

## Mandibular and mental foramen – A morphometric study in western Maharashtra

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### Abstract

Mandible is the only movable bone of the facial skeleton that forms almost the lower half of the face. In ontogeny, the mandible undergoes substantial morphological and dimensional changes. These changes are largely associated with development of primary and secondary dentition in the human.<sup>1</sup> The present study was undertaken to evaluate the anatomical features of mandible i.e. position of mental and mandibular foramina in western Maharashtra and to compare these findings with earlier studies. The findings of this study, variations in size, shape and relationships of dental and lower facial skeletal structure might be useful in providing important data to anatomists, archaeologists, forensic legal experts and maxillo-facial surgeons. Measurements were made on one hundred and ten dry, macerated adult human mandibles of unknown sex from western Maharashtra. Measurements of mental and mandibular foramen from various mandibular anatomical landmarks were taken. In present study it was observed that the most common position of mental foramen is in the line of long axis of 2nd premolar tooth which is universally accepted. Accessory mental foramen was found in one mandible located in line with anterior margin of 1st molar.

**Keywords:** Mandible, Mental foramen, Mandibular foramen, Accessory mental foramen, Dentulous, Edentulous.

### Introduction

Mandible is the only movable bone of the facial skeleton that forms almost the lower half of the face. It is one of the functionally and cosmetically important structures of the face that contributes to the facial contour.

Evolution of mandible, the lower jaw is of greatest interest in vertebrate history. It is one of the earliest innovations in the evolution of vertebrates.<sup>1</sup> The present study was undertaken to evaluate the anatomical features of mandible i.e. the position of mental and mandibular foramina in western Maharashtra and to compare these findings with earlier studies. The influence of the state of dentition on mandibular symmetry was also studied. Mental foramen (MF) is an important anatomical landmark to facilitate surgical, local anaesthetic, and other invasive procedures for dental surgeons performing periapical surgery in the mental region of the mandible. MF gives passage to mental nerve, mental artery, and vein.<sup>2</sup> Mandibular foramen is an irregular foramen located a little above the centre of the mandibular ramus on its medial surface. Inferior alveolar nerve and vessels pass through it, traverse the mandibular canal and supply the mandibular teeth.<sup>3</sup> The findings of this study, variations in size, shape and relationships of dental and lower facial skeletal structure might be useful in providing important data to anatomists, implantologists, orthodontists, archaeologists, forensic legal experts and maxillo-facial surgeons.

### Aim

To prepare morphometric database of human mandible using various parameters.

### Objectives

1. To compare the findings of the present study of western Maharashtra with the available data.
2. To contribute to quantitative aspect of mandibular morphology, that will be useful in preventing neurovascular complications after invasive procedures on the lower jaw.

### Materials and Methods

**Material:** Measurements were made on one hundred and ten dry, macerated adult human mandibles of unknown sex. All mandibles were obtained from Bharati Vidyapeeth Deemed University Medical College, Pune and other Medical Colleges in Maharashtra, with prior permission of the concerned authorities. The mandibles were apparently normal, without any structural deformity. Dentulous (teeth  $\geq$  14; n = 98) and Edentulous (without any teeth; n = 12) mandibles were included for this study. Parameters were measured bilaterally wherever required.

Equipment's:

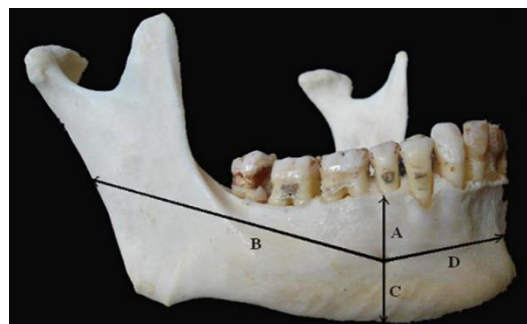
1. Geometrical Protractor with marking up to 180°
2. Digital Vernier Calliper with 0.01 mm. precision
3. Measuring scale having marking up to 150 mm
4. Flexible measuring tape
5. Marker Pen and Pencil
6. Plain white papers

