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Research Article - Basic and Applied Anatomy

# Position of mandibular foramen and its clinical implications

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## Abstract

Mandibular foramen is an irregular foramen located above the center on the medial surface of the ramus, containing the inferior alveolar nerve. This study aimed at determining the position of the mandibular foramen in adult Ethiopian populations. A cross-sectional study was conducted at the Department of Human Anatomy, College of Medicine and Health Sciences, University of Gondar, Ethiopia, on 130 human dry adult human mandibles of unknown gender and age. The position of right and left mandibular foramina was determined in reference to the distance of different landmarks with the help of sliding digital vernier caliper. The data were analyzed using SPSS version-20. The data were compared using Student's *t*-test. $P<0.05$ was considered as statistically significant. The average distance of mandibular foramen from the anterior border of mandibular ramus was 23.81 ± 0.332 mm (right side) and 24.73 ± 0.456 mm (left side); from the posterior border of the ramus was 16.99 ± 0.273 mm (right side) and 16.23 ± 0.252 mm (left side), $P<0.05$. The mandibular foramen was located 20.19 ± 0.379 mm and 19.32 ± 0.346 mm away from the gonion of right and left sides, respectively. Furthermore, on average the mandibular foramen was away from the mandibular notch at a distance of 21.82 ± 0.356 mm (right side) and 21.65 ± 0.329 mm (left side). Conclusion: Anatomical knowledge of the average distance of mandibular foramen from various anatomical landmarks is useful for surgeons to safeguard from neurovascular complication.

## Keywords

Mandible foramen, inferior alveolar nerve, failure of anesthesia.

## Introduction

Mandibular foramen (MF) is an irregular foramen located above the center on the medial surface of the ramus. The mandibular canal descends into the body of the mandible and opens into the mental foramen. It contains the inferior alveolar branch of the mandibular division of the trigeminal nerve, which in turn emerges as the mental nerve supplying the mandibular teeth (Beale and Robinson, 2008).

The position of the MF is an important anatomical landmark for effective anesthesia in the field of dentistry procedures that include dental extraction from the lower jaw and placing mandibular implants. The uncertainty in the location of the MF has

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been claimed to be the main factor for the high failure rate of anesthesia and complications of orthodontic procedures (Sandhya et al., 2015).

Usually, dentists implement inferior alveolar nerve blocking techniques; however, failure of anesthesia presumably happens due to variation in the position of the MF, as well as to the presence of an accessory mandibular foramen (Cvetko, 2014). Additionally, the absence of a specific anatomic bony landmark, as well as variation in width and height of the mandibular ramus may play an important role in the failure of anesthesia. The failure rate was estimated between 20-25% (Kanan et al., 2013). Thus, clear and precise information on the variations in the position of MF are important for an effective and a successful anesthesia during nerve block prior to the surgical intervention (Kanan et al., 2013).

Several studies have reported differences in the anatomy of the mandible among different ethnic groups throughout the globe. However, to the best of our knowledge, no study was conducted in Ethiopia. Hence, in the present study, an attempt was made to determine the position of the MF in adult dried Ethiopian mandibles with respect to the surgically encountered anatomical landmarks. Therefore, this study may provide necessary information to dentists and maxillofacial surgeons in Ethiopia.

## Material and methods

A cross-sectional study was conducted at the Department of Human Anatomy, College of Medicine and Health Sciences, University of Gondar, Ethiopia, from the 1st to the 20th of October 2016, to investigate the position of MF.

A total of 130 dry adult human mandibles collected in the Department of Human Anatomy for the purpose of teaching were used for the present study. The gender and exact age of each mandible was unknown. Mandibles which had sockets for third molars were selected; mandibles with gross pathological deformities were excluded from the present study.

As it is presented in Figure 1, the position of MF was determined using the distances of the mandibular foramen to the (a) base of mandible (MF-MB), (b) mandibular notch (MF-MN), (c) anterior border of the ramus (MF-AB) (d) posterior border of the ramus (MF- PB), (e) head of the mandible (MF- MH), (f) posterior edge of third molar socket (MF- TMS), (g) gonion (MF-G) and (h) midpoint on symphysis menti (MF- SM), which were measured on both sides with the help of a sliding vernier caliper. In order to maximize the accuracy of the results, the distances from the MF of various reference points were calculated as a mean of three measurements recorded independently by three data collectors. Measurements were recorded in millimeter (mm). A comparison of the mean values between the sides was performed using the t-test for independent samples and p-value $< 0.05$ was considered as statistically significant.

