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Digital Radiographic Analysis of Human Mandible A approach for Gender Detection

KEYWORDS

Mandibular ramus, Forensic Odontology, Sex determination, Forensic anthropology, Sexual dimorphism, Panoromic Radiography.

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ABSTRACT

The determination of sex is one of the most important aspect of forensic anthropology and is vital in medico-legal investigations. Available Dental Panoromic radiographs can serve as an effective tool for gender estimation.

Aim: The purpose of the present study was to evaluate the usefulness of mandibular ramus on panoramic radiograph in sex discrimination in central India population.

Materials and Methods: 150 patients were selected ageing between 18 to 70 years for the study and their Digitalized Panoromic radiographs were taken. Five parameters namely Maximum ramus breadth, Minimum Ramus breadth, Condylar height, Projection height of ramus and Coronoid height were taken into consideration, the values were measured and data was analyzed. Statistical Analysis was done using SPSS software.

Results: Greatest sexual dimorphism was best exhibited in parameter of maximum ramus breadth followed by maximum condylar height & projective height of ramus. All parameters exhibited significantly higher values in case of males than in females.

Conclusion: Discriminant analysis of mandibular ramus using panoramic radiography can be considered as a reliable tool for gender determination and can be used as an aid in forensic analysis.

Introduction:

Determination of sex can be done through morphological assessment which is one of the oldest approache in forensic anthropology and medico-legal examinations. The method may vary and depend upon the available bones and their conditions. The identification of sex is of significance in cases of mass fatality incidence where bodies are damaged beyond recognition. When entire adult skeleton is available for analysis, sex can be determined up to 100% accuracy. However in cases of mass disasters, many times only fragments of bones are found and determination of gender depends on available parts of skeleton. In such situations the field of forensic dentistry comes into role play.

The contribution of forensic dentistry to human identification takes two main forms: the identification of human remains according to dental records existing antemortem, and a postmortem dental profiling in cases where there are no antemortem records. Distinguishing males from females and the differences in ethnic groups by analyzing the morphological characterstics of bone is important in the fields of physical and forensic anthropology[1]. The skeletal components most often investigated for gender determination are the pelvis and skull along with the mandible because it is the strongest bone in the human body and persists in a well-preserved state longer than any other bone. Presence of a dense layer of compact bone makes it very durable and well preserved than many other bones.[2] Mandibular ramus can differentiate between sexes, as the stages of mandibular development, growth rates, and duration are distinctly different in both sexes. In addition, masticatory forces exerted are different for males and females, which influences the shape of the mandibular ramus.[3] The mental and mandibular foramina have been played a vital role in field of forensic dentistry by virtue of its stable relation with the base of this bone. Inspite of this, the differences between the sexes are generally more marked in the mandibular ramus than in the mandibular body. Hence Mandible is being a practical element to analyze sexual dimorphism in the fragmented bones, used by anthropologists and forensic dentists in the determination of sex. Skeletal characteristics vary by population; therefore, there is a need for population- specific standards.[2]

Various metrical studies in the past (Hanihara, 1959;[4] Giles, 1964;[5] Potsch-Schneider et al., 1985;[6] Steyn and Iscan, 1998;[7] Muñoz et al., 2001;[8]Vodanović et al., 2006;[9]Simona et al., 2007;[10] Saini et al., 2011[11]) have made use of various parameters pertaining to individual parts of the mandible for gender determination. But there are only a few studies which have utilized multiple parameters together and analyzed them for sex determination. From these studies this can be established that methods based on morphometric and measurements of mandible are accurate and can be utilized for determination of sex.

Dentofacial radiography has become a routine procedure & radiographs are taken at different periods during lifetime of large segments of population. The radiographs are indispensable tools that can also be used in forensic anthropology[12,13]. Amongst dental radiographs panoramic radiography is widely used for comprehensive overview of maxillofacial complex. The Skeletal characteristics visible on panoramic radiographs provide enough information when antemortem and postmortem films are compared hence they can be very vital in identification of human remains.[13] Multiple studies have been conducted in the past examining dry adult mandibles for sex determination but literature in regards to examination of mandible on panoramic radiographs is still scanty.

Thus following study was conducted with an aim to evaluate the usefulness of Mandibular Ramus in Sex Discrimination on Panoramic Radiograph in Central Indian Population and propose the use of same in forensic analysis.