## Methods

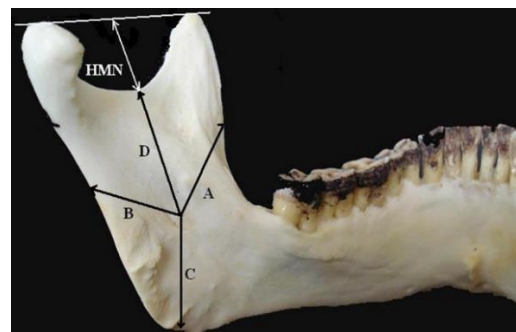
- All the linear measurements were taken with the help of flexible measuring tape, scale and digital vernier calliper and noted in mm.
- All the angular parameters were measured by tracing outline of the mandible on plain white paper and were noted in degrees, with the help of Protractor.
- Before measuring, the various anatomical landmarks were marked with the pencil.
  - Mental foramen (MF)
  - Mandibular foramen (MDF)

The parameters used are as follows:-

- Measurements of mental foramen from various mandibular anatomical landmarks; (Fig. 1)
  - Distance between centre of mental foramen and the most superior point of alveolar border in vertical axis (MF– AB).
  - Distance between centre of mental foramen and mid-point of the posterior border of the ramus (MF–PB).
  - Distance between centre of mental foramen and the most inferior point of the lower border of body of mandible in vertical axis (MF - IB).
  - Distance between centre of mental foramen and mid-point of symphysis (MF–SM).
- Measurements of mandibular foramen from various mandibular anatomical landmarks; (Fig. 2)
  - Distance between centre of mandibular foramina and mid-point of anterior border of ramus (MDF– AB).
  - Distance between centre of mandibular foramina and mid-point of posterior border of ramus (MDF–PB).
  - Distance between centre of mandibular foramen and the most inferior point of the lower border of mandible in vertical axis (MDF– IB)
  - Distance between centre of mandibular foramina and the most inferior point of the mandibular notch in vertical axis (MDF–MN).



**Fig. 1:** A (MF-AB), B (MF-PB), C (MF-IB), D (MF-SM)



**Fig. 2:** A (MDF-AB), B (MDF-PB), C (MDF-IB), D (MDF-MN)

## Observations

After completing the measurements of all the mandibles, data was arranged in the following groups:

- Dentulous group (n=98).
- Edentulous group (n=12).

Each parameter was studied by calculating Mean, Standard deviation (S.D.), 'Z' value, and 'P' value. Mean values of each parameter of right and left side in dentulous groups was analysed by applying Z test and in edentulous group by paired t – test.

Observations were noted as shown in the following tables 1-4 and bar diagram 1 & 2.

**Table 1: Showing measurements (in mm) Mental Foramen (MF) of Right (R) and Left (L) from various anatomical landmark in Dentulous (D) group n=98**

		Maximum	Minimum	Mean $\pm$ SD	Mean $\pm$ SD (R+L)	P value	Z value
MF-AB	R	22.99	5.43	13.95 $\pm$ 2.80	13.69 $\pm$ 2.42	0.1325	1.5043
	L	17.52	2.72	13.43 $\pm$ 2.04			
MF-PB	R	78.33	58.72	69.26 $\pm$ 3.69	69.46 $\pm$ 3.70	0.5100	0.6588
	L	80.43	58.72	69.66 $\pm$ 3.71			
MF-IB	R	16.27	9.80	12.69 $\pm$ 1.37	12.75 $\pm$ 1.49	0.7293	0.3461
	L	18.88	9.77	12.72 $\pm$ 1.62			
MF-SM	R	45.40	11.65	27.68 $\pm$ 3.69	27.80 $\pm$ 2.60	0.6224	0.4924
	L	31.33	11.83	27.91 $\pm$ 1.52			

Table 1 shows that the difference in the distance between the alveolar border and mental foramen, posterior border and mental foramen, inferior border and mental foramen & symphysis menti and mental foramen in dentulous mandibles on both sides is statistically insignificant.

**Table 2 : Showing measurements (in mm) Mental Foramen (MF) of Right (R) and Left (L) from various anatomical landmark in Edentulous (ED) group n=12**

		Maximum	Minimum	Mean $\pm$ SD	Mean $\pm$ SD (R+L)	P value
MF-AB	R	11	5.43	7.55 $\pm$ 2.46	8.45 $\pm$ 1.66	0.0047**
	L	10.69	8.66	9.35 $\pm$ 0.86		
MF-PB	R	72.62	59.65	66.35 $\pm$ 3.97	67.19 $\pm$ 4.09	0.0097**
	L	73.55	60.81	68.03 $\pm$ 4.21		
MF-IB	R	13.95	10.28	11.97 $\pm$ 1.13	12.10 $\pm$ 1.15	0.3358
	L	13.95	10.86	12.23 $\pm$ 1.17		
MF-SM	R	30.31	24.69	26.82 $\pm$ 2.30	26.97 $\pm$ 2.51	0.0410*
	L	31.33	24.69	27.12 $\pm$ 2.73		

