



## Evaluation of the Position of Mental Foramen for Clinical and Forensic Significance in terms of Gender in Dentate Subjects by Digital Panoramic Radiographs

<sup>1</sup>Shweta Thakare, <sup>2</sup>Amit Mhapuskar, <sup>3</sup>Darshan Hiremutt, <sup>4</sup>Versha R Giroh, <sup>5</sup>Kedarnath Kalyanpur, <sup>6</sup>KR Alpana

### ABSTRACT

**Introduction:** Evaluation of the position of mental foramen aids in forensic, surgical, endodontic, as well as diagnostic procedures. Thus, in view of this, the present study was conducted among the population of Pune, a central part of India, to determine the most regular location of the mental foramen and to estimate difference in position of mental foramen based on gender.

**Materials and methods:** The present retrospective study was commenced on 200 digital panoramic radiographs of dentate patients. The location of the representation of the mental foramen was traced. Measurements for evaluating distance of superior and inferior borders of the foramen in relation to the lower border of the mandible were made using the reference lines drawn from anatomical landmarks. The data so obtained were statistically analyzed using chi-square test.

**Results:** The most common position of mental foramen among Pune population in horizontal plane in both male and female patients was in line with second premolar followed by position in between first and second premolar, whereas in the vertical plane, most common position was at or in line with apex of second premolar followed by in between apex of first and second premolar. The variation in length of superior and inferior border of the foramen in relation to lower border of the mandible with respect to gender was found to be significant, with  $p$ -value  $<0.05$ .

**Conclusion:** There was no difference in position of mental foramen in horizontal and vertical planes based on gender.

**Clinical significance:** The stability of location of mental foramen and significant difference in length of superior and inferior border of the foramen in relation to lower border of the mandible with respect to gender offer its application in forensic identification of gender.

**Keywords:** Forensics, Mandible, Mental foramen, Panoramic radiographs.

**How to cite this article:** Thakare S, Mhapuskar A, Hiremutt D, Giroh VR, Kalyanpur K, Alpana KR. Evaluation of the Position of Mental Foramen for Clinical and Forensic Significance in terms of Gender in Dentate Subjects by Digital Panoramic Radiographs. J Contemp Dent Pract 2016;17(9):762-768.

**Sources of support:** Nil

**Conflict of interest:** None

### INTRODUCTION

Forensic research on living people is of utmost importance for identification of age and gender in case of the deceased in mass fatalities.<sup>1</sup> The mandible is considered as one of the strongest bone in the human skeleton that can survive in a well-conserved state much longer than any other bone. Forensic dentists and anthropologists consider morphological characteristics of this bone as an important feature that can be used for the determination of sex. Among various anatomical landmarks in the human skull, the mental foramen is regarded as a stable landmark on the mandible.<sup>2</sup>

The mental foramen is a funnel-like opening located on the surface of the anterolateral aspect of mandible.<sup>3</sup> The foramen is seen about halfway between the lower border of the mandible and crest of the alveolar process. Position of its image in relation to the tooth roots is influenced by projection angulation.<sup>4</sup>

<sup>1-4</sup>Department of Oral Medicine and Radiology, Bharati Vidyapeeth Deemed University Dental College and Hospital Pune, Maharashtra, India

<sup>5</sup>Department of Oral Medicine and Radiology, Sinhgad Dental College and Hospital, Pune, Maharashtra, India

<sup>6</sup>Department of Oral Medicine and Radiology, Bapuji Dental College and Hospital, Davangere, Karnataka, India

**Corresponding Author:** Darshan Hiremutt, Department of Oral Medicine and Radiology, Bharati Vidyapeeth Deemed University Dental College and Hospital, Pune, Maharashtra India, Phone: +919501544877, e-mail: dhiremutt.d@yahoo.com

Assessing accurate position of mental foramen also aids in surgical, endodontic, as well as diagnostic procedures, and its position is considered before implant surgery to avoid mental nerve injury.<sup>3</sup> The nerves and vessels transmitting through it provide sensory innervations and blood supply to important facial structures; these nerves are susceptible to injury during administration of local anesthesia and surgery.<sup>5</sup> Variation in the position of mental foramen is common, which can result in complications during surgical procedures.<sup>6,7</sup>

