

Effects of Gender and Ethnicity on Mandibular Canal Location on Malaysian Population

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Abstract

Mandibular canal is where the inferior alveolar nerve passes through and ends up with the mental nerve coming out from the mental foramen. It is an important and sensitive landmark that should be identified properly before many surgical procedures such as removal of the third molar or any extraction where the teeth are attached to the in order to avoid serious complications. Dental identification of an unknown person based on the examination of bodily remains could be performed either by an osteological or stomatological method, the expanding borders of dentistry have taken the dentist as an expert witness in the area of forensic sciences.

The main objective is to determine the position of the mandibular canal for both sexes and sides of the jaw of Malays, Chinese and Indians.

A total of 300 OPGs for three ethnic groups (Malays, Chinese and Indian) aged between 17-30 years old were selected from the Hospital USM archive which met the inclusion and exclusion criteria.

Males had significantly high mean values than females ($p < 0.001$) when measuring MCr-Line A and MCI-Line A, measurements showed highly significance difference between different ethnic groups (Malay, Chinese and Indians) ($p < 0.001$).

Measuring vertical location of the mandibular canal to the inferior border of the mandible can be a very useful tool predicting ethnicity and gender on Malaysian population.

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Introduction

The skull is one of the skeleton components which facilitate gender identification, when the skull is not found the mandible bone a part of the skull can be used instead because it showed to be that it is the strongest bone in the human body and can withstand high degree of temperature. When being well preserved within the mandible the mandibular canals are found which their location assist in prediction of ethnicity and gender^{1,2}.

Panoramic radiographs serves as a useful

tool in diagnosis of the mandible before starting with many dental procedures^{3,4}. It gives a good idea about the position of the mental foramen or any other abnormalities in the jaw, even though it is a 2-dimension technique it has an advantage of lowering the dose if the radiation than the other techniques^{5,6}

Mandibular canal is where the inferior alveolar nerve passes through it and ends up with the mental nerve coming out from the mental foramen. It is very important and sensitive landmark because if it is not identified properly before and surgical procedure like a removal of the third molar or any extraction where the teeth are attached to the canal it may lead to serious complications. Age and sex have a strong relationship when the mandibular canal changes its location and course⁷⁻⁹.

Mandibular canal is classified by Nortje (1977) into three types: (i) Type 1, mandibular canal is in touch with the root apex of the molars or away ≤ 2 mm, (ii) Type 2, mandibular canal is

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located in the middle between the apices of the permanent molars and the base of the mandible, and (iii) Type 3 mandibular canal is in contact with the base of the mandible or it is 2 mm away from it¹⁰.

Visibility of Mandibular canal on Digital panoramas is very clear and it appears as a dark radiolucent bunch wrapped by two radio opaque lines¹¹⁻¹².

Studies revealed that mandibular canal position can change from population to another, up to our knowledge only one study in Malaysia were done considering age, sex and ethnicity and there effects on mandibular canal location using CBCT technique^{6,13}, no study on Malaysian population used panoramic technique.

The aim of this study is to recognize the location of the mandibular canal and its relation to the inferior border of the mandible considering age, ethnicity and gender among Malaysian population.

Materials and methods

Materials

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). 300 digital panoramic radiographs were retrospectively recruited after screened by inclusion and exclusion criteria. The quality of images were similar to the quality of clinical standard (clearly showed the structure of interest, no distortions and no magnification errors) to ensure standardisation of the images. Exposure setting 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 another¹⁴.

Based on sample size calculation, total of 300 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) 100 Indian (50 male- 50 female).

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 and Indians 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

Mandibular canal location assessment

(MCr-Line A): The vertical distance from the least point of the right mandibular canal (MCr) opposite to the second molar perpendicular to an imaginary line (Line A) drawn below the inferior border of the mandible from the angle of the mandible to the anterior part below the chin

(MCI-Line A): The vertical distance from the least point of the left mandibular canal (MCI) opposite to the second molar perpendicular to an imaginary line (Line A) drawn below the inferior border of the mandible from the angle of the mandible to the anterior part below the chin. (Figure 1) illustrates the method of assessment.