## Results

In our study, 130 mandible bones were used. The position of MF was evaluated on the basis of various reference points, including the mandibular notch and symphysis

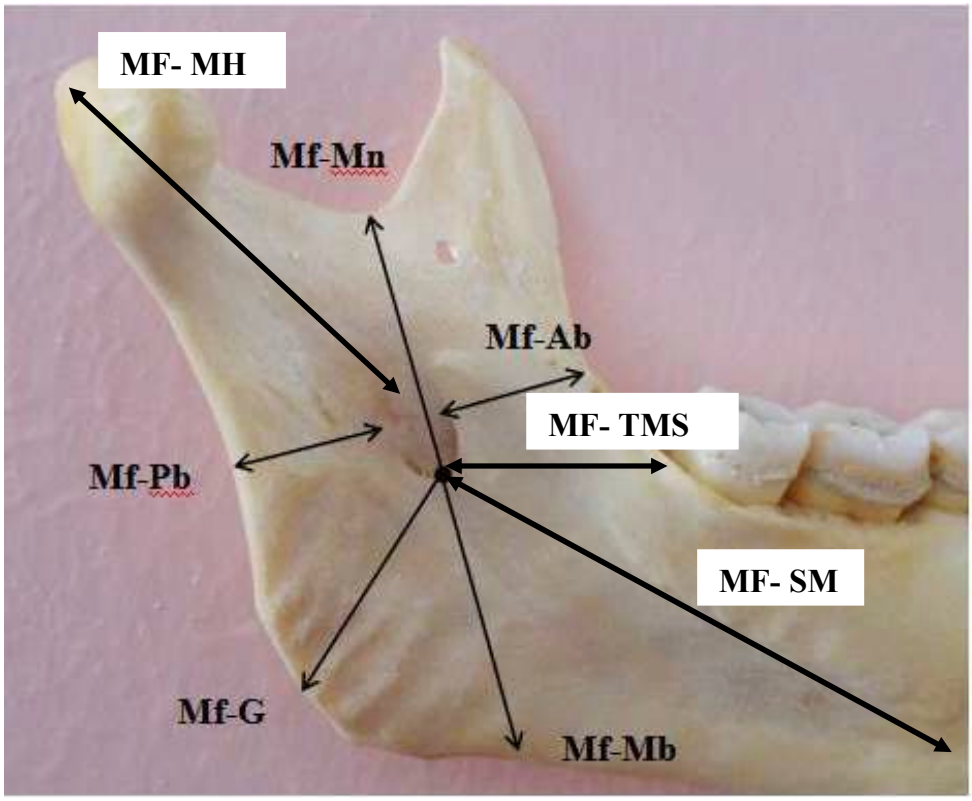


**Figure 1.** Representative example of the medial surface of mandible used to locate the position of mandibular foramen in relation to different reference points including mandibular notch. MF, Mf: mandibular foramen; MH: mandible head; Pb: posterior border of ramus; G: gonion; Mb: mandible base; SM: mid-point of symphysis menti; TMS: posterior edge of third molar socket; Ab: anterior border of ramus.

menti situated on the medial surface of the mandible. The mean distance for each reference point measurement of the right and left mandible is presented in Table 1.

The MF was located at an average distance of 29.98 ± 0.532 mm (right side) and 29.52 ± 0.554 mm (left side) from the base of the mandible, without significant difference (Table 1 and Figure 2a, b).

The MF was situated at an average distance of 21.82 ± 0.356 mm and 21.65 ± 0.329 mm away from the mandibular notch of right and left sides, respectively. The difference was not significant (Table 1 and Figure 3a, b).

Related to the anterior border of ramus of mandible, the MF was located on average at a distance of 23.81 ± 0.332 mm on the right side and 24.73 ± 0.456 mm on the left side (Table 1 and Figure 4a, b). The difference was not statistically significant.

