**Original article:**

**3D Computed Tomography (3D-CT) Study of the Mandibular Foramen in Iraqi Adults**

_Haider Ali Hasan¹, Hassan Faleeh Farhan AL-Sultani², Ahmed Hindy³, Hanan Ali Hameed⁴, Mohammad Khursheed Alam⁵._

**Abstract:**

**Purpose:** One of the extremely important mandibular anatomical landmarks is the Mandibular Foramen (MF). Knowledge the precise position of MF is essential for ramus surgical operations, administration of mandibular local anesthesia, and implants placement. This research was carried out to examine the precise location of MF in addition to evaluate the differences of its position between the right and left sides of the mandible and between males and females.

**Materials and Methods:** This is a retrospective study based on CT gathered from CT database presented at the Radiology Department, Hospital of Hilla. Subjects were Iraqi adults with no craniofacial abnormalities. A total of 60 head and neck scans were collected. CT images were of high resolution and reconstructed into 3D. Analyses were carried out by using MIMICs v7.0 (Materialised Corporation, Belgium), on each side of the mandible, seven landmarks were chosen to determine the distances from these landmarks to MF. **Results:** The descriptive statistical analysis containing means, standard deviations, minimum and maximum values for each variable were calculated for right and left mandible separately in addition to males and females. There were no differences noticed between the right and left measurements for both genders. Most males measurements tended to have larger measurements than females.

**Conclusion:** the MF location was highly variable amongst the Iraqi subjects. In both sides of the mandible, the MF position was more or less symmetrical and its position also displayed evidence of sexual dimorphism.

**Keywords:** 3D-CT; Mandibular foramen, Iraqi adult.

---

**Introduction**

The mandibular foramen (MF) is a hole located on the surface of ramus of mandible internally and considered as a slot for the mandibular vessels and nerve divisions. It is one of the most considerable anatomical mandible landmarks. Anatomical knowledge of its location is extremely important due to the route of the inferior alveolar nerve and its blood vessels through the foramen into the canal of the mandibular. The knowledge of these structures is crucial for a number of reasons, for examples, in administration of mandibular block injection, surgical intervention of the ramus and placement of implants. Knowing the correct location of MF is crucial due to a number of reasons particular for successful administration of local anesthesia and also for

---

1. Haider Ali Hasan Lecturer, Oral and Maxillofacial Surgery Department, College of Dentistry, University of Babylon, Iraq.
2. Hassan Faleeh Farhan AL-Sultani, Lecturer, Department of Preventive, Orthodontics and Pediatric Dentistry (P.O.P), College of Dentistry, University of Babylon, Iraq.
3. Ahmed Hindy, Lecturer, Prosthodontic Department, College of Dentistry, University of Babylon, Iraq.
4. Hanan Ali Hameed, Assistant Lecturer, Prosthodontic Department, College of Dentistry, University of Babylon, Iraq.
5. Mohammad Khursheed Alam, Associate Professor, Orthodontic Department, College of Dentistry, Jouf University, Sakaka, KSA.

**Correspondence to:** Dr. Haider Ali Hasan, College of Dentistry, University of Babylon, Iraq. Aljamea sq. 60 street. email: alshammar79@yahoo.com
any surgical intervention involving the mandible. The attempts to determine the location of MF are mostly done on cadavers and in other populations. Researchers also found that location of MF varies within the populations studied.

An earlier study by Nicholson on adults of East Indian dry skulls with age eighty years reported that the location of the MF was highly changeable. Another study on Zimbabwean mandibles showed that MF was also highly individualistic. Currently, information about MF position in Iraqi population is still lacking.

Previously, researches have used tools that include mostly dried cadavers and radiograph such as dental panoramic and lateral cephalometric to conduct their examination on MF. The advent of computed tomography (CT) has delivered as new means for medical inspection and now considered one of the excessively utilized imaging processes.

CT lets the gaining of speedy, reliable and reproducible images. Also, CT gets superior visualization than any other radiographic method. The quality of image was advanced with the coming of multislice CT Scanning, which gives extra slices in a short time. Furthermore, CT images can be reconstructed in to three dimensional (3D) images for better visualization.

The periapical, CT and panoramic radiographs accuracy in detecting the canal of mandible evaluated by Sonick et al. They discovered that CT is better technique in localizing the canal of mandible than others. Five different radiographic methods that used for visualization the canal of the mandibular have been studied by Lindh et al., i.e. periapical radiography, hypocycloidal tomography, panoramic radiography, computerized tomography and spiral tomography. They observed that direct CT visualization is the best tested methods, and in addition it provided a high inter- and intraobserver conformity rate.