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 MCr-Line A and MCI-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, MCr-Line A 0.93 ($p < 0.001$), MCI-Line A 0.96 ($p < 0.001$).

Results

Measurements between right mandibular canal and the inferior border of the mandible (imaginary line A) (MCr-Line A) showed a significant difference of mean MCr-Line A between the ethnic groups (*i.e.* Malay, Chinese, and Indians) after adjusted for age and gender, $F(2, 295) = 29.24$, $p\text{-value} < 0.001$. There was also a significant difference of mean MCr-Line A between males and females after being adjusted for age and ethnicity, $F(1, 295) = 30.96$, $p\text{-value} < 0.001$. Pairs of interaction were assessed (gender and ethnicity, gender and age, and age and ethnicity), there was no significant interaction

between ethnicity and gender, nor between ethnicity and age (p-values > 0.05), but there was a significant interaction between gender and age (p-value = 0.013). The results are displayed in Table 1 and 2 below.

MCR-Line A	Malay		Chinese		Indian	
	Male	Female	Male	Female	Male	Female
Mean	8.54	7.45	9.44	8.84	8.13	6.48
(SD)	1.90	1.37	2.02	1.79	1.98	1.29
Adj mean	8.55	7.47	9.47	8.85	8.11	6.45
(SE)	0.25	0.25	0.25	0.25	0.25	0.25

Table 1. Means, adjusted mean, standard deviation and standard error for MCR-Line A for ethnicity and gender.

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

	Df	F-stat	p-value*	Effect size η^2	Group 1	Group 2	Group 3
Main effects							
-Ethnicity	(2,295)	29.24	<0.001	0.165	Malay	Chinese	Indian
-Gender	(1,295)	30.96	<0.001	0.095	Female	Male	-
-E*G	(2,293)	2.25	0.107	0.015			
-E*A	(2,293)	1.73	0.179	0.012			
-G*A	(1,294)	6.25	0.013	0.021			
Covariates							
-Age	(1,295)	4.47	0.035	0.015			

Table 2. ANCOVA for the factors ethnicity and gender with MCR-Line A as a dependent variable and age as a covariate.

^aMulti-factorial ANCOVA, df = degree of freedom, E= Ethnicity, G= Gender, A= Age.

The pairwise comparisons showed a significant mean difference of MCR-Line A between Malay and Chinese; p-value < 0.001, between Chinese and Indian; p-value < 0.001, and between Malay and Indian; p-value = 0.010. The results are displayed in Table 3 below.

MCR-Line A			
Ethnic group (I)	Ethnic group (J)	Mean Difference (I-J) mm	P value*
Malay	Chinese	1.15	<0.001
Malay	Indian	0.73	0.010
Chinese	Indian	1.88	<0.001

Table 3. Pairwise comparisons of mean MCR-Line A between the ethnic groups.

*Bonferroni adjustment.

Measurements between the left mandibular canal and the inferior border of the mandible (imaginary line A) (MCI-Line A) showed a significant difference of mean MCI-Line A between the ethnic groups (i.e. Malay, Chinese, and Indians) after adjusted for age and gender, F (2, 295) = 29.65, p-value < 0.001. There was also

a significant difference of mean MCI-Line A between males and females after adjusted for age and ethnicity, F (1, 295) = 36.58, p-value < 0.001. Pairs of interaction were assessed (gender and ethnicity, gender and age, and age and ethnicity), all pairs showed no significant interaction (all p-values > 0.05). The results are displayed in Table 4 and 5 below.

MCI-Line A	Malay		Chinese		Indian	
	Male	Female	Male	Female	Male	Female
Mean	8.28	7.17	9.38	8.51	7.94	6.38
(SD)	1.69	1.38	2.02	1.55	2.09	1.42
Adj mean	8.29	7.18	9.40	8.51	7.92	6.34
(SE)	0.24	0.24	0.24	0.24	0.24	0.24

Table 4. Means, adjusted mean, standard deviation and standard error for MCI-Line A for ethnicity and gender.

