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CONE BEAM COMPUTED TOMOGRAPHIC ANALYSIS OF MENTAL FORAMEN RELATIVE TO THE AGE AND THE SEX

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ABSTRACT

Aim To analyze the mental foramen dimensions and location in relation to the age and the sex.

Methods: This study was done on 172 maxillofacial CBCT scans. Cases were analyzed from the archive of the Oral and Maxillofacial Radiology Department, Faculty of Dentistry, Ain-Shams University, using On-Demand software. Osteometric analysis of the dimensions and position of the mental foramen was done vertically, horizontally, and in relation to the midline. Classification of the mandibular canal emerging types was determined.

Results: The most common location of the mental foramen (MF) was presented in between and below the apices of premolars. The mandibular canal was emerging most in straight and posterior directions. All variables were statistically insignificant except horizontal position types 2 (in line with 4) and 3(between 4 and 5). In correlation with sex, all quantitative variables were statistically insignificant except superior and inferior mental foramen measurements. In correlation with age, all variables were statistically insignificant except for inferior mental foramen measurement, relation to the midline, and the MF vertical dimension which all showed inverse correlation.

Conclusions: In the studied sample of the Egyptian population, the most common location of the MF horizontally is between the first and second premolars, and vertically below the apices of premolars, commonly emerging straight or posteriorly as a MC. Males have a specific MF pattern and location other than females. MF pattern and location have a weak correlation with age. The vertical position and the relation to the midline are significantly different between the right and left sides.

KEYWORDS: mental foramen, Egyptian population, age, sex, cone beam computed tomography.

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INTRODUCTION

The relation between the mental foramen (MF) and the mandibular canal (MC) with the mandibular teeth is crucial for various dental procedures, such as, teeth extraction, implant insertion and even local anaethetic procedures. Moreover, the precision of the MF anatomy and morphology aids in forensic identification by enabling the determination of the person's age and sex [(1)].

Previous studies had evaluated the MF using different radiographic techniques such as cone beam computed tomography (CBCT), ultrasonography (US) and panoramic radiography [(2-5)]. Several morphometric and osteometric MF parameters were previously assessed in different populations [(2-8)]. However and to the best of our knowledge, limited studies were performed on the Egyptian population in relation to the age and the sex.

Therefore, this study was conducted to detect anatomical and morphological variations of the MF and the MC in relation to the age and the sex, using CBCT.

PATIENTS AND METHODS

Case selection

This work is a retrospective study that was approved by the Research Ethics Committee at the Faculty of Dentistry, Ain-Shams University (FDASU-Rec ER012320). Between January 2022 to August 2022, a total of 172 maxillofacial CBCT scans were analyzed from the archive of the Oral and Maxillofacial Radiology Department, Faculty of Dentistry, Ain Shams University, Cairo, Egypt.

The age range was selected between 20 and 60 years old. The documented age and sex of each case were considered the gold standard of the results. Exclusion criteria were the presence of impacted tooth, fracture, pathology, previous surgery or foreign body, at the region of the MF. Images with artifacts or incomplete scan volume were removed from data analysis as well.

Image Analysis

All CBCT scans were selected from the database of the department's CBCT machine i-CAT next generation (Imaging Sciences International, Hatfield, PA). The voxel size was selected to be 0.2 mm. Axial, coronal, and sagittal planes of all the scans were viewed in a darkened room on a 21" DELL Flatron monitor (DELL, Precision T79110 XL, United States) with a screen resolution of 1920 × 1200 pixels and 64-bit color depth using the i-CAT Vision software (Imaging Sciences International, Hatfield, PA). The reconstructed data sets were exported as Digital Imaging and Communications in Medicine (DICOM) image stacks and then transferred to another workstation to view the images using On Demand software (On demand 3D™ , Cybermed, South Korea).

Image standardization.

