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# Gender Determination- Role of Panaromic Radiography

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**Abstract**

Forensic sciences is a specialized field which analyzes evidence in the interest of justice. Gender is one of the primarily used in forensics to determine human identity and it is also necessary in mass disasters as it allows easy identification of the individual. This radiographic study on the mandibles from the Indian population aims to measure and determine if GA, MF, HI, CH and CDH are accurate in gender determination using orthopantomographs by applying Conventional (manual) and Digital (mouse-driven) and also to compare and elucidate more accurate method among the two for gender determination. Results indicated that GA is higher in females, while MF, HI, CH, and CDH were higher in males. Comparison between methods showed no significant differences in measurements for both genders, suggesting both manual and digital methods are equally effective for gender determination.

**Keywords:** Gender Determination, Orthopantomographs, Gonial Angle, Mental Foramen, Projective Height of The Ramus, Coronoid Height, Condylar Height, Manual Method, Digital Method.

## Introduction

Forensic odontology is an interdisciplinary field within dentistry that aids in justice by handling and inspecting dental evidence for victim and suspect identification in cases like mass disasters and organized crimes[1]. Determining sex is crucial when individual information is unavailable[2], particularly from skeletal remains[3]. The completeness of remains significantly impacts the reliability of sex determination[4]. The use of antemortem radiographs and dental records accelerates the identification process[5], with the mandible being particularly important due to its strength and sexual dimorphism[6].

Various methods exist for sex determination, including anthropology, rugoscopy, cheiloscopy, tooth prints, DNA analysis, and radiographs[7]. Morphometric analysis utilizes radiographs, photographs, dental charts, and casts for precise measurement[8], especially using panoramic radiographs for the mandible[9]. Antemortem orthopantomograms (OPGs) are valuable in identifying human remains, often taken during various life stages[10]. Postmortem radiographs are also routinely used to document injuries and aid in identification through comparison with antemortem images[11].

While determining gender based on teeth characteristics is challenging, X-ray examination of the mandible yields definitive results. Morphometric analyses, including measurements of the Gonial Angle (GA), Mental Foramen (MF), Projective height of the ramus (HI), Coronoid height (CH), and Condylar height (CDH), provide objective and reproducible data for sex determination[12]. Population-specific osteometric standards are essential for accurate assessments[13]. This study aims to evaluate the accuracy of these parameters in the Indian population using manual digital panoramic radiography[14].

## Material and method

The present study was conducted in the Department of Oral & Maxillofacial Pathology, Sri Sai College of Dental Surgery, Vikarabad, Telangana. Patients who were advised for digital OPG's to Radiology department were selected for the study. The study group comprised of a total of 100 digital OPG's of Indian origin. An approval from the Institutional Ethics was obtained prior to the beginning of the study and all the participants were given brief information regarding the purpose of the study. The inclusion and exclusion criteria of the study was as follows:

### Inclusion Criteria

1. Radiographs of the patients with full complement of permanent teeth.
2. Radiographs of the patients with minimal alveolar bone loss.
3. Ideal OPG's without any artifacts.

### Exclusion Criteria

1. Patients with congenital developmental anomaly of mandible.
2. Patients with pathological lesions of mandible
3. Patients with history of mandibular fracture or major surgical procedures involving the mandible
4. Patients who were pregnant

A total of 100 patients were divided into two groups namely, Group -A & B. Group A consist of 50 males and Group B consist of 50 females. After clinical examination of the subjects, OPGs were taken using Orthophos XG machine. Exposure parameters used were 64 KV, 8mA and 14.1 seconds. The following measurements were made from the reference lines drawn from the anatomical landmarks on the OPG's:

1. **GA:** The antegonial angle was measured by two lines parallel to the antegonial region that will intersect at the deepest point of the antegonial

notch.

2. **MF:** The distance between the superior margins of the mental foramen to the inferior border of the mandible on the both the sides.**(G-H)**
3. **HI**: Projective height of ramus between the highest point of the mandibular condyle and lower margin of the bone on both the sides.**(A-B)**
4. **CH**: Projective distance between coronion and inferior wall of the alveolar bone on both the sides.**(C-D)**
5. **CDH:** Height of the ramus of the mandible from the most superior point on the mandibular condyle to the tubercle, or most protruding portion of the inferior border of the ramus on both the sides. **(E-F).**[52]

The measurements were measured using **conventional** (manual) method and **digital** (mouse driven) method. In digital method **Image J analysis** software was used measuring the reference points.