Literature available shows variation in common position, which ranged between three positions, i.e., between two premolars, along the long axis of second premolar, and between second premolar and first molar, and this can be attributed to differences due to ethnic and racial groups. In a country like India, with diversity in population, because of differences in racial and ethnical background, variations in the position of the mental foramen might result among various population groups.<sup>8</sup> Thus, in view of this, the present study was conducted among the population of Pune, which is a part of Central India, to determine the most common position of the mental foramen and to estimate difference in position of mental foramen based on gender in a selected Central Indian population using 200 digital panoramic radiographs and to compare the results with those reported for other populations.

## MATERIALS AND METHODS

The present retrospective study was commenced on 200 digital panoramic radiographs (100 males and 100 females) selected randomly from the departmental archives of Bharati Vidyapeeth Deemed University Dental College and Hospital, Pune, which fulfilled the inclusive criteria. Demographic details were evaluated and patients hailing from Pune were enrolled for the study. Ethical clearance was obtained from the ethical committee of the institute. Group A consisted of 100 digital orthopantomography (OPG) of male subjects, and group B consisted of 100 digital OPG of female subjects. Selected radiographs

comprised of 200 completely dentate patients. Inclusive criteria consisted of patients within the age range of 15 to 59 years, radiographs with least artifacts in mental foramen region, and presence of mandibular teeth from left first molar to right first molar. Radiographs with any radiolucent or radiopaque lesions in mandibular arch, missing mandibular premolars, and mixed dentition were excluded from the study. These radiographs were analyzed by two specialist maxillofacial radiologists. The results were repeated with a random sample of 50 radiographs that were reexamined.

The position of the image of the mental foramen was recorded as follows:

Classification of position of mental foramen in horizontal plane and in vertical plane was carried out according to Parnami et al and Al Jasser.

The location of mental foramen in horizontal plane was recorded as follows (Table 1/Fig. 1):

*Position 1:* Located anterior to first premolar

*Position 2:* Situated in line with the first premolar

*Position 3:* Between the first and second premolar

*Position 4:* In line with second premolar

*Position 5:* Between the second premolar and first molar

*Position 6:* In line with the first molar.

The position of mental foramen in vertical plane was recorded as follows (Parnami et al) (Table 2/Fig. 2):

*Position a:* Located superior to the apex of first premolar

*Position b:* At or in line with the apex of first premolar

*Position c:* In between the apex of first and second premolar

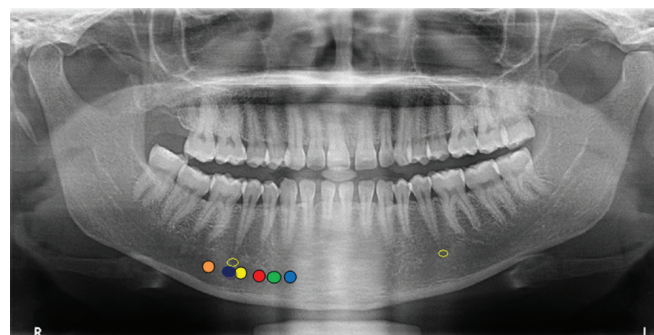


Fig. 1: Position of mental foramen in horizontal plane

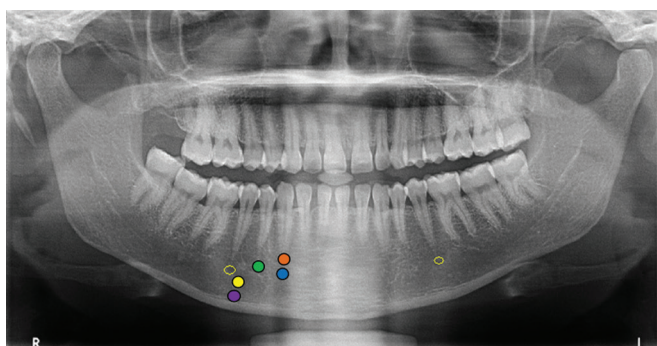
Table 1: Position of mental foramen in horizontal plane