Navigation through the axial, coronal and sagittal views was done to view the MF. For standardization, the view should show the MF at its maximum opening. **(figure 1).**

Quantitative MF variables:

On the cross-sectional cut, the vertical dimension of the MF was measured from the most superior to the most inferior points of the foramen [(9)]. **(figure 2)**

On the axial cut, the horizontal dimension of the MF was measured from the most medial to the most distal points of the foramen [(9)]. **(figure 3)**

The horizontal relation between the MF and the midline was measured on the reconstructed panoramic view. A line was drawn passing through the center of the MF. Another line was drawn passing exactly at the midline. The horizontal distance between the two lines was measured [(10)]. **(figure 4)**

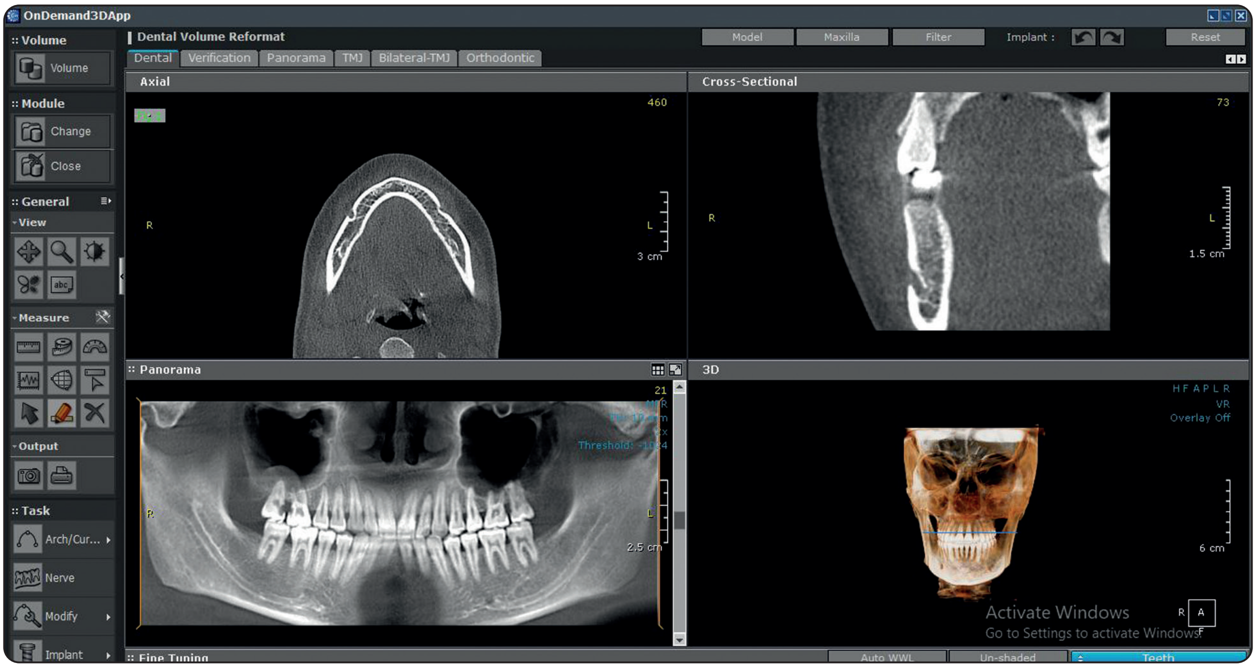

Fig. (1) Adjustment of the MF on the cross-sectional, axial, and reconstructed panoramic views for standardization.

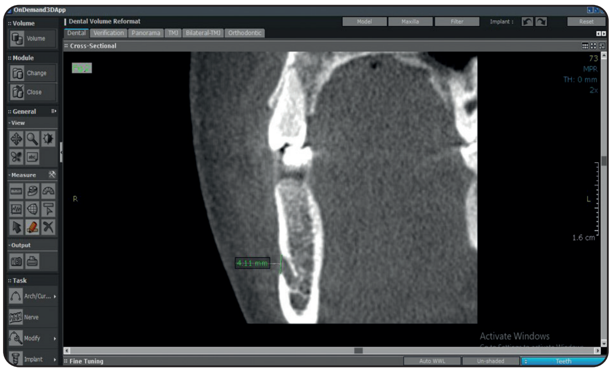

Fig. (2) MF vertical dimension on the cross-sectional cut.

Fig. (3) MF horizontal dimension on the axial cut.