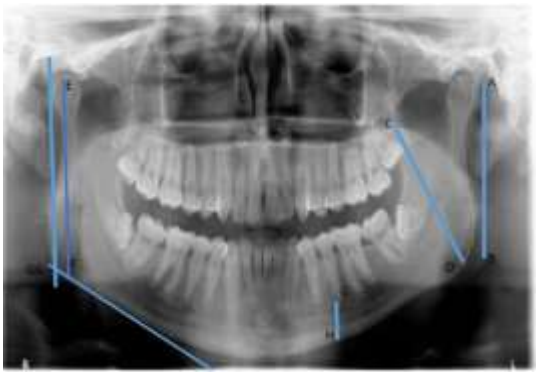

Figure 1: Mandible showing the reference points GA, MF, HI, CH and CDH.

GA (Right side)-$117^0$ & (Left side)-$121.9^0$

MF (Right side)-17.3mm & (Left side)-17.6mm(From point G to H) HI (Right side)-67mm (Left side)-67.5mm (From point A to B)

CH (Right side)-62.3mm & (Left side)-62.9mm(From point C to D) CDH (Right side)-69.5mm & (Left side)-69.8mm (From point E to F)

Armamentarium used for Manual Method consist of A pair of Gloves, OPG's, Divider, Scale, Pencil, Eraser, Protractor, Tracing sheet, image viewer (Beam light). In **conventional (manual)** method, the OPG's were measured using beam light underneath and on the tracing paper. Measurements were marked using a measuring scale, divider and a protractor. While in the **digital (mouse driven)** method the measurements were recorded with the help of **Image J Analysis** software in **WINDOWS 10 PROFESSIONA**L operating system.

**Statistical Analysis**

In the present study two observers were taken to estimate the inter-observer agreement by using Interclass correlation coefficient (ICC). A retrospective study was performed in which Observer 2 was blinded in regards to all the parameters. The single blinded study was done by comparing the GROUPS A & B using conventional and digital methods. These were performed in software "SPSS Version 26". Paired "t" test was performed to chose between left and right sides. Independent student t-test was applied to determine the mean value, standard deviation, t-value and p-value for each variable in males and females OPG's by using manual and digital method. Mean comparision was done between the groups using independent "t" test.

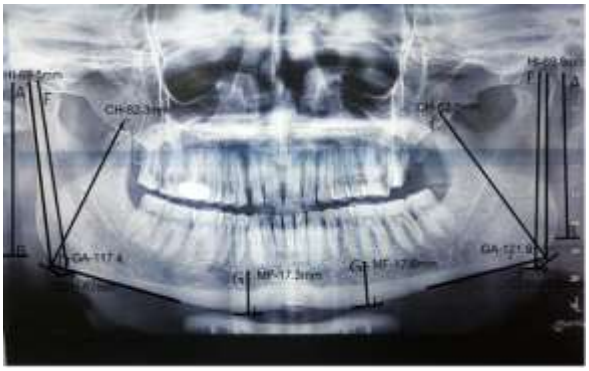

Figure 2: Mouse Driven Method showing GA, MF, HI, CH and CDH in Male

GA (Right side)-117.4$^0$ & (Left side)-121.9$^0$

MF (Right side)-17.3mm & (Left side)-17.6mm(From point G to H)

HI (Right side)-67mm (Left side)-67.5mm (From point A to B)

CH (Right side)-62.3mm & (Left side)-62.9mm(From point C to D) CDH (Right side)-69.5mm & (Left side)-69.8mm (From point E to F)

**Results and observation**

Results indicated significant gender differences across all parameters in both measurement methods, with GA being higher in females, while MF, HI, CH, and CDH were higher in males. Statistical analysis revealed a p-value <0.05, indicating significance. Interobserver variability was assessed, showing excellent agreement (ICC > 0.90) among observers. A paired t-test found no significant differences between left and right sides of OPGs, so the left side was used for analysis.

Cut-off values for gender classification were established, with MF showing the highest sensitivity (94%) and GA the lowest (51%). Comparison between methods showed no significant differences in measurements for both genders, suggesting both manual and digital methods are equally effective for gender determination.

Table 1: Cut off value, specificity & sensitivity for all the parameters in both males and females.

| Parameters | Groups | N | Mean | Cutoff value | Specificity | Sensitivity |
|---|---|---|---|---|---|---|
| GA | Males | 50 | 118.448 | <124.3 | 52% | 51% |
| | Females | 50 | 126.4 | >124.3 | | |
| MF | Males | 50 | 17.594 | >16.950 | 92% | 94% |
| | Females | 50 | 16.6 | <16.950 | | |
| HI | Males | 50 | 67.326 | >64.75 | 54% | 80% |
| | Females | 50 | 63.23 | <64.75 | | |
| CH | Males | 50 | 67.608 | >64.5 | 70% | 78% |
| | Females | 50 | 62.4 | <64.5 | | |
| CDH | Males | 50 | 68.19 | >65.95 | 56% | 76% |
| | Females | 50 | 64.17 | <65.95 | | |

MF is observed with highest sensitivity while the GA is observed with the least.

