ISSN- O: 2458 - 868X, ISSN–P: 2458 – 8687
Index Copernicus Value: 68 . 16
PubMed - National Library of Medicine - ID: 101731606

International Journal of Medical Science and Innovative Research (IJMSIR)
IJMSIR : A Medical Publication Hub
Available Online at: www.ijmsir.com
Volume – 5, Issue –3, May - 2020, Page No. : 88 - 96

Determination of sex by applying discriminant function analysis on the linear measurements of the mental and mandibular foramen using OPG- a retrospective study.

[1]Sukanya Desingurajan, BDS, Dept. Oral Medicine and Radiology, V. S. Dental College And Hospital, K. R. Road, V. V. Puram, Bengaluru, Karnataka , India - 560004

[2]Upasana Lingaiah , MDS, Dept. Oral Medicine and Radiology, V. S. Dental College And Hospital, K. R. Road, V. V. Puram, Bengaluru, Karnataka , India – 560004**.**

[3]Annaji A .G., MDS, Dept. Oral Medicine and Radiology, V. S. Dental College And Hospital, K. R. Road, V. V. Puram, Bengaluru, Karnataka , India - 560004

Corresponding Author: Sukanya Desingurajan, BDS, Dept. Oral Medicine and Radiology, V. S. Dental College and Hospital, K. R. Road, V. V. Puram, Bengaluru, Karnataka, India – 560004

Citation this Article: Sukanya Desingurajan, Upasana Lingaiah , Annaji A .G., "Determination of sex by applying discriminant function analysis on the linear measurements of the mental and mandibular foramen using OPG- a retrospective study.", IJMSIR- May - 2020, Vol – 5, Issue -3, P. No. 88 – 96.

Type of Publication: Original Research Article

Conflicts of Interest: Nil

Abstract

Background: Gender determination is the foremost step in forensic science, attained by human skeletal remains. Mandible, the lower jaw plays a pivotal role in determining the gender, as it is strong and difficult to disintegrate.

Aims: This study is carried out to determine sex by applying discriminant function analysis on the linear measurements of the mental and mandibular foramen using OPG.

Methods and Material: A total of 80 patients of 40 males and 40 females were examined with age ranging from 20 -59 years. Four linear measurements D1, D2, D3, and D4 from both right and left sides of the mandible are made in digital OPG image and values of both right and left and male and female were compared. The data obtained were tabulated and subjected to discriminant function analysis.

Statistical Analysis Used: Statistical Package for Social Sciences [SPSS] for Windows, Version 22.0. Released in 2013. Anmonk, NY: IBM Corp., was used to perform statistical analyses and Descriptive statistics was used.

Keywords: Gender determination, mental foramen, Mandibular foramen, Discriminant functional analysis, Digital panoramic radiograph, forensic science.

Introduction

Disaster may be caused by natural events such as flooding, earthquake or volcanic eruptions. Mishaps can also be due to human activities such as mass transport by land, sea, air and other causes include war, boundary disputes. In such instances, identification of the individual victims by nonvital means is one of the most reliable methods. In severe disintegration, due to soft tissue destruction visual recognition of facial features and finger prints are often impossible. This

circumstance requires the use of the hard calcified tissue such as human dentition jaws, pelvis and skull.

The difference between female and male are best reflected in pelvis and skull. After pelvis, skull is the important and dimorphic portion for sexual identification. Mandible plays a significant role in gender determination, when the entire skull is not available. [1]

Ancestral variations in morphology and measurements another important aspect regarding skull and skull bones. These variations in skull bone features can be useful in sex and ancestry estimation during forensic investigations.

The lower jawbone, Mandible is used for morphometric analysis for gender estimation in forensic and anthropological investigation owing to sex related morphometric differences. [2]

Mandible resists taphonomic process better than other skull bones and for the same reason it can be a reliable evidence for morphometric analysis during investigations.

In several studies, Sexual dimorphism of morphologic and morphometric features of mandible have been established. [3,4]

In terms of larger muscle attachments, robustness and overall size, measurements of the mandible are larger in males than females. Other traits such as genial flaring, broad ascending ramus, high symphysis and small mental eminence of mandible also shows male predominance. [5]

Mental foramen is located at the exit of the mental canal and opens on the lateral surface of the mandible with mental nerve and vessels passing through it. Mental foramen has four types of radiographic appearance: 1) continuous type where the mental and mandibular canal appear to be continuous, 2) separate type where the foramen and mandibular canal appears clearly separated, 3) diffuse type where border of the foramen is not distinguishable, 4) unidentified type. Because of the minimum resorption propensity of the basal bone, the mental foramen is considered as a stable landmark on mandibular radiographs. [6,7]

The mandibular canal is a canal located on the surface of the medial mandibular ramus and runs along from the mandibular foramen to the mental foramen. The mandibular canal is also a bony canal in the mandible that is the passageway for a portion of the trigeminal nerve and veins that supplies blood to the lower teeth.

