DOI: 10.7860/JCDR/2023/62858.18164

Original Article

Dentistry Section

A Comparative Analysis of Mandibular Ramus and Maxillary Sinus in Sex Determination among the Population of West Godavari, India: A Tool in Forensic Identification

ALAPATI NAGA SUPRIYA[1], SARIDENA UDAYASRI NAGA GAYATRI[2], RAVIKANTH MANYAM[3], P SWETHA[4], MHL SUPRAJA[5], JYOTHI PRAVALLIKA MEKA[6]

ABSTRACT

Introduction: The application of dental principles to legal issues is known as forensic dentistry. Among the skull's various bones, mandible is the strongest and most diverse bone and is crucial in determining sex. It has been reported in many studies that maxillary sinus seems to be intact, although other bones may be severely deformed and can be applied to determine sex.

Aim: To assess, analyse and compare the morphometric analysis of maxillary sinus and ramus of mandible for gender determination using digital Orthopantamograph (OPG).

Materials and Methods: A cross-sectional study was conducted in Department of Oral Medicine, Radiology and Oral Pathology, Vishnu Dental College, Bhimavaram, Andhra Pradesh, India. The study comprising of 64 individual radiographs (32 men and 32 women) were measured for mandibular ramus (maximum ramus width, condylar and coronoid height) and maxillary sinus length, width and compared bilaterally. The results were tabulated and statistically analysed using discriminant functional analysis after the mean values were calculated.

Results: The mean age of study population was 34.67±5.78 years. In the present study, the overall measurements of mandibular ramus were more in males than females whereas maxillary sinus measurements were more in females when compared to males. Condylar length (right and left), width of ramus (right) and width of maxillary sinus (left) were found to have statistical significance in determining the gender (p-value <0.001, 0.024, 0.024). Length of the condyle showed highest accuracy of 73.8% in gender determination.

Conclusion: The present study suggests that the mandibular ramus and maxillary sinus measurements using OPG are helpful in dealing forensics, with condylar height being the most accurate indicator for gender determination.

Keywords: Digital orthopantamograph, Forensic dentistry, Gender determination

INTRODUCTION

Forensic odontology is a multidisciplinary field of study that deals with issues of jurisdiction and the victim identification in large-scale disasters and analysing natural disasters with dental records. In criminal justice cases, Forensic Odontology also known as Forensic Dentistry, handles, examines, and evaluates dental evidence. Forensic dentistry plays a crucial role when other human identification techniques are either not indicated or not appropriate. Gender identification is the first step in the identification procedure for adult skeletons. All human populations have different sized and shaped adult male and female skeletons [1,2].

Sex identification depends mainly on the sections of the skeleton that are still present in cases of large-scale disasters where fragmented bones are typically discovered. The most frequently used part of the skeleton for gender identification is the skull, followed by the pelvis [1]. The mandible, the most dimorphic bone in the skull, may be crucial in determining sex in situations where the whole skull is not present. The largest thick, compact bone and sturdiest bone in the face is the mandible making it exceptionally resilient and well preserved for personnel identification in large-scale disasters [2]. In victims who are incinerated, the maxilla remains still intact and radiographic pictures offer sufficient measures of the maxillary sinus that can be used to determine sex [3,4].

Interpreting OPGs is a simple, non-invasive, economical, and reliable method for determining the un-identified. The OPG is routinely used in dentistry to obtain a complete overview of the maxillofacial complex which can be utilised to measure the mandibular ramus and maxillary sinus effectively [5]. The OPG can be used to determine gender from mandibular ramus and maxillary sinus measurements.

Several research have been done to determine the sex of dry adult mandibles [1,2,6], but a literature search found very few studies [6,7] that measured the mandibular ramus using digital panoramic radiograph. This is one of the first kind of study, attempted to determine the sex of an individual where numerous measurements of the maxillary sinus and mandibular ramus were measured, compared, and evaluated using digital OPG's in West Godavari population.

MATERIALS AND METHODS

A cross-sectional study was done on 64 OPG's (32 males, 32 females) in Department of Oral Medicine, Radiology and Oral Pathology, Vishnu Dental College, Bhimavaram, Andhra Pradesh, India. The study protocol was approved by Institutional Ethical Committee (IECVDC/22/UG01/OP/IVV/76), Vishnu Dental College, Andhra Pradesh for a period of four months, August 2022 to November 2022.

Inclusion criteria: Male and female patient radiographs with age group of 25-40 years without any pathologies, completely developed maxillary sinus, mandibular ramus and radiographs with adequate density, contrast and clarity were included in the study.

