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Morphometric Parameters of Mandibular Foramen in Adult Dry Mandible and Its Relationship with Side and Gender

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ABSTRACT: ***Background:*** The mandibular foramen enters the mandible obliquely centering on the medial aspect of the ramus. The inferior alveolar artery, vein and nerve enter the mandible at this aperture and pass through the bone via the mandibular canal. ***Methods:*** This cross-sectional descriptive study was carried out in the Department of Anatomy at Rajshahi Medical College, Rajshahi over a period of one year from January 2021 to December 2021. This study was conducted on 250 dried adult human mandibles (148 male and 102 female) gathered from the students at different Medical Colleges which mandibles met the eligibility criteria. The data were gathered purposively using a semi-structured questionnaire. All measurements were taken with digital sliding Vernier calipers and the results were analyzed via SPSS software, version 24.0. All tests were statistically significant at the acceptable probability level ($p < 0.05$). ***Results:*** The study revealed that more than 98% mandibular foramens were oval in shape. Among eight parameters, most of the difference between the right and left halves were not statistically significant ($p > 0.05$), except for the distance from the midpoint of the MF to the lowest point of the mandibular notch (MN), distance of mandibular foramen to symphysis menti and horizontal diameter of mandibular foramen which were statistically significant ($p < 0.05$) for all tests. Male mandibles had significantly higher distances from the midpoint of the MF to the anterior border (AB), posterior border (PB), lowest point of the mandibular notch (MN), inferior border (IB) to the base of the mandible, angle of the mandible and symphysis menti of both halves compared to females ($p < 0.001$). ***Conclusion:*** This study might be helpful in developing a reference database in our country for anatomists in general, dental surgeons and maxillofacial surgeons.

Keywords: Morphometric Parameters and Mandibular Foramen.

Article at a glance:

Study Purpose*: The purpose of the study was to determine the morphometric parameters of mandibular foramens and find out their variations with respect to side and gender.*

Key findings: *Most of the differences between the right and left halves of eight parameters were not statistically significant ($p > 0.05$), except for the distance from the midpoint of the MF to the lowest point of the mandibular notch (MN), distance of mandibular foramen to symphysis menti and horizontal diameter of mandibular foramen which were statistically significant ($p < 0.05$).*

Newer findings: *Male mandibles had significantly higher distances from the midpoint of the MF to the anterior border (AB), posterior border (PB), lowest point of the mandibular notch (MN), inferior border (IB) limited to the base of the mandible, angle of the mandible and symphysis menti of both halves.*

Abbreviations: *AB: Anterior border, IB: Inferior border, MF: Mandibular foramen, MN: Mandibular notch and PB: Posterior border.*

INTRODUCTION

The mandibular foramen is an irregular foramen that is placed just above the middle of the mandibular ramus at the medial surface. The mandibular foramen opens into the mandibular canal which travels downward and forward within the ramus, softly curving inferiorly within the body beneath the roots of the molar teeth. It connects with the roots of the molar teeth via small apertures and ascends in the premolar region to the mental foramen. The canal is not always easy to see on simple X-rays, especially anterior to the mental foramen.[1] Its walls can be made of either a thin layer of cortical bone or more commonly trabecular bone. Although the canal's buccal-lingual and superior-inferior locations vary greatly between mandibles, the mandibular canal is closer to the lingual cortical plate in the back two-thirds of the bone and closer to the labial cortical plate in the anterior third.[2] Bilateral symmetry of location of the canal in each half of the mandible is