Position	1 (Situated anterior to first premolar)		2 (In line with the first premolar)		3 (Between the first and second premolar)		4 (In line with second premolar)		5 (Between the second premolar and first molar)		6 (In line with the first molar)		Total
Gender	L	R	L	R	L	R	L	R	L	R	L	R	
Male 200	2	2	3	8	30	32	53	44	10	12	2	2	200
Female 200	3	2	4	4	36	24	40	50	14	16	3	4	200
Total 400	5	4	7	12	66	56	93	94	24	28	5	6	400

p-value >0.05 (nonsignificant)

**Table 2:** Position of mental foramen in vertical plane

Position Gender	a (Superior to the apex of first premolar)		b (At or in line with the apex of first premolar)		c (In between the apex of first and second premolar)		d (At or in line with the apex of second premolar)		e (Inferior to the apex of second premolar)		Total
	L	R	L	R	L	R	L	R	L	R	
Male 200	5	2	6	2	37	30	46	54	6	12	200
Female 200	4	2	4	2	30	24	48	52	14	20	200
Total 400	9	4	10	4	67	54	94	106	20	32	400

**Fig. 2:** Position of mental foramen in vertical plane

*Position d:* At or in line with the apex of second premolar  
*Position e:* Inferior to the apex of second premolar.

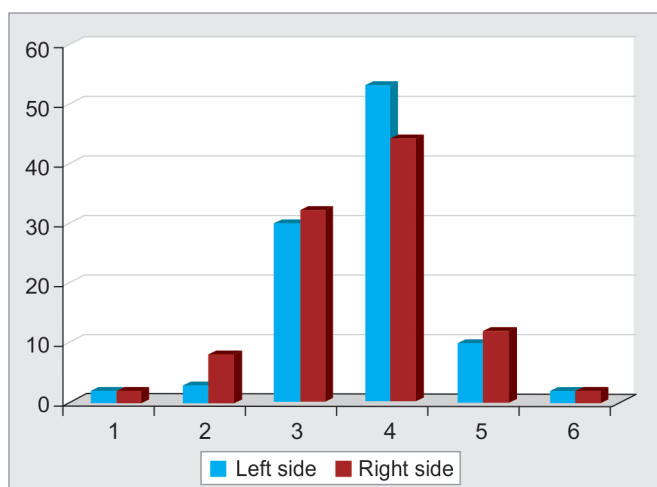
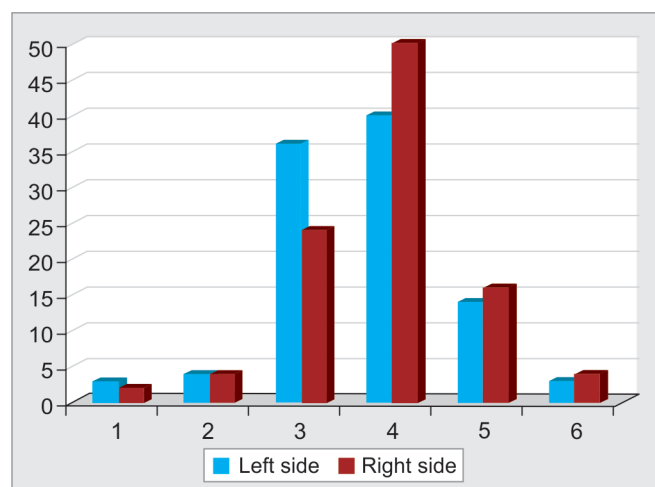
Measurements for evaluating distance of superior and inferior borders of the foramen in relation to the lower border of the mandible were made using the reference lines drawn from anatomical landmarks using an indelible pencil. To the superior and inferior borders of the foramen, tangents were drawn, and from tangents to the lower border of the mandible, perpendiculars were drawn bilaterally and a Vernier caliper was used for the measurements.<sup>9</sup> The data so obtained were evaluated using Statistical Package for the Social Sciences (SPSS) version 16. Mean values and percentage values were calculated. Statistical analysis was carried out using

chi-square test, with p-value <0.05 considered as statistically significant.