The vertical relation to the inferior border of the mandible was determined by measuring the distance from the most superior and the most inferior points of the MF to the inferior border of the mandible on the cross-sectional cut as superior MF and inferior MF measurements [11]. **(figure 5)**

Qualitative MF variables:

The vertical position of MF in relation to the roots of the related teeth was recorded according to Parnami et al.,2015 [12] as follows: **(figure 6)**

a- Superior to the apex of the first premolar.

b- At or in line with the apex of the first premolar.

c- Between the apex of the first and second premolars.

d- At or in line with the apex of second premolar.

e- Inferior to the apex of the second premolar.

For the horizontal position of the MF, the classification follows Parnami et al., 2015 [12] as follows: **(figure 7)**

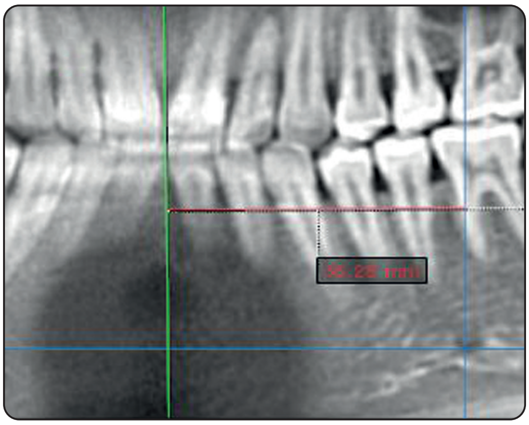

Fig. (4) The horizontal relation between the MF and the midline measured on the reconstructed panoramic view.

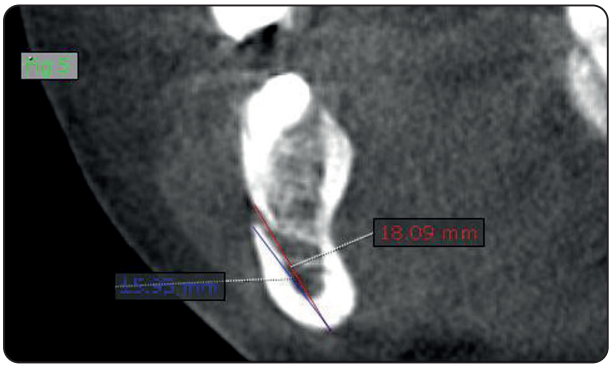

Fig. (5) The superior and the inferior MF measurements on the cross-sectional cut.

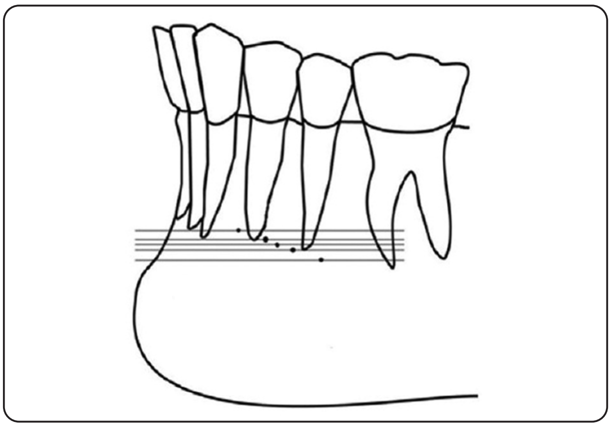

Fig. (6) The classification of the vertical position of the MF according to Parnami et al.,2015 (12)

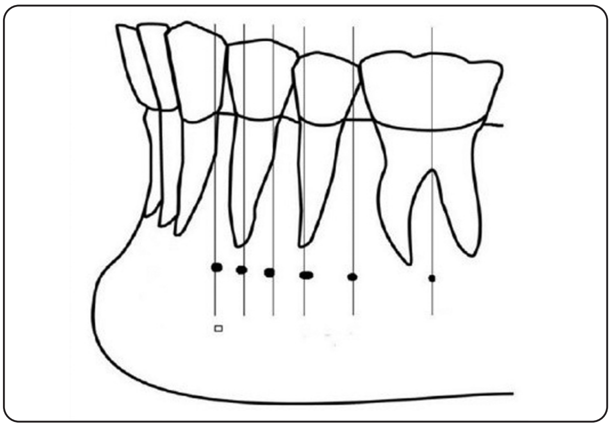

Fig. (7) The classification of the horizontal position of the MF according to Parnami et al.,2015 (12)

Position 1: Situated anterior to the first premolar.

