Original Article

# Morphometric Analysis Of Mandibular Foramen In Dry Adult Human Mandibles In North Indian Population And Its Possible Clinical Implication

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## Abstract

**Background:** In terms of generating good mandibular nerve blocks and preventing damage to the neurovascular bundles, the mandibular foramen (MF) is an anatomical feature of great relevance in local anesthetic and surgical operations.
**Objective:** This research study aimed to find out the exact position of the mandibular foramen in dry adult human mandibles from North Indian population. Measures were taken between the left and right sides of the mandibles using different landmarks.
**Method:** The location, size, form, and number of mandibular foramen in 125 dry adult human mandibles of undetermined age were noted. All the anatomical parameters were measured using a sliding digital vernier caliper, based on the location of the right and left mandibular foramina from the distinctive landmarks. Continuous data was expressed in mean ± SD while categorical data was measured in median ± IQR. For analyzing any association between study variables, Statistical Package for Social Sciences version 20 was used.
**Results:** In the study mean distance of mandibular foramen (MF) to anterior border of ramus was found to be 16.12mm on the right side and 16.83mm on the left side while the distance of MF from posterior border of ramus was 10.85mm on the right side and 11.26mm on the left side. The width of the ramus (AB-PB) as ascertained by measuring horizontal distance from the anterior border (AB) of the ramus to the posterior border (PB) of the ramus across the foramen was 31.95mm on the left and 31.41mm on the right side. On conducting a paired t-test, a statistically significant difference between the measurement of means on left and right side was found, in parameters of AB-MF and PB-MF while no statistical difference was found in AB-PB.
**Conclusions:** The result indicates significant differences in the location of mandibular foramen. The study showed that the mandibular foramen was located more posterior and at inferior aspect of the mandibular ramus along the vertical and horizontal axis. This study provides useful information for successful local anesthesia during various dental and other surgeries.

**Keywords:** Mandible, Mandibular foramen, Accessory mandibular foramen, landmark, anatomical landmark

## INTRODUCTION

Mandible is the longest, strongest and lowest bone of the face and bears the lower teeth. The mandible consist of a 'U' shaped body which faces anteriorly with its two vertical rami facing posteriorly [1]. Embryologically, body of mandible develops from fibrous mesenchymal tissue surrounding the Meckel's cartilage (cartilage of mandibular part, the first arch, is called Meckel's cartilage) [2]. The site of initial ossification as the primer for development of mandible has been called as the mandibular primary growth center (MdPGC) [2]. The mandible is an important facial bone that helps in the activity of eating, speaking and in expressing feelings.

Mandibular foramen (MF) is an asymmetrical foramen located on the medial surface of the mandibular ramus [3]. Thereafter it follows the anatomy of the mandible, continuing as mandibular canal that gives passage to inferior alveolar nerve and vessels which take course through the body of mandible antero-inferiorly and emerge through the mental foramen into the chin [3]. The inferior alveolar nerve and vessels in turn supply the gums, dental sockets and mandible [3]. However, the location of mandibular foramen may vary according to age and gender [4]. "The shape of the orifice of the mandibular foramen can be circular or even V-shaped in some individuals" [5].

The localization of the mandibular foramen is essential for facial surgeries involving the lower jaw, especially for dental and maxillofacial surgeries, as injuries to anatomical structures traversing the foramen has been documented [6]. If these essential structures, such as the inferior alveolar nerve and foramen, are not adequately recognized, issues such as altered feeling, numbness, and pain might ensue [7]. Injury to inferior alveolar artery might result in bleeding intra-operatively or post-operatively and may lead to ischemia. Moreover, variation in the position of mandibular foramen has important clinical implications [8, 9], while the presence of accessory mandibular foramen has been also noted [9].