Statistically significant \*(P < 0.05), highly significant\*\* (P < 0.01)

Abbreviations for Table 1 & 2: AB-Alveolar border (MF-AB), PB-Posterior border of ramus (MF-PB), IB-Inferior border of mandible (MF-IB), SM-Symphysis menti (MF-SM)

Table 2 shows that the difference in the distance between the alveolar border and mental foramen, posterior border and mental foramen, & symphysis menti and mental foramen in edentulous mandibles on both sides is statistically significant while the difference in the distance between inferior border and mental foramen statistically insignificant.

**Table 3: Showing measurements (in mm) of Mandibular Foramen (MDF) from various anatomical landmarks in dentulous group**

		Maximum	Minimum	Mean $\pm$ SD	Mean $\pm$ SD (R+L)	P value	Z value
MDF-AB	R	23.29	9.71	17.34 $\pm$ 2.69	17.49 $\pm$ 2.78	0.4423	0.7683
	L	29.76	8.99	17.64 $\pm$ 2.87			
MDF-PB	R	19.38	9.87	15.08 $\pm$ 1.88	14.94 $\pm$ 1.88	0.3253	0.9835
	L	18.32	11.11	14.81 $\pm$ 1.76			
MDF-IB	R	36.22	14.98	25.56 $\pm$ 4.33	25.44 $\pm$ 4.27	0.6863	0.4039
	L	38.94	12.11	25.31 $\pm$ 4.21			
MDF-MN	R	39.45	15.86	24.03 $\pm$ 6.83	23.99 $\pm$ 6.73	0.9290	0.0891
	L	37.90	11.43	23.96 $\pm$ 6.62			

Table 3 shows that the difference in the distance between the alveolar border and mandibular foramen, posterior border and mandibular foramen, inferior border and mandibular foramen, mandibular notch and mandibular foramen in dentulous mandibles on both sides is statistically insignificant.

**Table 4: Showing measurements (in mm) of Mandibular Foramen (MDF) from various anatomical landmarks in Edentulous (ED) group**

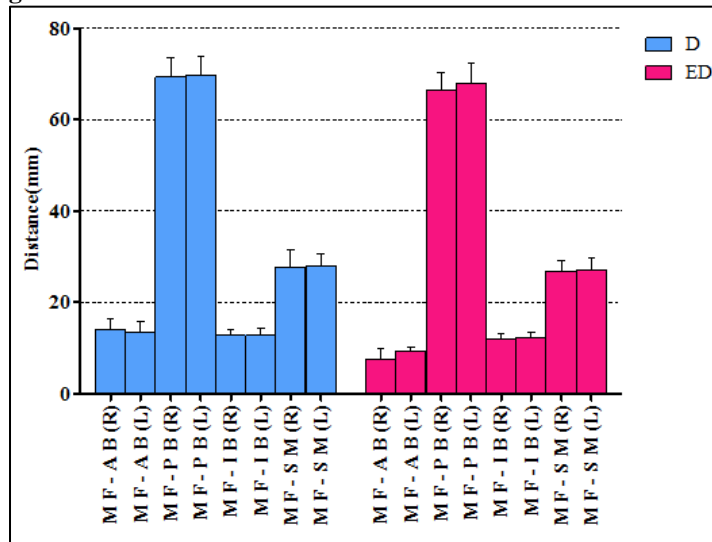
		Maximum	Minimum	Mean $\pm$ SD	Mean $\pm$ SD (R+L)	P value
MDF-AB	R	16.11	12.11	14.05 $\pm$ 1.57	14.53 $\pm$ 1.70	0.0154**
	L	16.99	12.40	15 $\pm$ 1.83		
MDF-PB	R	15.39	12.58	13.4 $\pm$ 0.76	13.83 $\pm$ 1.12	0.0843
	L	16.03	12.58	14.25 $\pm$ 1.49		
MDF-IB	R	24.40	18.33	21.06 $\pm$ 2.45	20.80 $\pm$ 2.33	0.3964
	L	23.73	18.53	20.54 $\pm$ 2.21		
MDF-MN	R	28.76	21.70	24.70 $\pm$ 2.68	25.45 $\pm$ 2.29	0.0183*
	L	28.62	23.40	26.21 $\pm$ 1.91		