CT imaging

CT images collections were carried out in the hospital of Hilla. These scans were of high resolution, helical scans obtained with General Electric (GE) Light Speed plus CT Scanner System (GE Company, Medical system group, Wisconsin, USA). The resolution of CT was at 1.25 mm spacing and 1.25 mm thickness. These scans were kept in a CT database at the Radiology Department of Hilla Hospital.

3D Reconstruction

CT scans were kept in DICOM3 format, transmitted to a personal computer, and recreated with a 3D image-segmentation program Mimics V17.0 software (Materialise, Leuven, Belgium). This software used the current axial view to produce sagittal and coronal cross-sections views. The Hounsfield Unit (HU), which expresses the gray scale, was accustomed for every tissue in the CT system.

Measurements

In this study seven points were chosen carefully and six mandibular parameters were frequently determined between recognized point landmarks on each of the 3D image-segmentation utilizing Mimics software program. Table 1 lists the landmarks used in this research and the linear distances distinct utilizing the landmarks that mentioned above. The six linear measurements performed on each 3D image. All the measurements done by single radiologist and repeated 3 times. Then after 2 weeks the second measurements were performed, which the results were blinded to decrease the bias of the examiner’s. For the third time, which is 2 weeks after the second measurements, the same blinding was done. The averages of three readings of each measurement were considered for the statistical analysis in order to reduce the intra-examiner variation.

Statistical analysis

SPSS software 22.0 (IBM, Armonk, NY, USA) was used to analyze the data. Normal distribution test has been used to evaluate the normality of the data. General descriptive statistics were calculated for each parameter and the differences between mean values for two sided of mandible and for two genders were compared utilizing independent t-tests. Statistical significance was set at $p<0.05$.

Results

Results for distances of MF from other mandibular landmarks are presented in tabular form separately for males and females. Means, standard deviations
(SD), minimum and maximum values are presented. From these tables, results showed that the variations of MF in different individuals were quite high as can be viewed from the maximum and minimum values. Differences between the left and right distances of MF from other mandibular landmarks are presented in Table 2 for males and Table 3 for females. None of the left and right measurements showed statistically significant differences \((p>0.05)\). Most measurements revealed that males have statistically significant larger distances of MF from other mandibular landmarks than females (Table 4).

**Discussion**

As far as the author is aware, this is the first 3D-CT study that looks into the precise location of MF in Iraqi population. In many previous studies, measurements of the craniofacial region including the mandible were performed individually for females and males for the reason that the differences were significantly detected between both genders.9 Other investigators Waitzman et al.10 have attained that the differences not significantly occurred between the genders or a variance just in some of the variables that measured. The variations in the size of the sample considered one of the reasons for disagreement between various studies, method of subject selection, method of measurement, landmarks used, regions studied or type of analysis carried out. In this study, measurements were standardized as much as possible. Differences in distances of MF from selected mandibular landmarks between males and females were observed. Therefore, results have been presented separately for males and females in the tables. Results were also presented separately for the left and right measurements.

Previous studies have used calipers with 0.05mm of error in their study.11 In this study, the use of MIMICs software produced more reliable digital measurement with precision of 0.01mm. Furthermore, in this study, 3D-CT images were utilized which was known to produce very reliable, precise and accurate image as compared to panoramic and cephalometrics radiograph.12 Results from error study further enhanced that the landmark location on 3D-CT using MIMICs software is both accurate and reproducible.

In Iraqi population, the distances between maximum and minimum values of MF to the selected landmarks are quite large. These findings are consistent with previous studies which conclude the same variability.13 Interpretation of location of MF to these mandibular landmarks can be difficult. However, landmarks that can be visualized clinically such as occlusal plane, gonion and menton are still recommended to be used to determine the location of MF by palpating on these landmarks.

In this study, no differences were noted between the left and right measurements. A study by Mbarj Kor1 showed that there was also no side variation in the position of MF. Another study by Goudot14 concluded that the position of left and right mandibular canal is symmetrical. From the lack of asymmetry finding, it can be concurred that measurements of MF from each landmark on one side are applicable to the contralateral measurements of the mandible.