Exclusion criteria: Radiographs with blurred images and artifacts caused by metallic objects, not covering entire maxillary sinus and mandibular ramus and any pathologies were excluded from the study.

Sample size calculation: Using the G power 3.1 software, sample size was calculated based on a desired power of 0.80, an alpha level of 0.05, and an accuracy of mandibular ramus and maxillary sinus for determination of sex was 84% and 90% [1]. The estimated sample size was 64.

Study Procedure

The OPG's of both male and female patients were conducted. Sex determination was done as per the measurement of the mandibular ramus (maximum ramus width, condylar and coronoid height) and maxillary sinus length and width. Description of measurements were recorded as follows [Table/Fig-1,2]:

Mandibular ramus

Maximum width of ramus: The distance between the anterior point of mandibular ramus to the posterior point of condyle and angle of jaw.

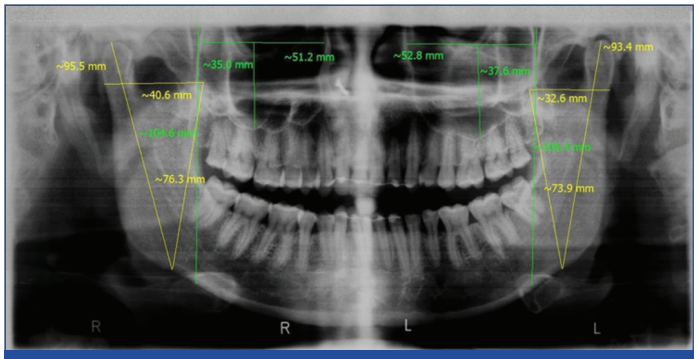
Condylar height: Most superior point on the mandibular condyle to lower border of ramus.

Coronoid height: Distance between coronion to lower border of bone.

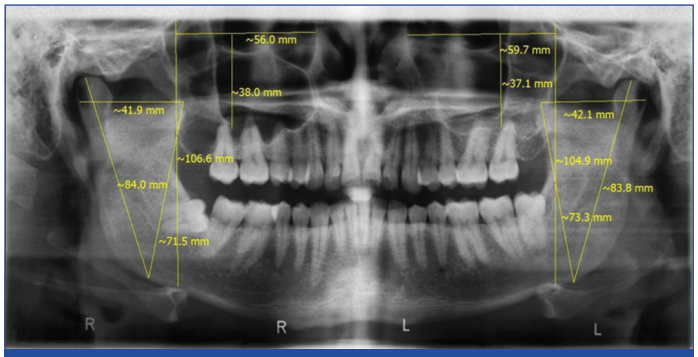
Maxillary sinus

Sinus width: Anterior part of sinus to most posterior part of sinus

Sinus length: Superior to inferior wall of sinus [1,3,4,6,7]



[Table/Fig-1]: Orthopantomogram (OPG) of female patient with mandibular ramus and maxillary sinus measurements made using SCANORA-5.2.6 version.



[Table/Fig-2]: OPG of male patient with mandibular ramus and maxillary sinus measurements made using SCANORA-5.2.6 version.

Measurements were made bilaterally, values obtained were entered in the Microsoft Excel sheet, average values were determined, the results tabulated, and statistical analysis was performed.

STATISTICAL ANALYSIS

The values obtained were entered in the Microsoft excel sheet and the tabulated data was analysed using Statistical Package for Social Sciences (SPSS) version 20 (International Business Management (IBM) version 20.0). Discriminate functional analysis was used to assess the morphometric analysis of maxillary sinus and mandibular ramus for gender determination with a 0.05 or lower p-value was found to be statistically significant.

RESULTS

The mean age of study population was 34.67±5.78 years with 50% males and 50% females (32 males and 32 females). Descriptive statistical analysis of all the odontometrical variables on OPG is shown in [Table/Fig-3]. Condylar length (right and left), width of ramus (right) and width of maxillary sinus (left) showed statistically significance (p-value <0.001, 0.024, 0.024) in determining gender. Other parameters like coronoid length (right and left), width of ramus (left), length of maxillary sinus (right and left), and width of maxillary sinus (right) were not statistically significant. All the above variables showed higher measurements in males than females except width of maxillary sinus which was higher in females than in males.