observed. The inferior alveolar nerve and vessels pass through the foramen and traverse the mandibular canal and divides into mental and incisive branches to supply the mandibular teeth and participates in the formation of the anterior loop.[3,4] Inferior alveolar nerve block is a common local anaesthetic technique used in dental practice. Understanding the three-dimensional path of the mandibular canal is important as it travels through the mandible and critical for avoiding inferior alveolar nerve damage during third molar surgery, mandibular osteotomies, dental implant surgery and mandibular bone graft harvesting.[5] But the failure rate of this technique is greater than 20% and the commonest cause for inferior alveolar nerve block failure is inaccurate localization of mandibular foramen.[6] Accurate knowledge of the anatomical position of these regions is thus very important for obtaining more successful inferior alveolar nerve block and preventing the problems common to orthognathic surgery.[7] Clarke & Holmes and Marzola asserted that the mandibular foramen is located 1 cm above the occlusal plane of the lower molars and at the same height as the gingival papillae of the upper teeth when the mouth is closed.[8, 9] However, according to Nicholson and Hetson *et al.*, the two mandibular rami vary in the same person, hence foramen identification cannot be standardized.[10, 11] Because mandibular foramens are important anatomical landmarks for surgical, local anesthetic and other invasive procedures, the study was conducted to assess the morphological and morphometric features of mandibular foramens in relation to surrounding landmarks, as well as their possible variations in terms of side and gender.

METHODS

This cross-sectional descriptive study was carried out in the Department of Anatomy at Rajshahi Medical College over the course of one year, from January to December 2021. This study was performed on dry adult human mandible bones which were collected from the students of the Department of Anatomy of Rajshahi Medical College as well as from the different Medical Colleges (Islami Bank Medical College, Rajshahi; Barind Medical College, Rajshahi; Rangpur Medical College, Rangpur; North Bengal Medical College, Sirajgonj; Kushtia Medical College, Kushtia; Pabna Medical College, Pabna; Shahid Ziaur Rahman Medical College, Bogra; Kumudini Women's Medical College, Tangail). However, the study eliminated deformed/damaged bones, misshapen bones and bones with congenital defects. The study includes 250 mandibles selected using a purposive selection technique. The data were gathered using a semi-structured questionnaire and sliding Vernier calipers. The gender of mandibles was identified by examining various gender determination criteria. The shape of mandibular foramen was observed, and their dimensions (horizontal and vertical diameter) were measured. All measurements were conducted using digital sliding Vernier calipers with 0.1 mm accuracy. To find out the position of Mandibular foramen (MF), MF-AB (distance from the midpoint of the MF to the nearest point of anterior border of the ramus), MF-PB (distance from the midpoint of the MF to the nearest point of posterior border of the ramus), MF-MN (distance from the midpoint of the MF to the lowest point of the mandibular notch), MF-IB (distance from the midpoint of the MF to nearest point in the inferior border of the mandible), MF-Go (distance of MF to most prominent point of angle of mandible) and MF-SM (distance of MF to symphysis menti) were measured. The data were analyzed via Statistical Package for the Social Sciences software. Quantitative variables were described by the mean & standard deviation, mode with minimum and maximum value of all the parameters of interest and to compare all aspect of measured morphometric parameters of adult mandible parameter's parameter unpaired t-test was done. The level of significance was set at 5% and p-value < 0.05 was considered as statically significant.

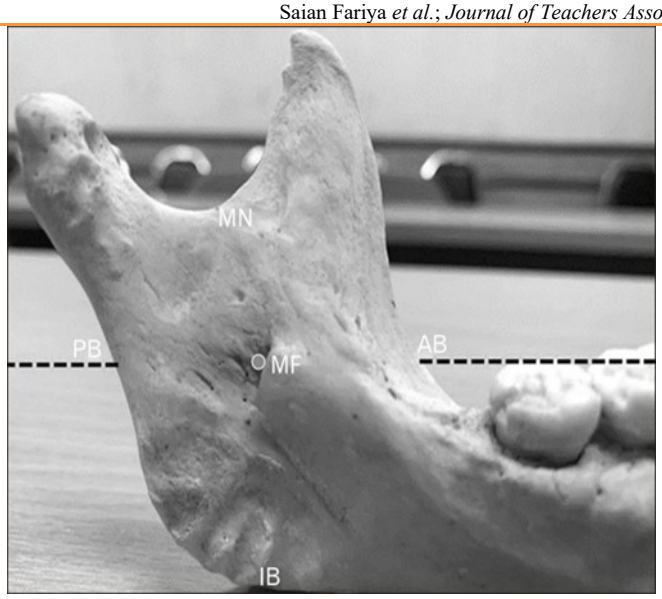

Figure 1: Figure Showed Parameters Measurements from Various Anatomical Landmarks