The mean distance of MF from the posterior border of the ramus of the mandible was 16.99 ± 0.273 mm and 16.23 ± 0.252 mm on the right and left sides, respectively; the difference was significant ($p<0.05$; Table 1 and Figure 5a, b).

**Table 1.** Reference points used to indicate the mandibular foramen on the medial surface of mandible.

| Reference points | Sides | N | Mean distance (mm) | Standard error of the mean | P (2-tailed) | 95% CI |
|---|---|---|---|---|---|---|
| **MF-MB** | Right | 130 | 29.98 | 0.532 | not significant | (-1.058, 1.965) |
| | Left | 130 | 29.52 | 0.554 | | |
| **MF-MN** | Right | 130 | 21.82 | 0.356 | not significant | (-0.793, 1.116) |
| | Left | 130 | 21.65 | 0.329 | | |
| **MF-AB** | Right | 130 | 23.81 | 0.332 | not significant | (-2.035, 0.189) |
| | Left | 130 | 24.73 | 0.456 | | |
| **MF-PB** | Right | 130 | 16.99 | 0.273 | <0.05 | (0.029, 1.494) |
| | Left | 130 | 16.23 | 0.252 | | |
| **MF-MH** | Right | 130 | 39.35 | 0.475 | not significant | (-0.607, 1.946) |
| | Left | 130 | 38.68 | 0.441 | | |
| **MF-TMS** | Right | 130 | 25.72 | 0.470 | not significant | (-0.949, 1.765) |
| | Left | 130 | 25.31 | 0.504 | | |
| **MF-G** | Right | 130 | 20.19 | 0.379 | not significant | (-0.141, 1.880) |
| | Left | 130 | 19.32 | 0.346 | | |
| **MF-SM** | Right | 130 | 74.09 | 0.706 | not significant | (-2.120, 1.720) |
| | Left | 130 | 73.29 | 0.673 | | |

**MF-MB**: mandibular foramen to base of mandible; **MF-MN**: mandibular foramen to mandibular notch; **MF-AB**: mandibular foramen to anterior border of ramus; **MF-PB**: mandibular foramen to posterior border of ramus; **MF-MH**: mandibular foramen to the head of the mandible; **MF-TMS**: mandibular foramen to the posterior edge of third molar socket; **MF-G**: mandibular foramen to the gonion; **MF-SM**: mandibular foramen to the mid-point on symphysis menti.

