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# Determination of Three-Dimensional Position of Mandibular Foramen Using CBCT

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## Abstract

**Aim:** The aim of this study is to determine the three-dimensional position of Mandibular foramen to guide the clinician for inferior alveolar nerve block and surgical procedures.

**Method and Materials:** CBCT scans of 500 mandibular foramens (MF) from 250 patients aged between 20 years and above were evaluated. Distances from the midpoint of the MF to anatomic landmarks were measured and Intergroup comparison i.e. comparison of numerical variables between age groups (>2groups) was done using One-way ANOVA test, between the position of MF & third molar (2 groups) was done using t-test.

**Result:** The position of MF in 3-dimensions was measured relative to the structural landmarks in the oral cavity which can easily be referred for surgical procedures. In this study it was observed that the mean distance from MF-A was 15.08±2.3 mm, MF-P was 13.8±2.09mm, MF-S was 18.6±4.4mm, and MF-I was 24.78 ±3.6 mm. The results clearly determined that MF is positioned posterior to the midpoint of the ramus of mandible horizontally and above the midpoint of the ramus of mandible vertically. A significant variation in the position of mandibular foramen in vertical position i.e. MF-Sub condylar notch higher at 41 years to 50 years age group which decreased with age was observed.

**Conclusion:** The location of the mandibular foramen varies with respect to gender and age. CBCT is the only imaging technology which helps view the anatomy directly hence this would help to better locate the mandibular foramen during various procedures.

**Keywords:** Mandibular anatomy; Mandibular foramen; CBCT; Inferior alveolar nerve; Anatomic landmarks

**Abbreviations:** MF: Mandibular Foramen; CBCT: Cone Beam Computed Tomography; FOV: Field of View; IAN: Inferior Alveolar Nerve

## Introduction

The mandibular foramen (MF) is an opening through which the inferior alveolar nerve (IAN) and vessels enter into the mandibular canal. It is classically located in the upper half of the medial aspect of the ramus of the mandible. Inferior Alveolar Nerve Block is most frequently used nerve block technique in Dental Practice [1]. The most frequent technique failure in anesthesia of IAN lies in the inappropriate setting of needle due to deviation location of mandibular foramen or other anatomic landmarks. The success of this technique depends on the proximity between the anesthetic needle and the mandibular foramen. Cone Beam Computed Tomography (CBCT) provides high-resolution images in Three Dimensions with relatively low radiation dose. Several studies have reported high accuracy when using CBCT for evaluation of various anatomical structures and their CBCT results show no statistically significant differences from actual measurements, although the measurements were done in micrometers.

The aim of this study was to determine;

a. The Three-Dimensional position of Mandibular Foramen from various anatomic landmarks

b. To provide most reliable and predictable indicators of the exact position of mandibular foramen.

c. To determine the deviation in the location of mandibular foramen if the third molar is missing.

## Material and Methods

CBCT scan records of six months duration were included in the study. The study received Institutional Ethics Committee's approval prior to commencement. All patients seeking treatment at the Institute and referred to Department of Oral Maxillofacial Radiology for CBCT scans of posterior mandible region were included in the study. Consent from all patients is routinely taken before any radiographic investigations where they are informed

about the possibility their records may be used for teaching and research purpose. CBCT scans were obtained using KODAK CS 3D Imaging system. All images were taken following a standard protocol for patient positioning and exposure parameter setting with variable Field of View (FOV). Voxel size 76 µm ×76µm ×76 µm Exposure parameter of 60-90kvp, 2-15mA and exposure time of 9-10.8 seconds for all the subjects.

### Inclusion criteria

a) All scans of posterior mandible including ramus taken in the Department of Oral and Maxillofacial Radiology between the age of 20 and above.

### Exclusion criteria

i. CBCT scans of Patient with edentulous mandible, multiple missing teeth, and a pathologic lesion in the region of interest.

ii. Partially reconstructed images and CBCT scan with artifact deteriorating the diagnostic quality of the scan.

The cross-sectional and panoramic sections of the CBCT scan were evaluated for location of the mandibular foramen using Altunsoy et al., [2]. The following linear measurements were recorded;

a) The shortest distance between the anterior border (A) and MF.

b) The shortest distance between the posterior border (P) and MF.

c) The shortest distance between the inferior point of the mandibular notch (S) and MF.

d) The shortest distance between the lower border of the ramus of mandible (I) and MF.

