



Gender Determination using Mandibular Ramus Flexure in Chennai Population - A Retrospective Study on Digital Panoramic Radiographs

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KEYWORDS

Mandibular ramus flexure, Gender determination, Digital panoramic imaging, Orthopantomogram.

ABSTRACT:

Aim: The aim of the study is to evaluate mandibular posterior flexure's validity and predictive accuracy in gender determination on digital panoramic radiographs. The objective of the study is to correlate the flexure of the posterior border of the ramus with that of gender.

Methods: The study was conducted on 200 digital panoramic images taken in the Department of Oral Medicine and Radiology. Each image was examined and analyzed by an individual observer based on Loth and Henneberg's 1996 criteria for the presence of mandibular ramus flexure on the posterior border of the ramus at the level of the occlusal plane. The scoring was assigned separately for the right and left mandibular ramus flexure and a total score was given for each panoramic radiograph obtained from adult male and female subjects.

Results: In the present study, we observed the overall predictive accuracy using mandibular ramus flexure to be 80% in the gender determination. A Kappa value of 0.601 was obtained and the predictive accuracy was higher for females than males.

Conclusion: Mandibular ramus flexure showed a substantial predictive accuracy, making it a viable tool for aiding gender determination in forensic dentistry. To enhance gender identification accuracy, it is advisable to incorporate a comprehensive set of parameters like maximum ramus breadth, maximum ramus height, coronoid height, projective ramus height, along with mandibular ramus flexure.

1. Introduction

Forensic dentistry encompasses handling, examining, assessing, and demonstrating dental proof to provide factual and unbiased information for legal proceedings. Criminal identification primarily relies on the analysis of available evidence at the crime scene, with a significant focus on skeletal and dental remains. These particular types of evidence, namely bones and teeth, are crucial due to their resilience in withstanding various environmental conditions. Forensic dentists need to

possess a diverse range of expertise since the dental records they acquire can either establish a person's identity or furnish authorities with crucial information [1, 2].

Gender, age, stature, and ethnic background constitute the primary elements of biological identity. Recognizing human skeletal remains using gender marks a fundamental stage in forensic inquiries and plays a pivotal role in facilitating subsequent analysis. Further, gender determination in forensic investigations holds



paramount importance, as age and stature are interdependent factors in the analysis. The evaluation of gender through bone examination holds significant value since subsequent interpretation and analyses hinge on this factor. Typically, morphological and metric analyses of bones are employed to ascertain gender [3, 4].

In situations such as mass disasters where the complete skeleton might not be accessible for identification purposes, the mandible assumes a crucial role in determining gender as it is the largest, strongest bone of the skull and also exhibits a high level of dimorphism as masticatory forces exerted are different for males and females [5].

Mandibular ramus flexure (MRF) which was first identified by Loth and Henneberg in 1996, has garnered global interest due to its remarkable precision in determining gender. According to their findings, this distinctive flexure is observed along the posterior edge of the ramus at the occlusal level of molars in adult males, and its absence in females indicates its occurrence either above or below the occlusal surface [6].

Forensic radiology uses radiological techniques to help medical & legal professionals identify injuries, illnesses, or developmental anomalies. Digital panoramic radiography is a widely used, non-invasive, cost-effective, and reliable method for dental diagnostics in forensics. Our study has chosen panoramic radiographs as the preferred imaging modality due to several advantages it offers over other imaging techniques. Orthopantomograms are non-invasive, cost-effective, and less time-consuming with very low radiation doses. Other imaging modalities like CT and CBCT are expensive, time-consuming, and offer higher radiation doses, making them less widely used in day-to-day dental practice. Additionally, it creates permanent radiographic records in dental practice that can be conveniently stored and reviewed by forensic experts, making it a valuable reference tool for court proceedings [7,8,9]. This is the first study to our knowledge that evaluated the predictive accuracy of the Loth and Henneberg guidelines with a larger sample size amongst an unstudied population.

This study aims to evaluate mandibular posterior flexure's validity and predictive accuracy in gender determination on digital panoramic radiographs. The objective of the study is to correlate the flexure of the posterior border of the ramus with that of gender.

2. Materials and Methodology

A study was conducted on a randomly selected set of 85 male and 115 female digital panoramic radiographs that were available in archives between March 11, 2023, and June 8, 2023, using a convenience sampling method. These images were obtained from patients who had visited the Department of Oral Medicine and Radiology at our Institution due to various dental ailments. The images were retrospectively taken for this study.