Figure 1 showed MF. 1. MF-AB: distance from the midpoint of the MF to the AB of the ramus. 2. MF-PB: distance from the midpoint of the MF to the PB of the ramus. 3. MF-MN: distance from the midpoint of the MF to the lowest point of the MN. 4. MF-IB: distance from the midpoint of the MF to the IB limited to the base of the mandible.

Figure 2: Photograph Showed Distance of the Mandibular Foramen to Angle

Figure 3: Photograph Showed Distance of the Mandibular Foramen to Symphysis Menti

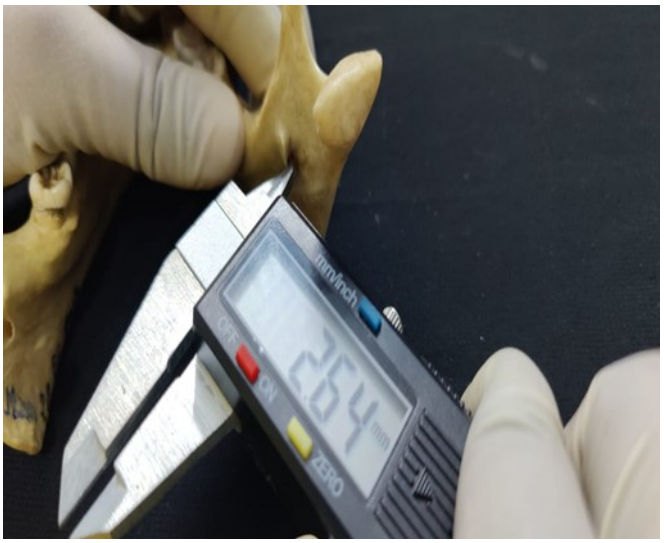

Figure 4: Photograph Showed Horizontal Diameter of Mandibular Foramen

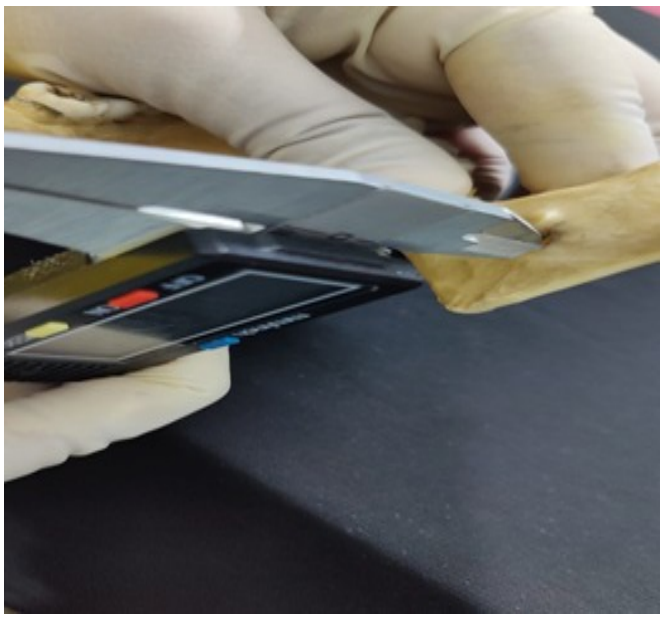

Figure 5: Photograph Showed Vertical Diameter of Mandibular Foramen

RESULTS

The shape of the mandibular foramina of the dry adult mandibles revealed that 99.2% in right halves & 98.4% in left halves of the mandibular foramens were oval and 0.8% in right halves & 1.6% in left halves were circular in shape (Figure 5).