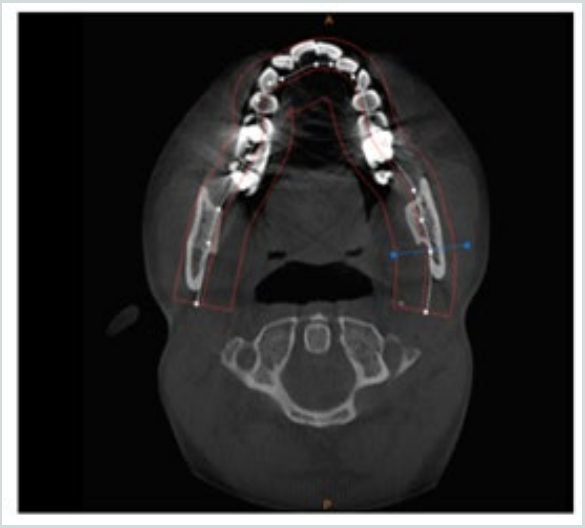

**Figure 1a:** Showing Mandibular Axial Section.
Showing Cross sectional CBCT Image of Mandible for Localization of Mandibular Foramen

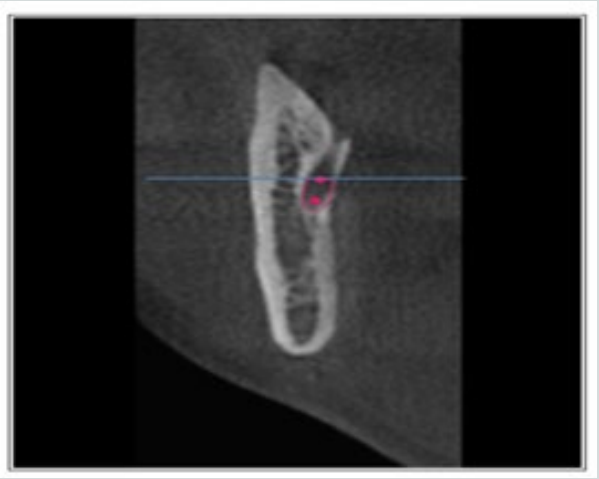

**Figure 1b:** Showing Mandibular Coronal Section.
Showing Cross sectional CBCT Image of Mandible for Localization of Mandibular Foramen


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e) The distance between the straight line of the cusps of the mandibular permanent molars (O) and MF. (Figure 1a & b)

Linear measurements of the mandible were carried out using CS 3D imaging software. CBCT scans were assessed by two observers individually at different times. The observers had a minimum of 3 years' experience in evaluating and reporting CBCT scans. All images were analyzed by displaying tomographic sections in axial, cross-sectional and panoramic planes. The scans were reviewed by the observers independently on an HP Compaq LE 1911 24 inches nonglossy monitor 1920 X 1200 resolutions, with a DIACOM workstation using Kodak Digital Imaging Software. Reading of the images was done under ideal conditions. Each radiologist was blinded to reduce intra and interobserver variation and bias. Each patient's age and gender were recorded, and the subjects were divided into 5 age-groups 20-30, 31-40, 41-50, 51-60, 61 and above age group.

## Statistical Analysis

### Determination of sample size

The sample size was determined using the expected mean difference and std deviation values from the literature. Total sample size 472 for 5 groups. The sample size was roundup to 500 subjects (Table 1 & 2). Data obtained was compiled on an MS Office Excel Sheet (v 2010) and was subjected to statistical analysis using Statistical package for social sciences (SPSS v 21.0, IBM). Descriptive statistics like the mean of numerical values & frequencies & % of categorical data has been depicted. Intergroup comparison i.e. comparison of numerical variables between age groups (>2groups) has been done using One-way ANOVA test, between the position of MF & third molar (2 groups) was done using t-test. Comparison of frequencies as per age groups & position of MF & presence or absence of the third molar has been done using chi-square test. For all the statistical tests, $p<0.05$ was considered to be statistically significant (Figure 2).

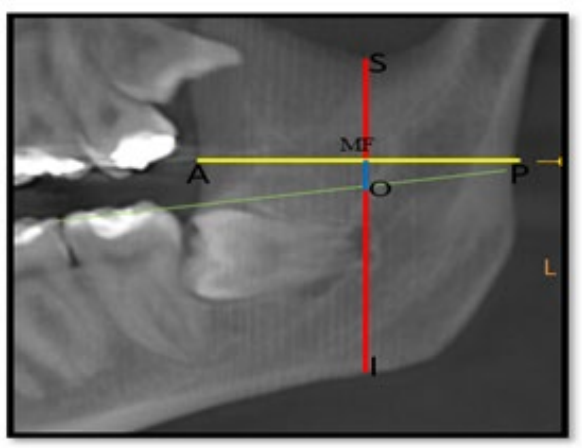


**Figure 2:** Showing Various Anatomical Landmarks on Ramus of Mandible from Center of Mandibular Foramen.

MF-A: The Shortest Distance Between the Anterior Border (A) and MF.