Objectives of the study were, 1) to measure the maximum ramus breadth, the minimum ramus breadth, maximum ramus height, the projective height of ramus and the coronoid height of mandible. 2) To assess the usefulness of these parameters as an aid in gender determination.

Materials and Method:

This retrospective study was conducted in the department of oral medicine and radiology, Sharad Pawar Dental College, Sawangi, Wardha. A total of 150 patients was selected for the study. Inclusion criteria includes age between 18 and 70 years, patients requiring

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panoramic radiographs for dental treatment, and patients giving consent for the study. Exclusion criteria includes, Patients above 80 years or below 17 years of age, patients with gross deformity, fracture, developmental disturbances of mandible, patients with edentulous mandibles, and patients not consenting for the study. The panoramic radiographs were taken by Planmecca Proline cc with inbuilt annotation software (70kVp, 12mA, 18sec) panoramic and cephalometric analysis system.

Following parameters were measured using mouse driven method(by moving the mouse and drawing the lines using points chosen on the digital panoramic radiographs) on annotation software:

- Maximum Ramus Breadth-Distance between most anterior point on ramus & line connecting most posterior point on condyle & angle of jaw.
- Minimum Ramus Breadth-Smallest Anteroposterior width of ramus.
- Condylar Height- From most superior point on condyle to the tubercle or most protruding portion on lower border of mandible.
- Projection Height of Ramus- Highest point of mandibular condyle & lower margin of bone.
- Coronoid Height-Projective distance between coronoid & inferior margin of bone.

The data obtained were subjected to discriminant analysis using the statistical package of SPSS 18 software. Discriminant function analysis was used for determination of variables that discriminate between male and female.

Results and Observation:

In the present study, Descriptive statistics of five mandibular ramus (Projective Height Of Ramus, Maximum Condylar Height, Coronoid Height, Maximum Ramus Breadth, Minimum Ramus Breadth) measurements and associated F ratios, for both sexes shows there is difference in projective height of ramus of mandible in males as it is significantly more in males (p value < 0.0001) as compared to females , similarly maximum condylar height, maximum ramus breadth and minimum ramus breadth is also more in males as compared to females, as the difference is statistically significant (Table 1).

Table 1 : Mean values OF Projective Height Of Ramus,Maximum Condylar Height,Coronoid Height,Maximum Ramus Breadth,Minimum Ramus Breadth

	Male		Female		Common values		
Variable	Mean(cm)	Standard Deviation	Mean (cm)	Standard Deviation	Wilk's Lambda	F	P
Projective Height Of Ramus	4.81	0.49	4.49	0.38	0.80	5.16	< 0.0001
Maximum Condylar Height	7.49	0.64	6.85	0.63	0.79	5.28	< 0.0001
Coronoid Height	3.74	0.40	3.57	0.44	0.92	2.56	0.03
Maximum Ramus Breadth	7.50	0.69	6.55	0.69	0.80	5.97	< 0.0001
Minimum Ramus Breadth	8.15	0.74	7.10	0.69	0.78	5.11	< 0.0001

The sex can be detected from the standardized and unstandardized coefficients, structured coefficients and sectioning point in original samples these functions by multiplying the values of mandibular ramus dimensions by the corresponding coefficients plus the constant which is the discriminant equation for that particular function. (Table 2)

Table 2: Coefficients and Sectioning points

Variable	Raw Coefficients	Standardized Coefficients	Structure Coefficients	Sectioning Point
Max. ramus breadth	0.191	-0.410	0.821	7.026
Min. ramus breadth	0.285	0.384	0.796	7.627
Condylar height	0.228	0.142	0.815	7.169
Projective ht. of ramus	0.345	0.402	0.819	4.647
Coronoid height	0.142	-0.161	0.943	3.653

For example, the discriminant equation for function 2 is given as
D = (maximum ramus breadth x 0.155) + (minimum ramus breadth x -0.135)+ (Coronoid height x 0.191) – 13.887

A discriminant value is obtained by using this formula. A discriminant score greater than sectioning point indicates male and less than sectioning point indicates female. The predictive accuracy using these variables was 76% (Table 3).

Table 3: Prediction Accuracy

True Group	Predicted Group Membership			
	Male	Female	Total	% Accuracy
Male	79	71	150	76%
Female	71	79	150	

Discussion:

Sexual dimorphism refers to those differences in size, stature and appearance between male and female that can be applied to dental identification because no two mouths are alike. It is known that gender dimorphism may be influenced by ethnic factors. For this reason, the same methodology may present different outcomes when applied in different communities for gender estimation. Since there are only a few studies done in this relation in Central Indian Population, we conducted the study among the population of Vidharbha region of Maharashtra state of Central India.