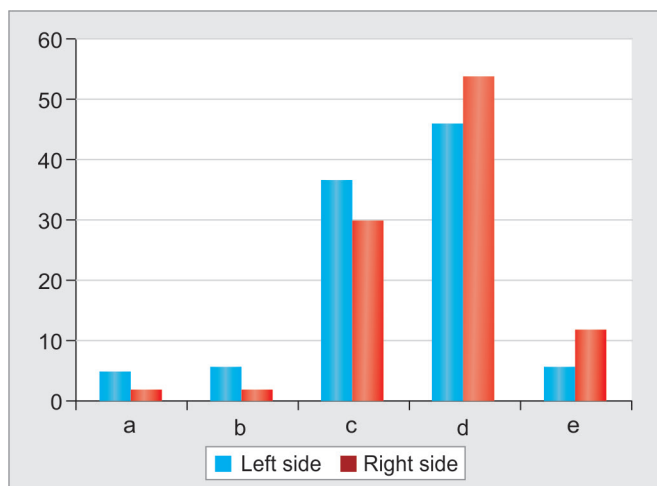
## RESULTS

Out of 200 panoramic radiographs, 100 were of male patients and 100 were of female patients. Total 400 mental foramen were studied, i.e., 200 males and 200 females accounting for the left and right mental foramen (100 of right side and 100 of left side) (Tables 1 and 2). Of the 100 left mental foramen analyzed in male subjects, 53% of the foramen were located with second premolar, while 30% of the foramen were in horizontal plane between the first and the second premolar. Of the 100 right mental foramen analyzed in male subjects, 44% of the foramen were in line with the second premolar, while 32% of the foramen were situated in horizontal plane between the first and the second premolar (Tables 1 and 2, Graph 1).

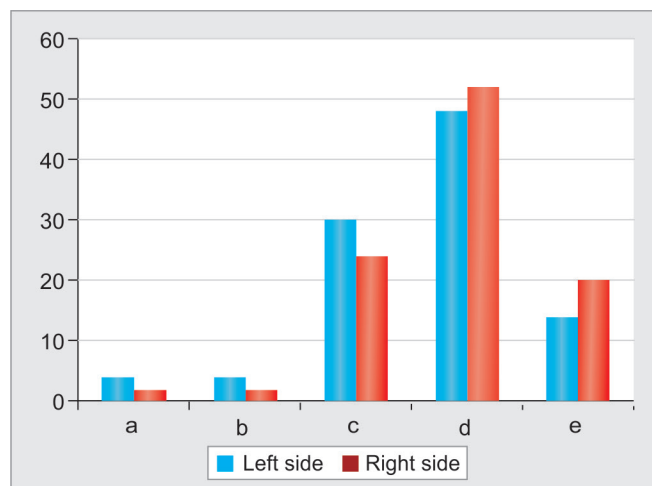
Of the 100 left mental foramen analyzed in female subjects, 40% of the foramen were in line with second premolar, while 36% of the foramen were in a position between the first and the second premolar in the horizontal plane. Of the 100 right mental foramen analyzed in female subjects, 50% of the foramen were in line with second premolar, while 24% of the foramen were in a position between the first and the second premolar in horizontal plane (Table 2, Graph 2).

**Graph 1:** Position of mental foramen in horizontal plane in male patients**Graph 2:** Position of mental foramen in horizontal plane in female patients





**Graph 3:** Position of mental foramen in vertical plane in male patients



**Graph 4:** Position of mental foramen in vertical plane in female patients

Of the 100 left mental foramen analyzed in male subjects, 46% of the foramen were in line with apex of second premolar, while 37% of the foramen were in a position between apex of the first and the second premolar in vertical plane. Of the 100 right mental foramen analyzed in male subjects, 54% of the foramen were at or in line with the apex of second premolar, while 30% of the foramen were in between the apex of first and the second premolar in vertical plane (Table 2 and Graph 3).