Dental surgeries often involve inferior alveolar nerve block which may fail due to variations in the anatomy of the mandibular foramen [10]. In a study conducted on predoctoral students, the most common cause for failure of inferior alveolar nerve block (IANB) was due to their inability to palpate the landmarks [11]. Similarly, another study on students and interns of a dental college also reported anatomical variations to be the most common reason for IANB failure [12]. These observations necessitate the importance of successful localization and recognition of the mandibular foramen in operative procedures involving the lower jaw. The aim of the present study thus is to provide an estimate of the location of mandibular foramen in dry adult human mandibles of North Indian origin such that important clinical application can be inferred from these observations.

## MATERIALS AND METHOD

**Study type and site**

The present cross sectional study was conducted in the Department of Anatomy, Shri Guru Ram Rai Institute of Medical and Health Sciences, Dehradun & Gautam Buddha Chikitsa Mahavidhyalaya, Dehradun.

**Sample size**

A total of 125 dry adult human mandibles were taken for the study. All the mandibles were undamaged with intact mandibular ramus along with mandibular foramina. The anatomical parameters were taken from both right and left side of the mandibular ramus and thus a total of 250 mandibular foramina were studied.

**Measurements of Anatomical parameters** - All the measurements were taken by one person by using digital vernier caliper and magnifying glass. The position of mandibular foramen and the distance of each mandibular foramen in relation to various landmarks in the mandibular ramus were measured using vernier calipers, which was calibrated to 0.01mm accuracy with range from 0-300 mm and had zero error. Both the jaws of the caliper were brought together until they touched each other and zero button was pressed before taking every other reading.

Figure 1: Measurement of different anatomical landmarks in relation to mandibular foramen using Digital Vernier Caliper

The following parameters were measured for both the sides of the mandibles to pinpoint the location of the MF:

i. Horizontal distance between the midpoint of the anterior margin of the mandibular foramen and the closest point of the anterior border of mandibular ramus (AB-MF).
ii. Horizontal distance between the midpoint of the posterior margin of the mandibular foramen and the closest point of the posterior border of the mandibular ramus (PB-MF).
iii. Horizontal distance from the anterior border (AB) of the ramus to the posterior border (PB) of the ramus across the foramen, in order to ascertain the width of the ramus (AB-PB).
iv. The vertical distance between the lowest point of mandibular notch and the upper limit of mandibular foramen (MN-MF).
v. The distance between the inferior limit of the mandibular foramen and the farthest point on the mandibular angle (MF-AG).
vi. Distance between the lowest point of the mandibular foramen to the inferior border of mandibular ramus (MF-IN).
vii. Vertical distance between the mandibular foramen to mandibular condyle (MF-MC).
viii. Measurement of the apex of retromolar trigone to the mandibular foramen (RT-MF).