S. No.	Parameter	Gender	Mean (mm)	Standard deviation (mm)	p-value
1	Width of maxillary sinus right-side	Male	45.312500	6.5816828	0.290
		Female	46.727273	3.7605911	
2	Width of maxillary sinus left-side	Male	46.250000	6.3296537	**0.024***
		Female	49.242424	3.8651512	
3	Length of maxillary sinus right-side	Male	39.812500	5.8223014	0.719
		Female	39.242424	6.8466703	
4	Length of maxillary sinus left-side	Male	40.187500	5.6135636	0.955
		Female	40.266667	5.7540565	
5	Condylar length on right-side	Male	86.125000	5.5343502	**<0.001***
		Female	80.090909	5.7736667	
6	Condylar length on left-side	Male	85.125000	6.0201275	**<0.001***
		Female	79.757576	5.0001894	
7	Coronoid length on right-side	Male	72.062500	5.9456544	0.063
		Female	69.242424	6.0623340	
8	Coronoid length on left-side	Male	71.875000	6.6514612	0.310
		Female	70.260606	6.0635148	
9	Width of the ramus on right-side	Male	39.437500	4.6206933	**0.024***
		Female	37.121212	3.3796965	
10	Width of the ramus on left-side	Male	38.968750	3.6762917	0.143
		Female	37.575758	3.8973573	

[Table/Fig-3]: Analysis of odontometrical variables in males and females.

The sex could be determined from calculations using the equations given below:

D_{Male}: -459.295+3.584 (width of max. sinus right-side)+0.146 (width of max. sinus left-side) -0.973 (length of max. sinus right-side)+5.213 (length of max. sinus left-side)+3.535 (condylar length on right-side)+0.925 (condylar length on left-side) -0.842 (coronoid length on right-side)+1.593 (coronoid length on left-side)+0.939 (width of ramus on right-side)+2.654 (width of ramus on left-side)

D_{Female}: -434.533+3.449 (width of max. sinus right-side)+0.343 (width of max. sinus left-side) -1.084 (length of max. sinus right-side)+5.217 (length of max. sinus left-side)+3.360 (condylar length on right-side)+0.778 (condylar length on left-side) -0.718 (coronoid length on right-side)+1.587 (coronoid length on left-side)+0.820 (width of ramus on right-side)+2.632 (width of ramus on left-side)

In the present study, the cut-off point was found to be -0.749. values greater than this sectioning point indicate male and values lesser than this point indicate female. Accuracy was calculated using discriminant functional analysis for gender determination using different odontometrical variables and depicted in [Table/Fig-4]. Length of the condyle showed highest overall accuracy in determining gender (73.8%) followed by width of ramus (right-69.2%), width of maxillary sinus (left- 67.7%), while length of maxillary sinus (right- 46.2%) showed least accuracy.

S. No.	Parameters	Accuracy		
		Male (mm)	Female (mm)	Overall (mm)
1	Condylar length on left-side	71.9	75.8	73.8
2	Condylar length on right-side	68.8	75.8	72.3
3	Width of the ramus on right-side	68.8	69.7	69.2
4	Width of maxillary sinus left-side	59.4	75.8	67.7
5	Width of maxillary sinus right-side	53.1	69.7	61.5
6	Coronoid length on right-side	62.5	57.6	60
7	Coronoid length on left-side	59.4	60.6	60
8	Width of the ramus on left-side	56.3	54.5	55.4
9	Length of maxillary sinus left-side	0	100	50
10	Length of maxillary sinus right-side	37.5	54.5	46.2

[Table/Fig-4]: Accuracy of gender determination using different odontometrical variables.

from the maxillary sinus assessed from OPG showed statistically significant gender differences (p-value 0.05), indicating that condylar length exhibited good sexual dimorphism which was in accordance with the results of Indira AP et al., Shakya T et al., Giles E, Humphrey LT et al., [1,6,11,14]. The present study revealed that men had larger mandibular ramus measurements than women, which was consistent with research by Indira AP et al., Mehta H et al., Shakya T et al., More CB et al., and Verma P et al., [1,2,6,7,15]. Comparison of the data for present study with similar studies from the literature has been done in [Table/Fig-5] [1,2,6,7,15].