Position 2: In line with the first premolar.

Position 3: Between the first and second premolars.

Position 4: In line with the second premolar.

Position 5: Between the second premolar and first molar.

Position 6: In line with the first molar.

Classification of the mandibular canal emerging types was determined according to Khojastepour L et al.,2015 [13]**.** They classified the relation into three emergence types: A) straight, B) anterior and C) posterior **(figure 8).**

All variables were evaluated bilaterally. The mean was calculated for the statistical analysis of quantitative variables only, while qualitative variables were evaluated separately on both sides.

Statistical analysis

Results were tabulated in excel sheet then analyzed by the statistical package for social sciences (SPSS) (version 22, SPSS Inc., Chicago, IL) and the level of significance was set at 0.05.

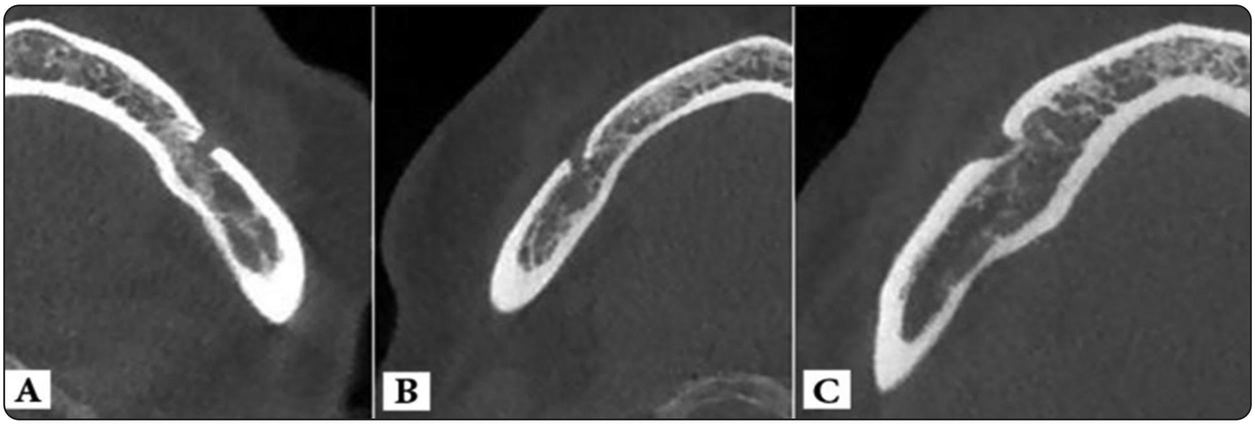

Fig. (8) Classification of the MC emerging types according to Khojastepour L et al.,2015. [13]

RESULTS

Categorical data were presented as frequency and percentage values and were analyzed using Fisher's exact test for intergroup comparisons and McNemar's test for intragroup comparisons. Numerical data were presented as mean and standard deviation (SD) values. Shapiro-Wilk's test was used to test for normality. Data were normally distributed and analyzed using independent and paired t-tests for inter and intragroup comparisons respectively. Correlations were analyzed using Spearman's rank order correlation coefficient. The significance level was set at $p<0.05$ within all tests. Statistical analysis was performed with R statistical analysis software version 4.1.3 for Windows*.

Descriptive statistics:

Descriptive statistics for qualitative and quantitative variables are presented in **(tables 1 and 2)**. According to the data distribution, 34.9% of cases were represented as males while 65.1% of cases were represented as females.

TABLE (1) Descriptive statistics for the qualitative variables.