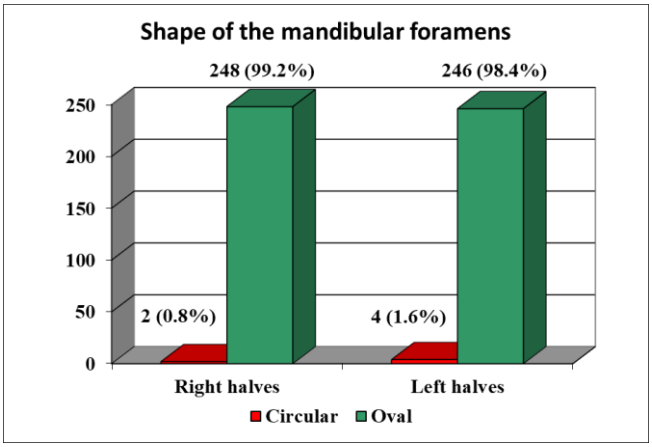

Figure 5: Distribution Pattern of Shape of the Mandibular Foramens of the Dry Adult Mandibles (n = 250)

Morphometric parameters of mandibular foramens (both halves) of the adult dry mandibles (n=250) showed that mean (±SD) distance from the midpoint of the mandibular foramen (MF) to the anterior border (AB) of the ramus of right halves was 16.69 (± 1.73) mm & left halves 16.79 (± 1.82) mm. Mean (±SD) distance from the midpoint of the MF to the posterior border (PB) of the ramus were 13.38 (± 1.84) for right halves & 13.32 (± 1.81) mm for left halves. The distance from the midpoint of the MF to the lowest point of the mandibular notch (MN) were 21.07 (± 2.26) mm for right halves and 21.25 (± 2.47) mm for left halves. Regarding mean (±SD) distance from the midpoint of the MF to the inferior border (IB) limited to the base of the mandible of right halves were 24.87 (± 3.45) mm & 24.97 (± 3.53) mm for left halves. The mean (±SD) distance of mandibular foramen to angle were 22.73 (± 3.55) mm & 22.87 (± 3.54) mm for right and left halves respectively. Mean (±SD) distance of mandibular foramen to symphysis menti of right halves were 72.49 (± 3.71) & for left halves 72.33 (± 3.95) mm. Mean (±SD) of horizontal and vertical diameter of mandibular foramens of right halves were 3.40 (± 0.50) mm & 2.67 (±0.47) mm respectively and for left halves were 3.33 ± 0.56 & 2.71± 0.45 mm, respectively. Among eight parameters, most of the right and left halves parameters difference were statistically not significant ($p > 0.05$) except distance from the midpoint of the MF to the lowest point of the mandibular notch (MN), distance of mandibular foramen to symphysis menti and horizontal diameter of mandibular foramen which were statistically significant ($p < 0.05$) for all tests.

Table 1: Morphometric parameters of mandibular foramens (Both halves) of the dry adult mandibles (n=250)

Morphometric parameters of mandibular foramens (Both halves)	Statistical measurements						t value	p value
	Halves	Mean ± SD	Median	Mode	Min	Max		
Distance from the midpoint of the mandibular foramen (MF) to the anterior border (AB) of the ramus of both halves in mm	Right	16.69 ± 1.73	16.52	14.36[a]	13.26	21.86	-1.82	> 0.05
	Left	16.79 ± 1.82	16.77	14.81[a]	12.20	21.90		
Distance from the midpoint of the MF to the posterior border (PB) of the ramus of both halves in mm	Right	13.38 ± 1.84	13.68	10.72	10.03	17.92	.96	> 0.05
	Left	13.32 ± 1.81	13.60	11.72[a]	9.22	17.53		
	Right	21.07 ± 2.26	20.86	18.67[a]	15.92	26.79	-2.33	< 0.05