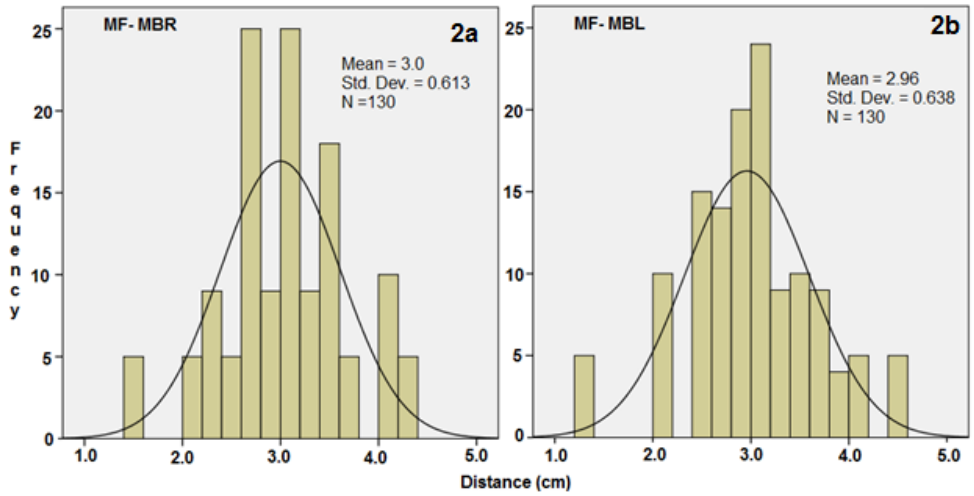


**Figure 2.** Distance of mandibular foramen from base of mandible; a) right side; b) left side.

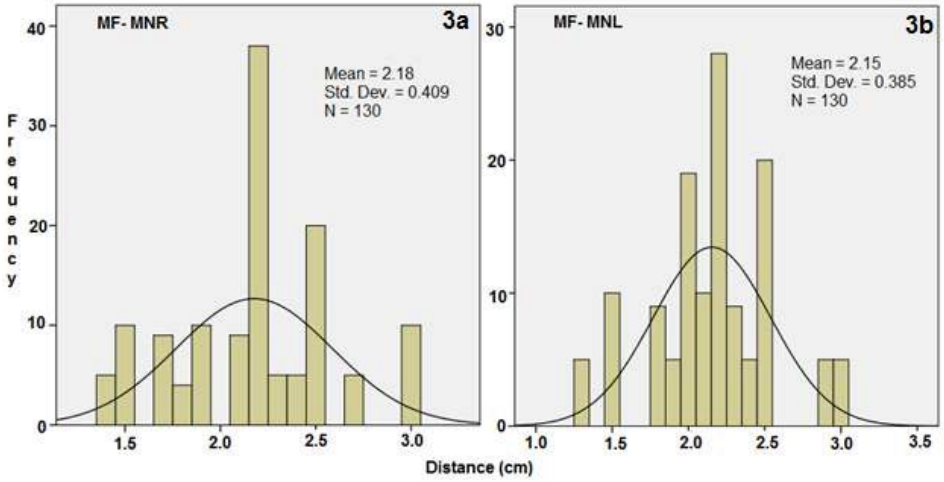


**Figure 3.** Distance of mandibular foramen from mandibular notch; a) the right side; b) left side.

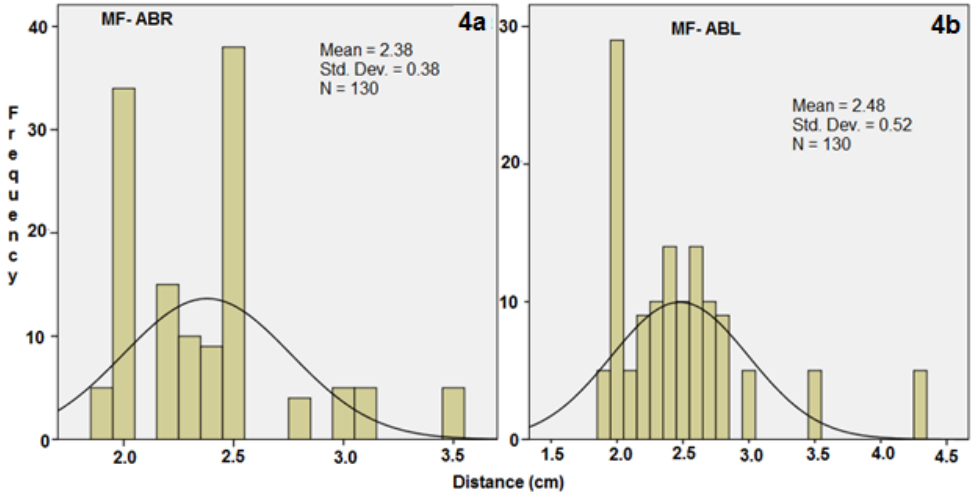


**Figure 4.** Distance of mandibular foramen from anterior border of ramus; a) right side; b) left side.

The MF was positioned from the mandibular head at an average distance of 39.35 ± 0.475 mm on the right side and 38.68 ± 0.441 mm on the left side (Table 1 and Figure 6a, b). The difference was not significant.

In our study, the distance from the posterior edge of the third molar socket to the MF was also taken as a reference point. The mean distance measurement was 25.72 ± 0.470 mm and 25.31 ± 0.504 mm on the right and left sides, respectively (Table 1 and Figure 7a, b). The difference was not significant.