Parameter			***Value***
Sex	***Male***	***n***	60
		%	34.9%
	Female	***n***	112
		%	65.1%
Horizontal position	***1***	***n***	0
		%	0.0%
	2	***n***	36
		%	20.9%
	3	***n***	96
		%	55.8%
	4	***n***	33
		%	19.2%
	5	***n***	7
		%	4.1%
	6	***n***	0
		%	0.0%
Vertical position	***A***	***n***	16
		%	9.3%
	B	***n***	73
		%	42.4%
	C	***n***	83
		%	48.3%
MC emerging	***Anterior***	***n***	22
		%	12.8%
	Posterior	***n***	69
		%	40.1%
	Straight	***n***	81
		%	47.1%

* [1]R Core Team (2022). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

TABLE (2) Descriptive statistics for the quantitative variables.

Parameter	(Mean±SD)
Age (years)	31.35±8.32
Superior MF	17.72±2.43
Inferior MF	14.85±2.10
Relation to the midline	14.85±2.10
Horizontal dimension	3.42±0.94
Vertical dimension	3.26±0.94

Association with the sex:

Qualitative variables:

There was a significant association between horizontal position of the MF and the sex with a significantly higher percentage of males having type (2) position, and a significantly higher percentage of females having type (3) (p<0.001). For the other parameters, there was no significant association. Associations between the sex and qualitative variables are presented in **(table 3)** and **(figures 9).**

Quantitative variables:

For superior and inferior MF measurements, males had significantly higher values than females (p<0.001). For other measurements, there was no significant difference between both sex types (p>0.05). Association between sex and quantitative variables are presented in **(table 4) and (figure 10).**

TABLE (3) Association between the sex and the qualitative variables.

Parameter			Male	Female	χ^2	p-value
Horizontal position	1	n	0	0	18.53	<0.001*
		%	0.0%	0.0%		
	2	n	23^{A}	13^{B}		
		%	38.3%	11.6%		
	3	n	23^{A}	73^{B}		
		%	38.3%	65.2%		
	4	n	12^{A}	21^{A}		
		%	20.0%	18.8%		
	5	n	2^{A}	5^{A}		
		%	3.3%	4.5%		
	6	n	0	0		
		%	0.0%	0.0%		
Vertical position	A	n	5	11	0.68	0.711
		%	8.3%	9.8%		
	B	n	28	45		
		%	46.7%	40.2%		
	C	n	27	56		
		%	45.0%	50.0%		
MC emerging	Anterior	n	4	18	3.10	0.212
		%	6.7%	16.1%		
	Posterior	n	26	43		
		%	43.3%	38.4%		
	Straight	n	30	51		
		%	50.0%	45.5%		

TABLE (4) Association between the sex and the quantitative variables.

Parameter	(Mean±SD)		t-value	p-value
	Male	Female		
Superior MF	19.27±2.09	16.89±2.19	**6.90**	**<0.001***
Inferior MF	16.09±1.71	14.19±1.99	**6.25**	**<0.001***
Relation to the midline	25.17±4.96	26.45±4.85	**1.65**	**0.101**
Horizontal dimension	3.49±0.79	3.38±1.01	**0.70**	**0.485**
Vertical dimension	3.14±0.84	3.33±0.99	**1.27**	**0.206**

**Significant (p<0.05)*

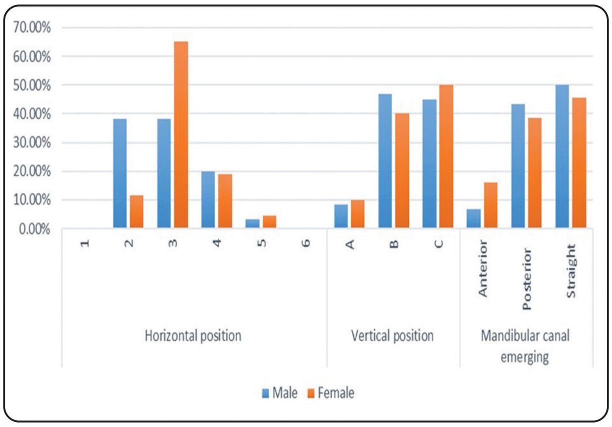

Fig. (9) Bar chart showing the association between the sex and the MF qualitative variables.