Patients aged 20 years and older who needed digital panoramic radiographs for various dental treatments were included in the study. Patients with developmental abnormalities, systemic conditions such as hyperparathyroidism, edentulous patients, patients with excessive loss of mandibular posterior teeth, over-erupted molars, patients with fracture of mandible, surgically treated maxillofacial regions, and panoramic images with artifacts or faults were excluded from the study. Radiographs were taken by a digital panoramic x-ray machine (Orthophos XG3) with exposure parameters of tube voltage (66 kvp), tube current (16 mA), and exposure time (15 s). The SIDEXIS software was used to process the image and mark the location for analysis.

The digital panoramic images were examined and analyzed by an individual observer according to the guidelines of Loth and Henneberg (1996) [10]. According to Loth and Henneberg, adult human males exhibit an angulation of the posterior border of the mandibular ramus at the level of the occlusal surface, whereas females generally display a straight posterior border of the ramus. When a flexure is present on female mandibles, the feature is never at the same level as that of males whereas it will be near the condylar process or close above the gonial angle.

When examining the mandible, a score of +1 is given if the posterior margin flexure of one side of the ramus coincides with the occlusal plane height at that same side. A score of -1 is given if the posterior margin of the ramus is straight, or if its flexure does not coincide with the occlusal plane height and is instead located either above or below it. If the posterior margin of the ramus is neither flexed nor straight, it is given a score of 0. The scoring was assigned separately for the right and left posterior MRF, and a total score was given for each digital panoramic radiograph obtained from adult male and female subjects. A score of 0, +1, or +2 identifies the



mandible as male, while a score of -1 or -2 identifies it as female.

3. Statistical Analysis

A significant sample size was established using a statistical power analysis (g*power free source program). The data was entered into a Microsoft Excel spreadsheet and analyzed using IBM SPSS 23 software in 2020. Kappa statistics were used to determine the correlation between two qualitative variables. A p-value less than 0.05 was considered statistically significant, while a p-value less than 0.001 was considered highly significant.

Table 1: Ramus shape scores

Total Score	No. of OPGs (%)
-2	115 (57.5)
2	85 (42.5)
Total	200 (100)

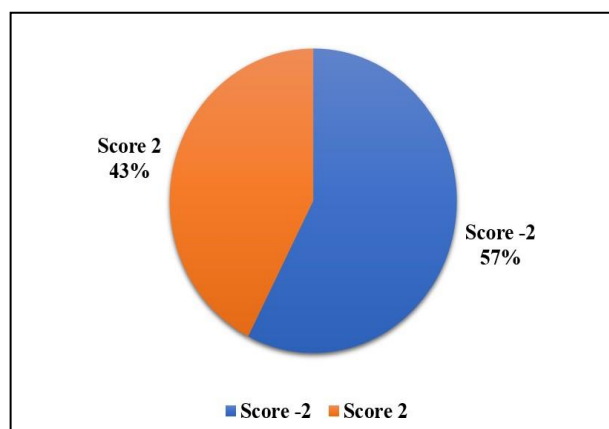


Figure 1: Ramus shape scores

Table 2: Gender identification

Gender	Total	Correctly identified (%)	Misdiagnosed (%)
Female	115	87 (75.7)	28 (24.3)
Male	85	73 (85.9)	12 (14.1)

Kappa vale = 0.601, p value < 0.001

Overall predictive accuracy = 80%

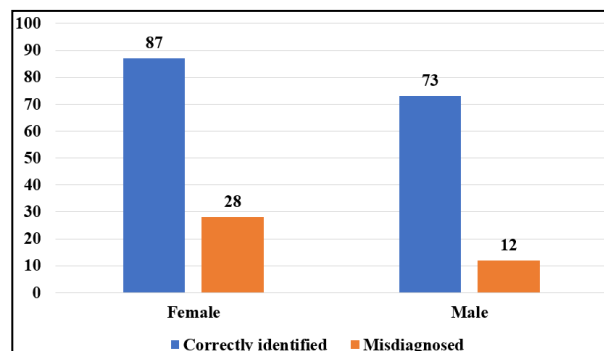


Figure 2: Gender identification

4. Results

In the present study, a total score of -2 was given to 115 digital panoramic radiographs [57.5%], and a score of 2 was given to 85 digital panoramic radiographs [42.5%] as shown in Table 1 and Graph [figure 1]

Among the 115 female digital panoramic radiographs, 87% were correctly identified, while among the 85 males, 73% were correctly identified through MRF. The kappa value of 0.601, as shown in Table 2 and Graph [figure 2], indicates a moderate agreement and an overall predictive accuracy of 80% in our study.

