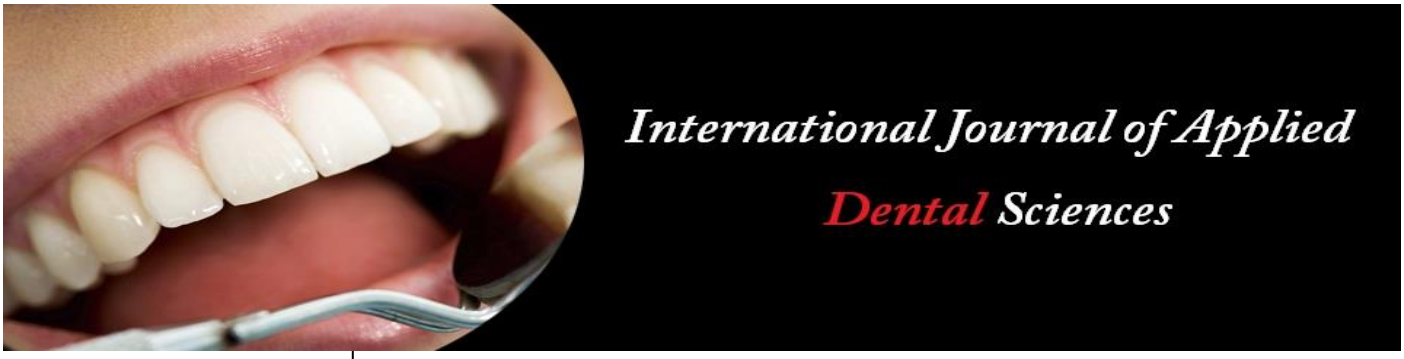

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Morphometric evaluation of effect of dimensions of the mandibular ramus and mental foramen on age and gender using digital panoramic radiographs in Kashmiri population: A retrospective study

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Abstract
Background: A retrospective study was conducted for the evaluation of 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 significance in forensic odontology.
Aim: To determine if there is any interrelation between two mandibular parameters (mental foramen, ramus height) in gender and age assessment and if these parameters could be used in future for age and gender determination in forensic odontology.
Materials and Methods: One hundred twenty 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 20.0 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, in case of ramus height in both the parameters (gender and age) 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 less significant changes in the dimensions of mental foramen and highly significant changes in case of ramus height as age advances. Also ramus height paves a way for the sexual dimorphism in the specified age groups. The results concluded that ramus height and the mental foramen can be used effectively in the identification of gender using digital panoramic radiography.

Keywords: panoramic radiograph, gender, age, mental foramen, ramus of mandible

Introduction
Identification of an individual is a mainstay of civilization and has always been of paramount importance to society. Identification of humans in the medico-legal sense refers to the determination of the individuality of a person which may be complete or partial [1]. Human identification had remained a very difficult task in forensic science and is mandated by laws and social rules [2]. Gender determination is a vital component of biological profile estimation during forensic identification of skeletonized or badly decomposed unknown individuals. From time to time, different methods have been utilized for sex and age estimation. There is a recent trend in the forensic anthropological community toward the use of more metric methods, nonmetric methods continue to be routinely used because of their relative ease of use and their perceived reliability and because they are frequently "passed-down knowledge [3]."
Age estimation is of great importance for the identification of victims of accidents and crimes and in case of deceased which have badly disfigured [4]. Chronological age assessment is an important part of medico legal practice. The procedures for age determination are complex and involve the consideration of many factors. Changes related to chronological age are seen in both hard and soft tissue. Amongst the hard tissues, bones are important as they undergo a series of changes from prenatal to postnatal life and changes in their composition and structure continue till old age and even after death. Hence, bones form a reliable source of information regarding growth and growth changes. Normally well-defined skeletal development in bones, cranial sutures and teeth take place at specific ages. However, these changes are significantly

affected by genetics, general health and other environmental factors [5].