MF and mandibular canal research are not uncommon.15-18 When locating MF in different genders, it is important to note that the distance of each variable to MF is generally larger in males as compared to females. This is not surprising as males have been shown to generally have larger mandible rather than female.19 These findings emphasized the need for clinicians to take sex differences into consideration when performing treatment as also suggested by Huertas and Ghafari.20

**Conclusion**

This study revealed that the location of MF in Iraqi adults showed quite high individual variability, but it can still be located with reference to specific landmarks in the mandible. Clinically visible landmarks such as occlusal plane, menton and gonion provide the best reference in clinical setting. Due to its variation in different individuals, it is recommended to individually identify the MF position prior to any clinical procedures. The measurements obtained from this study may provide surgeons and dentists with the correct and successful mandibular anesthesia, prevent inferior alveolar nerve injury during mandibular surgery and produce better outcome of intraosseous implant of the mandible.

**Acknowledgement:** None.

**Financial support and sponsorship:** None

**Conflict of Interest:** There are no conflicts of interest.

**Authors’ contribution**

HAH, HFA, AH, HAH and MKA contributed in data gathering and idea owner of this study. Study designed by HAH, HFA. Writing and submitting manuscript contributed by HAH, HFA, AH, HAH and MKA. Editing and approval of final draft done by HAH, HFA, AH, HAH and MKA.
**3D Computed Tomography (3D-CT) Study of the Mandibular Foramen in Iraqi Adults**

**Figure 1.** Illustration of human mandible showing various landmarks used in this study. A, MF. B, occlusal plane. C, condylion. D, coronoid tip. E, coronoid notch. F, gonion. G, menton.

**Table 1.** Definition of anatomical landmarks of the mandible and relevant length

| Mandibular landmarks / Mandibular length parameters | Definition |
|-----------------------------------------------------|------------|
| Mandibular foramen (MF)                             | Centre of Mandibular foramen |
| Occlusal plane                                      | The height of the cusps of the mandibular permanent molars |
| Condylion                                           | The most superior and posterior point of the condyle |
| Coronoid tip                                        | The most superior point on the coronoid process |
| Coronoid notch                                      | The most inferior point of the Mandibular notch |
| Gonion                                              | The most posterior and inferior point of the mandible |
| Menton                                              | Most inferior point of symphysis |
| MF- condylion                                       | |
| MF- coronoid tip                                    | |
| MF- coronoid notch                                  | |
| MF- gonion                                          | |
| MF-menton                                           | |
| MF-occlusal plane                                   | |

**Table 2:** Mean differences between left and right distances of MF from other mandibular landmarks in male.

| P value | SD    | Mean  | Variables          |
|---------|-------|-------|--------------------|
| 0.89    | ±0.2  | 0.07  | MF - Occlusal Plane |
| 0.96    | ±0.3  | 0.09  | MF-Condylion        |
| 0.97    | ±0.6  | 0.01  | MF-Coronoid         |
| 0.99    | ±0.6  | 0.006 | MF-Coronoid Notch   |
| 0.98    | ±0.3  | 0.01  | MF-Gonion           |
| 0.97    | ±0.3  | 0.04  | MF-Menton           |

**Table 3:** Mean differences between left and right distances of MF from other mandibular landmarks in female.

| P value | SD    | Mean  | Variables          |
|---------|-------|-------|--------------------|
| 0.96    | ±0.2  | 0.04  | MF- occlusal plane |
| 0.84    | ±0.2  | 0.08  | MF-condylion       |
| 0.98    | ±0.4  | 0.02  | MF-coroind         |
| 0.91    | ±1.1  | 0.02  | MF-coroind notch   |
| 0.93    | ±0.3  | 0.07  | MF-gonion          |
| 0.87    | ±0.51 | 0.04  | MF-menton          |

**Table 4:** Differences of means between males and females of mandibular variables

| P value | SD    | Mean  | Variables          |
|---------|-------|-------|--------------------|
| 0.01    | ±0.3  | 0.43  | MF- occlusal planeL |
| 0.05    | ±0.3  | 0.47  | MF-occlusal plane -R |
| 0.002   | ±0.49 | 1.86  | MF –condyle -L     |
| 0.002   | ±0.49 | 1.83  | MF- condyle-R      |
| 0.01    | ±0.9  | 1.56  | MF-coroind -L      |
| 0.01    | ±0.9  | 1.43  | MF-coroind-R       |
| 0.001   | ±0.90 | 2.36  | MF-coroind notch-L |
| 0.001   | ±0.91 | 2.34  | MF-coroind notch-R |
| 0.05    | ±0.4  | 0.08  | MF-gonion-L        |
| 0.04    | ±0.4  | 0.3   | MF-gonion-R        |
| 0.8     | ±0.5  | 0.10  | MF-mention -L      |
| 0.8     | ±0.73 | 0.12  | MF-mention-R       |
References:

1. Mbarjiorgu EF. A study of the position of the mandibular foramen in adult black Zimbabwean mandibles. *Cent Afr J Med* 2000;46(7):184-190.

