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Analysis of Mental Foramen Using Cone Beam Computed Tomography for Gender Determination in a Sample of Yemeni Population

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Abstract

Aim: To analyze the mental foramen dimensions and location for gender determination in a sample of Yemeni population. ***Methods:*** This is a retrospective study performed on 420 maxillofacial CBCT scans, 210 males and 210 females with age ranged from 20 to 60- years old. Osteometric analysis of the dimensions, shape and position of the mental foramen was performed. ***Results:*** In comparison between males and females, all mental foramen (MF) measurements were statistically significant except at the distance from the superior mental foramen to the alveolar crest. The all measurements of males were higher than females. MF with round shape was the most common between both males and females. The most common location of the MF was presented below the apices of the 2nd premolars. ***Conclusions:*** We can be concluded that the vertical and horizontal dimensions the MF and the distance from the lower border of the MF to the lower border of the mandible exhibits gender dimorphism in the Yemeni population. The shape and horizontal position of the MF do not show any difference denoting that they cannot be used for identification of gender.

Keywords: Mental foramen, Gender dimorphism, Sex determination, Mandible, Forensic anthropology.

INTRODUCTION

Gender is the determining characteristics for every human individual [1]. The mandible is the strongest bone and can withstand the taphonomic process much better than the other skeletal structures. Among various physiognomic features of the mandible that can be used in forensics, the mental foramen is considered to be one of the most stable and important landmarks [2].

Two-dimensional imaging modalities, including intra oral, extra oral, and panoramic radiography were used in the assessment of the mandible the mental foramen, but there are drawbacks of them, because mental foramen usually visible only in 50% of cases, due to canal opens superiorly and posteriorly in the mandible [3].

Hence, three-dimensional (3D) images specifically cone-beam computed tomography (CBCT) is upswing [4]. CBCT is a three-dimensional technology, become the most acceptable radiographic tool in dentistry for diagnosis, and treatment planning, because it provides 3D views of the dental arches and surrounding tissues with high resolutions and low dose of radiation [5]. Many recent studies proved that measurement of the CBCT is reliable and provide near accurate location and measurements of the anatomical landmarks [6-8].

Therefore, this study, was conducted for Yemeni adult population to differentiate gender depending on the CBCT morphometric analysis of the mental foramen.

SUBJECTS AND METHODS

Sample Size

The study sample size includes 420 CBCT images of mental foramen, 210 males and 210 females, with age ranged from 20 to 60-years old. The retrospective data had been collecting from January 2022 to December 2023 in the archive of many private radiology centers at Sana'a city, Yemen.

Inclusion Criteria:

1. Ages between 20 and 60 years.
2. Presence of premolars teeth.

3. No evidence of bone resorption in premolar region.

Exclusion Criteria:

1. Patients who have congenital or developmental disturbances in the mandible.
2. Patients with surgical intervention to the mandible or undergone orthognathic surgery.
3. Fracture of the lower jaw at the mental foramina area
4. Bad resolution Images.
5. Images with Crowding teeth.

Image Evaluation

In this study, all images were taken by a CBCT system unit (PaX-Flex3D P2, Vatech, Korea) using the following exposure parameters: kVP = 77 - 90, mA = 4.7–5.7, t =15–24 seconds, field of view = (12×8.5), and (12×9) cm, images were analyzed using measurements tools given in the software (Ez3D plus with Ez3D-I software).

Image Analysis:

All images were separately studied and analyzed for every case. first: The axial sections were generated in a way to exhibit the MF, and second: The panoramic curve was drawn to generate a panoramic view, and obtain data needed for the study.

Study Variables

1. **Measurements of MF:** CBCT images were measured according to *Bobat, 2015*(9) the following, figure 1:
   - Horizontal diameter of MF (HMD): horizontal distance from inner mesial to the distal side of the foramen.
   - Vertical diameter of MF (VMD): vertical distance from inner superior to the inferior side of the foramen.
   - Vertical distance from the superior margin of MF to the alveolar ridge (M1).
   - Vertical distance from the inferior margin of MF to the inferior border of the mandibular (M2).

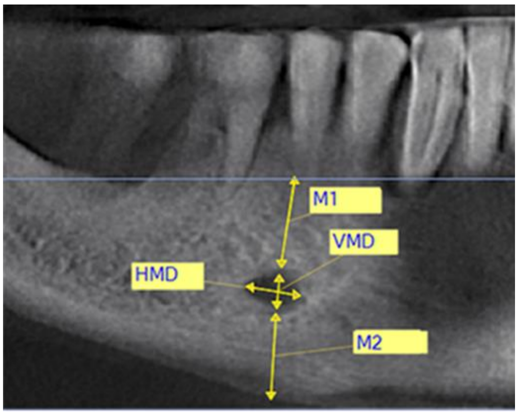

Figure 1: Mental Foramen Measurements

2. **Shape of MF:** The shape of MF was assessed according to the classification "proposed by *Zhang et al., (2015)* (10) depending on the ratio of two diameters (H: V), since H represented as a horizontal diameter of MF and V represented as a vertical diameter of MF, into one of three Types (Figure 3.9):
   - Type I: oval horizontal form, (H: V>1.24).
   - Type II: oval vertical form, (H: V<0.76).
   - Type III: round form, (0.76 ≤ H: V ≤ 1.24)".

