Original Article

Assessment of the Effect of Dimensions of the Mandibular Ramus and Mental Foramen on Age and Gender Using Digital Panoramic Radiographs: A Retrospective Study

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Abstract

Background: A retrospective study is conducted to evaluate the mental foramen size and ramus height using digital panoramic radiograph to see if these parameters could be used to determine a correlation with age and gender in dentate subjects and to show its relevance in forensic odontology. **Aim:** To determine if there is an interrelation between two mandibular parameters (mental foramen, ramus height) in gender and age assessment. **Materials and Methods:** Five hundred and forty-five high-quality radiographs of patients aged 20 years and above were selected to see superior and inferior aspects of the mental foramen and the ramus height. **Statistical Analysis:** Data obtained were analyzed using the SPSS 20 version software. The mean and standard deviations were calculated for each clinical parameter, and one-way ANOVA statistical test of significance was used to compare superior and inferior aspects of mental foramen and ramus height with age groups and gender for both right and left sides. Statistical significance was set at $P < 0.05$. **Results:** Highly significant relationship was observed, and it was also found that as the age advances, the mental foramen and ramus height increase on both the right and left sides; whereas the mental foramen and ramus height increase among males as compared to females on both the right and left sides. **Conclusion:** There were significant changes in the dimensions of mental foramen and ramus height as age advances. The results concluded that ramus height and the mental foramen can be used effectively in the identification of gender using digital panoramic radiography.

Keywords: *Gender, mandibular parameters, mental foramen, ramus height*

Introduction

Among humans, the bones of face and hands are considered as the only remnants of the original individuality. As such, they are more accessible, are more familiar socio-biologically, and have been extensively studied. It is not surprising to study these parts for identification purposes as the teeth and the bones of the craniofacial skeleton can be the best-preserved parts of human remains. Furthermore, their inherent complexity is expressed by a large variability in size, shape, and proportions which leads to individualization.[1]

Gender estimation is a vital component of biological profile estimation during forensic identification of skeletonized or badly decomposed unknown individuals. While there is a recent trend in the forensic anthropological community toward the use of more metric methods, nonmetric methods continue to be routinely employed because of their relative ease of use and their perceived reliability and because they are frequently "passed-down knowledge." Because of the aforementioned factors, nonmetric methods are often still utilized for biological profile estimation, in conjunction with metric assessments, particularly with the human skull and pelvis. The skull has historically been the most studied portion of the skeleton for both ancestral- and gender-related differences, while the pelvis, specifically the innominate and the pubic bone, is widely regarded as the best indicator of gender due to the sexual dimorphism related to childbirth and locomotion in females.[2] The mandible is the strongest bone in the human body and persists in a well-preserved state longer than any other bone.[3]

The radiographs are indispensable tools that can also be used in forensic anthropology. The accuracy of measurements on

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radiographs is based on the quality of the radiographs.[4] Image quality of the panoramic radiograph is increased by the digital panoramic radiography.[5]

The majority of the mandibular changes are expected to occur in the alveolar process; however, changes in the basal bone also occur throughout the life.[6] Thus, remodeling of the mandible with age, gender, and dental status also occurs throughout the life in many parameters such as gonial angle, antegonial angle, mental foramen, mandibular foramen, and mandibular canal. These changes can be easily evaluated in dried mandible as well as on radiographs.[7]

The mental foramen is an opening or a hole in the bone located on the external surface of the mandible in the region of the mandibular premolars. On a mandibular periapical radiograph, the mental foramen appears as a small, ovoid or round, radiolucent area located in the apical region of the mandibular premolars. The mental foramen is frequently misdiagnosed as a periapical lesion because of its apical location.[8] Knowledge of the position of the mental foramen is very important both when administering regional anesthesia and performing periapical surgery in the mandible.[9] Although it is often possible to identify the mental foramen by palpation and radiographically, knowing the normal range of possible location is essential.[10] The image of mental foramen is quite variable, and it may be identified only about half the time because the opening of the mental canal is directed superiorly and posteriorly.