Statistically highly significant \*\* (P < 0.01)

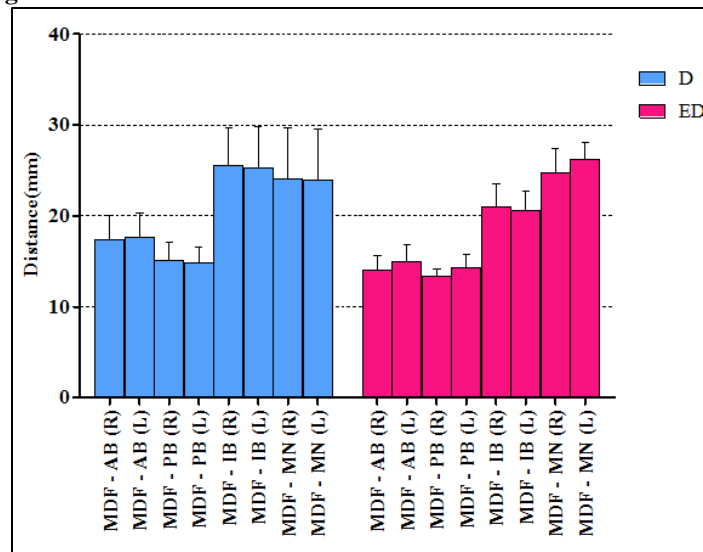
Abbreviations for Table 3 & 4: AB-Alveolar border (MDF-AB), PB-Posterior border of ramus (MDF-PB), IB-Inferior border of mandible (MDF-IB), MN-Mandibular notch (MDF-MN)

Table 4 shows that the difference in the distance between the alveolar border and mandibular foramen mandibular notch and mandibular foramen in edentulous mandibles on both sides is statistically significant. It also shows that the difference in the distance between the posterior border and mandibular foramen, inferior border and mandibular foramen edentulous mandibles on both sides is statistically insignificant.

**Bar diagram 1: Showing mental foramina measurements from the various anatomical landmarks**



**Bar diagram 2: Showing mandibular foramina measurements from the various anatomical landmarks**



Abbreviations for Bar Diagrams 1 & 2: AB-Alveolar border (MF-AB), PB-Posterior border of ramus (MF-PB), IB-Inferior border of mandible (MF-IB), SM-Symphysis menti (MF-SM), MN-Mandibular notch.

**Discussion**

Mandible presents a large number of parameters for morphometric study and has been widely studied over the last century. In the present study the parameters and their reference points are clearly defined and shown in the photographs. For comparison, we have selected database presented by those researchers who have selected similar reference points as in the present study. Majority of the studies done in different populations have focused their attention on sexual dimorphism. Some of the studies have been performed considering symmetry of the mandibles and have presented, compared values of right and left sides. In present study we have arranged our data in two groups i.e. dentulous and edentulous. We have

compared the two parameters on right and left sides in these two groups.

**A.** In the present study mean values of distances of Mental Foramen (MF)

From Alveolar border (MF-AB) in

1. Dentulous group on right side is 13.95 mm (maximum 22.99 mm, minimum 17.52 mm) and on left side is 13.43 mm, 5.43 mm, minimum 8.66 mm) Statistically these two values are insignificant.
2. Edentulous group on right side is 7.55 mm (maximum 11 mm, minimum 5.43 mm) and on left side is 9.35 mm (maximum 10.69 mm, minimum 2.72 mm) statistically these two values are highly significant. (P < 0.01) (Table 2)

From Posterior border (MF-PB) in

1. Dentulous group on right side is 69.26 mm (maximum 78.33 mm, minimum 58.72 mm) and on left side is 69.66 mm (maximum 80.43 mm, minimum 58.72 mm) Statistically these two values are not significant.
2. Edentulous group on right side is 66.35 mm (maximum 72.62 mm, minimum 59.65 mm) and on left side is 68.03 mm (maximum 73.55 mm, minimum 60.81 mm) Statistically these two values are highly significant. ( $P < 0.01$ ) (Table 4)

From Inferior border (MF-IB) in

1. Dentulous group on right side is 12.69 mm (maximum 16.27 mm, minimum 9.80 mm) and on left side is 12.72 mm (maximum 18.88 mm, minimum 9.77 mm) Statistically these two values are not significant.
2. Edentulous group on right side is 11.97 mm (maximum 13.95 mm, minimum 10.28 mm) and on left side is 12.23 mm (maximum 13.95 mm, minimum 10.86 mm) Statistically these two values are not significant.