3. **Position of Mental Foramen:** Position of MF was assessed according to the classification "proposed by *Aoun et al., (2017)* (11) which is as follows:
   - Position 1: In line with the long axis of the 1st premolar.
   - Position 2: Between the 1st and 2nd premolars.
   - Position 3: In line with the long axis of the 2nd premolar, figure 2.
   - Position 4: Between the 2nd premolar and the 1st molar.
   - Position 5: Under 1st molar.

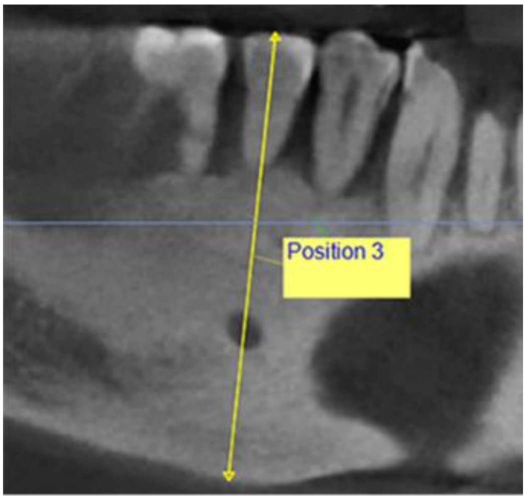

Figure 2: Position of Mental Foramen

Statistical Analysis:

Data were analyzed by the Statistical Package for Social Sciences (SPSS) version 24. Descriptive statistics (mean, variance, standard deviation, and minimum and maximum values) were used in the data analysis. The mean differences in the measurements of MF were analyzed by T-test in which *p-value* less than 0.05 was considered statistically significant.

RESULTS

Mental Foramen Measurements:

a. **Horizontal and Vertical Diameter of Mental foramen:** Table 1 illustrates that the Mental foramen height (MF-H) and width (MF-V) of 420 CBCT images were analyzed according to gender. The mean and SD of the MF-H in males were 3.94 mm and 0.90, while in females, they were 3.52 mm and 0.92, respectively (p = 0.000). Moreover, the mean and SD of the MF-V were 3.18 mm and 0.81 in males, while they were 2.96 mm and 0.81 in females (p = 0.005). The mean differences between male and female measures of both vertical and horizontal MFs. Significant differences between genders were shown in both MF-H (p = 0.000) and MF-V (p = 0.005).

b. **Vertical Distance from Superior Margin of MF to the Alveolar Ridge and from Inferior Margin of MF to the Inferior Border of the Mandibular:** As shown in table 1, the mean (SD) of the distance from the MF to crest of alveolar ridge (MF-M1) and to the inferior border of the mandibular bone (MF-M2) in males was 7.57 mm (4.37) and 11.87 mm (1.99), but in females, it was 7.66 mm (4.39) and 10.06 mm (1.97), respectively. Moreover, there was a significant difference in only the mean lengths of MF-M2 regarding gender (p = 0.000), while no significant difference was shown in MF-M1.

Table 1: MF Measurements according to gender:

MF Measurements	Gender				*P-value*
	Male (n=210)		Female (n=210)		
	Mean	SD	Mean	SD	
MF-H	3.94	0.90	3.52	0.92	0.000*
MF-V	3.18	0.81	2.96	0.81	0.005*
MF-M1	7.57	4.37	7.66	4.39	0.848
MF-M2	11.87	1.99	10.06	1.97	0.000*

Significant (p<0.05)

Shape of the Mental Foramen:

The shape of the MF in this study was classified into three types; horizontal oval, vertical oval and round shape which were assessed according to the percent of horizontal height to the vertical width of the MF. Table 2 shows that most of the cases were round in the shape of MF representing 52.9% (n=222), followed by the oval horizontal MFs representing 45.2% (n=190), then the oval vertical MFs representing 1.9% (n=8). The oval horizontal, oval vertical and round shape of the MF in males were found in 102 (48.6%), 1 (0.2%) and 107 (51%) respectively. While in females, they were found in 88 (41.9%), 7 (1.7%) and 115 (54.8%), respectively.

Table 2: Shape of MF according to gender and age:

Shape of MF	Gender N (%)		
	Male	Female	Total
Oval Horizontal	102 (48.6%)	88 (41.9%)	190 (45.2%)
Oval Vertical	1 (0.2%)	7 (1.7%)	8 (1.9%)
Round	107 (51%)	115 (54.8%)	222 (52.9%)
Total	210 (100%)	210 (48.6%)	420 (100 %)

Position of the Mental Foramen:

Table 3 illustrates the different locations of MF in relation to the adjacent teeth and gender. Majority of cases (48.6%) showed MF under the apex of the 2nd premolar (Male = 48.09%, female = 49.05%). In both male and female, the most common position of mental foramen was under the apex of 2nd premolar, followed by position which was under the 1st premolar, and finally between 1st and 2nd premolar. The differences between gender were occurred in last two positions, which were between 2nd Premolar and 1st Molar, and under 1st molar.