Distance from the midpoint of the MF to the lowest point of the mandibular notch (MN) of both halves in mm	Left	21.25 ± 2.47	20.91	17.79[a]	14.97	27.76		
Distance from the midpoint of the MF to the inferior border (IB) limited to the base of the mandible of both halves in mm	Right	24.87 ± 3.45	24.93	19.52[a]	15.31	33.12	-1.04	> 0.05
	Left	24.97 ± 3.53	24.67	22.83[a]	15.80	33.10		
Distance of mandibular foramen to angle of both halves in mm	Right	22.73 ± 3.55	22.71	19.83[a]	12.76	30.16	-1.36	> 0.05
	Left	22.87 ± 3.54	22.65	20.19[a]	13.21	30.26		
Distance of mandibular foramen to Symphysis Menti of both halves in mm	Right	72.49 ± 3.71	72.57	72.06	64.31	83.27	1.97	< 0.05
	Left	72.33 ± 3.95	71.89	70.33[a]	62.14	84.66		
Horizontal Diameter of Mandibular Foramen of both halves in mm	Right	3.40 ± 0.50	3.46	2.89[a]	2.05	5.05	2.06	< 0.05
	Left	3.33 ± 0.56	3.29	3.27	2.01	6.49		
Vertical diameter of mandibular foramen of both halves in mm	Right	2.67 ± 0.47	2.69	3.09	1.48	3.86	-1.12	> 0.05
	Left	2.71 ± 0.45	2.76	2.01[a]	1.85	3.81		

Multiple modes exist. The smallest value is shown

The distance from the midpoint of the MF to the anterior border (AB) of the ramus, posterior border (PB) of the ramus, lowest point of the mandibular notch (MN), inferior border (IB) limited to the base of the mandible, angle of the mandible and to symphysis menti of the mandible of both halves were higher in male mandibles than female and these differences were statistically highly significant ($p < 0.001$) for all tests.

Table-2: Difference of mean (± SD) distance of mandibular foramens from different anatomical landmarks of the dry adult mandibles between male (n=148) and female (n=102) bones.

Variables	Halves	Sex of Mandibles	N	Mean	Std. Deviation	t	P
Distance from the midpoint of the MF to the anterior border (AB) of the ramus of Both halves in mm	Right	Male	148	17.06	1.85	4.40	<.001
		Female	102	16.16	1.37		
	Left	Male	148	17.26	1.87	5.28	<.001
		Female	102	16.12	1.50		
Distance from the midpoint of the MF to the posterior border (PB) of the ramus of Both halves in mm	Right	Male	148	14.19	1.57	9.90	<.001
		Female	102	12.20	1.54		
	Left	Male	148	13.98	1.67	7.60	<.001
		Female	102	12.38	1.58		
Distance from the midpoint of the MF to the lowest point of the mandibular notch (MN) of both halves in mm	Right	Male	148	21.61	2.13	4.71	<.001
		Female	102	20.30	2.22		
	Left	Male	148	21.71	2.46	3.58	<.001
		Female	102	20.59	2.35		
Distance from the midpoint of the MF to inferior border (IB) limited to the base of	Right	Male	148	26.45	2.91	10.46	<.001
		Female	102	22.57	2.84		
	Left	Male	148	26.57	3.07	10.34	<.001
		Female	102	22.64	2.77		

the mandible of both halves in mm							
Distance from the midpoint of the MF to angle of the mandible of both halves in mm	Right	Male	148	24.42	2.93	11.13	<.001
		Female	102	20.26	2.86		
	Left	Male	148	24.50	3.10	10.76	<.001
		Female	102	22.52	2.71		
Distance from mandibular foramen to symphysis menti of the mandible of both halves in mm	Right	Male	148	74.01	3.29	8.96	<.001
		Female	102	70.29	3.15		
	Left	Male	148	73.97	3.62	9.13	<.001
		Female	102	69.95	3.12		

