Original article:

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

Haider Ali Hasan[1], Hassan Faleeh Farhan AL-Sultani[2], Ahmed Hindy[3], Hanan Ali Hameed[4], Mohammad Khursheed Alam[5].

Abstract:

Purpose: One of the extremely important mandibular anatomical landmarks is the Mandibular Foramen (MF). Knowledge the preciseposition of MF is essentialforramus surgical operations, administration of mandibular local anesthesia, and implants placement. This research was carried out to examine the precise location of MF in addition toevaluate 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 statisticalanalysis 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.

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Introduction

The mandibular foramen (MF) is ahole 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 blockinjection, 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: alshammari79@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.[1] Researchers also found that location of MF varies within the populations studied.[2]

An earlier study by Nicholson[3]on adults of East Indian dry skulls with age eighty yearsreported that the location of the MF was highly changeable. Another study on Zimbabwean mandibles showed that MF was also highly individualistic.[1]Currently, information about MF position in Iraqi population is still lacking.

Previously, researches have used tools that include mostly dried cadavers and radiograph such a dental panoramic and lateral cephalometric to conduct their examination on MF.The advent of computed tomography (CT) has deliveredas new means for medical inspectionand now considered one of the excessively utilized imaging processes.[4,5]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.[6]

The periapical, CTand panoramic radiographs accuracy in detecting the canal of mandible evaluated by Sonick et al.[7] They discovered that CT is better techniquein 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.[8], 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 intraobserverconformity rate.

Subjects and methods

Subjects

This was a retrospective study of Iraqi subjectswho had their CT scan at the Radiology Department, Hospital ofHilla to diagnose conditions other than craniofacial deformities. Randomly selected 60 individuals CT scans (30 males and 30 females) with an age range of 18 - 40 years were taken.All subjects had a good health status, anddidn'thave any considerable systemic disease.

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 1.25mm 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 sixmandibular parameters were frequentlydetermined between recognized point landmarks on each of the 3D image-segmentation utilizingMimics 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. Thenafter 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 performedindividuallyfor females and males for the reason thatthe differences were significantlydetected between both genders.[9] Other investigators Waitzman et al.[10] have attainedthat the differences not significantly occurred between the genders or a variancejust in some of the variables that measured.Thevariations in the size of the sample considered one of the reasons for disagreement between variousstudies, method of subject selection, method of measurement, landmarks used, regions studied or typeof 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 MlMICs 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 Mbarjiorgu[1] showed that there was also no side variation in the position of MF. Another study by Goudot[14] 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.

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Authors' contribution

HAH, HFA, AH, HAH and MKAcontributed in data gathering and idea owner of this study. Study designed byHAH, HFA. Writing and submitting manuscript contributed byHAH, HFA, AH, HAH and MKA. Editing and approval of final draft done by HAH, HFA, AH, HAH and MKA.

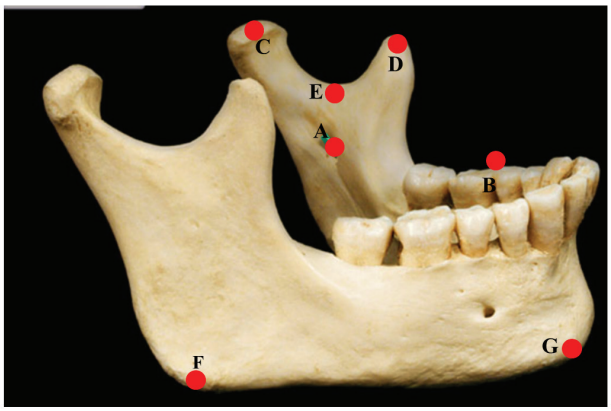

Figure 1. Illustration of human mandible showing various landmarks used in this study . A, MF. B, occlusal plane. C, condylion . D, coronoid tip. E, coronoid notch. F, gonion. G, menton.

Table1. 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-coronoid
0.91	±1.1	0.02	MF-coronoid 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-coronoid -L
0.01	±0.9	1.43	MF-coronoid-R
0.001	±0.90	2.36	MF-coronoid notch-L
0.001	±0.91	2.34	MF-coronoid 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

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