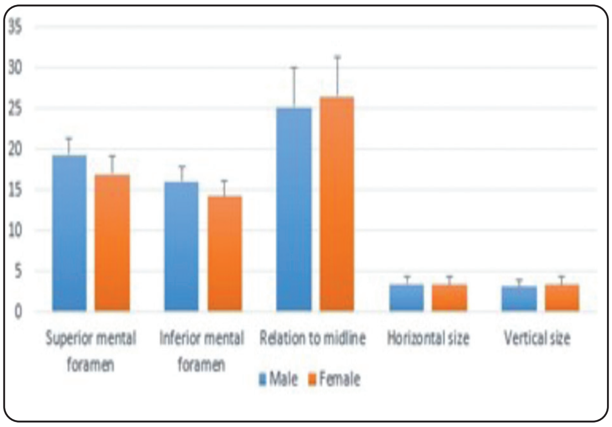

Fig. (10) Bar chart showing the association between the sex and the MF quantitative variables.

Associations and correlations with age:

Qualitative variables:

For different parameters there was no significant association (p>0.05). Association between the age and qualitative variables are presented in **(table 5)**.

TABLE (5) Association between the age and the qualitative variables.

Parameter		Age (Mean±SD)	f-value	p-value
Horizontal position	*1*	0.00±0.00	**0.00**	**1**
	2	31.33±6.13		
	3	31.41±8.96		
	4	31.24±7.51		
	5	31.14±13.46		
	6	0.00±0.00		
Vertical position	*A*	28.69±7.52	**1.08**	**0.355**
	B	33.15±8.26		
	C	29.99±8.39		
MC emerging	*Anterior*	28.14±9.56	**1.79**	**0.170**
	Posterior	31.91±7.07		
	Straight	31.52±9.01		

Quantitative variables:

There was a weak negative correlation between the age and the inferior MF dimension, relation to the midline and the vertical dimension) which was statistically significant (p<0.05). For other parameters, there was no significant correlation (p>0.05). Correlation between the age and the quantitative variables are presented in **(table 6)** and in **(figure 11)**.

TABLE (6) Correlation between the age and the quantitative variables.

Parameter	r_s	*p-value*
Superior MF	**-0.120**	**0.126**
Inferior MF	**-0.170**	**0.024***
MF position in relation to the midline	**-0.170**	**0.022***
MF Horizontal dimension	**0.062**	**0.422**
MF Vertical dimension	**-0.200**	**0.010***

Spearman's rank order correlation coefficient, *significant (p<0.05)

Difference between right and left sides:

Qualitative variables:

For different parameters, there was no significant difference between both sides (p>0.05). **(Table 7).**

TABLE (7) Difference between right and left side in the qualitative variables.

Parameter			*Right*	*Left*	χ^2	*p-value*
Horizontal position	***1***	***n***	0	0	**1.39**	**0.709**
		%	0.0%	0.0%		
	2	***n***	19	17		
		%	22.1%	19.8%		
	3	***n***	45	51		
		%	52.3%	59.3%		
	4	***n***	19	14		
		%	22.1%	16.3%		
	5	***n***	3	4		
		%	3.5%	4.7%		
	6	***n***	0	0		
		%	0.0%	0.0%		
Vertical position	***A***	***n***	7	9	**0.39**	**0.825**
		%	8.1%	10.5%		
	B	***n***	38	35		
		%	44.2%	40.7%		
	C	***n***	41	42		
		%	47.7%	48.8%		
MC emerging	***Anterior***	***n***	12	10	**0.66**	**0.721**
		%	14.0%	11.6%		
	Posterior	***n***	32	37		
		%	37.2%	43.0%		
	Straight	***n***	42	39		
		%	48.8%	45.3%		

Quantitative variables:

For superior and inferior MF measurements, values measured on the right side were significantly higher than those on the left side ($p<0.05$). While for relation to the midline, values measured on the left side were significantly higher than measurements on the right side ($p=0.026$). For other measurements, there was no significant difference between both sides ($p>0.05$). The differences between the right and left sides in quantitative variables are presented in **(table 8)**.

TABLE (8) Difference between right and left side in the quantitative variables.

