyle can assist in gender determination. Modified reverse panoramic radiographic technique is a noble and practical tool in visualization of both condyles, which most of the times cannot be clearly visualized in orthopantomogram due to the overlapping of anatomical structures.

Key Words: *Condyle, forensic, mandible, reverse panoramic radiography*

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Introduction

Sex determination of unidentified human skeletal relics has always been confronted by forensic experts to explain the disaster situation.[1] Variation on structural makeover of both genders' skull and pelvis serves as a tool for identification.[2,3] Identification in forensic is based mainly on the anthropometrical temperament of skeleton.[4] Skull and mandible being the strongest bone which are usually preserved in extreme conditions.[5,6]

Accuracy of sex identification by skull bones is considered to be 90%.[7] Mandible, the only movable bone of the skull, next to the pelvis, serves as a gizmo for gender identification.[6] Mandibular condyle serves as the growth center and functional unit of joint, possesses varied morphology. A normal variation of the condylar morphology occurs with age, gender, facial type, functional load, occlusal force, malocclusion type, and between right and left sides.[8,9]

Condyle since time is the area of interest for anthropologists, and it has been proposed that size of condyle in males is greater than females.[10] Measurement of condyle is usually been studied in two planes, i.e., anteroposterior and mediolateral, of which mediolateral is being more allied with gender.[8] Various conventional radiographic techniques are exploited for condylar imaging, of which orthopantomogram (OPG) provides the panoramic view of both condyles but many a times shows slight degree of distortion and magnification error.[11] Long back Markus *et al*. (1986) have proposed reverse panoramic radiographic technique, which was further modified by Chandra *et al*.[3] for imaging of the lambdoid suture. This quite unexplored technique has been further modified in the present study to obtain a relatively clear and undistorted imaged condyle for gender determination. The present study is one of its innovative arrays for imaging of the mandibular condyle in the field of forensic radiology.

Address for correspondence:
Dr. Shweta Dwivedy, E-mail: dwivedyshweta@gmail.com

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Materials and Methods

This prospective and unicentric study was conducted on 60 randomly selected healthy individuals (30 males and 30 females) between the age of 25 to 45 years keeping in consideration that the development of condyle is completed and no pathological conditions are present in this age group. Approval for study was taken from Institutional Human Ethics Committee and Institutional Research and Development Committee which is in accordance with Helsinki Declaration. Written informed consent was obtained from each individual after explaining the purpose and nature of the study. Dental and clinical records of the patients were recorded in a prescribed pro forma. Individuals with history of disorders related to the temporomandibular joint or mandible, history of temporomandibular joint surgery, clinical characteristics of endocrine disturbances, nutritional diseases, or hereditary facial asymmetries were excluded from the study.

Slight modification was done in the "modified reverse panoramic technique" described by Chandra *et al*.[3] Individuals were positioned in reverse manner in Kodak 8000 Digital Panoramic system (Carestream Health, Inc., 150 Verona Street, Rochester, New York-USA 14608) at standard exposure parameters (80 kVp, 10 mA, and 13.9 s). Adequate radiation protection measures were taken, maintaining the mid-sagittal plane centered within the image layer of the X-ray unit. Chin rest was so adjusted to place condylar region close to lateral center of rotation bilaterally equal. Height was adjusted at the level of external auditory meatus and head tilted upward to make Frankfort horizontal plane 10°–15° to floor [Figures 1-3]. Patients' head was stabilized centrally with the assistance of central head stabilizer. Patient was instructed to slightly open the mouth to attain the position of nonocclusion and avoid overlapping of adjacent anatomical structures. The resultant image obtained gave a clear undistorted, nonoverlapped image of lateral (anteroposterior border) aspect of the mandibular condyle bilaterally along with mastoid air cells, occipital bone, and cervical vertebrae [Figure 4].

Metric quantification of maximum anteroposterior diameter of both right and left mandibular condyles was done by Trophy Dicom Software (Carestream Health, Inc.), calibrated considering magnification rate of panoramic machine. Parametric Student's *t*-test was applied to compare the mean and average values of male and female [Table 1]. Discriminant analysis for the individuals was done to classify male and female categories based on the equation derived as:

F (X) = −42.98 + 8.996 (average)

F (X) - discrimination point for male and female.