Table 2: Comparison of means in all the parameters between Manual and Digital methods in Males

| Parameters | Groups | N | Mean | SD | p value |
|---|---|---|---|---|---|
| GA | Manual | 50 | 118.484 | 2.299 | 0.938 |
| | Digital | 50 | 118.484 | 2.335 | |
| MF | Manual | 50 | 17.594 | .470 | 0.933 |
| | Digital | 50 | 17.602 | .478 | |
| HI | Manual | 50 | 67.326 | 3.000 | 0.950 |
| | Digital | 50 | 67.364 | 3.023 | |
| | Manual | 50 | 66.608 | 2.992 | |

| | | | | | |
|---|---|---|---|---|---|
| CH | Digital | 50 | 66.092 | 4.978 | 0.531 |
| CDH | Manual | 50 | 68.190 | 3.116 | 0.944 |
| | Digital | 50 | 68.234 | 3.146 | |

p value <0.05 is considered to be insignificant

Table 3: Comparison of means in all the parameters between Manual and Digital methods in Females

| Parameters | Groups | N | Mean | SD | p value |
|---|---|---|---|---|---|
| GA | Manual | 50 | 126.404 | 2.181 | 0.591 |
| | Digital | 50 | 126.644 | 2.274 | |
| MF | Manual | 50 | 16.156 | 0.570 | 0.986 |
| | Digital | 50 | 16.154 | 0.574 | |
| HI | Manual | 50 | 63.230 | 4.341 | 0.985 |
| | Digital | 50 | 63.246 | 4.324 | |
| CH | Manual | 50 | 62.352 | 4.241 | 0.987 |
| | Digital | 50 | 62.366 | 4.245 | |
| CDH | Manual | 50 | 64.166 | 4.394 | 0.904 |
| | Digital | 50 | 64.060 | 4.366 | |

p value <0.05 is considered to be significant.

**Discussion**

In forensic cases, reliable gender estimation is crucial for identifying unknown human remains and understanding regional variations and population history. Determining gender from fragmented jaws and dentition is a vital aspect of forensics, especially when pelvic and skull standards are lacking. The mandible, being the most dimorphic and well-preserved bone, aids significantly in sex and race determination. Notable differences exist between male and female mandibles across populations, although factors like nutrition and physical activity can affect bone size.

This study focused on analyzing parameters such as GA,MF,HI, CH using OPGs. Researches of Joo JK in 2013[15] and Humonen in 2010[16] indicates that females typically have a higher GA. The males have shown to have greater values for MF and HI in our study which was consistent with the studies done by Thomas CJ in 2004[17], Catovie in 2002[18], Mahima VG[7] in 2009, Sahin P[19] in 2015, G. Renjith[20] and Rani A.[21] In 2019, along with their associates, who concluded that MF in males are higher than females as the MF is sexually dimorphic. Giles E[27] in 1964, Franklin[6] in 2006 and Dayal[23] in 2008 along with their associates reported HI was highly significant in gender determinationn with an accuracy of 85%, 87.5% and 75.8% respectively. Our study was similar to these studies in which HI had an accuracy of 80%. Our study showed significant differences between males and females. Saini V and her associates in 2011 had found an accuracy of 74.2% in their study for CH which is accordance to our study where we observed to get 72% accuracy.[5]

Our findings align with these studies, establishing that MF demonstrated the highest sensitivity (94%) and specificity (92%) for gender determination, contrasting with GA's

lower values (51% and 52%).Both manual and digital methods for measuring these parameters yielded similar results, suggesting either approach is viable. The digital method, while being more efficient and less prone to error, requires technical skill. In contrast, the manual method is accessible but time-consuming. Ultimately, this research reinforces the utility of OPGs in forensic gender estimation. Though both the methods showed no significant differences amongst each other, mouse driven method is still preferred over the manual method to eliminate the minor mistakes and record the measurements with no errors.

**Conclusion**

Gender is one of the primarily used in forensics to determine human identity and it is also necessary in mass disasters as it allows easy identification of the individual. Mandible is usually preferred bone in forensics as it remains intact and also sexually dimorphic. The parameters chosen in the study were GA, MF, HI, CH and CDH. It was observed that there were significant differences between males and females. The highest sensitivity in determining gender was noticed in MF while the least was observed in GA.

The study highlights significant gender differences but found no method-specific variations. Limitations include its reliance on 2D OPG assessments, suggesting future research should utilize 3D scans and involve larger, more diverse samples for more definitive results.

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