Parameter	*(Mean±SD)*		*t-value*	*p-value*
	Right	*Left*		
Superior MF	17.90±2.45	17.53±2.41	**2.22**	**0.029***
Inferior MF	15.03±2.32	14.68±1.84	**2.08**	**0.040***
Relation to midline	25.24±4.84	26.77±4.90	**2.27**	**0.026***
Horizontal dimension	3.40±0.94	3.44±0.94	**0.34**	**0.733**
Vertical dimension	3.20±0.90	3.32±0.98	**1.20**	**0.232**

****Significant (p<0.05)***

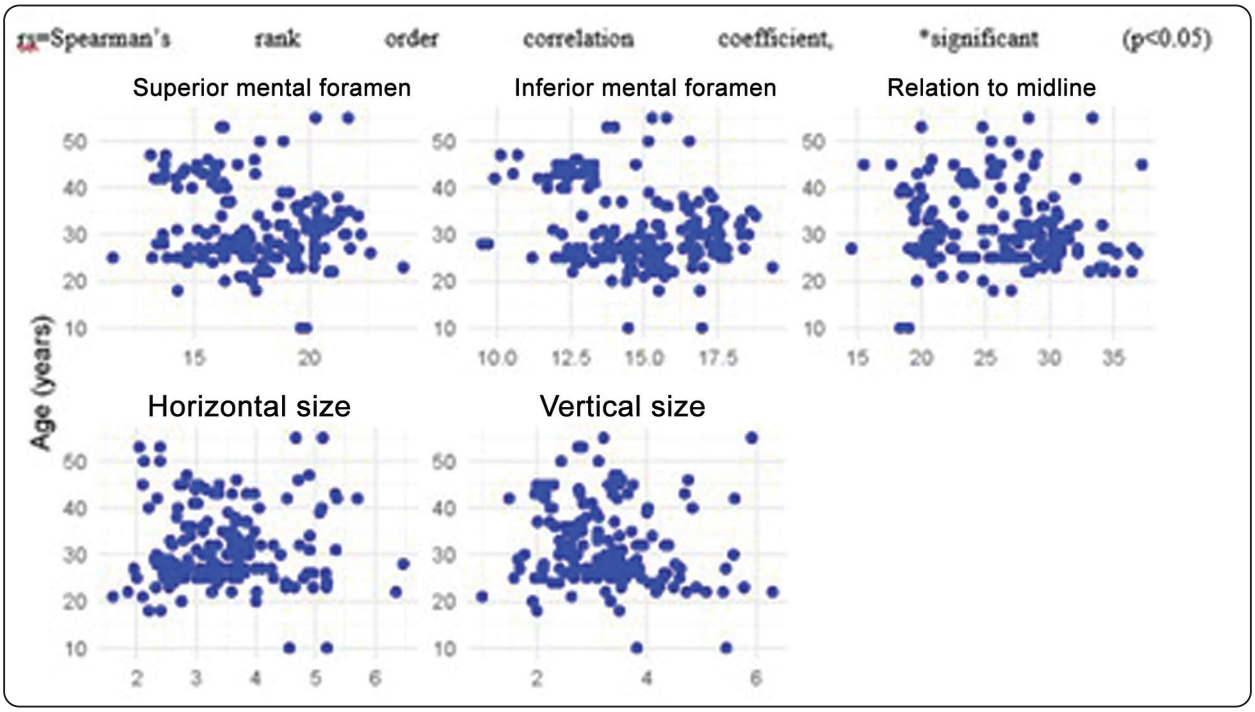

Fig. (11) Scatter plot showing the correlation between age and the MF quantitative variables.

DISCUSSION

This study aim was to detect variations in MF anatomy and its correlation with the age and the sex using CBCT in a sample of Egyptian population. Proper determination of the location and anatomical variations of MF is needed for different dental anesthetic and surgical procedures [14,15,16].

Since conventional radiographs may fail to identify these variations, CBCT is of fundamental importance in this process. [5] Numerous methods, including manual identification, direct inspection during surgery, computed tomography (CT), panoramic or periapical radiography, magnetic resonance imaging (MRI), and CBCT, have been proposed as effective ways to locate the MF. Most of these techniques have drawbacks, including expense, radiation exposure, and magnification [4].

Osteometric analysis of the dimensions and position of the mental foramen was done vertically, horizontally, and in relation to the midline. Classification of the mandibular canal emerging types was determined. All variables were correlated with the age and the sex.