From Symphysis Menti (MF-SM) in

1. Dentulous group on right side is 27.68 mm (maximum 45.40 mm, minimum 31.33 mm) and on left side is 27.91 mm (maximum 11.65 mm, minimum 11.83mm) Statistically these two values are not significant.
2. Edentulous group on right side is 26.82 mm (maximum 30.31 mm, minimum 24.69 mm) and on left side is 27.12 mm (maximum 31.33 mm, minimum 24.69 mm) Statistically these two values are significant. ( $P < 0.05$ ) (Table 2)

Guillaume Captier et al<sup>4</sup> found no difference between right and left side of distances of mental foramen in dentulous as well as edentulous group.

We compared the mean values of distances of mental foramen from the posterior & inferior borders in dentulous mandibles with the available data. Mean value of distance from posterior border was 69.46mm in our study, 68.85mm (W. Apinh-asmit et al),<sup>5</sup> 65.38mm (LBL Prabhudha)<sup>6</sup> & 74.14 mm (Teen Meei wang et al).<sup>7</sup> Mean value of distance from inferior border was 12.75 mm in our study, 14.88 mm (W. Apinh- asmit et al), 12.25mm (LBL Prabhudha) & 14.7 mm (Teen Meei wang et al).

1. The antero-posterior position of mental foramen was studied by many researchers. In the present study, we found the most common antero-posterior position in the line with the longitudinal axis of second mandibular premolar tooth (58.16%). We compared our findings with the studies of other authors. Their findings were as follows Jennifer Neo in Indian population (Right 51%, Left 43%) in Malay population (Right 69.4%, Left 66%),<sup>8</sup> Kim, In-Soo et al (64.3%),<sup>9</sup> LBL Prabhudha and BG Nanayakkara (75%),<sup>6</sup> NM Al Jasser and AL Nwoku (45.3%),<sup>10</sup> Nazar Al Talabani et al (55%),<sup>11</sup> Oguz O and Bozkir MG (61.76%),<sup>12</sup> Shankland

WE 2<sup>nd</sup> (75.36%),<sup>13</sup> Teen - Meei Wang et al (58.98%),<sup>7</sup> W. Apinh-asmit et al (69.98%),<sup>5</sup> Wei Cheong Ngeow and Yusof Yuzawati (69%).<sup>14</sup> In contrast, Moiseiwitsch JR,<sup>15</sup> and Taiseer Al-Khateeb et al<sup>16</sup> observed the most common position of mental foramen in between mandibular premolar teeth which was the second most common position of mental foramen in the present study. In whites, Cutright B et al<sup>17</sup> found most common position in between first and second premolar teeth; however, in Blacks he found posterior to second premolar.

2. In his study, Xie Q et al<sup>18</sup> found the height of the basal bone below mental foramen was smaller in old edentulous women than in young and old dentate women. He attributed this to alveolar bone resorption in old edentulous women.
3. In the present study we found Accessory mental foramen (AMF) in one mandible (0.90%) (Fig. 3), located in line with the 1st molar tooth. LBL Prabhudha<sup>6</sup> (8.33%), Shankland WE 2<sup>nd</sup><sup>13</sup> (6.62%) and Toh H et al<sup>19</sup> have also reported accessory mental foramina in their studies.



**Fig. 3: AMF (Accessory mental Foramen)**

- B.** In the present study mean values of distances of Mandibular Foramen (MDF)

From Anterior border (MDF-AB) in

1. Dentulous group on right side is 17.34 mm (maximum 23.29 mm, minimum 9.71 mm) and on left side is 17.64 mm (maximum 29.76 mm, minimum 8.99 mm) Statistically these two values are insignificant.
2. Edentulous group on right side is 14.05 mm (maximum 16.11 mm, minimum 12.11 mm) and on left side is 15 mm (maximum 16.99 mm, minimum 12.40 mm) statistically these two values are significant. ( $P < 0.01$ ) (Table 4)

From Posterior border (MDF-PB) in

1. Dentulous group on right side is 15.08 mm (maximum 19.38 mm, minimum 9.87 mm) and on left side is 14.81 mm (maximum 18.32 mm, minimum 11.11 mm) statistically these two values are not significant.
2. Edentulous group on right side is 13.4 mm (maximum 15.39 mm, minimum 12.58 mm) and on left side is 14.25 mm (maximum 16.03 mm,

minimum 12.58 mm) statistically these two values are not significant.