MF-P: The Shortest Distance Between the Posterior Border (P) and MF.

MF-S: The Shortest Distance Between the Inferior Point of The Mandibular Notch (S) and MF

MF-I: The Shortest Distance Between the Lower Border of Ramus of Mandible (I) and MF

MF-O: The Distance Between the Straight Line of The Cusps of The Mandibular Permanent Molars (O) and MF

**Table 1:** Distribution as Per Age.

| | | Frequency | Percent |
|---|---|---|---|
| | 20-30 years | 161 | 32.2 |
| | 31-40 years | 90 | 18 |
| | 41-50 years | 118 | 23.6 |
| | 51-60 years | 93 | 18.6 |
| | >60 years | 35 | 7 |
| | Total | 497 | 99.4 |
| Missing | | 3 | 0.6 |
| | Total | 500 | 100 |


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**Table 2:** Distribution as Per Gender.

| | Frequency | Percent |
|---|---|---|
| Males | 262 | 52.4 |
| Female | 238 | 47.6 |
| Total | 500 | 100 |

**Table 3:** Position of MF.

| | | Frequency | Percent |
|---|---|---|---|
| | Above | 300 | 60 |
| | Below | 187 | 37.4 |
| | Total | 487 | 97.4 |
| Occlusal level | | 13 | 2.6 |
| | Total | 500 | 100 |

**Table 4:** Comparison of Numerical Variables as Per Age groups.

| Age Groups | | N | Mean | Std. Deviation | Std. Error | p Value of One-Way ANOVA |
|---|---|---|---|---|---|---|
| MF-A (in mm) | 20-30 years | 161 | 15.232981 | 1.9917878 | 0.1569749 | |
| | 31-40 years | 90 | 14.799 | 2.3758098 | 0.2504323 | |
| | 41-50 years | 118 | 15.088136 | 2.3827431 | 0.2193493 | 0.53 |
| | 51-60 years | 93 | 14.876344 | 2.0764936 | 0.2153224 | |
| | >60 years | 35 | 14.84 | 2.2426612 | 0.3790789 | |
| | Total | 497 | 15.025594 | 2.1925243 | 0.0983482 | |
| MF-P (in mm) | 20-30 years | 161 | 13.705031 | 2.1680723 | 0.170868 | |
| | 31-40 years | 90 | 14.406667 | 3.1431681 | 0.331319 | |
| | 41-50 years | 118 | 13.817034 | 2.0980615 | 0.1931422 | 0.066 |
| | 51-60 years | 93 | 13.586022 | 2.426242 | 0.2515896 | |
| | >60 years | 35 | 14.502857 | 2.3849387 | 0.4031282 | |
| | Total | 497 | 13.892596 | 2.4318282 | 0.1090824 | |
| MF-S (in mm) | 20-30 years | 161 | 17.450932 | 3.873195 | 0.3052505 | |
| | 31-40 years | 90 | 18.560667 | 4.8257925 | 0.5086832 | |
| | 41-50 years | 118 | 18.605932 | 4.4020837 | 0.4052446 | 0.026* |
| | 51-60 years | 93 | 17.123656 | 3.3248536 | 0.3447713 | |
| | >60 years | 35 | 18.062857 | 3.8895097 | 0.6574471 | |
| | Total | 497 | 17.907968 | 4.1297207 | 0.1852433 | |
| MF-I (in mm) | 20-30 years | 161 | 24.777019 | 3.5902515 | 0.2829515 | |
| | 31-40 years | 90 | 24.978556 | 3.4898207 | 0.3678594 | |
| | 41-50 years | 118 | 24.786441 | 3.6856598 | 0.3392925 | 0.091 |
| | 51-60 years | 93 | 25.594624 | 4.4946675 | 0.4660753 | |
| | >60 years | 35 | 26.474286 | 4.3633731 | 0.7375447 | |
| | Total | 497 | 25.08827 | 3.852122 | 0.1727913 | |
| MF-O (in mm) | 20-30 years | 161 | 3.046708 | 1.4929986 | 0.1176648 | |
| | 31-40 years | 90 | 3.351111 | 2.6045873 | 0.2745476 | |
| | 41-50 years | 118 | 3.491525 | 1.9867758 | 0.1828975 | 0.265 |
| | 51-60 years | 93 | 3.462366 | 1.5819576 | 0.1640414 | |
| | >60 years | 35 | 3.545714 | 2.1367021 | 0.3611686 | |
| | Total | 497 | 3.320362 | 1.9192154 | 0.0860886 | |