For the horizontal position of the MF, no cases were found for type 1 (anterior to the first premolar) and type 6 (in line with the first molar). These results were like those obtained by Gungor et al., 2006[17] and Zmyslowska-Polakowska, et al.,2019 [9].

Most of the cases (55.8%) showed horizontal position 3 (between the first and second premolars) followed by type 2 (20.9%) (in line with the first premolar) and type 4 (19.2%) (in line with the second premolar), while type 5 was the least common (4.1%) (between the second premolar and first molar). Previous studies have shown that the MF was commonly found between 1st and 2nd premolars. These studies were done among Turkish, Indian, and UK populations [17,18,19].

Regarding the vertical position of the MF, 48.3% of cases were in type C (below the apices of 4 and 5), 42.4% was presented in type B (in line with apex of 4) while type A (superior to apex of 4) was presented in 9.3% of cases.

This was in accordance with Shalash et al., 2020[20] who studied the MF variations in the Egyptian population and concluded that the most common position of the MF was below the 2nd premolar. Other studies on the Saudi population[1,21] showed that type c was the most frequent type. Many other studies had similar findings[22,23,24]. In addition, Zmyslowska-Polakowska, et al.,2019[9] studied the MF in the Polish population and found out that type C was the most frequent regardless the age and the sex. The second most frequent position of the MF was at the level of the apices of the first and second mandibular premolar teeth roots (type B).

The mandibular canal emerging type varied into anterior, posterior, and straight types. Among the study sample, straight and posterior types (47.1%, 40.1%) were presented more than anterior type (12.8%).

Kieser et al., 2002 [25] stated that the posterior MC type was the most common among the studied population, while this was the least common type in a study conducted by Khojastepour et al., 2015 in a selected Iranian population [13].

Regarding the qualitative variables and their correlation with the sex, all variables were statistically insignificant except horizontal position types 2 and 3 ($p<0.05$). The horizontal position type 2 was higher in males (38.3%) while horizontal position type 3 was higher in females (65.2%).

Regarding the quantitative variables and their correlation with the sex, all variables were statistically insignificant except for the superior MF and the inferior MF dimensions ($p<0.05$). Both measurements were higher in males. The superior MF mean was 19.27 with 2.09 SD, while the inferior MF mean was 16.09 with 1.71 SD.

On the other hand, Zmyslowska-Polakowska et al.,2019 [9] showed a statistically significant difference in the MF dimensions in relation to the sex of the Polish population. In addition, Gungor et al.,2017 [26] Zhang et al.,2015 [27] and Kalender et al.,2012 [28] found that the horizontal and vertical diameters of the MF in a CBCT study were higher in men in comparison to women.

Variation between studies may be due to different types of the studied population, methods of evaluation, and the type of the technique used whether panoramic scans or CBCT. [20]

In correlation with age, all variables were statistically insignificant except the inferior MF, relation to the midline and the vertical dimension. However, they showed inverse correlation which means that these measurements were decreasing with age, while this correlation was weak (p value near to zero).

However, Zmyslowska-Polakowska et al., 2019[15] found that the most frequent horizontal MF location in older patients was between the first and second premolars (position 3) and, next, in the long axis of the second premolars (type 4), in young patients.

All qualitative variables were statistically insignificantly different between the right and left sides, while for quantitative variables, superior MF, inferior MF, and the relation to the midline were statistically significantly different between the right and left sides ($p<0.05$). However, Voljevica et al., 2015 [29] observed, in the patients of Bosnia, a statistically significant difference in the horizontal MF position between the right and left sides.

The observations of the present study and the related previous studies suggest that the MF, MC and the related parameters are variable among different populations. This makes the precise assessment of their characteristics for every population very helpful in the clinical dental practice [9].

CONCLUSION

In the studied sample of the Egyptian population, the most common location of the MF horizontally is between the first and second premolars, and vertically below the apices of premolars, commonly emerging straight or posteriorly as a MC. Males have a specific MF pattern and location other than females. MF pattern and location have a weak correlation with age. The vertical position and the relation to the midline are significantly different between the right and left sides.

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