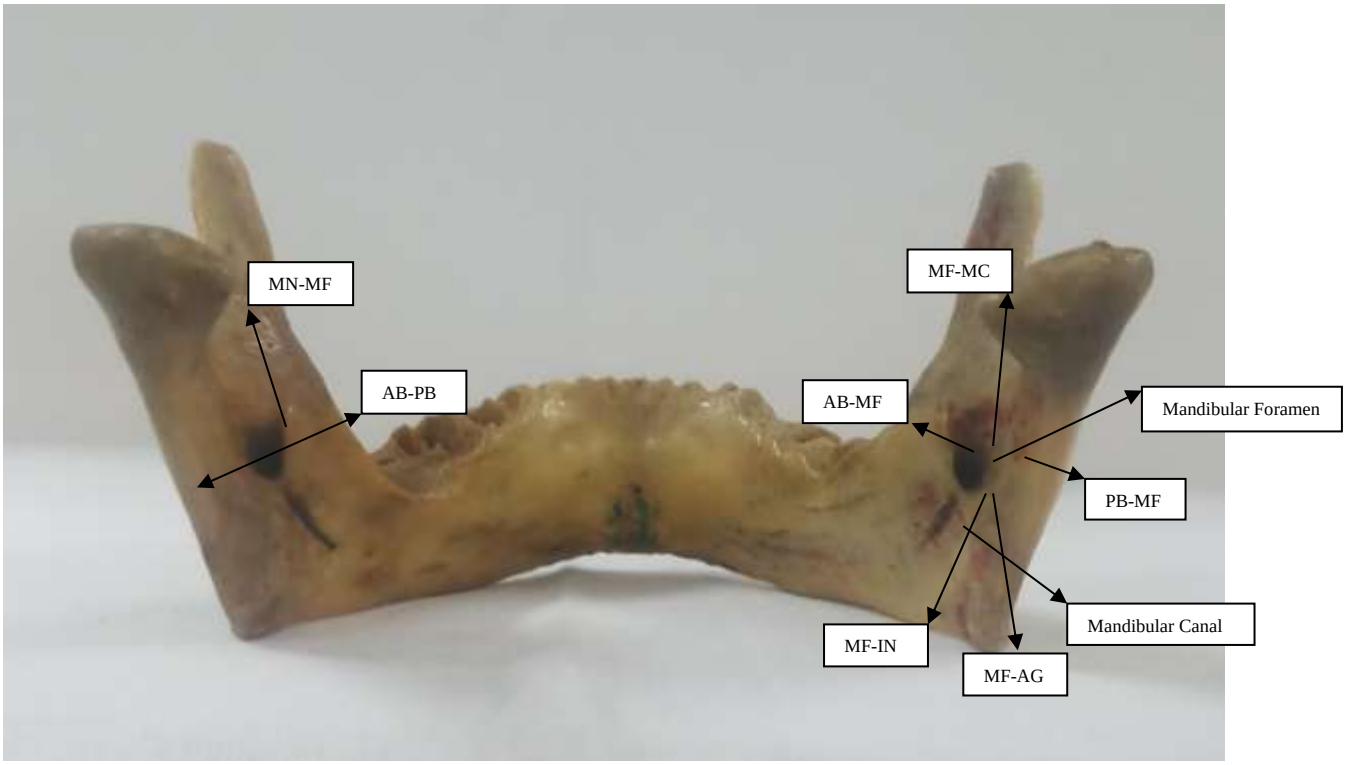

Figure 2: Representation of anatomical landmarks in relation to mandibular foramen

