Digital Analysis of mental foramen position reveals effects of ethnicity and gender on Malaysian population

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Abstract

Mental foramen is a funnel-shaped structure which releases the mental nerve. It is an important landmark and must be located before any surgical procedures to avoid complications such as neurovascular bundle damage. The location of mental foramen also plays an important role in estimating age and sex. Mental foramen position can be identified easily using radiographic views like panoramic, cone beam computed tomography (CBCT), computed tomography (CT) and magnetic resonance imaging (MRI). Mandible bone a part of skull can be used instead of the whole skull especially that the mandible showed that it is the strongest bone in the human body and withstand high degree of temperature being well preserved, within the mandible mental foramina are found which there position easily indicates race and sex

The main objective is to assess the variation of position of the mental foramen for both sexes and sides of the jaw of Malays and Chinese.

A total of 200 digital panoramic views for two main ethnic groups (Malays and Chinese) aged between 17-30 years old were selected from the Hospital USM archive which met the inclusion and exclusion criteria, horizontal and vertical measurements of the mental foramen were done by using digital ruler of Planmeca Romexis software Finland. Sex and Ethnicity difference were evaluated.

Males had significantly high mean values than females ($p < 0.001$) when measuring all parameters (horizontal and vertical) while only MFr-IBM and MFl-IBM of vertical measurements showed high mean in Chinese than Malay ($p < 0.001$).

it is now possible to state that ethnicity and gender can easily be indicated by the vertical and the horizontal measurements of the mental foramen among Malaysian population.

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Introduction

Mental foramen is a funnel-shaped structure which releases the mental nerve. It is an important landmark and must be located before surgical procedures to avoid complications such as neurovascular bundle damage. The location of mental foramen also plays an important role in estimating age and sex[1].

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The location of mental foramen goes through three main phases from childhood to old ages. In a newborn it is located near to the inferior border of the mandible and posteriorly to the first molar bud. When the permanent teeth start to erupt the mental foramen moves anteriorly and superiorly toward the first and second premolars, while during old age, due to loss of teeth and bone resorption the mental foramen is closer to the alveolar border[1].

Wical and Swoope (1974), Lindhe et al. (1995), Guler et al. (2005) and Singal and Sharma (2017) reported that the alveolar bone between the mental foramen and the inferior border of the mandible is not affected by bone resorption and remains without any change through life[2-5]. However, distance between the mental foramen and the inferior border of the

mandible remains constant through life[6].

Anatomical landmarks can be identified easily using radiographic views like panoramic, cone beam computed tomography (CBCT), computed tomography (CT) and magnetic resonance imaging (MRI)[7-11]. In panoramic views, the mental foramen can be easily detected in more than 75% of the views and some are misdiagnosed as a radiolucent area[12,13]. To improve the appearance of the mental foramen in the panoramic views it is advised to tilt the patient's head 5 degrees downward to the horizontal bar of the panoramic machine[14].

Position of Mental foramen was determined by several studies on Malaysian population Al juboori et al 2013 reported that most commonly located between 1st and 2nd premolars while (Ngeow& Yuzawati 2003), (Alias et al. 2017) and Ngeow et al 2010 reported that the commonest location is in line with the second premolar[6,15-17].

The skull is one of the skeleton components which can assist in determination of ethnicity and gender. When skull is not found mandible bone a part of skull can be used instead, because the mandible have shown that it is the strongest bone in the human body and can withstand high degree of temperature. Being well preserved, within the mandible, the mental foramina are found in a location which can aid in the prediction of age and sex[18].

The aim of the present study is assess the variation of the position of the mental foramen and to determine sex and race by measuring the distance between the mental foramen and the nearby anatomical landmarks. Few studies on Malaysian population studied the effects of sex and race on mental foramen position.

Materials and methods

The study was conducted at the Department of oral and maxillofacial radiology, school of dental sciences Universiti Sains Malaysia (USM). Study was approved by the **JEPeM-USM (18060266)**. 200 digital panoramic radiographs were retrospectively recruited after screened by inclusion and exclusion criteria. The quality of images were the quality of clinical standard (clearly showed the structure of interest, no distortions and no magnification errors) to ensure standardisation of the images. Exposure settings were standardised for all radiographs *i.e.* 60-80 kvP, 8-10 mA and 10s exposure time (Helsinki, Finland). All images were saved in DICOM format that is known clinically acceptable method of image transfer from one centre to another[19].