Orthopantomography also known as panoramic tomography and Panoramic radiography, a single tomographic image which captures the facial structure such as the maxilla and mandible dental arch, teeth, temporomandibular joint and also a part of the maxillary sinus. This remarkable quality of Orthopantomography allows dentists to analyse and record all the masticatory components and its interrelationship. It has less exposure, time consuming and cost effective. Hence, it can be applied in forensic medicine with the utilization of portable units. This approach allows the extra-oral examination of the dental status in less time in larger population. In these Orthopantomography, the foramen appears as radiolucent areas. [8]

Several studies show that, the position and the measurements of the mandibular canal and the mental foramen are influenced by gender. But there are scarce studies which used discriminant functional analysis for gender determination. [9-12]

Hence in the present study, the relative anatomical positioning of mental foramen and the mandibular foramen is used for gender determination. The measurements of mandible in male and female patients

were studied and the data obtained were subjected for discriminant function analysis to derive an equation for sex estimation.

Subjects and Methods

The sample size has been estimated using the G Power software v. 3.1.9.2. Considering the effect size to be measured (d) at 65%, power of the study at 80% and the margin of the error at 5%, the sample size obtained is 78. Rounding off the sample size to 80. So, each study group will comprise of 40 samples [40 samples x 2 groups = 80 samples].

A retrospective study was performed in department of Oral medicine and Radiology, V. S. Dental College and Hospital,Bengaluru. The sample size includes 80 panoramic radiographs of 40 males and 40 females of age ranging from 29-59 years which were included in the present study. These radiographs were evaluated according to gender; they were divided into four groups according to age:

- Group 1: 10 males and 10 female radiographs from 20-29 years of age
- Group 2:10 males and 10 female radiographs from 30-39 years of age
- Group 3: 10 males and 10 female radiographs from 40-49 years of age
- Group 4: 10 males and 10 female radiographs from 50-59 years of age;

Radiographs, were taken using Dentsply Sirona (Orthophos XG) digital panoramic and cephalometric system (64 kVp, 8 mA, 14.1 s).

Radiographs of high quality were carefully chosen for the analysis. Ideal OPG of completely dentate patients with minimum age of 20 years and maximum of 59 years which showed appropriate position of the mental and mandibular foramen and with clearly visible mandibular foramen were considered.

Radiographs with other lesions, pathologies, congenital abnormality and patients who endured surgical intervention and other artifacts which impeded mental and mandibular foramen were not considered.

Methodology

The panoramic images that was taken using Sirona digital X-ray machine and stored in the system were considered. The images on the monitor were examined and the resolution was enhanced to optimum. These radiographs are used for making linear measurements on the mandible. According to Amorim et al linear vertical measurements were done on the radiographs.In which four linear measurements (D1,D2,D3,D4) on each side (left and right) were done.[11]

D1 denotes the vertical distance from the most inferior point on the mental foramen to the inferior most point on the base of the mandible.

D2 denotes the vertical distance from the most superior point on the mental foramen to the superior most point of alveolar crest.

D3 denotes the vertical distance from the most inferior point of the mandibular notch to the most superior point on the mandibular foramen.

D4 denotes the vertical distance from the most inferior point of the mandibular notch to the inferior edge ramus of the mandible.

After the agreement of the two observers, the measurements were made.

Statistical analysis

Statistical Package for Social Sciences [SPSS] for Windows, Version 22.0.Released in 2013.Anmonk, NY:IBM Corp.,was used to perform statistical analyses.

Descriptive statistics

Descriptive analysis of all explanatory and outcome parameters was done using frequency and proportions

for categorical variables, whereas in mean and SD (Standard Deviation) for continuous variables.

Inferential statistics

Independent Student t Test was used to compare the mean linear measurements at different points on right and left sides between males and females. Similar comparisons were performed based on the different age groups.

Student Paired t Test was used to compare the mean linear measurements at different points between right and left sides among males and females. [Table 1 and 2].