The relative development (size, strength, and angulation) of the muscles of mastication is known to influence the expression of mandibular dimorphism as masticatory forces exerted are different for males and females.[11] Humphrey *et al*. showed that the sites associated with the greatest morphological changes in size and remodeling during growth, mandibular condyle and ramus, in particular, are generally the most sexually dimorphic. Measurements of the mandibular ramus tend to show higher sexual dimorphism, and differences between the sexes are generally more marked in the mandibular ramus than in the mandibular body.[12]

This study aimed to determine if there is a correlation between two mandibular parameters (mental foramen, ramus height) and age and gender in dentate subjects. These data may enable future advances in forensic cadaver identification, as well as monitoring growth patterns of individuals in forensic odontology assessments.

Materials and Methods

Materials used

Panoramic radiographs of dentate subjects were selected from the outpatient department with the age of 20 years and above including almost equal number of both males and females.

All the radiographs were taken with VATECH Digital Panoramic X-ray System (PaX-400C) with tube voltage of 70–80 kVp and tube current of 10–12 mA having 13–13.5 exposure time on Kodak radiographic film.

Study subjects

All subjects were positioned in the machine according to the manufacturer's manual. All images were examined on the monitor and the resolution enhanced to what is considered optimum. The selected radiographic images were imported by Easy Dent Digital software (A practice management software by Data Tec) with specific tools for making linear measurements on images of the mandibular jaw using mouse-driven method (by moving the mouse and drawing lines using chosen points on the digital panoramic radiograph).

Ethical clearance

The present study is retrospective and study protocol is approved by the Institutional Ethical Committee.

Methodology

Sample size

All panoramic radiographs were taken into consideration taken within 5-month duration. There were 1002 panoramic radiographs recorded in this period, of that 545 high-quality radiographs of the patients aged 20 years and above were selected according to the inclusion and exclusion criteria to see superior and inferior aspects of the mental foramen and the ramus of the mandible.

Inclusion criteria

- Panoramic radiographs of both dentulous and partial edentulous patients aged 20–90 years
- Panoramic radiographs where both mental foramen and ramus were clearly visible
- Evidence of resorption in the mandibular arch, especially in premolar and first molar region, and mandibular ramus area should be minimum or absent
- Only high-quality radiographs with no visible errors.

Exclusion criteria

- Panoramic radiographs with positioning errors which could cause distortions in the dimensions
- Hereditary facial asymmetries
- Radiographs of completely edentulous patients
- Surgical intervention, patients with orthognathic surgeries
- Presence of pathologies, periodontal lesion, and congenital anomaly in the lower jaw that could affect the interpretation of radiographic image.

Examiner reliability

To ensure consistency and to avoid intra-observer and inter-observer bias, one observer was responsible for selection and measurements of radiographs based on the inclusion and exclusion criteria which were later verified by the supervisor by random selection. The Cohen's kappa

Table 1: Age-wise comparison of right and left superior and inferior aspects of mental foramen

Age group	20-40 years	41-60 years	61-90 years	*F*-test	*P*	Significant (S) non-significant (NS)
Right superior mental foramen	12.3+1.57	12.6+1.47	12.7+1.40	7.046	0.000	S
Right inferior mental foramen	12.1+1.67	12.6+1.46	12.7+1.40	7.221	0.001	S
Left superior mental foramen	10.4+1.49	11.4+7.67	11.1+1.33	1.700	0.166	NS
Left inferior mental foramen	10.4+1.49	10.9+1.45	11.2+1.32	7.559	0.002	S

$P \leq 0.05$ - Significant, CI=95 %, CI: Confidence interval

Table 2: Age-wise comparison of right and left ramus height

Age group	20-40 years	41-60 years	61-90 years	*F*-test	*P*	Significant (S) non-significant (NS)
Right ramus height	44.6+4.17	45.01+4.41	45.7+4.20	1.445	0.229	NS
Left ramus height	43.9+4.09	44.4+4.30	44.6+3.61	1.327	0.265	NS