Of the 100 left mental foramen analyzed in female subjects, 48% of the foramen were at or in contour with the apices of second premolar, while 30% of the foramen were in between the apex of first and the second premolar in vertical plane. Of the 100 right mental foramen analyzed in female subjects, 52% of the foramen were at or in line with the apex of second premolar, while 24% of the foramen were in between the apex of first and the second premolar in vertical plane (Table 3 and Graph 4).

In males, distance in centimeters between superior border of the foramen and the lower border of the mandible (S-L) on right side was  $17.21 \pm 1.9$ , on left side was  $17.18 \pm 2.1$ , in females on right side was  $15.85 \pm 2.4$ , on left side was  $15.72 \pm 2.2$ . In males, distance in centimeters between inferior border of the foramen and the lower border of the mandible (S-L) on right side was  $13.02 \pm 2.2$ , on left side was  $12.97 \pm 2.1$ , in females on right side was  $11.31 \pm 2.5$ , on left side was  $11.26 \pm 2.3$ . The variation in length of superior border and inferior border of the foramen in relation to lower border of the mandible with respect to gender was found to be significant, with  $p$ -value  $<0.05$ .

## DISCUSSION

Mental foramen is considered an imperative anatomical landmark, the position of which assists surgical, local

anesthetic, and other invasive procedures for maxillofacial surgeries. Its location should be taken into account before any surgery in this region to avoid any injury to the neurovascular bundles passing through these foramina. Occasionally, mental foramen is misdiagnosed as a radiolucent lesion situated in the apical area of the mandibular premolar teeth. Therefore, knowledge of accurate anatomical position of mental foramen is of paramount importance in periodontal surgery or flap surgery, especially in mandibular premolars, surgical orthodontics, and retrograde amalgam fillings.<sup>13</sup>

Variations in position of mental foramen are common, which can cause complications during surgical procedures.<sup>22</sup> The most popular method for identification of mental foramen was proposed by Fishel et al in 1976.<sup>3</sup>

In the present study conducted among the population of Pune belonging to Central India, the most frequent location of mental foramen was in continuity with second premolar in both the left and right sides followed by the position of mental foramen between the first and second premolar. Various studies conducted in different states of India reported variation in results. Mental foramen below the apices of the second premolar as most frequent spot was reported by Patel et al<sup>11</sup> in Gujarati population, Udhaya et al<sup>15</sup> in South Indian Population, Singh and Srivastav<sup>17</sup> in Lucknow, Uttar Pradesh, and Shankland<sup>21</sup> in Asian Indians. However, studies conducted by Babshet<sup>6</sup> among Dharwad, Karnataka population, Gada and Nagda<sup>12</sup> in Mumbai city, Moogala et al<sup>13</sup> in Andhra population, Jamdade et al<sup>14</sup> in Rajasthan reported the most common position of mental foramen between first and second premolars. Table 4 describes various studies revealing position of mental foramen in various ethnic groups. Thus, the position of the mental foramen attributes to variations in different populations and ethnic groups.

**Table 3:** Measurement of distance of superior and inferior border of the foramen in relation to lower border of the mandible

Gender	Distance between superior border of the foramen and the lower border of the mandible (S-L)		Distance between inferior border of the foramen and the lower border of the mandible (I-L)		p-value
	Right	Left	Right	Left	
Male	17.21 ± 1.9	17.18 ± 2.1	13.02 ± 2.2	12.97 ± 2.1	<0.05 S
Female	15.85 ± 2.4	15.72 ± 2.2	11.31 ± 2.5	11.26 ± 2.3	