Averages were calculated from right and left sides for males and females with respect to different study variables to perform step-wise discriminant function analysis for gender prediction. The level of significance [P-Value] was set at $P<0.05$. Discriminant function analysis for the linear measurements of the mental and mandibular foramen for the gender discrimination was performed.

As per the analysis outcomes, D1, D2 and D4 swere considered as the strong significant predictors for gender prediction. The Unstandardized canonical coefficients for the same were 0.41, 0.19 and 0.07 respectively.

The unstandardized and standardized coefficients, structure matrix, group centroids and sectioning point for the discriminant function are provided [Table 5]. To predict the gender of an unidentified individual, the linear measurements is correspondingly multiplied with the respective un-standardized coefficient and added to the constant. If the value obtained is greater than the sectioning point, the individual is considered as male; if the value obtained is less than the sectioning point, the individual is considered as female.

Result

As per the analysis outcomes, D1, D2 and D4 were considered as the strong significant predictors for gender prediction. The Gender Prediction equation (Discriminant value) = -13.54 + (0.41 x D1) + (0.19 x D2) + (0.07 x D4).The Predicted gender model showed a high sensitivity of 82.5% and specificity of 85.0% and the overall accuracy of 83.8% of grouping correctly the originally grouped cases.

Discussion

The morphological features of the human skeletal remains contributed to the evolution of forensic medicine that used these features in the revealing of sex, among much other identification such as age. There are many studies conducted in order to identify the sex using mandible, In the mental and mandibular foramen are used as an indicator in sex identification using OPG (Orthopantomography) and Cone Beam Computed Tomography(CBCT). Owing to the reduced availability and cost expensive nature of Cone Beam Computed tomography (CBCT), our study was conducted using OPG. So, in the present study, we have tried to associate the distance between the mental and the mandibular foramen as an indicator of gender using discriminant functional analysis by OPG (Orthopantomography).

OPG provides several advantages over other modalities of radiology as mentioned earlier. Various studies have been done to determine the gender using the mandible but only few studies have been done which applies discriminant function analysis to determine sex. This is one of the distinct features of the study. It also derives an equation for gender determination.

In our study [TABLE 1 and 2] shows the mean values of the distance between different measurements such as D1, D2, D3, D4. are greater in males than in the

females. A study conducted by Alias et al showed that the measurement between lower border of the mental foramen was greater in males than in the females. [13] Study conducted by Suragimath et al, found sexual dimorphism in the distances from superior and inferior border of mental foramen to the lower border of mandible, which showed there is difference between males and females.[14]

While a study conducted by Al-Mufti et al., indicated that the vertical measurements from mandibular and mental foramen are potent indicators for sex determination and useful in differentiating male gender from female.[15]They noticed that sexual differences were more in mandibular ramus height proving its significance in sex determination when compared to the body of the mandible.

A study conducted by Indira et al, noticed that sexual differences were more in mandibular ramus height proved to have significance in sex determination when compared to the body of the mandible.[16]A study conducted by Ghouse et al, showed that both sides of mandible was similar with slight discrepancies in measurements, and also stated it can be used for analysis, and the means of measurements of D1, D2, D3 and D4 were significantly higher in male than female. The study analysis showed that D2 is highly sensitive, D1 highly accurate, D3 highly specific and D4 highly significant, which was similar to the present study.[17] Studies conducted by Morant et al Hrdlicka et al,Martin et al,(which was cited in Humphery et al)[18]have proved sexual determination in mandible, which shows the measurements are greater in males. In all the above studies, it was proved that the values were greater in males. But the exact value to consider it to be greater can be determined by applying discriminant function analysis.

Discriminant function analysis is a statistical procedure that classifies unknown individuals and the probability of their classification into a certain group.[19] Only few studies were done for gender determination using discriminant function analysis.

A study was conducted by Rengith et al, using discriminant equation with a cutting score based on anatomical position of mental foramen for sex estimation in Chinese population of Malaysia which showed accuracy of 85.7%. [20]Hanihara et al in their study with four mandibular variables attained accuracy of 85% in Japanese population.[21] Giles et al conducted sex estimation studies on mandibles of American population with 84% accuracy.[22]Steyn et al observed 81.5% accuracy in mandibular measurements in South African White population for sex estimation.[23]While a study conducted by Dayal et al showed that in South African Population the accuracy was about 80% to 85% .[24] A study on Osteometric Assessment of Various Mandibular Morphological Traits for Sexual Dimorphism by Discriminant Function Analysis in Jordanians was done by Wala M. Amin using eight parameters showed accuracy of 83.8%.[25]

In the present study, using four parameters D1, D2, D3, D4 we have used the stepwise discriminant analysis and the best predictors of sex (D1, D2, D4) were selected. High sensitivity of 82.5% and specificity of 85.0% was achieved. A reliable level of estimation of sex using the equation showed 83.8% accuracy. This is consistent with all the above mentioned studies.

