Original Article

Predictive Accuracy of Mandibular Ramus Flexure as a Morphologic Indicator for Gender Determination: A Radiographic Study

Asma Maniyar, Prashant Patil, Vajendra Joshi, K R Kiran Kumar, R T Shilpa

From the Department of Oral Medicine and Radiology, Navodaya Dental College, Raichur, Karnataka, India

Abstract

Introduction: In forensic medicine, the identification of age and gender is an initial step and it plays a vital role in determining one's identity. The skeletal components most often investigated for gender determination are pelvis and skull, with the mandible being a practical element to analyze sexual dimorphism in the fragmented bones. Mandibular ramus can be used to differentiate between sexes and it also expresses strong univariate sexual dimorphism.

Aim: Determination of gender by using mandibular ramus posterior flexure.

Materials and Methods: A radiographic retrospective study was conducted on 25 male and 25 female Orthopantomographs taken in the Department of Oral Medicine and Radiology. Strict exclusion criteria were applied in selecting images. The images were taken using digital panoramic x-ray machine ORTHOPHOS – XG5-Sirona Dental System, Germany (68kvp, 8ma, 14.1 s). To process the images and mark, the location for analysis SIDEXES software was used. Each image was examined for the presence of a flexure on the posterior border of the ramus, which was carefully delineated and the occlusal plane marked, guided by the height of cusp tips of the mandibular molars.

Results: In the present study, we observed the overall accuracy using mandibular ramus posterior flexure was 64% in the determination of gender with $P = 0.0032$. The predictive accuracy was higher for females compared to males.

Conclusion: Mandibular ramus flexure can be considered as supplementary rather than definitive mean of sex determination. Hence, it is better to include as many parameters as possible for attaining the accuracy.

Key Words: *Gender determination, mandibular ramus flexure, orthopantomographs*

Received: 30 September, 2020.
Revision: 09 January 2021.
Accepted: 30 March, 2021.
Published: 30 June, 2021.

Introduction

In forensic dentistry, age or gender determination is an initial step in determining one's identity.[1] Gender estimation using the bone is a very important part of a study in the field of anthropology and forensic sciences as further interpretations and analysis are based on it. Normally, morphological and metric analyses are used to determine the gender using bone.[2]

As evident from the earlier studies, among all the bones the skull is the most dimorphic and easily sexed portion of the skeleton after the pelvis, providing an accuracy of up to 92%.[2] But in cases where an intact skull is not found, the mandible may play a vital role in gender estimation as it is the most dimorphic, largest, strongest bone, and also movable part of the skull.[2] The presence of a dense layer of compact bone makes it very durable and hence, it remains well-preserved than many other bones. In the forensic and physical anthropologic fields, it is considered as hardest facial bone that retains its shape better than other bones. Dimorphism in the mandible is reflected in its shape and size;[3] male bones are generally bigger and more robust than female bones.[4]

Access this article online

Quick Response Code:

Website: www.ijofo.org

DOI: 10.4103/ijfo.ijfo_21_20

The examination of morphologic features led to discovery of a distinct angulations of the posterior border of mandibular ramus at the level of occlusal surface of the molars in adults[5] which was termed as flexure that refers to "the quality or state of being flexed."[6]

Mandibular ramus flexure (MRF) discovered by Loth and Henneberg[5] in 1996 has drawn worldwide attention due to its exceptionally high accuracy in sex determination. According to Loth and Henneberg the distinct flexure is present in the posterior border of ramus at the level of occlusal surface of the molars in adult males and is not seen in females, if present, it was either above or below the occlusal surface.[7,8]

With this background, the current study is undertaken to evaluate the validity and predictive accuracy of mandibular posterior flexure in gender determination.

Address for correspondence:
Dr. Prashant Patil,
E-mail: prashantomdr@gmail.com

How to cite this article: Maniyar A, Patil P, Joshi V, Kumar KR, Shilpa RT. Predictive accuracy of mandibular ramus flexure as a morphologic indicator for gender determination: A radiographic study. J Forensic Odonto 2021;6:13-6.