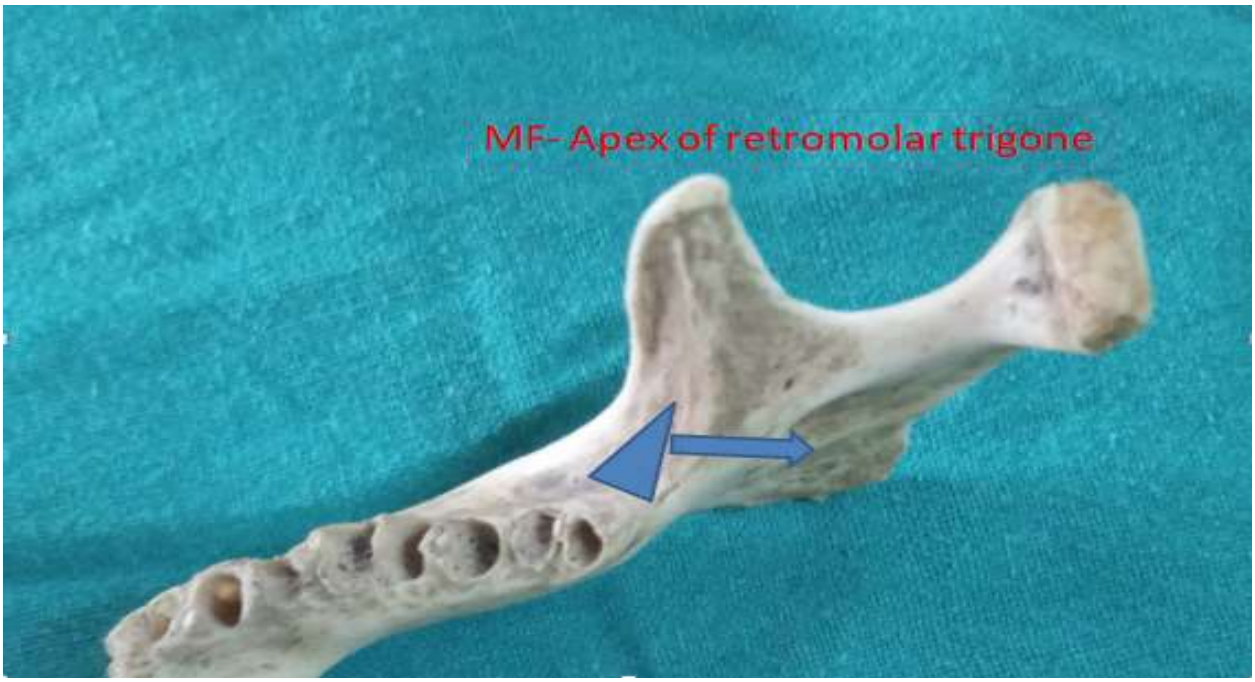

Figure 3: Representative image showing measurement in between the apex of retromolar trigone to mandibular foramen (RT-MF).

The mandibles were also examined for the existence of accessory mandibular foramina surrounding the mandibular foramen on the medial surface of mandibular ramus using an easy visual inspection with a magnifying glass.

**Data Collection and Analysis**

All the measurements were taken on both sides for each space individually and the observed data were compared. The vertical and transverse diameters were used to calculate the size of mandibular foramina. Continuous data was expressed

in mean ± SD while categorical data was measured in median ± IQR. To analyze for any association between variables, paired sample t-test was used in the IBM software, Statistical Package for Social Sciences version 20. For all purposes a p-value of <0.05 was considered as statistically significant.

## RESULTS

In the present study a total of 125 mandibles were studied with the aim to find the location of mandibular foramen from various other anatomical landmarks on the bone. The mean horizontal distance from the midpoint of the anterior margin of the mandibular foramen and the closest point on the anterior border of mandibular ramus (AB-MF) on the left side was 16.84 ± 2.39 mm while on the right side it was 16.13 ± 2.07 mm, Table-1; which was found to be statistically significant difference, t(124) = 3.378, p = .001, Table-2. Similarly, a statistically significant difference was found between the mean horizontal distance of the midpoint of the posterior margin of the mandibular foramen and the closest point on the posterior border of the mandibular ramus (PB-MF) on the left side, 11.26 ± 1.94 mm and the right side, 10.85 ± 1.74 mm, Table-1; t(124) = 2.172, p = .032, Table-2. The mean vertical distance between the lowest point of mandibular notch and the upper limit of mandibular foramen (MN-MF) on the left side was 19.79 ± 3.18 mm which was greater than on the right side, 18.92 ± 3.09 mm, Table-1. On measuring the mean distance between the inferior limit of the mandibular foramen and the farthest point on the mandibular angle (MF-AG), it was found to be 21.80 ± 3.22 mm on the left side and 20.31 ± 3.20 mm on the right side, Table-1. Paired t-test concluded that the mean difference between both MN-MF and MF-AG was significant; t(124) = 2.884, p = .005 and t(124) = 4.343, p <.001 respectively, Table-2.