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*: Statistically Significant Difference (p<0.05)

**: Statistically Highly Significant Difference (p<0.01)

#: Non-Significant Difference (p>0.05)

**Table 5:** Comparison of Variables Between Gender.

| Gender | | N | Mean | Std. Deviation | Std. Error Mean | t value | p value |
|---|---|---|---|---|---|---|---|
| MF-A (in mm) | Males | 262 | 15.71534 | 2.048903 | 0.126582 | 7.571 | 0.000** |
| | Females | 238 | 14.3021 | 2.123158 | 0.137624 | | |
| MF-P (in mm) | Males | 262 | 14.5779 | 2.417744 | 0.149369 | 6.971 | 0.000** |
| | Females | 238 | 13.13034 | 2.204779 | 0.142915 | | |
| MF-S (in mm) | Males | 262 | 18.6842 | 4.310238 | 0.266287 | 4.485 | 0.000** |
| | Females | 238 | 17.06092 | 3.723926 | 0.241386 | | |
| MF-I (in mm) | Males | 262 | 26.18359 | 3.929961 | 0.242794 | 7.07 | 0.000** |
| | Females | 238 | 23.85912 | 3.36458 | 0.218093 | | |
| MF-O (in mm) | Males | 262 | 3.230992 | 2.136419 | 0.131988 | -1.119 | 0.264# |
| | Females | 238 | 3.423109 | 1.641784 | 0.106421 | | |

*: S Significant Difference (p<0.05)

**: Statistically Highly Significant Difference (p<0.01)

#: Non-Significant Difference (p>0.05)

**Table 6:** : Comparison of Position of MF with Gender.

| | | Position of MF | | Total |
|---|---|---|---|---|
| | | 1 | 2 | |
| Gender | Males | 148 | 105 | 253 |
| | Females | 152 | 82 | 234 |
| Total | | 300 | 187 | 487 |

## Result

Comparing anatomical landmarks with the position of mandibular foramen, there was a statistically significant difference seen with a comparison of means of MF-O (in mm) with respect to the position of MF (p<0.05) with higher values of MF-O in a position below (Table 3). Comparing anatomical landmarks as per Age groups, there was a statistically significant difference seen with a comparison of MF-S between age groups (p<0.05), with higher values for 41-50 years & least for 51-60 years. (Table 4). As per Gender, there was a statistically highly significant difference seen with comparison of all numerical variables between gender (p<0.01), with higher values in males as compared to females except for MF-O where there was a statistically non-significant difference seen with comparison between gender (p>0.05) (Table 5 & 6)

**Table 7:** Comparison of Numerical Variables as Per Third Molar.

| Third Molar | | N | Mean | Std. Deviation | Std. Error Mean | t value | p value |
|---|---|---|---|---|---|---|---|
| MF-A (in mm) | Present | 324 | 15.02256 | 2.3044641 | 0.1280258 | -0.202 | 0.840# |
| | Absent | 172 | 15.06459 | 1.9979763 | 0.1523443 | | |
| MF-P (in mm) | Present | 324 | 14.0025 | 2.568409 | 0.1426894 | 1.171 | 0.242# |
| | Absent | 172 | 13.735 | 2.1174042 | 0.1614506 | | |
| MF-S (in mm) | Present | 324 | 18.38938 | 4.447956 | 0.2471087 | 3.469 | 0.001** |
| | Absent | 172 | 17.05233 | 3.2940395 | 0.2511682 | | |
| MF-I (in mm) | Present | 324 | 24.69404 | 3.8591732 | 0.2143985 | -3.246 | 0.001** |
| | Absent | 172 | 25.86221 | 3.7298734 | 0.2844002 | | |
| MF-O (in mm) | Present | 324 | 3.412346 | 2.0166571 | 0.1120365 | 1.425 | 0.155# |
| | Absent | 172 | 3.154186 | 1.725572 | 0.1315736 | | |


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*: Statistically Significant Difference (p<0.05)

**: Statistically Highly Significant Difference (p<0.01)

#: Non-Significant Difference (p>0.05)

Comparing the position of various anatomical landmarks with presence or absence of mandibular third molar, There was a statistically highly-significant difference seen with comparison of means of MF-S (in mm) & MF-I (in mm) with respect to third molar (p<0.01) with higher values of MF-S (in mm) in third molar present cases & MF-I (in mm) having lower values in third molar present cases, Also there was a statistically non-significant difference seen with comparison of means of MF-A, MF-P & MF-O with respect to third molar (p>0.05) (Table 7). The means and distribution of ages, as well as distances from the examined landmarks to the MF with the standard deviations, are summarized in Table below.