Materials and Methods

The present study was conducted on randomly selected 25 males and 25 females Orthopantomographs (OPG) images of patients who reported the Department of Oral Medicine and Radiology for various dental reasons at Navodaya Dental College and Hospital, Raichur. Panoramic radiographs (n = 50) were taken on adult patients and each image was given a code.

Inclusion criteria

Patients of age 18 years and above and who are advised for OPG's for various dental treatments were included.

Exclusion criteria

(1) Patients with developmental abnormalities, systemic conditions like hyperparathyroidism and edentulous patients (2) Images that showed excessive loss of mandibular posterior teeth , over erupted , tilted anomalous molars (3) Digital OPG's with trauma and/or surgically treated maxillofacial region, evidence of developmental anomalies/ pathologies affecting the maxillofacial region (4) Radiographs with artifacts or faults were excluded.

Digital panoramic X-ray machine (ORTHOPHOS – XG5-Sirona Dental System, Germany) with the standard exposure parameters of tube voltage (68kvp), tube current (8 ma) and exposure time (14.1 s) was used to expose the films. SIDEXIS software was used to process OPG images and mark the location for analysis. All radiographs obtained were interpreted on Hp LV1911-Monitor (18.5") by a single observer.

The OPG images were examined and analyzed according to the guide lines given by Loth and Henneberg (1996).[5] First, Each OPG image was examined for a possible presence of a flexure at the posterior margin of the ramus, and if present the height of flexure was carefully marked. Second, the occlusal plane level was delineated as guided by the height of cusp tips at the occlusal surfaces of the mandibular molars. Further it was evaluated whether or not the ramus flexure coincided with the occlusal plane level; the deepest flexure point on the curving ramus margin was traced on both the sides. A tangent line was drawn passing through two points, first was the most prominent point on the posterior profile of the condylar head and the second point marked the maximum convexity of the posterior margin of the mandibular angle. The height of the occlusal plane was marked by a line passing through the most prominent cusp tips of the first and second mandibular molars. Third molars, if present were not used in the determination of occlusal plane height [Figure 1].

The OPG images of the entire sample were scored according to Loth and Henneberg (1996) method. Score points were given separately for the left and right ramus of each image, and then were added together and the total score was used in gender prediction.

A score of (+1) was given when a posterior margin flexure of one side ramus coincided with the occlusal plane height at that side;

A score of (−1) was given to a straight posterior margin ramus and also to a ramus in which the flexure of its posterior margin did not coincide with the height of the occlusal plane but located either above or below the occlusal plane level, i.e., near the condyle or the mandibular angle;

A score of (0) was given to a ramus in which the posterior margin was neither flexed nor straight.

In our study, the scores of both right and left were added, a total score of (+2) was assigned to the OPG in which both ramus had a flexure coincided with the occlusal plane [Figure 2]; a score of (−2) was given when both ramus had straight posterior margins or to ramus flexure of which did not coincide with the occlusal plane but were high near the condyle or low near the mandibular angle [Figures 3 and 4]; a total score of (+1) was given when one ramus was flexed at occlusal level and the other was indeterminate; a total score of (0) was assigned to the OPG in which either both rami were indeterminate or one ramus was flexed at the occlusal level and the other was straight; a total score of (−1) was given to the OPG, in which one ramus was straight while the other was indeterminate. OPG images of total scores of (0, +1, +2) indicated male subjects, whereas images of total sores of (−1, −2) indicated female subjects.

Statistics

The data were collected by using a structured pro forma. Data thus collected were entered in MS excel sheet and was analyzed using SPSS (Statistical Package for Social Sciences) Version 23.0 IBM USA [H.O Bangalore, Karnataka ,India] 2020. Qualitative data were expressed in terms of percentages .The correlation between two qualitative variables was determined by using kappa statistics .A $P < 0.05$ was considered as statistically significant whereas a $P < 0.001$ was considered as highly significant.