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

	df	F-stat	p-value*	Effect size η^2	Group 1	Group 2	Group 3
Main effects							
-Ethnicity	(2,295)	29.65	<0.001	0.167	Malay	Chinese	Indian
-Gender	(1,295)	36.58	<0.001	0.110	Female	Male	-
-E*G	(2,293)	1.04	0.353	0.007			
-E*A	(2,293)	1.59	0.207	0.011			
-E*A	(1,294)	3.26	0.072	0.011			
-G*A							
Covariates							
-Age	(1,295)	4.85	0.028	0.016			

Table 5. ANCOVA for the factors ethnicity and gender with MCI-Line A as a dependent variable and age as a covariate.

^aMulti-factorial ANCOVA, df = degree of freedom, E= Ethnicity, G= Gender, A= Age.

The pairwise comparisons showed a significant mean difference of MCI-Line A between Malay and Chinese; p-value < 0.001, between Chinese and Indian; p-value < 0.001, and between Malay and Indian; p-value = 0.038. The results are displayed in Table 6 below.

MCI-Line A			
Ethnic group (I)	Ethnic group (J)	Mean Difference (I-J) mm	P value*
Malay	Chinese	1.22	<0.001
Malay	Indian	0.61	0.038
Chinese	Indian	1.83	<0.001

Table 6. Pairwise comparisons of mean MCI-Line A between the ethnic groups.

*Bonferroni adjustment.

Discussion

Detailed anatomy of mandibular canal course was assessed to emphasize and show the importance of locating the mandibular canal

while doing clinical procedures or for forensic purposes to determine the gender or the ethnicity. Recognizing mandibular canal by panoramic radiographs is a useful and a low costing method which can render the canal more easily identified. Panoramic radiographs are now essential when examining patients so they can be readily available in dental records of the patients whenever they are needed for any forensic investigation. Up to our knowledge no study assessed vertical position of the least point of the mandibular canal to the inferior body of the mandible on Malaysian population using panoramic radiographs.

In this study our aim was to clearly determine variability between ethnicity and gender by assessing vertical position of the mandibular canal in Malaysian population using digital panoramas and Planmeca romexis software. At the level of ethnicity, vertical measurements of the right and left mandibular canals were statistically significant (MCr-Line A and MCI-Line A). The distance between the least point of the of the mandibular canal opposite to second molar to the inferior border of the mandible right and left sides resulted in high means respectively for Chinese ,Malay with least mean for Indians. At the level of gender determination both right and left measurements were statistically highly significant and showed to be larger in males than in females.

Many studies assessed the vertical position of the mandibular canal to the inferior border of the mandible with different reference points to the inferior border of the mandible using panoramic radiographs and other radiographic techniques.

Another study done by Abdullah SY et al 2012 on Malaysian population assessed the vertical position from the least pointof the mandibular canal 20 mm away from the distal aspect of the mental foramen opposite to the mandibular second molar to the inferior border of the mandible. The author included 60 samples (30 Male – 30 female) in his study aged between 20-60 years old, samples were divided according to ethnicity to three groups Malay, Chinese and Indian. Each group containing 20 participants with equally divided by gender to 10 males and 10 females¹⁵.

Samples were examined using cone beam computed tomography (CBCT) and SimPlant software in both sides. At the level of

ethnicity One way Anova test revealed statistically significant difference in the location of the mandibular canal between the three ethnic groups with P value 0.002, similar results were obtained from our recent study examining the same ethnic groups with P value <0.001. Post hoc Bonferroni indicated that the difference in the location of the mandibular canal is only between Chinese and Indian (p= 0.002) and Malay and Chinese (p=0.024). On our recent study Bonferrni adjustment indicated the difference in the same ethnic groups as above study with difference in p values Chinese and Indian (p=<0.001) and Malay and Chinese (p=<0.001)¹⁵. Regarding gender, male values were statistically significant with P value of 0.004, an almost 1 mm higher when compared to the mean values of females, showing similar results to our study with a P value <0.001. When the author used the independent t test to compare the mean value between gender among the three ethnic groups he found that the Malay males mean value were higher than females and statistically significant, Chinese males mean values were higher than females but statistically insignificant and Indian males mean value were 0.04 lesser than females mean values. Unlike the findings of Abdullah SY et al, in our study all male mean values were greater than female mean values and statistically significant¹⁵.