Table-1 Descriptive characteristics of the mean distances of mandibular foramen to various landmarks on mandible on each side (n= 125)

| Measure | Minimum | Maximum | Mean | Std. Error Mean | Std. Deviation |
|---|---|---|---|---|---|
| AB-MF Left | 11.04 | 24.40 | 16.84 | .2135 | 2.39 |
| AB-MF Right | 12.36 | 23.12 | 16.13 | .1845 | 2.06 |
| PB-MF Left | 6.96 | 16.14 | 11.26 | .1732 | 1.94 |
| PB-MF Right | 7.31 | 14.71 | 10.85 | .1560 | 1.74 |
| AB-PB Left | 25.00 | 47.00 | 31.95 | .2906 | 3.25 |
| AB-PB Right | 25.67 | 38.82 | 31.41 | .2610 | 2.92 |
| MN-MF Left | 10.99 | 28.86 | 19.79 | .2844 | 3.18 |
| MN-MF Right | 11.23 | 27.60 | 18.92 | .2768 | 3.09 |
| MF-AG Left | 15.50 | 30.68 | 21.80 | .2879 | 3.22 |
| MF-AG Right | 14.93 | 28.31 | 20.30 | .2866 | 3.20 |

| | | | | | |
|---|---|---|---|---|---|
| MF-IN Left<br><br>MF-IN Right | 15.86<br><br>19.87 | 33.60<br><br>36.44 | 24.90<br><br>25.29 | .2938<br><br>.3172 | 3.28<br><br>3.55 |
| MF-MC Left<br><br>MF-MC Right | 14.82<br><br>25.91 | 46.63<br><br>44.33 | 33.90<br><br>34.29 | .4254<br><br>.4051 | 4.76<br><br>4.53 |
| RT-MF Left<br><br>RT-MF Right | 6.05<br><br>5.64 | 24.94<br><br>19.88 | 11.68<br><br>11.40 | .2134<br><br>.1952 | 2.39<br><br>2.18 |

*MF- mandibular foramen, AB- anterior border of mandibular ramus, PB- posterior border of the mandibular ramus, MN- mandibular notch, AG- mandibular angle, IN- inferior border of mandibular ramus, MC- mandibular condyle, RT- retromolar trigone

The width of the ramus was measured by measuring the horizontal distance from the anterior border (AB) of the ramus to the posterior border (PB) of the ramus across the foramen (AB-PB), with mean AP-PB distance found to be 31.95 ± 3.25 mm on the left side and 31.41 ± 2.92 mm on the right side, Table-1; which was not found to be a statistically significant difference, Table-2. Mean distance between the lowest point of the mandibular foramen to the inferior border of mandibular ramus (MF-IN) was found to be 24.90 ± 3.28 mm on the left side and 25.29 ± 3.54 mm on the right side whereas the mean vertical distance between the mandibular foramen to Condyle (MF-MC) was found to be 33.90 ± 4.76 mm on the left side and 34.29 ± 4.53 mm on the right side respectively, Table-1 and both the measurements were not found to be significantly different, Table-2. On measurement of the mean distance of the apex of retromolar trigone to the mandibular foramen (RT-MF), it was found that the mean distance was slightly greater on the left side, 11.68 ± 2.38 mm than on the right side, 11.40 ± 2.19 mm, Table-1; however, this difference was not found to be a statistically significant difference, Table-2.

Table-2 Paired differences between the mean distances of mandibular foramen to various landmarks on mandible on each side (n= 125)

| Measure | Mean | Std. Deviation | Std. Error Mean | 95% Confidence Interval of the Difference | | Sig. |
|---|---|---|---|---|---|---|
| | | | | Upper | Lower | |
| AB-MF Left<br>AB-MF Right | .71040 | 2.35143 | .21032 | .29412 | 1.12668 | .001 |
| PB-MF Left<br>PB-MF Right | .40816 | 2.10114 | .18793 | .03619 | .78013 | .032 |
| AB-PB Left<br>AB-PB Right | .53936 | 3.53515 | .31619 | -.08648 | 1.16520 | .091 |
| MN-MF Left<br>MN-MF Right | .86384 | 3.34912 | .29955 | .27094 | 1.45674 | .005 |
| MF-AG Left<br>MF-AG Right | 1.50191 | 3.86611 | .34580 | .81749 | 2.18634 | .000 |
| MF-IN Left<br>MF-IN Right | -.38233 | 3.66907 | .32817 | -1.03187 | .26721 | .246 |
| MF-MC Left<br>MF-MC Right | -.39751 | 4.20740 | .37632 | -1.14236 | .34733 | .293 |
| RT-MF Left | .28776 | 2.20016 | .19679 | -.10174 | .67726 | .146 |