Results

In the present study, over all predictive accuracy of 64% was attained in determining the gender using mandibular ramus posterior flexure. The study group consisted of 50 subjects among which 25 were males and 25 were females. Among 25 female 21 OPG, i.e., 84% were correctly identified by MRF. Among 25 male 11 OPG i.e., 44% were correctly identified by MRF with a kappa value 0.280 and $P = 0.0032$ as shown in Table 1.

So, in our study population, gender identified correctly by MRF is 32, i.e., 64% is overall predictive accuracy.

In the present study, scores were assigned to right and left posterior MRF in adult male and female OPG's and scores were added together. The distribution of predicted sex and its percentage, indicated by ramus shape is shown in [Graph 1 and Table 2].

Discussion

In forensic dentistry, the sex of an unknown individual can be determined based on the data from the morphology and metric features of the skull and the mandible, soft tissues, dental records as well as by DNA analysis of teeth.[3] The morphological features of mandible like gonial flare, chin

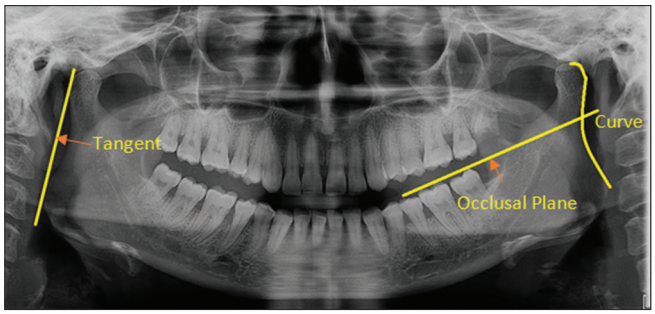


Figure 1: An Orthopantomographs image illustrating a tangent line of the mandibular condyle and angle; a line marking the occlusal plane and a curve marking flexure of the posterior margin of the mandibular ramus

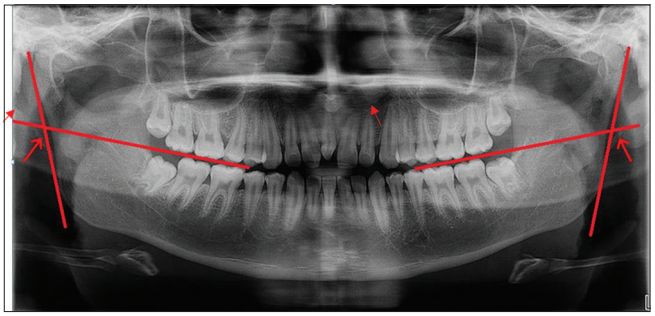


Figure 2: An orthopantomographs image of adult male , note that the deepest flexure point on both rami coincides with the level of the occlusal plane, as indicated by the arrow , given score of (+1) for each ramus and a total score of (+2)

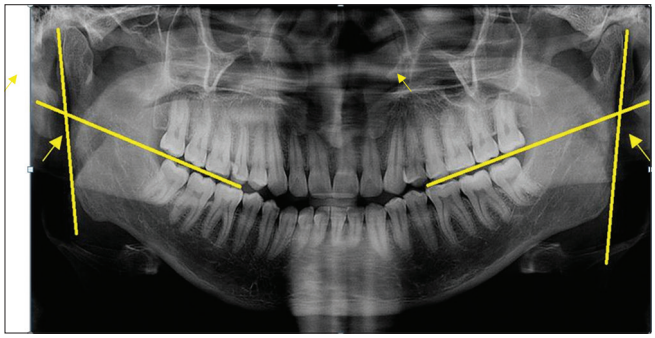


Figure 3: An orthopantomographs image of an adult female, note that the deepest flexure point on both rami indicated by the arrows located near the condyle, given a score of (−1) for each ramus and a total score of (−2)