Amorim et al.2009 conducted a study on a Brazilian population measuring the vertical position from the mandibular canal opposite to the second molar to the inferior border of the mandible without putting any reference point or tangent on the inferior border of the mandible. Their study sample included 300 panoramic radiographs consisting of 101 Male and 199 Female with for different age groups. group 1 were Female aged from 18-40, group 2 Female aged more than 40 years old, group 3 Males aged between 18-40 and group 4 males aged more than 40 years old. All radiographs were digitalized and then imported by Radioimp 1,0 software¹⁶, the measurement done were statistically insignificant among the four study groups with age ranging from 18-40, concluding that this area remains constant through adult life without any effects of age and gender. This was totally contrary with our recent findings showing significant difference among Malaysian population aged 17-30 on ethnicity and gender¹⁶. Jayam et al. 2015 examined the distance

between the least point of the mandibular canal to the inferior border of the mandible on both right and left sides of 200 panoramic radiographs among Indian population. After drawing the tangent from the chin to the angle of the mandible below the base of the mandible, the measurements were taken from the least point of the canal perpendicular to the tangent 90 degrees using hi tech point pen with vernier calipers to minimize errors, Four groups were included in the study, group 1 dentate participants in which 25 males and 25 females aged between 20-30, group 2 were dentate participants in which 25 males and 25 females aged between 30-40. Group 3 were edentulous participants, 25 males and 25 females aged between 40-50. Group 4 were edentulous participants 25 males and 25 females aged between 50-60. We focused on group 1 as it is near to our age group. Similar to our results males in their study showed higher mean values than females but were all statistically non significant unlike our results which showed high statistical significance between males and females. Jayam et al. were not able to demonstrate significance of results due to the big range of age and splitting the samples between dentulous and edentulous participants¹⁷.

In another study by Xie Q, et al. conducted in 1996 in Sweden to assess the vertical position of the mandibular canal to the inferior border of the mandible, the author studied a population of three groups two dentulous and one edentulous. The first group were dentulous participants with age ranges from 18-38, 63 males 68 females. The second group were dentulous participants with age ranges from 52-81, 46 males 45 females. The third group were edentulous participants with age range from 76-86, 32 males 96 females. Panoramic radiographs were used to measure the distance between the mandibular canal and the inferior border of the mandible. Radiographs were scanned and digitalized after tracing and measurements were done from the right and the left sides from the least point of the mandibular canal to a tangent drawn below the mandible from the chin anteriorly to the angle of the mandible posteriorly. Results showed that males had statistically significant higher mean values than females on all age groups. Similar results were obtained from our recent study when comparing the same age¹⁸

In 2012 Ozturk et al conducted a study in USA where they examined 52 adult skulls collected from the University of Pittsburgh dental school Dissection room. Out of these 52 dried skulls 36 were males and 16 females, 33 were Caucasian ethnicity and 19 were from other different ethnic groups. 27 were aged more than 40 years while 25 were aged less than 40 years Age, gender and ethnicity were determined after analyzing the skulls¹⁹.

All skulls were examined using computed tomography (CT). Before exposing the skulls an orthodontic wire was inserted into the mandibular foramen until it reached the mental foramen to get a clear view of the mandibular canal. Following exposure, the measurement was done from the superior border of the mandibular canal opposite to the second molar to the inferior border of the mandible without any reference point or a tangent drawn below the border of the mandible. All measurements were done by Iumavision software. Results showed significance between the different age groups with lowest mean values in Caucasians ethnic group in the two age groups. This was similar to our results in our recent study proposed measurement show significance difference between Malaysian ethnic groups. Males showed higher mean values than females but were statistically non significant, in contrary to our recent study results which showed males having higher mean values than females and statistically significant¹⁹.