| | | | | | | |
|---|---|---|---|---|---|---|
| RT-MF Right | | | | | | |

*MF- mandibular foramen, AB- anterior border of mandibular ramus, PB- posterior border of the mandibular ramus, MN- mandibular notch, AG- mandibular angle, IN- inferior border of mandibular ramus, MC- mandibular condyle, RT- retromolar trigone

## DISSCUSSION

The present study was conducted on dry adult human mandibles of north Indian origin. The purpose of the study was to delineate the location of mandibular foramen with respect to various anatomic landmarks on the mandible in this population, with the objective that such knowledge would be of benefit to dental specialists and oncologists, who plan on surgeries or in estimating the field of radiation to the mandible. This knowledge is also vital because the position of mandibular foramen varies according to age and gender [4, 13], ethnicity [14] and facial type [15] of an individual.

AB-MF and PB-MF

In the present study, the mean horizontal distance from the midpoint of the anterior margin of the mandibular foramen and the closest point on the anterior border of mandibular ramus (AB-MF) on the left side was 16.84 mm and on the right side it was 16.13 mm, while the mean horizontal distance of the midpoint of the posterior margin of the mandibular foramen and the closest point on the posterior border of the mandibular ramus (PB-MF) on the left side and the right side was, 11.26 mm and 10.85 mm respectively. This indicates that the mandibular foramen of the mandibles of north Indian population is located more posteriorly on the mandibular ramus. Moreover, measures for both AB-MF and PB-MF were statistically different on either side. Similar findings were reported from Indian subcontinent by Shenoy V et al [16] in south India, Hoque et al [17] in Bangladesh, Chimurkar V et al [18] in central India and Kaur R et al [19] in north India, Table-3. On international comparison, findings of Oguz et al [20] in Turkish population, Ennes & Medeiros [21] in Brazil and Jain et al [22] in Latvia found that the mean AB-MF was greater than mean PB-MF, Table-3; which was identical to the present study.

However, on comparing the measures obtained from mandibles from Indian subcontinent including the present study, with the measures obtained from outside, it was found that except for the study by Chimurkar V et al [18] in central India; the mean AB-MF and PB-MF distances was shorter in Indian mandibles. This may be attributed to ethnicity, dietary habits and facial type.

AB-PB

The width of the ramus (AB-PB) as ascertained by measuring horizontal distance from the anterior border (AB) of the ramus to the posterior border (PB) of the ramus across the foramen was marginally longer on the left side, 31.95 mm than on the right side, 31.41 mm; however, this difference was not statistically significant. These findings were similar to a study done by Shalini et al. [23] in south India.

MN-MF

The mean vertical distance between the lowest point of mandibular notch and the upper limit of mandibular foramen (MN-MF) on the left side was 19.79 mm and on the right side was 18.92 mm. This difference was found to be statistically significant. The finding was similar to findings by Chimurkar V et al [18] and Jain et al [22] but was in contrast with other studies by Kaur R et al [19] in north India in which the MN-MF distances was longer on both sides, Table-3. This can be explained on the basis that the measure was taken between the mandibular notch and lower border of the mandibular foramen. Similarly difference in measures of MN-MF, between our study and other international studies [20, 24] may be due to racial differences.

MF-IN

Mean distance between the lowest point of the mandibular foramen to the inferior border of mandibular ramus was found to be 24.90 mm on the left side and 25.29 mm on the right side. The measures were comparable to Indian studies [18, 19], however, in contrast to the present study, MF-IN measure on left side was found to be greater in both the studies. Marked variation in measures were also found on international comparison [22, 24].