$P \leq 0.05$ - Significant, CI=95 %, CI: Confidence interval

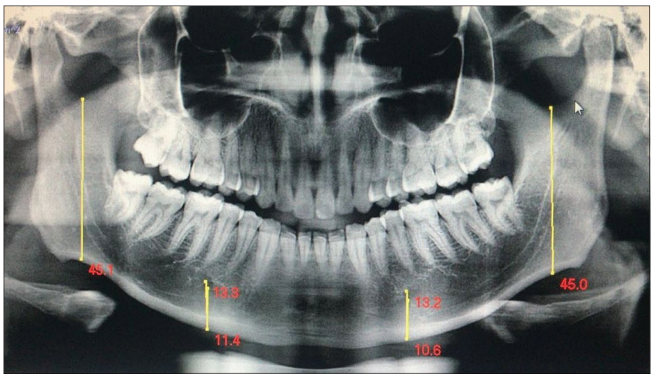

Figure 1: Panoramic radiograph showing measurements of ramus height and dimensions of superior and inferior aspects of mental foramen on both right and left side

was used to assess intra- and inter-observer variability. The intra-observer variability was excellent (κ = 0.80) and inter-observer variability was excellent (κ = 0.85).The parameters were measured as follows [Figure 1].

Mental foramen

The tangents were drawn to the superior and inferior borders of the foramen, and the perpendiculars were drawn from the tangents to the lower border of the mandible bilaterally. The distance was measured from the superior aspect of the mental foramen to the lower border of the mandible (S-L) and the inferior aspect of the mental foramen to the lower border of the mandible (I-L).[13]

Ramus height

A modification of the technique given by Amorim *et al*. was used.[14] Ramus height is measured as a line parallel to the ramus line from the deepest point on the sigmoid notch up to a tangent drawn to the lower border of the mandible.

Statistical analysis of the study

All the collected data were entered in the Microsoft Word Excel Sheet 2007 version, and the data obtained were analyzed using the Statistical Package for the Social Sciences (SPSS) 20 Version (IBM, Armonk, New York, USA) for the descriptive analysis and statistical tests of significance. The mean and standard deviations were calculated for each clinical parameter, and one-way ANOVA statistical test of significance was used to compare superior and inferior aspect of mental foramen and ramus height with age groups and gender for both right and left sides. Statistical significance was set at $P < 0.05$.

Results

When one-way ANOVA was applied to see the age-wise comparison of right and left superior and inferior aspects of mental foramen, it was found that there was a significant relationship between them except in relation to left superior aspect of mental foramen, but it was also found that as the age advances, the mental foramen increases. On the other hand, there was nonsignificant relationship between ramus height on both right and left sides of the mandible (P = 0.000, 0.001, 0.002 and 0.166 in respect to mental foramen and in respect to ramus height P = 0.229, 0.265) [Tables 1 and 2].

Tables 3 and 4 show the gender-wise comparison of right and left ramus height and superior and inferior aspect of the mental foramen. It was found that there was a significant relationship between them, and it was also found that the superior and inferior aspects of mental foramen and ramus height decrease among females as compared to males on both the right and left sides (P = 0.000).

When one-way ANOVA was applied to see the relationship between right and left superior and inferior aspect of mental foramen among male and female aged 20–40 years, it was found that there was significant relationship between them and males had increased superior and inferior aspects of the mental foramen as compared to females on both right and left sides (P = 0.000) [Table 5].

Table 6 shows the relationship between right and left ramus height among males and females aged 20–40 years (one-way ANOVA). It was found that there was highly significant relationship between right and left ramus height among males and females aged 20–40 years where males had increased height as compared to females on both right and left sides (P = 0.000).

When one-way ANOVA was applied to see the relationship between right and left superior and inferior aspects of the mental foramen among males and females aged 41–60 years, it was found that there was significant relationship between them and males had increased superior and inferior aspects of the mental foramen as compared to females on both right and left sides (P = 0.000) [Table 7].

Table 8 shows relationship between right and left ramus height among males and females aged 41–60 years (one-way ANOVA). It was found that there was highly significant relationship between right and left ramus height among males and females aged 41–60 years where males had increased height as compared to females on both right and left sides (P = 0.000).

When one-way ANOVA was applied to see the relationship between right and left superior and inferior aspects of the mental foramen among males and females at the age of 61–90 years, it was found that there was significant relationship between them and males had increased superior and inferior aspects of the mental foramen as compared to females on both right and left sides (P = 0.008, 0.003) [Table 9].

Table 10 shows the relationship between right and left ramus height among males and females at the age of 61–90 years (one-way ANOVA). It was found that there was highly significant relationship between right and left ramus height among males and females at the age of 61–90 years where male subjects show increase in ramus height as compared to ramus height in female subjects on both right and left sides (P = 0.000).