2. Gowgiel JM. The position and course of the mandibular canal. *J Oral Implant* 1992;18:383-385.

3. Nicholson ML. A study of the position of mandibular foramen in the adult human mandible. *Anat Rec* 1985; 212:110-112.

4. Cormack AM. Early two-dimensional reconstruction (CT scanning) and recent topics stemming from it. Noble lecture, December 8, 1979. *J Comput Assist Tomogr* 1979;4:658-664.

5. Hounsfield GN. Nobel lecture, 8 December 1979. Computed medical imaging. *J Radiol* 1980;61:459-468.

6. Herman GT and Liu HK. Display of three-dimensional information in computed tomography. *J Comput Assist Tomogr* 1977;1:155-160.

7. Sonick M, Abrahams J and Faiella RA. A comparison of the accuracy of periapical, and computerized tomographic radiographs in locating the mandibular canal. *Int J Oral maxillifac Imp* 1994;9:455-460.

8. Lindh c, petersson A and Klinge B. Visualization of the mandibular canal by different radiographic techniques. *Clin Oral Impl Res* 1992;3:90-97.

9. Farkas LG, Posnick JC and Hreczko TM. Anthropometric growth study of the head. *Cleft Palate Craniofac J* 1992;29:303-308.

10. Waitzrman AA, Posnick JC, Armstrong DC et al. Craniofacial skeletal measurements based on computed tomography: Part 11. Normal values and growth trends. *Cleft Palate Craniofac J* 1992;29:118-128.

11. Uchida Y, Yamashita Y, Goto M et al. Measurement of anterior loop length for the mandibular canal and diameter of the mandibular incisive canal to avoid nerve damage when installing endosseous implants in the interferominal region. *J Oral Maxillofac Surg* 2007;65:1772-1779.

12. Ylikontiola L, Kirmunen J and Oikarinenu K. Factors-Affecting Neurosensory Disturbance after Mandibular Bilateral Sagittal Split Osteotomy. *J Oral Maxillofac Surg* 2000;58:1234-1239.

13. Afşar A, Haas DA and Rossouw PE. Radiographic localization of mandibular anesthesia landmarks. *Oral Surg Oral Med Oral pathol Oral RadiolEndod* 1998;86(2):234-241.

14. Goudot P. The mandibular canal of the “Old Man” of Cro-Magnon: anatomical-radiological study. *J Cranio-Maxillofac Surg* 2002; 30:213-218.

15. Zaman S, Alam MK, Enezei HH, Basri R, Rahman SA. Mental foramen, inferior alveolar canal and morphology of maxillary sinus: a review. *Int J Pharma Bio Sci* 2015; 6(3):1222-1228.

16. Zaman S, Alam MK, Yusa T, Mukai A, Shoumura M, Rahman SA, Basri R. Mental Foramen Position Using Modified Assessment System: An Imperative Landmark for Implant and Orthognathic Surgery. *J Hard Tissue Biol* 2016;25(4):365-370.

17. Alam MK, Alhabib S, Alzarea BK, Irshad M, Faruqi S, Sghaireen MG, Patil S, Basri R. 3D CBCT morphometric assessment of mental foramen in Arabic population and global comparison: imperative for invasive and non-invasive procedures in mandible. *Acta Odontologica Scandinavica* 2018;76(2):98-104.

18. Alam MK, Ganji KK, Alzarea BK, PatilS,Sghaireen M, Basri R, Suzuki Y, Sugita Y, Maeda H. 3D CBCT Assessment of the Mandibular Canal in a Saudi Arabian Subpopulation. *J Hard Tissue Biology* 2019;28(1):87-92.

19. Snodell SF, Nanda RS and Currier GF. A longitudinal cephalometric study of transverse and vertical craniofacial growth. *Am J Orthod Dentofacial Orthop* 1993;104:471-483.

20. Huertas D and Ghafari J. New posteroanterior cephalometric norms: a comparison with craniofacial measures of children treated with palatal expansion. *Angle Orthod* 2001;71:285-292.