Table 3: MF location according to gender with respect to adjacent teeth

MF Location	Gender N (%)		
	Male	Female	Total
Under Apex of 1st Premolar	41 (19.5 %)	44 (20.95%)	**85 (20.2%)**
Under Apex of 2nd Premolar	101(48.09%)	103 (49.05%)	**204 (48.6%)**
Between 1st & 2nd Premolar	36 (17.1%)	29 (13.8%)	**65 (15.5%)**
Between 2nd Premolar & 1st Molar	20 (9.5%)	23 (11%)	**43 (10.2%)**
Under 1st Molar	12 (5.7%)	11 (5.2%)	**23 (5.5%)**
Total	**210 (100%)**	**210 (100%)**	**420 (100%)**

DISSCUSSION

Forensic dentistry can have a key role in the identification of human gender. Calculation and morphometric analysis of the jaw and skull are precise method and can be used for gender determination [12-14]. The MF is stable landmark through life and bone resorption has no effect on the distance of mental foramen to lower border of mandible [15]. Lindh *et al.*, and Guler *et al.*, suggested the stability of the mental foramen doesn't depend on the alveolar process resorption above the foramen [16,17]. Therefore, in the present study MF was used as a landmark for gender determination, and the study used 420 CBCT images of the MF for male and females in sample of Yemeni population with age ranged from 20 to 60 -years old.

In this study the M1, vertical measurements from the superior edge of the mental foramen to the crest of the alveolar ridge showed no significant differences between males and females. In contrast to Ajmal *et al.*, [18] and Bose *et al.*, [19] who reported a significant difference which was higher in males than in females.

The data collected from this study showed a significant difference in M2, the distance from the lower border of the mental foramen to the lower border of the mandible, which was higher in males in comparison to females, this result is agreed with Suragimath *et al.*, [20] who studied the Maharashtra population in India, which were in accordance with a study carried out in the South Indian population by Mahima *et al.*, [21], a study conducted in the North Indian population by Chandra *et al.*, [22] and studies conducted in various parts of the world by Thomas *et al.*, [23] and Catovic *et al.*, [24]. The possible explanation is that males have a greater bite force due to greater muscle tone which can aid in the deposition of more bone in the lower border of the mandible. In contrast to perspective study conducted by Asrani and Shah, they found there was no significant difference in the distance from the lower border of the mental foramen to the lower border of the mandible [25]. On the contrary, Vodanovic *et al.*, found that the mean value from the inferior border of the MF to the lower border of the mandible does not exhibit sexual dimorphism [26].

Regarding horizontal and vertical MF dimensions, this study showed a statistically significant difference in the MF dimensions in relation to the gender, which was higher in males in comparison to females. This is similar to the results reported by Zmyslowska-Polakowska *et al.*, [27] of the Polish population. In addition, Gungor *et al.*, [28] Zhang *et al.*, [11] and Kalender *et al.*, [29] who found that the horizontal and vertical diameters of the MF in a CBCT study were higher in men in comparison to women.

According the shape of the mental foramen, round shape was the most common in both males and females (52.9%), followed by the horizontal oval (45.2%) and then vertical oval (1.9%). A similar result from other studies were obtained, in Malaysia and observed that the shape of MF was round in 54.4% and oval in 45.6% [30]. Besides, in the Egyptian population, it was round in 75% and oval in 25% [31]. Another study conducted in 2018 by using CBCT scans found that the round shape of the MF was higher than oval [32].

In the current study, the position of the mental foramen of the most of cases (males and females) were under the apex of the 2nd premolar. This result agrees with those reported by Al-Mahalawy *et al.*, [30], Panjnoush *et al.*, [33], Zhang *et al.*, [11], but it does not agree with those of Goyushov *et al.*, [32], Chen *et al.*, [35], Von Arx *et al.*, [36] and Kalender *et al.*, [29] who reported that most of the cases were located between the 1st and 2nd premolars. Previous studies have shown that the MF was commonly found between 1st and 2nd premolars. The second most frequent position of the MF was between the apices of the first and second mandibular premolar teeth roots. Regarding the gender, in this study, no significant differences were observed in the frequencies of the foramen's horizontal position and the second premolar teeth as the most common MF location in males and females, this consistent with other studies by Rodriguez-Cardenas *et al.*, [37] and Farhadi *et al.*, [38] who showed the line below the second premolar teeth as the most common MF location, with no significant difference in foramen position between males and females.

CONCLUSION

Based on the results of this study, we can be concluded that the vertical and horizontal dimensions the MF and the distance from the lower border of the MF to the lower border of the mandible exhibits gender dimorphism in the Yemeni population. The shape and horizontal position of the MF do not show any difference denoting that they cannot be used for identification of gender.

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