Based on sample size calculation, total of 200 panoramas were recruited from archives of Hospital USM for patients aged between 17-30 years (100 Malay(50 male- 50 female), 100 Chinese (50 male- 50 female)), the calculation of the sample size was based on the recommendation of Hair et al. (2006)[20].

Inclusion Criteria

All participants in this study has fulfilled the following, 1-Only x-rays with no image distortion, no magnification errors and clearly show the structures of interest were included, **2**- A complete data in the records**, 3-** Age 17-30 years old**, 4-**Ethnic group Malays and Chinese based on their new identification card (NRIC).

Exclusion Criteria

1- Known history of chronic medical illness, 2-Hormonal deficiency patients, 3- Patients having bone development disorders or any craniofacial deformities

Methods and Data extraction

According to Amorim et al. (2008)[21] the method was done through measuring three variables on digital panoramas after identifying the mental foramens and drawing the midline, which is determined by inserting vertical line from the nasal septum and anterior nasal spine to the symphysis menti using the digital ruler of Romexis software and inserting Lines A,B and C.

1- (MFr-Line A) (MFl-Line A) Distance from the least point of the mental foramen (MF) to the inferior border of the mandible (imaginary line A). Imaginary Line A is drawn as a straight line tangent to the inferior border of the mandible from the angle of the mandible to the anterior part below the chin (Figure 1).

2- (MFr-MID) Horizontal distance from the most medial point of the right mental foramen perpendicular to the mid-line. (Figure2).

3- (MFr-MFl) Horizontal least distance from the medial border of the left mental foramen to the medial border of the right mental foramen. The horizontal line was perpendicular to the midline and the medial border of each foramina was determined by tangent lines (line B-line C) parallel to midline (Line B= tangent drawn from

the medial border of the left mental foramen/ Line C= tangent drawn from the medial border of the right mental foramen (Figure 3).

Statistical analysis

Data were analyzed using SPSS version 24 (Armonk, New York, USA) , Two way Ancova test was carried out, level of significance was set at 0.05, the reliability of measuring MFr-MFl, MFr-MID, MFr-Line A and MFl-Line A was assessed using ICC (intraclass correlation coefficient). Intra-rater reliability of all measurements of parameters were excellent with high level of agreement 0.99 ($p<0.001$). Inter-rater reliability of all parameters were also excellent with high value of agreement as follow, MFr-MFl 0.95 ($p<0.001$), MFr-MID 0.94 ($p<0.001$), MFr-Line A 0.90 ($p<0.001$), MFl-Line A 0.94 ($p<0.001$).

Results

In the present study, males and females were equally divided into each ethnic group Malay and Chinese, MFr-Line A and MFl-Line A were the two variables showing significantly differences with high mean values in Chinese more than Malays. All variables (MFr-MFl, MFr-MID, MFr-Line A, MFl-Line A) showed to be significant and with higher mean values for males than females.

Measurements between right and left mental foramens (MFr-MFl) found that there was no significant difference between the Malay and Chinese after being adjusted for age and gender, but there was a significant difference between males and females after being adjusted for age and ethnicity. Pairs of interaction assessed (gender and ethnicity, gender and age, and age and ethnicity), all pairs showed no significant interaction. (Table 1, 2)

MF-MF	Malay		Chinese	
	Male	Female	Male	Female
Mean	58.62	55.55	61.12	55.89
(SD)	6.33	5.74	5.72	5.84
Adj mean	58.61	55.56	61.13	55.88
(SE)	0.84	0.84	0.84	0.84

Adj = adjusted, SD = Standard Deviation, SE = Standard Error.

Table 1. Means, adjusted mean, standard deviation and standard error for MFr-MFl for ethnicity and gender.

	df	F-stat	p-value[a]	Effect size η^2	Group 1	Group 2
Main effects						
-Ethnicity	(1,196)	2.85	0.093	0.014	Malay	Chinese
-Gender	(1,196)	24.46	<0.001	0.111	Female	Male
-E*G	(1,195)	1.71	0.192	0.009		
-E*A	(1,195)	3.85	0.051	0.019		
-G*A	(1,195)	0.11	0.743	0.001		
Covariates						
-Age	(1,196)	0.30	0.582	0.002		

[a]Multi-factorial ANCOVA, df = degree of freedom, E= Ethnicity, G= Gender, A= Age.

Table 2. Ancova for the factors ethnicity and gender with MFr-MFl as a dependent variable and age as a covariate.