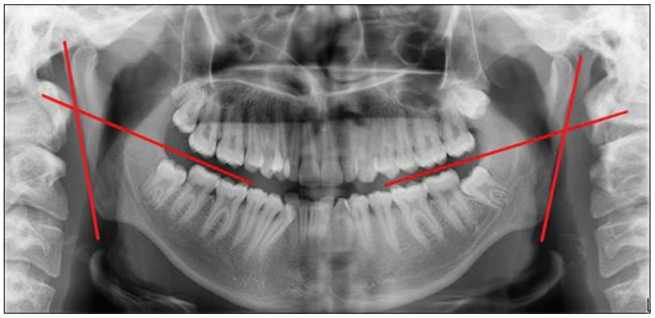


Figure 4: An orthopantomographs image of adult female, note the straight posterior margins of both rami with no flexure, given a score of (−1) for each ramus and a total score of (−2)

Table 1: Distribution of gender identification

Gender	Total	Correctly identified (%)	Misdiagnosed (%)
Female	25	21 (84)	4 (16)
Male	25	11 (44)	14 (56)

Table 2: Distribution of Ramus Shape Scores

Total score	Number of OPG (%)
−2	31 (62.0)
−1	4 (8.0)
1	5 (10.0)
2	10 (20.0)
Total	50 (100.0)

OPG: Orthopantomograph

shape, and shape of lower border have also been studied for sexual dimorphism among which MRF has gained favor for accuracy.

Determination of gender by using MRF dating back to 1996 (Loth and Henneberg) to till date has raised considerable interest among researchers with varied observation and interpretation.

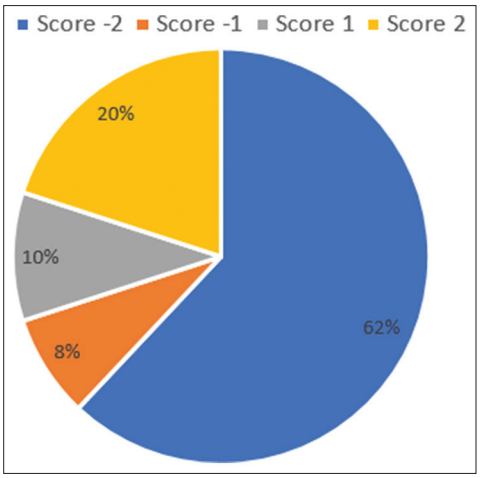
The present study showed an overall predictive accuracy of 64% with a $P = 0.031$ for mandibular flexure in gender determination using OPG Images. It is noteworthy that 0 score was not observed in the tested sample. The subjects were clearly distributed among total scores of −2, −1, 1 and +2 only as shown in Graph 1.

Many advocates of this method (Loth and Henneberg 1996) of gender determination have reported a positive co-relation in its support (Saini *et al.* 2011 and Shivaprakash and Vijaykumar 2014) Where as others have challenged its validity and predictive accuracy (Koski *et al*., 1996; Oettlé *et al*., 2005; Hu *et al*., 2006).[9]

In the study conducted by Loth and Henneberg in 1996, they proved by taking a single indicator, i.e., MRF an accuracy of 94.2% and they confirmed that flexure of the posterior border of the ramus at the level of occlusal plane of the teeth help in identification of the gender.[5]

In our study, predictive accuracy was higher for females than for males. Many researchers believed that this method of the determination of gender had a higher predictive accuracy for males than for females (Donnelly *et al*.; Haun; Hill; Kemkes-Grottenthaler *et al*., 2002; Balci *et al*.; Oettlé *et al*.; Shivaprakash and Vijaykumar), whereas others thought that the method was of more diagnostic sensitivity to females (Suazo *et al*.; Tamer, 2012).[9] The differences among researchers in the reported value of the overall predictive accuracy of ramus flexure could be firstly, due to the differences in the nature of the employed samples. Most researchers employed and worked on samples that comprised “pathological” cases which increased the risk of misdiagnosis and compromised the accuracy of sex prediction. Second, it may also be attributed to the subjective assumption of the exact location of flexure of the posterior margin of mandibular ramus.[7]