## Discussion

Local anesthetic failure is an unavoidable aspect of dental practice. A number of factors contribute to this, which may be related to either the patient or the operator. Patient-dependent factors may be anatomical, pathological or psychological. The setting up of many dental treatments depends upon achieving excellent local anesthesia. Pain-free functioning is of obvious benefit to the patient, it also helps the operator as treatment can be performed in a calm, unhurried manner. The MF cannot be palpated clinically; therefore, there are specific landmarks to determine its location such as the external and internal oblique ridges, the anterior border of the ramus, and the occlusal plane [3]. The mandible is in a constant phase of remodeling with growing age. It shows a differential growth pattern and remodeling at different areas. The eruption and shedding process of the teeth plays an important role in bone remodeling, particularly at the anterior border of the ramus and the alveolar crestal plane, which may affect the position of MF and, hence, affect the successful action of local anesthesia (IANB) [4]. The understanding of the MF position is of a prime importance for surgical procedures in dentistry and enables a more effective anesthesia effect [5]. Various studies have been done for investigation of the position of MF using autopsy specimens and radiographic techniques such as panoramic, lateral oblique, cephalometric radiography and CT [1]. With advancement in digital imaging and introduction of CBCT, MF position investigation by using a 3-dimensional plane and measurement points has become easier [6]. CBCT allows 3D visualization of the oral and maxillofacial complex at a much smaller radiation dose than produced by conventional CT [6] and provides an image with minimal unequal magnification and distortion and produces more reliable and accurate data [2].

In the present study, the position of MF in 3-dimensions was measured relative to the structural landmarks in the oral cavity which can easily be referred for surgical procedures. In this study we observed the mean distance from MF-A was 15.08±2.3 mm, MF-P was 13.8±2.09mm, MF-S was 18.6±4.4mm, and MF-I was 24.78±3.6 mm. This result clearly showed that MF is positioned posterior to the midpoint of the ramus of mandible horizontally and above the midpoint of the ramus of mandible vertically. We observed significant variation in the position of mandibular foramen in vertical position i.e. MF-S higher at 41ysr to 50 years age group which decreases with age; the results were in consistent with the result obtained by [2]. except for MF-P, which increases with age in their results. The means of the distance from the midpoint of mandibular foramen shows a higher value for males of MF-A, MF-P, MF-S, and MF-I than the Females of same age group except for MF-O, the results are inconsistent with the results obtained in previous studies.

The molar occlusal plane may help to locate the MF. In this study, the result showed that the location of mandibular foramen was 3.2±2.0 mm above the level of the occlusal plane on the higher side. In the previous studies by [2]. in his study in CBCT images found that the location of the MF is just posterior to the middle of the ramus, 2.5-3.6 mm above the occlusal plane of the molars [7]. found that the MF is positioned nearly 1.58 mm behind the midpoint of the ramus horizontally 4.27 mm above the midpoint vertically. Nicholson's in 1985 [8] concluded from his studies on 80 dry bones that the position of the MF was variable which was responsible for the occasional failure in IAN Block [9]. stated that "In children aged 3 years MF is located 4.12 mm below the occlusal plane; in 9 years at the occlusal plane; in adults, it is 4.16 mm above the occlusal plane" our results are consistent with the results reported in the previous studies [10]. in his study of Dry mandible found that the position of mandibular foramen is at the level of the occlusal plane. This was observed in only a few subjects in our study. Presence or absence of mandibular third molar may affect the position of mandibular foramen we observed means of MF-S (in mm) & MF-I (in mm) with respect to the third molar (p<0.01) with higher values of MF-S (in mm) in third molar present cases & MF-I (in mm) having lower values in third molar present cases. If the third molar is absent lower values of MF-S (in mm) & MF-I (in mm) having higher values. The result showed if the third molar is absent the mandibular foramen is positioned slightly above the middle of the ramus of mandible vertically. The above findings help in the success of anesthesia of the IAN block. When a dentist is aware of the location of MF from the anterior border of ramus, he/she could be sure of his/her depth of insertion to reach the nerve. The knowledge of the position of MF in relation to the occlusal plane of mandibular teeth helps the dentist to select the site of needle insertion.

## Conclusion

CBCT is often an investigation of choice prior to any dental or surgical procedure still Radiologist should always look for secondary anatomical landmarks or vital structures. This would


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be helpful for a Dentist to introduce a new technical modification to create more successful anesthesia and to perform good surgeries in the Ramus of the mandible.

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