If the value comes below zero then considered as female whereas if value is above zero male.

The average values of all the sixty samples were placed in the function and scores were calculated. Since the sex of the sample was known, overall accuracy of function in identifying correctly was also calculated.

Results

Mean condylar maximum anteroposterior diameter for males on the left and right side was 10.24067 ± 1.029945 and 10.20667 ± 1.017412 mm, respectively, while in females, it was 9.373333 ± 0.99756 and 9.43 ± 1.132331 mm, respectively. Average value of maximum condylar anteroposterior diameter for males and females was 10.21533 ± 0.99595 and 9.401667 ± 1.048026 mm, respectively. Mean and average values of both right and left sides were observed greater in males as compared to females and were considered highly significant [Table 1].

The predictive accuracy of the discriminant function using average condylar length in correctly identifying the females and males showed a decent accuracy of 63.3%. Hence, statistically, it has good predictive value for both females and males.

Discussion

In forensic, the groundwork of identification is mainly laid by determination of age and sex of the skeletal remains. It can be done using either nonmetric discrete traits or anthropometric methods, along with newer molecular methods. Metric

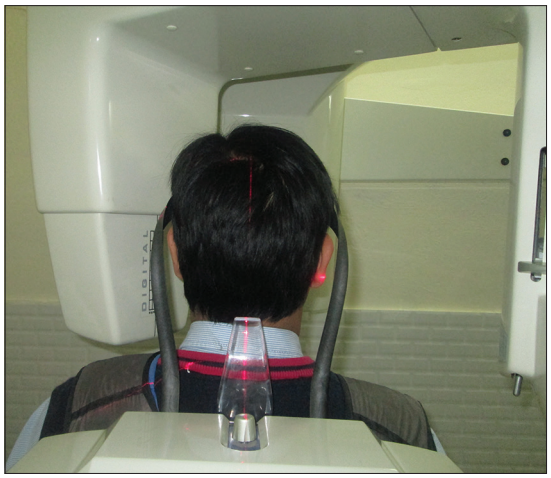

Figure 1: Patient desired height position in the panoramic machine

Figure 2: Lateral view position of patient's head according to reference lines of panoramic machine

Figure 3: Patient positioning in panoramic machine\

Table 1: Student *t*-test to compare parameters

Gender	*n*	Mean±SD	*t*	df	*P*
Left side					
Female	30	9.373333±0.99756	−3.313	58	0.002
Male	30	10.24067±1.029945			
Right side					
Female	30	9.43±1.132331	−2.795	58	0.007
Male	30	10.20667±1.017412			
Average					
Female	30	9.401667±1.048026	−3.083	58	0.003
Male	30	10.21533±0.99595			

SD: Standard deviation

analysis is advantageous and more reliable compared to nonmetric as it depends on the difference in duration of growth of different individuals of both sexes.[1] Furthermore, discriminant function analysis, the statistical technique used in the present study, applies combination of variables between the groups to explore the differences and gives the best variable to predict the sex. It is been proposed that discriminant function equation is population specific and hence can be a method for sex determination.

Mandible is considered being the most dimorphic bone of the skull.[12,13] Mandible as a whole has been studied by various nonmetric methods and proved to be quiet reliable for sex determination.[13] Metric analyses support the nonmetric characteristics of forensic remains and conclude the reliable identification.[5] Mandible as a whole is quiet reliable in forensic studies[6] but its fragmentary reliability is still under question.[13] In the present study, contribution of