In the present study, the maxillary sinus was measured on both sides to determine gender. The width of the left-side's maxillary sinus was found to be the best variable for gender discrimination and was statistically significant. In contrast, Uthman AT et al., found that the best variable for determining gender was the height of the left maxillary sinus [16]. The results of a different study performed by

S. No.	Author's name and year	Place of study	Number of subjects	Sample considered	Parameters assessed	Conclusions
1.	Shakya T et al., 2022 [6]	Nepal	150 (75 M, 75 F)	OPG of patients aged 18 years and above of both sex without any pathologies	Maximum ramus breadth, minimum ramus breadth, condylar height/maximum ramus height, projective height of ramus and coronoid height	Morphometric analysis of mandibular ramus using digital OPG showed a high sexual dimorphism
2.	Verma P et al., 2020 [15]	Rajasthan	200 (74 M, 126 F)	OPG of patients aged between 21-70 years without any pathologies	Maximum ramus breadth, minimum ramus breadth, condylar height, projective height of ramus and coronoid height	Mandibular ramus can be considered as valuable tool in gender determination
3.	Mehta H et al., 2020 [2]	Udaipur	1800 (900 M, 900F)	OPG of patients aged between 20-50 years without any pathologies	Maximum ramus breadth, minimum ramus breadth, condylar height/maximum ramus height, projective height of ramus, coronoid height, angle of mandible	Mandibular ramus breadth and gonial angle have been found to be the most reliable parameters in gender determination
4.	More CB et al., 2017 [7]	Gujarat	1000 (500 M, 500F)	OPG of patients aged between 21-60 years without any pathologies	Maximum ramus breadth, minimum ramus breadth, coronoid height, condylar height/ maximum ramus height, projective ramus height	Measurements of mandibular ramus using OPG are helpful in sex determination
5.	Indira AP et al., 2012 [1]	Bangalore	100 (50 M, 50 F)	Male and female patient OPG's with age group of 20-50 years without any pathologies	Maximum ramus breadth, minimum ramus breadth, condylar height/maximum ramus height, projective height of ramus and coronoid height	Mandibular ramus can be considered as a valuable tool in gender determination
6.	Present study (Dr Supriya, 2023)	West Godavari, Andhra Pradesh	64 (32 M, 32 F)	Male and female patient OPG's with age group of 25-40 years without any pathologies	Mandibular ramus (maximum ramus width, condylar and coronoid height), maxillary sinus length and width	Condylar height is the most important factor in sex determination followed by width of mandibular ramus and width of maxillary sinus

[Table/Fig-5]: Comparison of the present study with various similar studies [1,2,6,7,15, Present study].

DISCUSSION

In forensic anthropology and medicine, particularly in criminal investigations, the hunt for the missing, and attempts to reconstruct the lives of ancient populations, the ability to determine sex from human remains is crucial. The first most important step in a forensic investigation is the identification of skeletal remains. At the scene of a crime, accident, or major disaster, human remains are partially recovered where sex determination is dependent on these fragmented skeletal remains only [8,9]. The pelvis is the most sexually dimorphic part of the human skeleton, which exhibits significant sex differentiation. The reliability of the human skull for sex determination is 92%, making it also an essential part of forensic examination [10,11]. Although the other bones suffer severe disfigurement in explosions, combat, and other mass tragedies like aeroplane accidents, the maxillary sinuses have been seen to be intact [3,4]. The biggest and toughest bone of the face, the mandible, may be the only remaining bone at these incidents that can be used to help determine the sex [12,13], with the above mentioned benefits of the mandibular ramus and maxillary sinus in the current study, the authors utilised various parameters in sex determination.

In the present research, measures of the maxillary sinus and mandibular ramus were analysed using discriminant functional analysis. Three measurements from the mandibular ramus and one de Queiroz CL et al., suggested that the height and width of the right and left maxillary sinuses were significant for sex discrimination [3].

It has been shown that socio-environmental elements like diet, food, climate, etc., affect the development and appearance of bones. Numerous research have found that each population's skeletal characteristics vary, emphasising the need for population-specific osteometric standards for sex determination [1,6,7,11,15]. The mandible and maxillary sinus measurements can be recorded using the OPG, which is a reliable and accurate tool.

Limitation(s)

All the digital OPG's were interpreted by only one observer.

CONCLUSION(S)

The mandibular ramus has significant sexual dimorphic characteristics when compared to the maxillary sinus. According to the present research, the most important factor in determining sex is condylar height followed by width of mandibular ramus and width of maxillary sinus. Therefore, the authors strongly advise using the mandibular ramus and maxillary sinus as a tool for forensic examination to help in gender determination. Further research on more diverse populations is advised in considering the results to determine the importance of these characteristics.