DISCUSSION AND CONCLUSIONS

The mandibular foramen is approximately midway between the distal aspect of the last molar (cheek) tooth and the ventral aspect of the mandible. Additionally, the foramen is approximately 2 to 5 mm distal to the third molar tooth. After this location is determined, an infusion needle of appropriate length can be "walked along" the medial aspect of the mandible to the mandibular foramen for infusion of the local anesthetic. This effectively blocks the mandibular premolar and molar (cheek) teeth.The present study showed the shape of the mandibular foramens were oval and only a few (0.8% in right halves & 1.6% in left halves) of them were circular in shape. Mean (±SD) of horizontal and vertical diameter of mandibular foramen of right halves were 3.40 (± 0.50) mm & 2.67 (±0.47) mm respectively and for left halves were 3.33 ± 0.56 mm & 2.71 ± 0.45 mm respectively. In this study, the morphometric parameters of mandibular foramens of the adult dry mandibles (n=250) reveals that mean (±SD) distance from the midpoint of the mandibular foramen (MF) to the anterior border (AB) of the ramus of right halves were 16.69 (± 1.73) mm & left halves were 16.79 (± 1.82) mm. The findings of Oguz and Bozkir[6] and Shalini *et al.* were similar to the present study.[12] Findings of, Russa and Fabian and Thunyachareon *et al.* were higher than the present study but Ennes and Medrios much lower than the present study.This study showed, Mean (±SD) distance from the midpoint of the MF to the posterior border (PB) of the ramus were 13.38 (± 1.84) mm for right halves & 13.32 (± 1.81) mm for left halves which were similar to Oguz and Bozkir, Russa and Fabian and a bit lower than Thunyachareon *et al.* and Shalini *et al.*[6, 12-15] Findings of Ennes and Medrios were much lower than the present study.In present study, the distance from the midpoint of the Mandibular foramen to the lowest point of the mandibular notch (MN) were 21.07 (± 2.26) mm for right halves and 21.25 (± 2.47) mm for left halves which was similar to Oguz and Bozkir[6], Thunyachareon *et al.*, Shalini *et al.* and Russa and Fabian. Findings of Ennes and Medrios were much lower than the present study. Regarding mean (±SD) of distance from the midpoint of the MF to the inferior border (IB) limited to the base of the mandible of right halves were 24.87 (± 3.45) mm & 24.97 (± 3.53) mm for left halves which were lower than the findings of Oguz and Bozkir. In the present study again mean (±SD) distance of mandibular foramen to angle for right halves was 22.73 (± 3.55) mm & for left halves was 22.87 (± 3.54) mm which was near to Kilarkaje *et al.* Oguz and Bozkir found the parameters lesser than the present study. In another study, the findings were higher.[6, 12-16]

Regarding, the mean (±SD) distance of mandibular foramen to symphysis menti of right halves were 72.49 (± 3.71) mm & for left halves was 72.33 (± 3.95) mm. Findings of Kilarkaje *et al.* were a bit lesser than the present study. Similar findings were observed in the study of Hoque *et al.*[16, 17] In the present study, a paired sample t-test revealed that on an average among eight parameters most of the right and left halves parameters difference of all mandibles were statistically not significant ($p > 0.05$) except distance from the midpoint of the MF to the lowest point of the mandibular notch (MN), distance of mandibular foramen to symphysis menti and horizontal diameter of mandibular foramen, which were statistically significant ($p < 0.05$). Thunyachareon *et al.* found no significant difference between right and left except for distance of mandibular foramen to anterior border of ramus which was statistically significant ($p < 0.05$).[14-32] Regarding comparison between sex, statistically significant difference found in the parameter of mandibular foramen to inferior border. There were some limitations of the study. A purposive sampling technique was selected, and the sample size was

small, only 250. If it was larger, the results would have been more accurate.

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Conflict of Interest: Authors declared no conflict of interest.

Ethical Approval

Ethical approval of the study was obtained from the Ethical Review Committee, Rajshahi Medical College, Rajshahi. Informed consent was taken from all participants. All the study methodology was carried out following the relevant ethical guidelines and regulations.

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