Table 3: Genderwise comparison of right and left superior and inferior mental foramen

	Gender		*F*-test	*P*
	Male	Female		
Right superior mental foramen	13.01±1.38	11.5±1.29	166.8	0.001 (S)
Right inferior mental foramen	13.02±1.33	11.5±1.47	155.6	0.000 (S)
Left superior mental foramen	11.7±6.56	9.9±1.24	18.52	0.000 (S)
Left inferior mental foramen	11.4±1.34	9.9±1.24	165.3	0.000 (S)

$P \leq 0.05$ (S), CI=95%. CI: Confidence interval; S: Significant

Table 4: Genderwise comparison of right and left ramus height

	Gender		*F*-test	*P*
	Male	Female		
Right ramus height	47.02±3.60	42.3±3.43	227.9	0.002 (S)
Left ramus height	46.5±3.48	41.3±3.11	263.9	0.000 (S)

$P \leq 0.05$ (S), CI=95%. CI: Confidence interval; S: Significant

Table 5: Genderwise comparison of right and left superior and inferior mental foramen among 20-40 years age study subjects

	Gender		*F*-test	*P*
	Male	Female		
Right superior mental foramen	12.8±5.51	11.2±3.16	81.607	0.001 (S)
Right inferior mental foramen	12.8±1.41	11.2±1.54	71.997	0.000 (S)
Left superior mental foramen	11.2±1.36	9.6±1.19	95.408	0.000 (S)
Left inferior mental foramen	11.1±1.43	9.7±1.22	69.872	0.000 (S)

$P \leq 0.05$ (S), CI=95%. CI: Confidence interval; S: Significant

Table 6: Genderwise comparison of right and left ramus height among 20-40 years age study subjects

	Gender		*F*-test	*P*
	Male	Female		
Right ramus height	46.6±3.74	42.7±3.61	74.021	0.003 (S)
Left ramus height	46.2±3.65	41.7±3.24	1.4.7	0.000 (S)

$P \leq 0.05$ (S), CI=95%. CI: Confidence interval; S: Significant

Discussion

The identification of sex from human remains is of fundamental importance in forensic medicine and anthropology, especially in criminal investigations as well as in the identification of missing persons and in attempts at reconstructing the lives of ancient populations. One of the important aspects of forensics is to determine sex from fragmented jaws and dentition.[15] Identification of sex based on morphological marks is subjective and likely to be inaccurate, but methods based on measurements and morphometry are accurate and can be used in the determination of sex from the skull.[11,12] Mandibles were used for the analysis for two simple reasons: first, there appears to be a paucity of standards utilizing this element, and second, this bone is often recovered largely intact.

It was found from the present study that there was significant comparison between superior and inferior aspects of mental foramen and age groups, except left superior aspect of the mental foramen. It was noticed that as the age advances, the mean also increases. Mean value of the distance between mental foramen and tangent drawn to base of mandible had no statistical differences between the analyzed age groups, which was consistent with the studies of Amorim MM *et al*.,[14] Afsar A *et al*.,[6] Shendarkar *et al*.,[16] and Enlow DH *et al*.[17] According to Bhardwaj *et al*., it was concluded that age was less clearly related to mental foramen.[18]

When gender was compared with mental foramen, there was significant comparison among the groups. Similar findings were also found by Rai and Arand in 2009 and their study indicated that measurements of mental foramina to alveolar ridge can be useful for specifying gender.[19] Wical and Swoope in 1974 described that despite the alveolar bone resorption above the mental foramen,

Table 7: Genderwise comparison of right and left superior and inferior mental foramen among 41-60 years age study subjects

	Gender		*F*-test	*P*
	Male	Female		
Right superior mental foramen	13.2±1.32	11.7±1.22	71.527	0.002 (S)
Right inferior mental foramen	13.1±1.32	11.8±1.27	58.46	0.000 (S)
Left superior mental foramen	12.4±1.36	10.1±1.22	4.943	0.027 (S)
Left inferior mental foramen	11.6±1.32	10.1±1.20	67.95	0.000 (S)