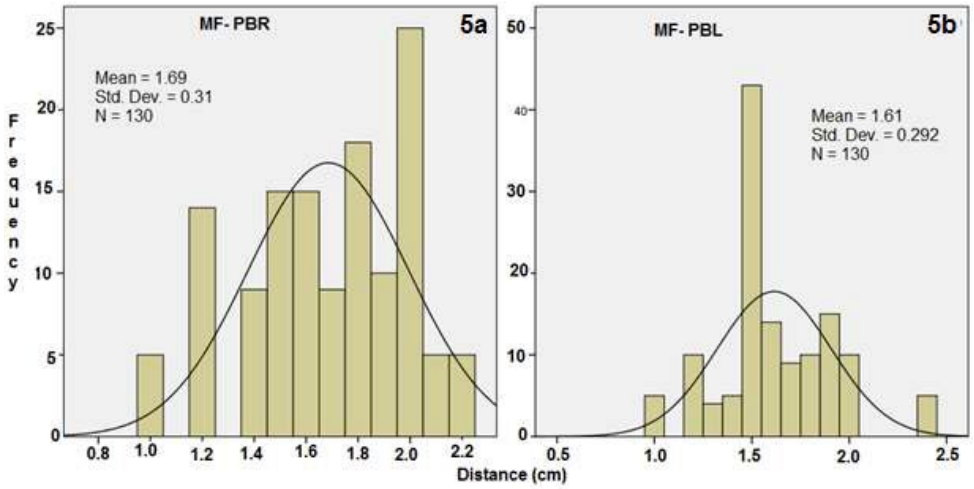


**Figure 5.** Distance of mandibular foramen from posterior border of ramus; a) right side; b) left side.

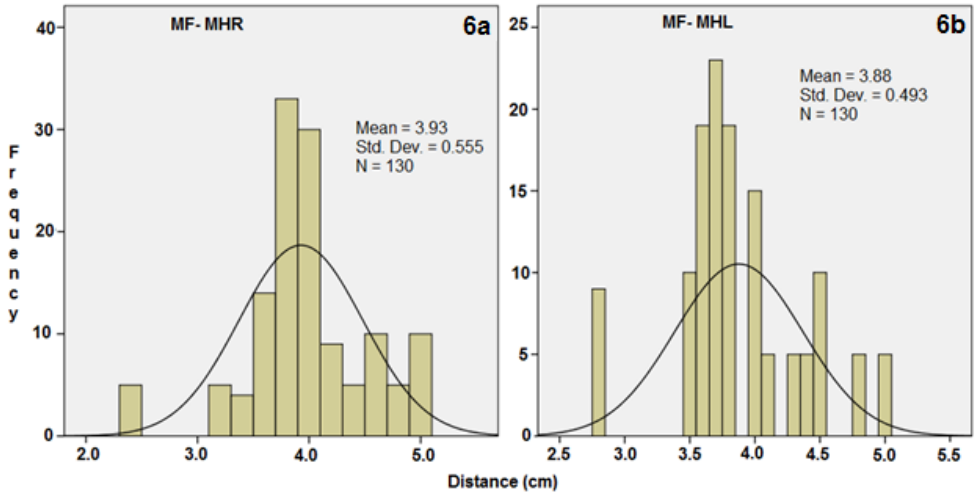


**Figure 6.** Measured distance of mandibular foramen from mandibular head; a) right side; b) left side.

The mean and distribution of the distance of the MF from the gonion is presented in Table 1 and Figure 8a, b. The mean distance of MF from the right and left sides of the gonion, respectively was 20.19 ± 0.379 mm and 19.32 ± 0.346 mm; the difference was not significant.

The MF was positioned at an average distance from the symphysis menti of 74.09 ± 0.706 mm and 74.29 ± 0.673 mm on the right side and left side, respectively (Table 1 and Figure 9a, b); the difference was not significant.