In 1998, Muller conducted a study for determining sex from a single mandibular character and found that gonial flaring



Graph 1: Distribution of ramus shape scores

provides a more accurate indicator of gender (76%) than either chin shape or ramus flexure.[10]

In 1998, Donnelly *et al*. also performed the double-blind test, and they identified that there is an association between sex and mandibular gonial flexure.[11]

In 2008, Ivan Claudio determined the sex of sub adult Brazilian mandibles by observing the shape of mandibular body. They performed a blind test on two sets of sample collection using Loth and Henneberg criteria. Their results showed accuracy of 57.5 and 60.5%, being the most sensitive test for determining males (70%) than for females (38%–46%).[12] The results accuracy were lower than those reported by Loth and Henneberg. Hence, they could not justify the need to assess the diagnostic methods of sex in sub adults in specific populations.

There are also controversies regarding the accuracy of the ramus flexure as an indicator of gender because of pathological conditions such as Paget's disease, acromegaly, and other systemic diseases.[1]

Since the objective of this investigation was to evaluate the validity and efficacy of ramus flexure as a sex predictor, it was imperative to employ a strictly normative sample and exclude all "pathological" and trauma cases that may confuse diagnosis and also reduce predictive accuracy of ramus flexure trait.

Conclusion

MRF can be used in gender identification. The present study showed that it provides moderately acceptable over all predictive accuracy, i.e., 64% and could be considered as supplementary rather than definitive mean of sex determination. It is better to include as many parameters as possible for attaining a better accuracy in gender determination.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. James L, Nagaraj T, Gogula S, Sumana CK, Nigam H, Saxena S. Determinnation of gender by using mandibular flexure – A radiographic study. J Indian Acad Oral Med Radiol 2019;31:152-4.
2. 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.
3. AlShamout R, Ammoush M, Alrbata R, AlHabahbah A. Age and gender differences in gonial angle, ramus height and bigonial width in dentate subjects. Pak Oral Dent J 2012;32:817.
4. Raj JD, Ramesh S. Sexual dimorphism in mandibular ramus of south Indian population. J Anthropol 2013;9:253-8.
5. 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.
6. Aparna IN, Dhanasekar B, Gupta L, Lingeshwar D. Medial mandibular flexure: A review of concepts and consequences. Int J Oral Implantol Clin Res 2011;2:67-7.
7. Badran DH, Othman DA, Thnaibat HW, Amin WM. Predictive accuracy of mandibular ramus flexure as a morphologic indicator of sex dimorphism in Jordanians. Int J Morphol 2015;33:1248-54.
8. Saini V, Srivastava R, Shamal SN, Singh TB, Pandey AK, Tripathi SK. Sex determination using mandibular ramus flexure: A preliminary study on Indian population. J Forensic Leg Med 2011;18:208-12.
9. Shivaprakash S, Vijaykumar AG. Sex determination by using mandibular ramus posterior flexure – A prospective study. Int J Health Sci Res 2014;4:155-9.
10. Muller EK. A test of the accuracy of techniques used to determine sex in the mandible. Am J Phys Anthropol 1998:26:168-9.
11. Donnelly SM, Hens SM, Rogers NL, Schneider KL. Technical note: A blind test of mandibular ramus flexure as a morphologic indicator of sexual dimorphism in the human skeleton. Am J Phys Anthropol 1998;107:363-6.
12. Ivan Claudio SG. Blind test of mandibular morphology with sex indicator in sub adult mandibles. Int J Morphol 2008;26:845-8.