This study has also derived an equation for prediction of gender. But this study has been conducted with smaller sample size. Further studies are required with larger sample size, in different race and ethnicity. Further studies must be done to validate the equation

derived from the study, so that they and be can be applied for gender determination.

Conclusion

This study has derived an equation for the gender prediction (Discriminant value). This formula has proved to be significant in the examined sample**.** The results revealed that D1, D2 and D4 measurements were sensitive parameters, and exhibits sexual dimorphism and can be used for sex estimation in forensic dentistry. This specific equation serves as a baseline data for investigators for gender determination. Further studies are required including subjects from different race and ethnicity to validate the relevance of the study in larger populations.

Tables

Table 1 : Comparison of mean linear measurements at different points on Right Side between males and females using Independent Student t Test

Variables	Gender	N	Mean	SD	Mean Diff	P-Value
D1	Males	40	14.70	1.96	2.15	<0.001*
	Females	40	12.55	1.48		
D2	Males	40	19.81	2.68	1.85	0.002*
	Females	40	17.96	2.48		
D3	Males	40	17.75	3.56	1.60	0.04*
	Females	40	16.15	3.09		
D4	Males	40	57.54	4.84	5.17	<0.001*
	Females	40	52.38	4.67		

P value≤0.05 is considered as statistically significant

* - Statistically Significant

Table 2 : Comparison of mean linear measurements at different points on Left Side between males and females using Independent Student t Test

Variables	Gender	N	Mean	SD	Mean Diff	P-Value
D1	Males	40	14.85	2.08	2.18	<0.001*
	Females	40	12.67	1.79		
D2	Males	40	19.85	2.90	2.43	<0.001*
	Females	40	17.42	2.89		
D3	Males	40	17.48	3.37	1.77	0.02*
	Females	40	15.71	2.96		
D4	Males	40	56.68	4.88	4.04	<0.001*
	Females	40	52.65	5.03		

P value≤0.05 is considered as statistically significant

* - Statistically Significant

Table 3: Step-wise discriminant function analysis of diff. linear measurements for Gender Prediction									
Steps	Variables Entered	Wilk's Lambda				Exact F			
		Statistic	df1	df2	df3	Statistic	df1	df2	Sig.
1	D1	0.69	1	1	78	35.044	1	78	<0.001*
2	D2	0.62	2	1	78	23.743	2	77	<0.001*
3	D4	0.59	3	1	78	17.857	3	76	<0.001*

P value<0.05 is considered as statistically significant

* - Statistically Significant

At each step, the variables that minimizes overall Wilk,s Lambda is entered.

A. Maximum number of steps is 8.

B. Minimum partial F to enter is 3.84.

C. Maximum partial F to remove is 2.71.

Table 4:Discriminant Function coefficients		
Variables	Coefficients	Value
D1	0.41	
D2	0.19	
D4	0.07	
Constant		-13.54

As per the analysis outcomes, D1, D2 & D4 were considered has the strong significant predictors for gender prediction.

Table 5: Discriminant function coefficients for Gender Determination that entered the analysis						
Variables	Unstd. Coefficient	Str. Matrix	Std. Co efficient	Group Centroids		Sectioning Point
				Males	Females	
D1	0.41	0.80	0.66	0.829	-0.829	0.000
D2	0.19	0.50	0.47			
D4	0.07	0.61	0.32			

Unstandardized = Unstd Unstandardized. Discriminant function evaluated at group means. Standardized (STD). Matrix - pooled within groups correlations between discriminating variables and Standardized Canonical discriminant function. Discriminant score more than sectioning point is categorized as Males, less than sectioning point is considered as Females.

References

1. Acharya AB, Sivapasundaram B. Forensic odontology. Shafer's Textbook of Oral Pathology. 5th ed. New Delhi: Elsevier; 2006.1199-22
2. Giles E. Sex determination by discriminant function analysis of the mandible. Am. J. Phys. Anthrop. 1964; 22: 129-36.