Cartes G et al. carried out a retrospective study assessing the vertical position of the mandibular canal, the study sample was 442, 262 females and 180 males consisting of four groups; group 1 were females aged between 18-34 years old, group 2 were female aged more than 35 years old, group 3 were males aged between 18-34 years old and group 4 were males aged more than 35 years old, Auto CAD 2010 software was used to measure the vertical distance from the least point of the mandibular canal to the inferior border of the mandible without a reference point or a tangent below the base of the mandible to ensure standardization. Results presented showed greater mean values on all age groups for males than females with statistical significant agreeing with our recent study¹³.

A previous study conducted in 2011 determined the vertical position of the mandibular

canal on Brazilian population. The study sample consisted of 63 panoramic radiograph. Participants were divided into three groups according to the presence and absence of the lower posterior teeth. Group 1 patient radiograph showing right and left posterior teeth, Group 2 patient radiographs showing only one side posterior teeth and group 3 patient radiographs showing bilateral absence of posterior teeth. All radiographs were assessed on a negatoscope covered with black mask then anatomical landmarks were traced on a paper sheet and all measurements were done bilaterally²⁰.

Results revealed no statically difference between dentate and edentulous patients when measuring the distance between the least point of the mandibular canal and the inferior border of the mandible, although dentate patients showed higher mean values than edentulous patients. When comparing dentate group with our study it showed almost near mean values which showed statically significant difference between genders²⁰.

Author	Year	Country	Gender	Age group	Mean value mm	sides	Technique
Amorim et al. ¹⁶	2009	Brazil	F=199 M=101	18-40	M 6.94 F 6.86	unilateral	panorama
				>40	7.32 6.87		
Jayam et al. ¹⁷	2015	India	F=50 M=50	20-30	M 7.50 F 7.28	unilateral	panorama
				30-40	7.84 7.70		
Di Paula et al. ²⁰	2011	Brazil	M+F=21	≥18	R 8.42 L 7.78	Bilateral	panorama
Cartes G et al. ¹³	2018	Chile	F=80 M=262	18-34	M 8.47 F 7.71 L 8.54 7.60	Bilateral	panorama
				≥35	R 8.19 7.37 L 7.86 7.26		
Afkhami et al. ²¹	2013	Iran	F=64 M=36	18-40	M 6.05 F 5.16	unilateral	panorama
Xie Q, et al. ¹⁸	1996	Sweden	F=68 M=63	18-34	M 7.70 F 7.00	Bilateral	panorama
Ozturk, Potluri, and Vieira ¹⁹	2012	USA	F=16 M=36	<40	11.04	unilateral	CT
				≥40			
Abdullah SY et al. ¹⁵	2012	Malaysia	M+F=60	20-60	7.96	Bilateral	CBCT
Current study	2020	Malaysia	F=150 M=150	17-30	7.95	Bilateral	panorama

Table 7. Showing vertical distance from the lowest point of the mandibular canal to the inferior border of the mandible in different populations.

M= Male, F= Female, R= Right, L= Left, CT= Computed tomography, CBCT= Cone Beam Computed Tomography.

Conclusions

Results from our study revealed statically difference between gender and ethnicity on Malaysian population in the right and left measurements done for the vertical location of the mandibular canal, these measurements

showed very sensitive difference between male and female and between the three ethnic groups (Malay, Chinese, Indian) so it can be used as a useful tool in forensic dentistry predicting gender and ethnicity. This study gives a hint for Dental Surgeons about the location of the mandibular canal for Malaysians preventing them to avoid any injury during clinical procedures when treating Malaysians.

Ethics

Study was approved by the JEPeM-USM (18060266).

Declaration of Interest

The authors declare that they have no conflict of interest.

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