$P \leq 0.05$ (S), CI=95%. CI: Confidence interval; S: Significant

Table 8: Genderwise comparison of right and left ramus height among 41-60 years age study subjects

	Gender		*F*-test	*P*
	Male	Female		
Right ramus height	47.2±3.67	42.02±3.41	118.1	0.004 (S)
Left ramus height	46.7±3.49	41.3±3.29	132.4	0.000 (S)

$P \leq 0.05$ (S), CI=95%. CI: Confidence interval; S: Significant

Table 9: Genderwise comparison of right and left superior and inferior mental foramen among 61-90 years age study subjects

	Gender		*F*-test	*P*
	Male	Female		
Right superior mental foramen	12.9±1.29	11.7±1.41	8.865	0.004 (S)
Right inferior mental foramen	13.1±1.12	11.7±1.73	12.917	0.001 (S)
Left superior mental foramen	11.3±1.22	10.2±1.39	8.235	0.006 (S)
Left inferior mental foramen	11.5±1.08	10.1±1.58	13.748	0.004 (S)

$P \leq 0.05$ (S), CI=95%. CI: Confidence interval; S: Significant

Table 10: Genderwise comparison of right and left ramus height among 61-90 years age study subjects

	Gender		*F*-test	*P*
	Male	Female		
Right ramus height	47.1±3.57	41.1±2.51	34.562	0.002 (S)
Left ramus height	45.6±3.11	41.3±3.21	20.868	0.000 (S)

$P \leq 0.05$ (S), CI=95%. CI: Confidence interval; S: Significant

the distance from the foramen to the inferior border of the mandible remains relatively constant throughout the life.[20] Lindh *et al*. in 1995 and Güler *et al*. in 2005 also suggested that the stability of this region does not depend on resorption of alveolar process above the foramen.[21,22]

It was revealed from the present study that gender-wise, there was significant comparison with mental foramen. Our results were in agreement with previous studies carried out in other populations by Yosue and Brooks.[23] Al-Khateeb *et al*. showed in a study that there are significant differences in position of mental foramen in males and females.[24] The results of the present study are also in accordance with another study conducted by Ural *et al*.[25] Mahima., Catovie *et al*., and Thomas *et al*. showed that mean values of mental foramen were significantly high in males as compared to females, which was not found true for the present study.[26,27]

In our study, significant differences were found between different age groups and ramus height. In one of the studies, there was not a significant difference in the minimum of ramus breadth mean between the two genders, except in the age group of 20–34 years ($P > 0.05$).

In Steyn and Işcan's study, a significant difference in ramus height was reported between the two genders,[28] but in Merrot *et al.*'s study, the ramus height was a little higher in women than men, but this difference was not significant.[29] Similar results were found in our present study, but males had higher ramus height as compared to females. Minimum ramus breadth measurement was found to be the best parameter in the present study, which is consistent with other osteometric studies by Giles and Vodanovic *et al.*,[15,30] where breadth measurements were found to be very dimorphic. This is related to the differences in musculoskeletal development and to the differences related to a different growth trajectory in males and females.

An interesting finding was found in our present study that among all the age groups and in both the genders, the difference and relation were highly significant in relation to superior and inferior aspects of the mental foramen, both right and left sides and right and left ramus height. As the age advances, the mental foramen distance as well as ramus height increases among males as compared to females.

Conclusion

There were significant changes in dimensions of the mental foramen and ramus height as age advances. Age was less clearly related for left superior mental foramen. The present study which has been conducted to evaluate the dimensions of mental foramen and ramus height in digital panoramic radiograph to identify possible interrelationships between these groups on both right and left sides and gender of the patient analyzed the results and concluded that ramus height and the dimensions of mental foramen can be used effectively in identification of gender. The digital panoramic radiographs are used in the morphometric analysis which shows the uniqueness of craniofacial features with distinct dimensions for gender assessment. Since this technique is widely used because of easy availability and low cost of panoramic radiographs, newer diagnostic tools such as three-dimensional computer imaging, mass spectrometry, DNA test, and high-performance liquid chromatography should also be taken into account.

The application of this study is reliable although it has its own limitations. The quality and accuracy of radiographs, age limitations, larger samples size, and minimizing the inter-observer variations might have given the better results.

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Conflicts of interest

There are no conflicts of interest.

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