Measurements between the medial point of the right mental foramen and midline MFr-MID showed no significant difference between the Malay and Chinese after adjusted for age and gender, but there was a significant difference for MFr-MID between males and females after adjusted for age and ethnicity. Pairs of interaction assessed (gender and ethnicity, gender and age, and age and ethnicity), all pairs showed no significant interaction. (Table 3, 4)

MF-MID	Malay		Chinese	
	Male	Female	Male	Female
Mean	29.45	28.09	30.12	27.45
(SD)	3.56	3.18	3.54	3.54
Adj mean	29.45	28.09	30.13	27.44
(SE)	0.49	0.49	0.49	0.49

Adj = adjusted, SD = Standard Deviation, SE = Standard Error.

Table 3. Means, adjusted mean, standard deviation and standard error for MFr-MID for ethnicity and gender.

	df	F-stat	p-value[a]	Effect size η^2	Group 1	Group 2
Main effects						
-Ethnicity	(1,196)	0.001	0.970	0.00	Malay	Chinese
-Gender	(1,196)	16.93	<0.001	0.08	Female	Male
-E*G	(1,195)	1.84	0.176	0.009		
-E*A	(1,195)	1.00	0.318	0.005		
-G*A	(1,195)	0.68	0.410	0.003		
Covariates						
-Age	(1,196)	0.41	0.524	0.002		

[a]Multi-factorial ANCOVA, df = degree of freedom, E= Ethnicity, G= Gender, A= Age.

Table 4. Ancova for the factors ethnicity and gender with MFr-MID as a dependent variable and age as a covariate.

Measurements between the least point of the right mental foramen to the inferior border of

the mandible MFr-Line A revealed a significant difference between Malay and Chinese after adjusted for age and gender, and a significant difference of MFr-Line A between males and females after adjusted for age and ethnicity. Pairs of interaction assessed (gender and ethnicity, gender and age, and age and ethnicity), all pairs showed no significant interaction (Table 5,6)

MFr-Line A	Malay		Chinese	
	Male	Female	Male	Female
Mean	13.20	12.05	14.07	13.13
(SD)	1.57	1.45	2.07	1.76
Adj mean	13.20	12.05	14.07	13.13
(SE)	0.24	0.24	0.24	0.24

Adj = adjusted, SD = Standard Deviation, SE = Standard Error.

Table 5. Means, adjusted mean, standard deviation and standard error for MFr-Line A for ethnicity and gender.

	df	F-stat	p-value[a]	Effect size η^2	Group 1	Group 2
Main effects						
-Ethnicity	(1,196)	15.99	<0.001	0.075	Malay	Chinese
-Gender	(1,196)	18.39	<0.001	0.086	Female	Male
-E*G	(1,195)	0.17	0.678	0.001		
-E*A	(1,195)	1.41	0.237	0.007		
-G*A	(1,195)	2.75	0.099	0.014		
Covariates						
-Age	(1,196)	0.07	0.788	0.000		

[a]Multi-factorial ANCOVA, df = degree of freedom, E= Ethnicity, G= Gender, A= Age.

Table 6. Ancova for the factors ethnicity and gender with MFr-Line A as a dependent variable and age as a covariate.

Measurements between the least point of the left mental foramen to the inferior border of the mandible MFl-Line A revealed a significant difference between Malay and Chinese after adjusted for age and gender and a significant difference of MFl-Line A between males and females after adjusted for age and ethnicity. Pairs of interaction assessed (gender and ethnicity, gender and age, and age and ethnicity), all pairs showed no significant interaction except gender and age showed significant interaction between gender (Male and female) and age, interaction is significant: meaning the distribution of age is not similar for male and female. (Table 7, 8).

MFl-Line A	Malay		Chinese	
	Male	Female	Male	Female
Mean	13.42	12.28	14.19	13.36
(SD)	1.28	1.74	1.99	1.74
Adj mean	13.42	12.28	14.19	13.36
(SE)	0.24	0.24	0.24	0.24

Adj = adjusted, SD = Standard Deviation, SE = Standard Error.

Table 7. Means, adjusted mean, standard deviation and standard error for MFl-Line A for ethnicity and gender.

	df	F-stat	p-value[a]	Effect size η^2	Group 1	Group 2
Main effects						
-Ethnicity	(1,196)	14.63	<0.001	0.069	Malay	Chinese
-Gender	(1,196)	16.52	<0.001	0.078	Female	Male
-E*G	(1,195)	0.44	0.507	0.002		
-E*A	(1,195)	1.59	0.209	0.008		
-G*A	(1,195)	4.29	0.040	0.022		
Covariates						
-Age	(1,196)	0.00	0.985	0.000		

[a]Multi-factorial ANCOVA, df = degree of freedom, E= Ethnicity, G= Gender, A= Age.