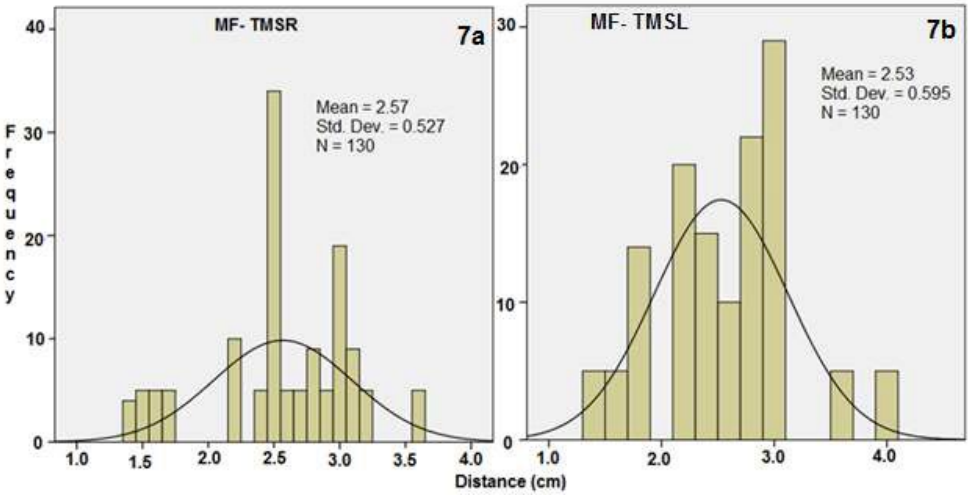


**Figure 7.** Distance of mandibular foramen from posterior edge of third molar socket; a) right side; b) left side.

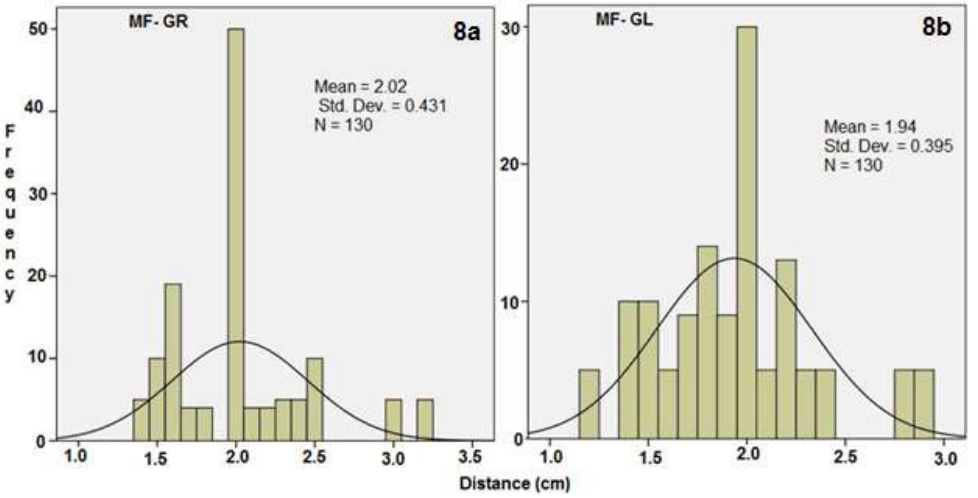


**Figure 8.** Distance of the mandibular foramen from gonion; a) right side; left side.

## Discussion

Various anatomists have attempted to instigate morphometric methods to ascertain the location of the MF as a landmark for applying inferior alveolar nerve anesthesia. Unfortunately, locating the MF is difficult since there is no specific bony mandibular landmark for its position (Khan and Ansari, 2016). These authors have also