S: Significant

**Table 4:** Comparison of present study with previous literature

Authors	Population/country of study	Results
Bharathi et al <sup>10</sup>	20 Indians and 20 Iranians	Mental foramen below the apex of the second premolar in 52.5% of Indians, 47.5% of Iranians; 45% of it was between the first and second premolars among Indians and 47.5% of Iranians
Patel et al <sup>11</sup>	Dried adult human skulls, Saurashtra region of Gujarat	The longitudinal axis of the second premolar for right side was 40.32% and left side 43.55% followed by the longitudinal axis which passed between the first and second premolars
Babshet et al <sup>8</sup>	Dharwad, Karnataka, India	43% in between first and second premolars and 39% in line with second premolar
Gada and Nagda et al <sup>12</sup>	Mumbai City (India)	Between the two premolars (63%), followed by position behind the second premolar (20.67%)
Moogala et al <sup>13</sup>	In dry dentate and edentulous mandibles in coastal Andhra population of Andhra Pradesh State	In between the first and second premolars (40–50%)
Jamdade et al <sup>14</sup>	Indian population (Jaipur, Rajasthan)	First and second premolars (46.1%) followed by in line with the longitudinal axis of the second premolar (45.5%)
Udhaya et al <sup>15</sup>	South Indian Population	At the level of the root of the second premolar, midway between the inferior margin and the alveolar margin of the mandible
Afkhami et al <sup>16</sup>	Tehran, Iran	67% were below the second premolar, 24% were between the first and second premolars
Singh and Srivastav <sup>17</sup>	Dried adult human Indian mandibles (Lucknow, Uttar Pradesh)	Below the apex of second premolar in 68.8%, between first and second premolars in 17.8%, and between second premolar and first molar in 11.5%
Shah et al <sup>18</sup>	Indian population, Gujarat	Between first and second premolars 63.86% and in line with second premolar 26.36%
Haghanifar and Rokouei <sup>7</sup>	Iranian population	Between the first and second premolars in 47.2% of patients and in line with the second premolar in 46%
Ilayperuma et al <sup>5</sup>	Adult dry mandibles in Sri Lankan population	In line with the longitudinal axis of the lower second premolar (52.94%) followed by a position between first and second premolar (26.47%)
Olasoji et al <sup>19</sup>	Nigerian adults	The most common location was the interdental space between the first and second mandibular premolars followed by the position apical to the second premolars
Ngeow and Yuzawati <sup>20</sup>	Malay population	In line with the longitudinal axis of the second premolar (69.2%) followed by position between the first and second premolar (19.6%)
Al Jasser and Nwoku <sup>6</sup>	Saudi Arabia	In line with the longitudinal axis of the second premolar (45.3%) followed by in between the first and second premolars (42.7%).
Shankland <sup>21</sup>	Asian Indians	Below the second premolar in 75.36% of cases

Factors affecting location include the muscle forces, diet or eating habits, size and shape of neurocranium, position of head, facial biotype, teeth size, environmental and socioeconomic factors; racial and ethnic characteristics along with genetic constitution could also change the mandibular morphology and masticatory function.<sup>23</sup>

Frequent failures are well documented during mental nerve blocks, which shows its variability of location.<sup>10</sup> The position and orientation of the mental foramen is imperative to performing anesthetic block before the

clinical procedures in mandibular anterior teeth and also to conserve the integrity of the mental nerve trunk in surgical interventions. The mental nerve injury can cause permanent or transitory sensitive, tactile, and thermal changes.<sup>23</sup>

Panoramic radiographs were utilized in the present study to assess the mental foramen as it provides more wide and reliable field to view anatomy of the mandible as compared with periapical radiographs. Swamy et al<sup>24</sup> also utilized a similar method to commence the study among

population of Bengaluru, India. Limitation of the present study was the use of panoramic radiographs for locating mental foramen instead of commencing an anatomic study on skulls. However, Olasoji et al<sup>19</sup> studied mental foramen among northern Nigerian adults on skulls and panoramic radiographs randomly and did not find any significant difference between both methods for locating the mental foramen. It requires further studies for large sample size, which would consider position of mental foramen depending on gender and age.