The mandible is the strongest bone in the human body and persists in a well-preserved state longer than any other bone and remains intact despite the bacterial decomposition and sustaining extreme temperatures. Therefore, the use of morphological features of the mandible is a common approach used by anthropologists and forensic dentists in sexual dimorphism. Skeletal characteristics vary by population; therefore, there is a need for population-specific standards for sex determination. Among many anatomical landmarks in human skull, the mental foramen is a stable landmark on the mandible. It is a funnel-like opening in the lateral surface of the mandible at the terminus of the mental canal. It lies near the apices of premolars and transmits mental nerves and vessels. The opening is directed outward, upward and posteriorly [6]. 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 [7]. 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 [8]. 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 [9].

Radiography being a non-destructive method plays a vital role in forensic dentistry to uncover the hidden facts, which cannot be seen by means of physical examination [10]. The radiographs are indispensable tools that can also be used in forensic anthropology. The accuracy of measurements on radiographs is based on the quality of the radiographs [11]. Image quality of the panoramic radiograph is increased by the digital panoramic radiography [12].

This study aimed to determine if theres is a correlation between two mandibular parameters (mental foramen, ramus height) in terms of age and gender in dentate subjects. These data may enable future advances in forensic age and gender differentiation challenges.

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 OPGs were taken by New-Tom VGi Scanner (QR srl; Verona, Italy) in standard resolution mode (tube potential: 50-85KV, tube current: 12mA, andtime: 14s).

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 n imported by DICOM software- 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 535 panoramic radiographs recorded in this period, of that 120 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 20–80years
- 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.

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 ofthe 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.

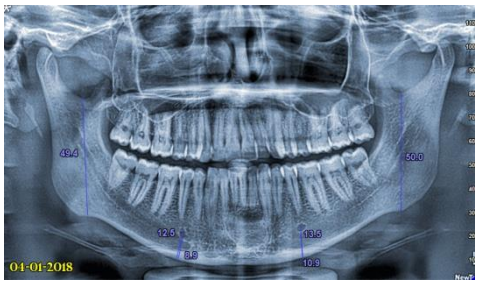

Fig 1: Panoramic radiograph showing measurements of ramus height and dimensions of superior and inferior aspects of mental foramen on both right and the left side.

Statistical Methods: The recorded data was compiled and entered in a spreadsheet (Microsoft Excel) and then exported to data editor of SPSS Version 20.0 (SPSS Inc., Chicago, Illinois, USA). Data were expressed as Mean±SD. Analysis of variance (ANOVA) was employed to compare various study

parameters. A P-value of less than 0.05 was considered statistically significant.

Results

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

Parameter	20-40 Yrs		41-60 Yrs		61-80 Yrs		F-value	P-value
	Mean	SD	Mean	SD	Mean	SD		
Right superior mental foramen	14.61	2.05	13.56	2.18	13.78	1.56	3.398	0.037*
Right inferior mental foramen	11.59	2.05	10.63	2.03	11.73	1.82	2.884	0.061
Left superior mental foramen	14.02	1.89	13.32	1.61	13.48	1.23	2.063	0.132
Left inferior mental foramen	11.17	1.80	10.33	1.48	11.21	1.83	2.881	0.062

*Statistically Significant (*P-value*<0.05)

Table 1 is showing age wise comparison of right and left superior and inferior aspects of mental foramen and it was found that only right superior mental foramen showing statistically significant difference among different age groups.

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

Parameter	20-40 Yrs		41-60 Yrs		61-80 Yrs		F-value	P-value
	Mean	SD	Mean	SD	Mean	SD		
Right ramus height	48.73	4.18	46.53	4.82	48.29	2.71	3.096	0.049*
Left ramus height	48.19	4.73	45.49	3.97	48.58	3.43	4.844	0.010*

*Statistically Significant (*P-value*<0.05)

Table 2-showing age wise distribution of right and the left ramus height (Right ramus height p=0.049, Left ramus height p=0.010) and there has been seen statistically significant differences on both the sides of the mandible.