3. Loth SR, Henneberg M. Mandibular ramus flexure: a new morphologic indicator of sexual dimorphism in the human skeleton. Am J Phys Anthropol. 1996; 99:473-85.
4. Balci Y, Yavuz MF, Cağdir S. Predictive accuracy of sexing the mandible by ramus flexure. Homo. 2005;55:229-37.
5. Vinay G. et al. Sex Determination of Human Mandible Using Metrical Parameters. Journal of Clinical and Diagnostic Research. 2013;7: 2671-2673
6. Yosue T, Brooks SL. The appearance of mental foramina on panoramic radiographs. I. Evaluation of patients. Oral Surg Oral Med Oral Pathol. 1989; 68: 360-4.
7. Pérez-Pérez A, Alesan A, Roca L. Measurement error: inter-and intraobserver variability. An empiric study. International Journal of Anthropology. 1990;5:129-35.
8. Rockenbach MI, Sampaio MC, Costa LJ, Costa NP. Evaluation of mandibular implant sites: correlation between panoramic and linear tomography. Braz Dent J 2003;14:209-13.
9. Mahima VG, Patil K, Srikanth HS. Mental foramen for gender determination: A panoramic radiographic study. Med Leg Update. 2009;9:33–5.
10. Chandra A, Singh A, Badni M, Jaiswal R, Agnihotri A. Determination of sex by radiographic analysis of mental foramen in North Indian population. J Forensic Dent Sci 2013; 5:52-5
11. Amorim MM, Borini CB, Lopes SLPC, Haiter-Neto F, Caria PHF. Morphological description of mandibular canal in panoramic radiographs of Brazilian subjects: Association between anatomic characteristics and clinical procedures. Int J Morphol, 2009; 27.
12. Rashid SA, Ali J. Morphometric analysis of mandibular canal course and position in relation to gender and age of Iraqi sample using digital panoramic imaging. J Baghdad College Dentistry. 2011; 23.
13. Alias A, Ibrahim AN, Abu Bakar SN, Shafie MS, Das S, Mohd. Nor F. Morphometric and morphological study of mental foramen in the malaysian population: Anatomy and forensic implications. International Medical Journal Malaysia. 2017;16:47-53
14. Suragimath G, Ashwinirani SR,Christopher V, Bijjargi S, Pawar R, Nayak A. Gender determination by radiographic analysis of mental foramen in the Maharashtra population of India. J Forensic Dent Sci 2016;8:176.
15. Al-Mufti KS. Digital panoramic radiographic Study of the mental and mandibular foramina locations in the (23-25) years old age group patients. A Master Thesis, Department of Oral and Maxillofacial Radiology, College of Dentistry, University of Hawler; 2008.
16. Indira AP, Markande A, David MP. Mandibular ramus: An indicator for sex determination - A digital radiographic study. J Forensic Dent Sci 2012;4:58-62.
17. Ghouse N, Nagaraj T, James L, Swamy NN, Jagdish CD, Bhavana TV. Digital analysis of linear measurements related to the mental and mandibular foramina in sex determination. Journal of Medicine, Radiology, Pathology and Surgery. 2016;2:5-9.
18. Humphrey LT, Dean MC, Stringer CB. Morphological variation in great ape and modern human mandibles. J Anat 1999;195:491-513.

19. Renjith G, Mary DP, Soe K, Wan MY, Beh HC, Phuah WH, Tseu AT. Sex estimation by discriminant function analysis using anatomical location of mental foramen. Forensic Science International: Reports. 2019;1:100018.
20. Hanihara K. Sex diagnosis of Japanese skulls and scapulae by means of discriminant functions. J Anthropol Soc Nippon 1959;67:191- 7.
21. Giles E. Sex determination by discriminant function analysis of the mandible. Am. J. Phys. Anthrop. 1964; 22: 129-36.
22. Steyn M, Iscan MY. Sexual dimorphism in the crania and mandibles of South African whites. Forensic Sci Int. 1998; 98:9–16
23. Dayal MR, Spocter MA, Bidmos MA. An assessment of sex using the skull of black South Africans by discriminant function analysis. Homo 2008;59:209- 21.
24. Amin WM. Osteometric Assessment of Various Mandibular Morphological Traits for Sexual Dimorphism in Jordanians by Discriminant Function Analysis. International Journal of Morphology. 2018 ;36.