MF-AG and MF-MC

The mean distance between the inferior limit of the mandibular foramen and the farthest point on the mandibular angle (MF-AG) was found to be 21.80 mm on the left side and 20.31mm on the right side and this difference was statistically significant whereas the mean vertical distance between the mandibular foramen to Condyle (MF-MC) was found to be 33.90 mm on the left side and 34.29 mm on the right side.

RT-MF

Mean distance of the apex of retromolar trigone to the mandibular foramen (RT-MF) was slightly greater on the left side, 11.68 mm than on the right side, 11.40 mm which was marginally greater from a study by Shalini et al. [23] but different from another study by Valente et al. [25] which found the mean distance of mandibular foramen from the apex of retromolar trigone to be 14.23±2.57 mm on the right side and 14.40±2.48 mm on the left side.

Table -3 Comparison of anatomical measures derived from previous studies with present study findings

| Study by authors | Sample of the country | Side | AB-MF | PB-MF | MN-MF | MF-IN |
|---|---|---|---|---|---|---|
| Ooguz & Bozkir (2000) | Turkey | Right | 16.90 | 14.09 | 22.37 | |
| | | Left | 16.78 | 14.37 | 22.17 | |
| Prado et al (2010) | Brazil | Right | 19.2±3.6 | 14.2±2.4 | 23.6±3.1 | 28.3±3.9 |
| | | Left | 18.8±3.8 | 13.9±2.6 | 23.1±3.0 | 28±3.8 |
| Varsha Shenoy et al (2012) | India (South, India) | Right | 16.1 | 11.7 | | 23.60 |
| | | Left | 16.3 | 11.3 | | 23.60 |
| Hoque et al (2013) | Bangladesh | Right | 16.34 | 14.14 | 22.29 | |
| | | Left | 16.27 | 14.04 | 22.18 | |
| Jain et al (2020) | Latvia | Right | 16.88 | 12.31 | 17.41 | 19.80 |
| | | Left | 17.33 | 11.75 | 18.01 | 20.11 |
| Chimurkar Vilas et al (2020) | India | Right | 17.58 | 13.61 | 19.54 | 26.86 |
| | | Left | 17.22 | 13.30 | 19.84 | 27.31 |
| Kaur R et al (2022) | India (Punjab) | Right | 16.41±2.42 | 13.51±2.10 | 23.44±3.86 | 23.85±4.21 |
| | | Left | 16.18±2.47 | 14.16±2.27 | 23.05±3.99 | 24.81±4.77 |
| Present study | North India | Right | 16.13 | 10.85 | 18.92 | 25.29 |
| | | Left | 16.84 | 11.26 | 19.79 | 24.90 |

Clinical implications

The present study was carried out to localise the position of mandibular foramen with the help of measurement of anatomical structures in relation to it. Since mandibular foramen contains vital structures and cannot be localised by palpation, it becomes essential that its correct identification is ensured while operating in its vicinity especially as a site for inferior alveolar nerve block which is routinely used by dental surgeons. The present study therefore adds to the existing knowledge and will be useful in dental surgeries, maxillofacial surgeries and for oncological procedures.

## CONCLUSION

The mandibular foramen is located more posteriorly and superiorly along the mandibular ramus in north Indian population.

**Author Contributions:** Conceptualization: SC, SA. Data acquisition: SC, SA, SM. Data analysis or interpretation: SC, SS. Drafting of the manuscript: SC, SA, SS. Critical revision of the manuscript: SC, SA, SS, SM. Approval of the final version of the manuscript: all authors.

**Ethical approval**

This study was approved by the Ethics Committee, Shri Guru Ram Rai institute of Medical and Health Sciences, Dehradun, Uttarakhand.

**Conflict of interest:** None

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