Table 8. Ancova for the factors ethnicity and gender with MFl-Line A as a dependent variable and age as a covariate.

Discussions

In this study vertical and horizontal measurements of the mental foramens where assessed and evaluated among two ethnic groups Malay and Chinese who are the majority of the Malaysian population using digital panorama Planmeca Romexis software (2.9.2.R) (Helsinki, Finland).

As mentioned in the literature review Mandibular bone undergoes ossification in the early stages of human development, leading to changes in the morphological appearance in the mandible and also affects the tooth eruption, these changes together can play as an indicator for sex and ethnicity thus helping in human identification purposes.

In our current study the aim was to determine variability between ethnicity and gender by assessing vertical and horizontal position of the mental foramen. At the level of ethnicity vertical measurements of the mental foramens were significant in two variables MFr-Line A and MFl-Line A the distance between the least point of the lower border of the mental

foramen to the inferior border of the mandible right and left sides with high mean on Chinese more than Malay, while horizontal assessment (MFr-MFl) right mental foramen to the left mental foramen, (MFr-MID) right mental foramen to midline where found not useful and non significant variables when assessing ethnicity. At the level of gender determination all variables were significant and showed to be larger in males rather than females.

Digital panoramas were used because they give broad area of visualization of the mandible and all anatomical areas are seen clearly, thus leading to stability and standardization in the methods of identifying mental foramena[22,23].

Measurements between right and left mental foramena showed high mean value in males than in females but there was no significance difference between different ethnicities. Same measurements were conducted by Marieiro LMB et al 2017 measuring the distance between right and left mental foramens using CBCT BlueSky Plan3 software, distance was measured in order to facilitate implant replacement, they found a significant difference between the means of distances in males and females[24].

Distance between Mental foramen and midline was measured by Shaaban and El-Shall 2017 in 18-30 age group, and was statically not significant which disagrees with the results of our recent study showing significantly difference between males and females when measuring the distance from the most medial point of the right mental foramen to the midline[18]. Another study by Mohamed, et al 2016 revealed that distance between right mental foramen to midline shows statically significant differences between males and females in 19-30 age groups, this agrees and coincide with the recent study[25].

Numerous studies agreed the recent study and was conducted by (Rashid and ali 2011) and (Gloria Cartes et al 2018). They measured the distance between the least point of the mental foramen to the inferior border of the mandible showing statically significance between males and females with mean higher in male than female[26,27], another study reported by Shaaban and El-Shall 2017 and Mohamed, et al 2016 concluded that males showed higher mean values than females at 18-30 age group when measuring the least point of the mental foramen to the inferior border of the mandible[18,25].

A previous study conducted by Aspalilah Alias (AA) et al 2017 was carried out on Malaysian population between three ethnic groups Malay, Chinese and Indians in including three age groups; (18-30),(31-50),(51-74) using postmortem computed tomography (PMCT) at Hospital Kuala Lumpur. They measured the same two variables as our current study, the distance between the least point of the mental foramen to the inferior border of the mandible and the distance from the medial border of the mental foramen to the symphasis menti of the mandible. The first variable was found to be highly significant difference in all age groups between males and females, surprisingly there was no significant differences between all age groups when evaluating the distance between the medial border of the mental foramen to the symphasis menti which was contrary with the recent study. These two variables were measured in our recent study and found to be significant when comparing males and females[6]. The major finding which also disagreed with Aspilas study is that the distance between least point of the mental foramen right and left to the inferior border of the mandible was found to be significant when differentiating between Malay and Chinese at ethnicity basis. This was an important study to compare as it shares the same population and the same age group (18-30 years old), the difference was the sample size was not equal and gender were not equally distributed, they had 79 dentulous patients (48 males, 31 females) [6].

Conclusions

It is now possible to state that ethnicity and gender can easily be indicated by the vertical and the horizontal measurements of the mental foramen among Malaysian population. all parameters measured were very sensitive toward differentiation between genders making mental foramen location a useful tool to differentiate male from female, only two parameters (MFr-Line A)(MFl-Line A) there measurements revealed a valid and sensitive statistical result to differentiate between the two ethnic groups (Malay and Chinese). Panoramas were found useful for measuring distances between mental foramena and the surrounding anatomical areas. It is a very excellent tool to be used in forensic dentistry.

Ethics: Study was approved by the **JEPeM-USM (18060266)**

Declaration of Interest

The authors report no conflict of interest.

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