In comparison to techniques of sex determination based on analysis of morphological marks, morphometric analysis of skeletal remnants seems more objective and more accurate. Amongst skeletal remnants mandible becomes the choice of bone in this study primarily because, first as it possesses resistance to damage and disintegration process and second there appears to be paucity of standards when utilizing this bone.[2]

The current study uses Discriminant Function Analysis of Mandible and uses measurement of five variables on panoramic radiography. The results showed that all the five variables demonstrated statistically significant sex difference between sexes, thus suggesting that mandibular ramus expresses strong sexual dimorphism. Amongst the five variables greatest sexual dimorphism was expressed by Maximum Ramus Breadth followed by Maximum Condylar Height & Projective Height of Ramus. Overall prediction rate using the five variables is 76%.

Discriminant analysis is used to classify individuals into two or more alternative groups on the basis of a set of measurements. Hence, discriminant function analysis may serve as an entirely objective statistical technique for sex determination.[14]However, when discrete traits are used for sexing a fragment of the mandible like the ramus or condyle, it becomes indeed very unreliable even in expert hands .The predictive value yielded by condyle alone was low and further studies may be required before utilizing it as a diagnostic tool.[14] In 1998, Muller tested procedures for determining sex from a single mandibular character and found that gonial flaring provides a more accurate indicator of sex (76%) than either chin shape or ramus flexure[15]In 1998, Donnelly et al. did a blind test of mandibular ramus flexure as a predictor of sex, and reported that the association between sex and ramus flexure was weak and that the trait could not be consistently identified.[16]

Nancy AFK, Hazem MM and Tamer MAW conducted a study , & concluded that a moderate overall predictive accuracy of (83%) was attained in diagnosing the sex by observing the posterior edge of the mandibular ramus in adult Egyptians orthopantomographs.[17] Humphery et al concluded that almost any site of mandibular bone

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deposition, resorption or remodelling have potential for becoming sexually dimorphic. Hence mandibular ramus & mandibular condyle particular are generally the most sexually dimorphic as they are the sites associated with the greatest morphological changes in size & remodelling during growth.[18] Giles et al investigated sexual dimorphism of mandibular ramus and found that maximum ramus height ,maximum ramus breath, minimum ramus breath highly significant with an accuracy of 85%.[5] Saini et al studied mandibular ramus in dry adult mandible and found that mandibular ramus expresses strong sexual dimorphism.[11] The overall prediction rate using five variables was 80.2%. The best parameter in his study was coronoid height, condylar height & projective height of ramus. Dayal et al (2008) found ramus height to be best parameter with75.8%.A.Indira (2012)found minimum ramus breadth as best predictor with 76% accuaracy.[19] In the present study, the mean value of projective height of ramus,maximum condylar height,coronoid height,maximum ramus breadth,minimum ramus breadth was found to be greater in males than in females and the results were in accordance with study conducted by T Jayachandra.[20] The comparison of projective height of ramus, maximum condylar height, coronoid height, maximum ramus breath, minimum ramus breath between males and females showed extremely significant difference (p = 0.0001).Maximum ramus breath was found to be best parameter in present study which is consistent with other osteometric studies by Giles (1964)[5], Rangnath et al (2008),[21]Vinay G.(2013). [22] where breath measurements were found to be very dimorphic. This can be attributed to differences in musculoskeletal development and to the differences related to a different growth trajectory in males & females.[1]

Limitations of this study includes the in ability to reliability determine the gender in both Pediatric and Geriatric age groups, and also in patients with edentulous mouths and osseous disorders affecting mandible.

Conclusion:

The identification of sexual dimorphism still relies almost exclusively upon as many dimorphic skeletal morphological features as possible. The mandibular ramus parameters must be considered for anthropological and forensic purposes as it possesses resistance to damage and disintegration process. The current study found that Discriminant analysis of mandibular ramus using panoramic radiography is a reliable tool for gender determination and can be used as an aid in forensic analysis.

Recommendations: Further studies can be conducted in more diverse populations and different age groups for establishing population and age specific osteometric standards for sex determination.

Conflict Of interest :-None

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