5. Discussion

Forensic odontology uses various conventional methods such as computer-generated dental records, dental imaging, bite mark analysis, DNA analysis, cheiloscopy, and rugoscopy. Recent advancements in forensic dental identification include facial reconstruction, comparison microscopes, and tongue prints. Healthcare professionals and medical experts have shown a notable degree of awareness regarding emerging technologies in the fields of forensic science and odontology. However, this study features panoramic radiographs over advanced imaging modalities such as CT and CBCT as they remain the mainstay of comprehensive dental care that is ubiquitous and familiar to dental professionals, making them a useful option in forensics to determine gender [11, 12].

During male puberty, the ramus flexure emerges due to late-stage growth and muscle development in the mandible's condylar region. It is not consistent until later adolescence, which is why our study has included patients aged 20 or older. Mandible morphology is influenced by masticatory muscles and cranial shape. The flexure likely results from changes in muscle size,



strength, and positioning, especially the masseter and medial pterygoid which connect just below the mandibular ramus and temporalis and lateral pterygoid muscles attach high above the flexure [9].

The utilization of mandibular ramus flexure as a gender identification indicator was initially introduced by Loth and Henneberg in 1996. During the period of rapid mandibular growth, before the cessation of temporomandibular growth, gender dimorphism in the mandibular ramus is influenced by sex hormones and the masticatory forces.

According to our study, the overall predictive accuracy for gender determination based on mandibular flexure is 80%. This result is consistent with the findings from a previous study conducted by Loth and Henneberg in 1996 [9], considered the primitive of its kind. Although Loth and Henneberg used mandibular specimens, they identified mandibular ramus flexure as a single indicator for gender identification.

Our study also aligns with prior studies on diagnosing gender through mandibular ramus flexure in panoramic imaging and mandibular specimens: James et al., 2019 [1], Maniyar et al., 2021 [3], Shivaprakash et al., 2013 [5] and Y.Balci et al 2005[6]. These studies achieved predictive accuracies of 64%, 64%, and 76%, 90.6% respectively.

In our study, we found that the predictive accuracy was higher for females than for males, which is consistent with the findings of Maniyar et al. (2021) [3]. However, our results were not in line with those of Donnelly SM et al. (1998) [13], where predictive accuracy was reported to be higher in males than females. The discrepancy in results may be due to the fact that the samples employed in the latter study were mandibular specimens, and the exact location of the mandibular ramus flexure was subjectively assumed by two different observers.

In 2008, Ivan Claudio SG et al employed the shape of the mandibular body to determine the gender of subadult Brazilian mandibular specimens. They conducted a blind test on two sets of sample collections using criteria established by Loth and Henneberg. Their findings revealed an accuracy rate of 57.5% and 60.5%. Notably, this method exhibited greater sensitivity in identifying males to females which is not in accordance with our

study, this may probably be due to the fact that our study is a radiographic study [14].

According to Muller et al, 1998 [15], the study focused on determining more precise gender indicators in the mandible. When three gender indicators -gonial flaring, chin shape & ramus flexure were considered gonial flaring is a more precise gender indicator, with an accuracy rate of 76%, surpassing both chin shape and ramus flexure as reliable indicators whereas in our study we obtained an accuracy of 80% using ramus flexure only as a reliable indicator. However, our study did not involve chin shape and gonial flaring.

In our research, we analyzed a larger sample size of digital panoramic radiographs compared to previously published studies and found that the mandibular ramus flexure was 80% accurate in determining gender. Nevertheless, this study has its own shortcomings of relying on a single observer to collect and analyze the data. Therefore, future studies with more observers to overcome individual subjectivity are warranted to confirm and extend the findings.

6. Conclusion

Mandibular ramus flexure stands as a valuable means for gender identification due to its resilience against damage and disintegration process. Utilizing digital panoramic radiographs for mandibular ramus measurements proves to be a dependable method. This study underscores its substantial predictive accuracy, making it a viable tool for aiding gender determination in forensic dentistry. To enhance gender identification accuracy, it is advisable to incorporate a comprehensive set of parameters like maximum ramus breadth, maximum ramus height, coronoid height, projective height of ramus along with the mandibular ramus flexure.

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