REFERENCES

[1] Indira AP, Markande A, David MP. Mandibular ramus: An indicator for sex determination-A digital radiographic study. J Forensic Dent Sci. 2012;4(2):58-62.
[2] Mehta H, Bhuvaneshwari S, Singh MP, Nahar P, Mehta K, Sharma T. Gender determination using mandibular ramus and gonial angle on OPG. J Indian Acad Oral Med Radiol. 2020;32(2):154-58.
[3] de Queiroz CL, Terada AS, Dezem TU, De Araujo LG, Galo R, Oliveira-Santos C, et al. Sex determination of adult human maxillary sinuses on panoramic radiographs. Acta stomatol Croat. 2016;50(3):215-21.
[4] Supraja S, Anuradha A, Guduru V, Kiresur MA, Pasupuleti MK, Vignatha P. Importance of sexual dimorphism of the maxillary sinus and mandibular inter coronoid distance of Vijayawada city population in Andhra Pradesh: An original research. J Forensic Sci Med. 2021;7(3):91-94.
[5] Schulze R, Krummenauer F, Schalldach F, d'Hoedt B. Precision and accuracy of measurements in digital panoramic radiography. Dentomaxillofac Radiol. 2000;29(1):52-56.
[6] Shakya T, Maharjan A, Pradhan L. Morphometric analysis of mandibular ramus for sex determination on orthopantomogram. JNHRC. 2022;20(1):65-71.
[7] More CB, Vijayvargiya R, Saha N. Morphometric analysis of mandibular ramus for sex determination on digital orthopantomogram. J Forensic Dent Sci. 2017;9(1):01-05.
[8] Saini V, Srivastava R, Rai RK, Shamal SN, Singh TB, Tripathi SK. Mandibular ramus: An indicator for sex in fragmentary mandible. J Forensic Sci. 2011;56(1):13-16.
[9] Scheuer L. Application of osteology to forensic medicine. Clinical Anatomy: The Official Journal of the American Association of Clinical Anatomists and the British Association of Clinical Anatomists. 2002;15(4):297-312.
[10] Krogman WM. The human skeleton in forensic medicine. I. Postgraduate Medicine. 1955;17(2):A-48.
[11] Giles E. Sex determination by discriminant function analysis of the mandible. Am J Phys Anthropol. 1964;22(2):129-35.
[12] Đurić M, Rakočević Z, Đonić D. The reliability of sex determination of skeletons from forensic context in the Balkans. Forensic Sci Int. 2005;147(2-3):159-64.
[13] Hu KS, Koh KS, Han SH, Shin KJ, Kim HJ. Sex determination using nonmetric characteristics of the mandible in Koreans. J Forensic Sci. 2006;51(6):1376-82.
[14] Humphrey LT, Dean MC, Stringer CB. Morphological variation in great ape and modern human mandibles. J Anat. 1999;195(4):491-513.
[15] Verma P, Mahajan P, Puri A, Kaur S, Mehta S. Gender determination by morphometric analysis of mandibular ramus in sriganganagar population: A digital panoramic study. Indian J Dent Res. 2020;31(3):444-48.
[16] Uthman AT, Al-Rawi NH, Al-Naaimi AS, Al-Timimi JF. Evaluation of maxillary sinus dimensions in gender determination using helical CT scanning. J Forensic Sci. 2011;56(2):403-08.

PARTICULARS OF CONTRIBUTORS:
1. Associate Professor, Department of Oral Pathology, Vishnu Dental College, Bhimavaram, Andhra Pradesh, India.
2. Undergraduate Student, Department of Oral Pathology, Vishnu Dental College, Bhimavaram, Andhra Pradesh, India.
3. Professor and Head, Department of Oral Pathology, Vishnu Dental College, Bhimavaram, Andhra Pradesh, India.
4. Professor, Department of Oral Pathology, Vishnu Dental College, Bhimavaram, Andhra Pradesh, India.
5. Postgraduate, Department of Oral Pathology, Vishnu Dental College, Bhimavaram, Andhra Pradesh, India.
6. Postgraduate, Department of Oral Medicine and Radiology, Vishnu Dental College, Bhimavaram, Andhra Pradesh, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Dr. Alapati Naga Supriya,
Associate Professor, Department of Oral Pathology, Vishnu Dental College,
Bhimavaram-534202, Andhra Pradesh, India.
E-mail: nagasupriya.a@vdc.edu.in

PLAGIARISM CHECKING METHODS: [Jain H et al.]
- Plagiarism X-checker: Jan 13, 2023
- Manual Googling: Feb 14, 2023
- iThenticate Software: Feb 14, 2023 (11%)

ETYMOLOGY: Author Origin

EMENDATIONS: 7

AUTHOR DECLARATION:
- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? Yes
- For any images presented appropriate consent has been obtained from the subjects. Yes

Date of Submission: **Jan 12, 2023**
Date of Peer Review: **Jan 30, 2023**
Date of Acceptance: **Feb 18, 2023**
Date of Publishing: **Jul 01, 2023**