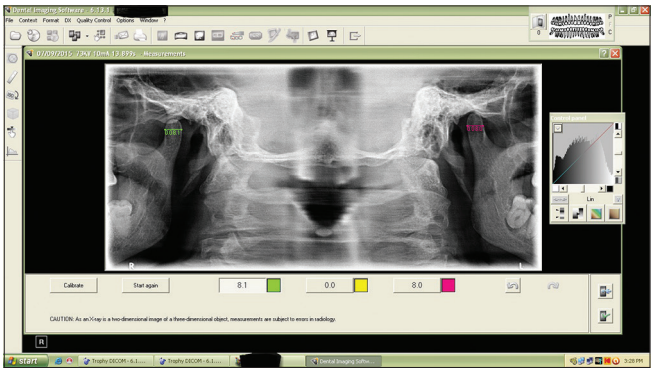

Figure 4: Resultant image

maximum anteroposterior diameter was considered for gender dimorphism. Various other studies have been reported with ramal height and breath, ramal obliqueness, sigmoid notch shape, bicondylar width, and position of mental foramen and several other parameters (Pokhrel and Bhatnagar 2013[13]) confirming the dimorphic character of human mandible. It has been proposed that condyle and ramus, which are the sites associated with greatest morphological changes in size and remodeling during growth process, are particularly the most dimorphic regions of the mandible.[6,12,14-20] This theory is now also validated by the present study which has been proved by the radiographic metric analysis through a novel reverse panoramic radiographic technique.

In the present study, 60 healthy individuals were considered between the age group of 25 and 45 years, considering that as the growth of condyle cease by late teens or early twenties,[10] and regressive changes are frequent in the advanced age. Literature search till date has not revealed any radiographic study considering both condyles simultaneously for forensic identification. In this manner, the present study is one of its own types utilizing reverse panoramic radiographs for forensic intention. Reverse panoramic technique shows the lateral aspect of mandibular condyle that is generally overlapped in OPG.[11] Similar to the present study, a radiographic study done on lateral cephalograph and submentovertex radiograph by Tadej *et al*. (1989) has proposed that lateral cephalograph showed no significant difference in condylar width between male and female.[21] Similarly in a study conducted by Hinton R.J (1983) on Eskimos and American Caucasian population comparing various mandibular joint parameters between male and female population, conclude condylar length in Eskimos as the only parameter that having higher metric values in males.[10] However, in a study by Suazo *et al*. done on subadult population, males have shown higher anteroposterior condylar dimension as compared to the females but was not statistically significant,[19] but in the present study done on adult population, this difference came out to be significant. Pokhrel and Bhatnagar have considered four mandibular parameters in Indian population to ensure for mandibular dimorphism on dry mandible, all the parameters including anteroposterior mandibular condyle diameter have shown higher values for males compared to females and difference been statistically significant, and same

level of difference in size of condyle is been derived in the present study as well.[13] Similar to the present study, a discriminant function was derived by Pokhrel and Bhatnagar for condylar measurement, and it proved to be 70.9% accurate with lower accuracy rate for females, whereas in the present study, the discriminant function derived from condylar length has overall accuracy of 63.3%,[13] the average size of condyle 10.21533 ± 0.99595 mm for male and 9.401667 ± 1.048026 mm for female. Similar result reported by Kaur *et al*. on computed tomography (CT) images that the average anteroposterior diameter of the mandibular condyle is 10.85 ± 1.40 mm.[22] Close to similar condylar anteroposterior size has been reported by Rodrigues *et al*.[23] However, in contrast, Saini has reported that condylar measurements were not significant in sex determination.[24]

Dimorphic character of the human mandible is not only proved by the metric analysis but also various nonmetric studies (S.R. Loth and M. Hennenberg 2001;[25] M. Coquerelle *et al*. 2011;[26] Franklin *et al*. 2008;[12] D. Franklin *et al*. 2007;[25] Wangi L *et al*. 2013[28]) have confirmed this fact.[25-28] However, dimorphic character of mandible greatly depends not only on the variable pattern of growth, remodeling of bone, malocclusion, trauma, and other developmental abnormalities[15] and diseases[9] but also on the geographic distribution and functional habits.[10,12,29] Various methods are reported in literature for metric analysis of the mandibular condyle for both immortals and mortal studies which include anthropometric measurements, radiographic assessment through CT scan, magnetic resonance imaging, and other radiographic modality, of which the present technique is distinctive. Still it has some limitations such as unequal magnification, difficult patients positioning, and population-specific studies for condylar dimorphism which are hindering the reliability of the present technique.

Conclusion

The present study concludes that dimorphism of the mandibular condyle exists for given population under study, and reverse panoramic radiograph can be quiet reliable and practical approach for condylar imaging and metric analysis. Although the present study is only a pilot study and more extensive approach toward it is required on a larger sample.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of interest

There are no conflicts of interest.

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