From Inferior border (MDF-IB) in

1. Dentulous group on right side is 25.56 mm (maximum 36.22 mm, minimum 14.98 mm) and on left side is 25.31 mm (maximum 38.94 mm, minimum 12.11 mm) statistically these two values are not significant.
2. Edentulous group on right side is 21.06 mm (maximum 24.40 mm, minimum 18.33 mm) and on left side is 20.54 mm (maximum 23.73 mm, minimum 18.53 mm) statistically these two values are not significant.

From Mandibular notch (MDF-MN) in

1. Dentulous group on right side is 24.03 mm (maximum 39.45 mm, minimum 15.86 mm) and on left side is 23.96 mm (maximum 37.90 mm, minimum 11.43 mm) statistically these two values are not significant.
2. Edentulous group on right side is 24.70 mm (maximum 28.76 mm, minimum 21.70 mm) and on left side is 26.21 mm (maximum 28.62 mm, minimum 23.40 mm) statistically these two values are significant. ( $P < 0.01$ ) (Table 4).
3. The mean values of distances of mandibular foramen from mandibular notch on both right and left sides in dentulous group are less than in edentulous mandibles

We compared the mean values of distances of mandibular foramen from the posterior & inferior borders in dentulous mandibles with the available data. Mean value of distance from posterior border was 14.94mm in our study and 14.20mm in a study conducted by A.C. Gabriel.<sup>20</sup> Mean value of distance from inferior border was 25.44 mm in our study and 21.49mm in a study conducted by A.C. Gabriel.<sup>20</sup>

4. A.C. Gabriel<sup>20</sup> described correlation between mandibular foramen and breadth of ramus. He stated that more upright ramus, then the higher will be the mandibular foramen, the greater will be the distance of this foramen from the posterior border and broader will be the ramus.
5. Hayward J et al<sup>21</sup> noted mean values of anterior dimension was greater than the mean values of the posterior dimension of the ramus and no appreciable difference was found in position of mandibular foramen on right and left side.
6. F.B. Prado et al<sup>22</sup> observed statistically significant difference in position of mandibular foramina in dentate and edentate mandibles. In dentate mandibles measurements showed significant differences compared to the edentate mandibles except for MDF-MN. (Table 6). He concluded that the mandibular foramina position changes with loss of teeth and this variability may be responsible for occasional failure of inferior alveolar nerve block.

**Table 5: Showing comparison of mean values of distances of Mental Foramen (MF) from anatomical landmarks in dentulous (D) & edentulous groups with the study of Guillaume Captier**

			Present study (mm)	Guillaume Captier et al (mm)
MF-PB	D	R	69.26	73.79
		L	69.66	74.02
	ED	R	66.35	73.93
		L	68.03	74.55s
MF-IB	D	R	12.69	13.79
		L	12.72	13.75
	ED	R	11.97	13.45
		L	12.23	13.65
MF-SM	D	R	27.68	25.96
		L	27.91	26.00
	ED	R	26.82	26.24
		L	27.12	26.29

**Table 6: Showing comparison of mean values of distances of Mandibular Foramen (MDF) in dentulous (D) and edentulous (ED) group with available data**

			Present Study (mm)	F.B. Prado et al (mm)	Guillaume Captier et al (mm)
MDF-AB	D	R	17.34	19.2	-
		L	17.64	18.8	-
	ED	R	14.05	17.5	-
		L	15	17.4	-
MDF-PB	D	R	15.08	14.2	15.39
		L	14.81	13.9	15.41

	ED	R	13.4	12.8	14.90
		L	14.25	12.9	14.57
MDF-IB	D	R	25.56	28.3	-
		L	25.31	28	-
	ED	R	21.06	26.4	-
		L	20.54	26.4	-
MDF-MN	D	R	24.03	23.6	24.87
		L	23.96	23.1	23.86
	ED	R	24.70	23.4	24.67
		L	26.21	22.9	24.74

### Conclusion

1. In edentulous group symmetry of mandible was affected by absence of teeth.
2. Distance of mental foramen from alveolar border, posterior border and symphysis menti and distances of mandibular foramen from anterior border and mandibular notch were statistically significant,
3. Most common position of mental foramen in the line of long axis of 2nd premolar tooth.
4. Accessory mental foramen was found in one mandible.

The present study involved the preparation of morphometric database of Human mandibles in Indian population which needs to be extended further to evaluate hidden parameter like mandibular body thickness which will be of great use to implantologists.

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