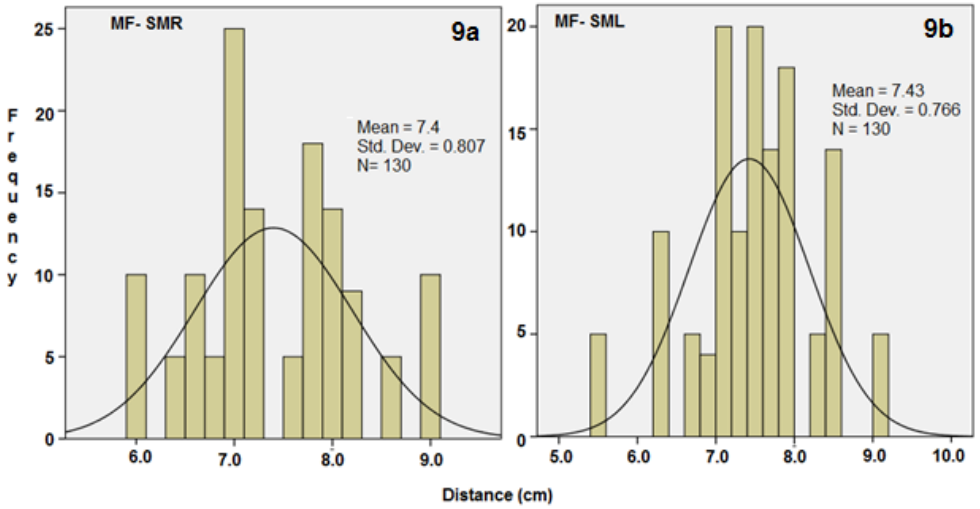


**Figure 9.** Measured distance of mandibular foramen from symphysis menti; a) right side; b) left side.

revealed that the absence of reliable bony landmarks as well as anatomical variation and age related mandibular changes may cause the high failure rate of anesthesia. Consequently, this has led to the development of various methods for locating the MF, which have yet to be proven to achieve a high success rate. Operator caused error when attempting to perform inferior alveolar nerve anesthesia should also be viewed as an additional cause of failure.

While there has been considerable research on the MF in various ethnic groups, there have been few morphometric studies on the MF in African groups. A recent Tanzanian study assessed 44 cadaveric mandibles of adult black male Tanzanians (30-45 years) found bilateral concurrence of the MF superior to the occlusal plane of the first molar and second premolars in all the mandibles. The study also claimed that the inferior alveolar nerve block can be successfully accomplished by locating the MF at 10.4 mm and 13.9 mm superior to the occlusal plane of the first molar or second premolar, and 20 mm from the anterior border of the ramus (Russa and Fabian, 2014)

In contrast, another African study on 38 dry mandibles from adult black Zimbabweans revealed significant differences in the location of the MF. The average MF was 20.8 mm (left) and 25.6 mm (right) posterior to the midpoint of the ramus width bilaterally (Mbajiorgu, 2000).

A study done on 79 mandibles of adult Kenyan Bantus indicated that 64.6% MF were located inferior to the posterior extension of the occlusal plane, while 30.7% were located alongside of the occlusal plane. Additionally, 56.1% MF were located inferior to the second premolar while 31.1% were found between the first molar and the second premolar. Moreover, the opening of the MF was posterosuperior in 72.5% of the mandibular surfaces. The study also found 4.5% of mandibular samples with multiple MF (Mwaniki and Hassanali, 1992). In the present study various morpho-

metric measurements were not significantly different between sides. Thus, it is proposed that failure to locate the MF for inferior alveolar nerve anesthesia is probably due to human inability to find the nerve and not due to anatomical variation. At this time, there is a lack of consensus on how to evaluate the correct position of MF (Barker and Davies, 1972; Hayward et al., 1977; Hetson et al., 1988; Murphy and Grundy, 1969; Nicholson, 1985) and despite the abundance of these ways there is still a considerable failure rate. Various authors have estimated inferior alveolar nerve anesthesia failure rates between 20% and 25% (Qudusia et al., 2016), and 29% and 35% of the patients (Levy, 1981; Robertson, 1979).

Other authors have reported that human error in inferior alveolar nerve anesthesia is a likely cause for incorrect needle placement (Qudusia et al., 2016). At present, the principal landmarks used for needle insertion for inferior alveolar nerve anesthesia are between the pterygomandibular raphe and the coronoid notch, superior to the occlusal plane of the lower teeth (Khalil, 2014). There are eight alternative methods to access the inferior alveolar nerve; however, the success rate of these methods has not received rigorous evaluation (Khalil, 2014).

In summary, the position of MF is crucial for correct performance of inferior alveolar nerve anesthesia. During the surgical procedure, the failure of the anesthesia is probably due more to operator error than to anatomical variation.

In conclusion, in the present study the MF was found situated at the same distance from the anatomical landmarks on the right and left sides, thus indicating bilateral symmetry. Our findings may be useful for maxillofacial surgeons and radiologists during surgical procedures and X-ray film interpretations.

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