Table 3: Gender-wise comparison of right and left superior and inferior aspects of mental foramen

Parameter	Male		Female		F-value	P-value
	Mean	SD	Mean	SD		
Right superior mental foramen	14.5	1.82	14.0	2.29	1.732	0.191
Right inferior mental foramen	11.6	2.02	11.0	2.05	2.586	0.110
Left superior mental foramen	14.0	1.91	13.5	1.58	1.908	0.170
Left inferior mental foramen	11.2	1.76	10.7	1.73	1.697	0.195

Table 3-showing gender wise comparison of right and left superior and inferior aspects of mental foramen and it was found that there was a non significant difference seen among genders and it was also found that superior and inferior aspect of mental foramen decrease among females as compared to males on both right and the left side.

Table 4: Gender-wise comparison of right and left ramus height

Parameter	Male		Female		F-value	P-value
	Mean	SD	Mean	SD		
Right ramus height	50.1	3.67	46.0	3.89	35.259	<0.001*
Left ramus height	49.9	4.03	45.1	3.69	44.737	<0.001*

*Statistically Significant (*P-value*<0.05)

Table 4-showing gender wise comparison of right and left ramus height of the mandible and it was found that there was a significant difference seen among genders and it was also found that ramus height decrease among females as compared to males on both right and the left side.(*p*=<0.001).

Table 5: Gender-wise comparison of right and left superior and inferior aspects of mental foramen among 20-40 years subjects

Parameter	Male		Female		F-value	P-value
	Mean	SD	Mean	SD		
Right superior mental foramen	14.6	2.039	14.6	2.084	0.016	0.899
Right inferior mental foramen	11.5	2.203	11.6	1.956	0.024	0.876
Left superior mental foramen	14.2	2.283	13.9	1.535	0.396	0.531
Left inferior mental foramen	11.3	1.732	11.1	1.870	0.340	0.561

Table 5-showing gender-wise relationship of right and left superior and inferior aspects of mental foramen among males and females aged 20-40 years (one way-ANOVA), it was found that there was a non significant difference among genders in this age group .

Table 6: Gender-wise comparison of right and left ramus height among 20-40 years subjects

Parameter	Male		Female		F-value	P-value
	Mean	SD	Mean	SD		
Right ramus height	50.9	4.121	47.0	3.395	19.192	<0.001*
Left ramus height	51.2	4.307	45.9	3.605	32.443	<0.001*

*Statistically Significant (*P-value*<0.05)

Table 6-showing gender-wise relationship of right and left ramus height among males and females aged 20-40 years (one way-ANOVA), it was found that there was a highly significant difference among genders in this age group .where males have shown increased ramus height on both the sides as compared to females (p=<0.001).

Table 7: Gender-wise comparison of right and left superior and inferior aspects of mental foramen among 41-60 years subjects

Parameter	Male		Female		F-value	P-value
	Mean	SD	Mean	SD		
Right superior mental foramen	14.4	1.57	12.4	2.42	8.264	0.007*
Right inferior mental foramen	11.4	1.79	9.5	1.86	8.978	0.005*
Left superior mental foramen	13.7	1.59	12.8	1.53	2.658	0.113
Left inferior mental foramen	10.6	1.52	10.0	1.38	1.611	0.214

*Statistically Significant (*P-value*<0.05)

Table 7-showing gender-wise relationship of right and left aspects of superior and inferior mental foramen among males and females aged 41-60 years (one way-ANOVA),it was found that there was a statistically significant difference among genders seen in right superior mental foramen (p=<0.007). and in right inferior mental foramen (p=<0.005), it was also found that males had increased superior and inferior aspects of mental foramen as compared to females on both right and left side.