In spite of clinical importance of mental foramen, it also offers importance in forensic application because mandibular characteristics are extremely useful in gender determination.<sup>25</sup>

Wical and Swoope,<sup>26</sup> Lindh et al,<sup>27</sup> and Guler et al<sup>28</sup> commenced studies and reported that even with resorption of the alveolar bone above the mental foramen, the space from the foramen to the inferior border of the mandible remains relatively constant throughout life. Thus, stability of this part is not affected by resorption of alveolar process above the foramen.

Chandra et al<sup>9</sup> concluded that the length from lower border of the mandible to the mental foramen exhibits sexual dimorphism, and panoramic radiography is an efficient tool for assembly of planned dimensions and can be measured as an added radiographic method to establish gender from the skeletal remains. The present study also revealed that the variations in length of superior and inferior border of the foramen in relation to lower border of the mandible with respect to gender were found to be significant. Similarly, Thakur et al,<sup>25</sup> Mahima,<sup>1</sup> and Naroor et al<sup>2</sup> reported the possibility that the height of the mandible and the distance from the superior margin of the mental foramen to the alveolar crest can be used to determine gender. Probable values among various groups could be a good indicator for gender determination among various racial and ethnic groups. This method is of particular importance in mass disaster events when the jaws are available for identification in fragments.<sup>9</sup>

## CONCLUSION

Most common position of mental foramen among Pune population in horizontal plane in both male and female patients was in line with second premolar followed by position in between first and second premolar, whereas in vertical plane most common position was at or in line with apex of second premolar followed by in between apex of first and second premolar. There was no difference in position of mental foramen in horizontal as well as in vertical plane based on gender. Literature review suggests variation in location among various racial and ethnic groups.

Hence, understanding the importance of anatomical variations of the mental foramen as well as determining

its location during the radiological examinations preoperatively is of clinical importance. Furthermore, there is stability of location of mental foramen as it is not affected by resorption of alveolar process above the foramen, and significant difference in length of superior and inferior border of the foramen in relation to lower border of the mandible with respect to gender offers its application in forensic identification of gender.

## REFERENCES

1. Mahima VG. Mental foramen for gender determination: a panoramic radiographic study. *Medico-Legal Update* 2009;9(2):33-35.
2. Naroor N, Shenai P, Chatra L, Veena KM, Rao PK, Shetty P. Gender determination using the mental foramen. *J Cranio Max Dis* 2015 Jul;4(2):144-147.
3. Parnami P, Gupta D, Arora V, Bhalla S, Kumar A, Malik R. Assessment of horizontal and vertical position of mental foramen in Indian population in terms of age & sex in dentate subjects by panoramic radiographs: a retrospective study with review of literature. *Open Dent J* 2015 Jul;9(2):297-302.
4. White SC, Pharoah MJ. *Oral radiology: principles and interpretation*. 4th ed. St. Louis: Mosby; 2000. p. 186.
5. Ilayperuma I, Nanayakkara G, Palahepitiya N. Morphometric analysis of the mental foramen in adult Sri Lankan mandibles. *Int J Morphol* 2009 Dec;27(4):1019-1024.
6. Al Jasser NM, Nwoku AL. Radiographic study of mental foramen in a selected Saudi Population. *Dentomaxillofac Radiol* 1998 Nov;27(6):341-343.
7. Haghaniifar S, Rokouei M. Radiographic evaluation of the mental foramen in a selected Iranian population. *Indian J Dent Res* 2009 Apr-Jun;20(2):150-152.
8. Babshet M, Sandeep R, Burde K, Nandimath K. Evaluation of the position of mental foramen and its correlation with age in selected Indian population, using digital panoramic radiograph. *Int J Dent Sci Res* 2015 Jul;3(4):87-91.
9. Chandra A, Singh A, Badni M, Jaiswal R, Agnihotri A. Determination of sex by radiographic analysis of mental foramen in North Indian population. *J Forensic Dent Sci* 2013 Jan;5(1):52-55.
10. Bharathi U, Rani RM, Basappa S, Kanwar S, Khanum N. Position of the mental foramen in Indian and Iranian subjects: a radiographic study. *J Int Oral Health* 2016 Jan;8(1):1-3.
11. Patel R, Patel R, Patel M. Morphometric analysis of the mental foramen in adult human mandible in Saurashtra region. *Int J Anatomy Physiol* 2015;4(6):81-84.
12. Gada SK, Nagda SJ. Assessment of position and bilateral symmetry of occurrence of mental foramen in dentate Asian population. *J Clin Diagn Res* 2014 Feb;8(2):203-205.
13. Moogala S, Sanivarapu S, Boyapati R, Devulapalli NS, Chakrapani S, Kolaparthi L. Anthropometrics of mental foramen in dry dentate and edentulous mandibles in Coastal Andhra population of Andhra Pradesh State. *J Indian Soc Periodontol* 2014 Jul;18(4):497-502.
14. Jamdade AS, Yadav S, Bhayana R, Khare V, Pardhe N, Mathur N. Radiographic localization of mental foramen in a selected Indian population. *Innovative J Med Health Sci* 2013;3(5):249-253.
15. Udhaya K, Saraladevi KV, Sridhar J. The morphometric analysis of the mental foramen in adult dry human mandibles:

- a study on the South Indian population. *J Clin Diagn Res* 2013 Aug;7(8):1547-1551.
16. Afkhami F, Haraji A, Boostani HR. Radiographic localization of the mental foramen and mandibular canal. *J Dent (Tehran)* 2013 Sep;10(5):436-442.
17. Singh R, Srivastav AK. Study of position, shape, size and incidence of mental foramen and accessory mental foramen in Indian adult human skulls. *Int J Morphol* 2010 Dec;28(4):1141-1146.
18. Shah PP, Parikh KK, Shah MJ, Khan M. Radiographic study of mental foramen in a selected Indian population in Kheda District, Gujarat. *J Indian Acad Oral Med Radiol* 2013 Jan;25(1):13-17.
19. Olosoji HO, Tahir A, Ekanem AU, Abubakar AA. Radiographic and anatomic locations of mental foramen in Northern Nigerian adults. *Niger Postgrad Med J* 2004 Sep;11(3):230-233.
20. Ngeow WC, Yuzawati Y. The location of mental foramen in a selected Malay population. *J Oral Sci* 2003 Sep;45(3):171-175.
21. Shankland WE. The position of the mental foramen in Asian Indians. *J Oral Implantol* 1994;20(2):118-123.
22. Yosue T, Brooks SL. The appearance of mental foramina on panoramic radiographs. I. Evaluation of patients. *Oral Surg Oral Med Oral Pathol* 1989 Sep;68(3):360-364.
23. Amorim MM, Prado BF, Borini CB, Bittar TO, Volpato MC, Groppo FC, Caria PH. The mental foramen in dentate and edentulous Brazilian's mandible. *Int J Morphol* 2008;26(4):981-987.
24. Swamy NN, Nagaraj T, Ghouse N, Jagadish CD, Sreelakshmi N, Goswami RD. Radiographic study of mental foramen type and position in Bangalore population. *J Med Radiol Pathol Surg* 2015;1:5-8.
25. Thakur M, Reddy VK, Sivaranjani Y, Khaja S. Gender determination by mental foramen and height of the body of the mandible in dentulous patients: a radiographic study. *J Indian Acad Forensic Med* 2014 Jan-Mar;36(1):13-19.
26. Wical KE, Swoope CC. Studies of residual ridge resorption. Part 1. Use of panoramic radiographs for evaluation and classification of mandibular resorption. *J Prosthet Dent* 1974 Jul;32(1):7-12.
27. Lindh C, Peterson A, Klinge B. Measurements of distance related to the mandibular canal in radiographs. *Clin Oral Implant Res* 1995 Jun;6(2):96-103.
28. Guler AU, Sumer M, Sumer P, Bicer I. The evaluation of vertical heights of maxillary and mandibular bones and the location of anatomic landmarks in panoramic radiographs of edentulous patients for implant dentistry. *J Oral Rehabil* 2005 Oct;32(10):741-746.