Table 8: Gender-wise comparison of right and left ramus height among 41-60 years subjects

Parameter	Male		Female		F-value	P-value
	Mean	SD	Mean	SD		
Right ramus height	48.9	3.43	43.3	4.62	16.024	<0.001*
Left ramus height	47.4	3.15	43.0	3.59	13.995	0.001*

*Statistically Significant (*P-value*<0.05)

Table 8-showing gender-wise relationship of right and left ramus height among males and females aged 41-60 years (one way-ANOVA), it was found that there was a highly significant difference seen among genders (p=<0.001), it was also found that males had increased ramus height as compared to females on both right and left side.

Table 9: Gender-wise comparison of right and left superior and inferior aspects of mental foramen among 61-80 years subjects

Parameter	Male		Female		F-value	P-value
	Mean	SD	Mean	SD		
Right superior mental foramen	14.0	1.57	13.5	1.63	0.414	0.530
Right inferior mental foramen	12.3	1.91	10.7	1.24	3.263	0.092
Left superior mental foramen	13.9	1.04	12.8	1.35	2.944	0.108
Left inferior mental foramen	11.7	2.17	10.4	0.57	1.929	0.187

Table 9-showing gender-wise relationship of right and left aspects of superior and inferior mental foramen among males and females aged 61-80years (one way-ANOVA), it was found that there was a non- significant difference seen among genders, it was also found that males had increased superior and inferior aspects of mental foramen as compared to females on both right and left side.

Table 10: Gender-wise comparison of right and left ramus height among 61-80 years subjects

Parameter	Male		Female		F-value	P-value
	Mean	SD	Mean	SD		
Right ramus height	49.9	1.58	45.7	2.02	21.861	<0.001*
Left ramus height	50.4	2.27	45.5	2.77	15.119	0.002*

*Statistically Significant (*P-value*<0.05)

Table 10-showing gender-wise relationship of right and left ramus height among males and females aged 61-80 years (one way-ANOVA), it was found that there was a significant difference seen among genders in both sides and it was also found that highly significant difference among genders (p=<0.001) for right ramus height as compared to left ramus height, it was also found that males had increased ramus height as compared to females on both right and left side.

Discussion

Sex determination from human remains is of fundamental importance in forensic medicine and anthropology, especially in case of criminal investigations as well as in the identification of badly decomposed missing individuals and in attempts at reconstructing the lives of ancient populations. One of the important aspects of forensics is to determine sex from disfigured and fragmented jaws and dentition [15].

Identification of sex based on morphological data 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 [16, 17]. Mandibles being a stongest bone were used for the analysis for two simple reasons: first, there appears to be a paucity of standards utilizing this bone, and second, this bone is often recovered largely intact as they are extremely durable in fire and can resist the bacterial decomposition. It was found from the present study that there was not a significant comparison between superior and inferior aspects of mental foramen and age groups, except in right superior aspect of the mental foramen. 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*. [18], Shendarkar *et al*. [19], and Enlow DH *et al*. [20] According to Bhardwaj *et al*., it was concluded that age was less clearly related to mental foramen [21]. which is similar to our study. 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 [22]. Wical and Swoope in 1974 described that despite the alveolar bone resorption above the mental foramen, the distance from the foramen to the inferior border of the mandible remains relatively constant throughout the life [23]. 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 [24, 25]. 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 [26]. Al-Khateeb *et al*. showed in a study that there are significant differences in position of mental foramen in males and females [27]. The results of the present study are also in accordance with another study conducted by Ural *et al*. [28]. 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 [29, 30]. In our study, significant differences were not found between different age groups except in the age group of 41-60 years showing significant difference. it was also found in the present study that in case of ramus height highly significant differences had been seen among genders on both the sides. 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, [31] but in Merrot *et al*.'s study, the ramus height was a little higher in women than men, but this difference was not significant [32]. in the present study results highly significant differences had been found among genders, with males had higher ramus height as compared to 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 right and left ramus height on both the sides. Also 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 ramus height of the mandible as age advances. Age was less clearly related for mental foramen dimensions .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 in identification of gender and is also population specific. 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, and larger samples size might have given the better results.

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