Morphometric analysis of mandibular canal course and position in relation to gender and age of Iraqi sample using digital panoramic imaging

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ABSTRACT

Background: The knowledge of the course and position of the mandibular canal in relation to anatomical landmarks of the jaw is of great importance in certain dental interventions; therefore it involves preservation of the anatomic structures that pass through it. Morphometric study by means of digital panoramic radiography reveals the differences and inherent alterations between genders or ages, it has become a useful tool in research that analyzes the craniofacial complex development process, which are important for planning the dental, clinical and surgical procedures. The aim of the study was undertaken to analyze mandibular canal morphology and position along its course and its relation to mandibular anatomical landmarks by using digital panoramic radiography.

Materials and Methods: 300 subjects, (150 male and 150 female) were examined, age distribution of them was ranging between (20-49) years old, factors considered included the age and sex of the patients. Ten linear vertical measurements were performed on the radiographic image of each subject on both right and left sides of the mandible (600) sides, to evaluate the position of the mandibular canal along its course. The relation of proximity between the mandibular canal and the roots of the mandibular posterior teeth were also evaluated.

Results: Statistically significant differences were observed in six of the linear measurements between genders, males almost have higher measurements than females. However, no significant linear trend was evident between age groups of the same gender for any of the measurements. The most frequent position of the mental foramen was between the two mandibular premolars, the mandibular canal presented a relation of proximity to the roots of the mandibular third molar, moving gradually away from the roots of the other posterior teeth.

Conclusion: the measurements related to the mandibular canal performed in this study can be influenced by the gender but are independent of age.

Key words: Mandibular canal, position, morphometry. (J Bagh Coll Dentistry 2011; 23(sp. issue):92-99).

INTRODUCTION

The mandibular canal (MC), or the inferior alveolar canal (IAC), is a canal within the mandible that is beginning in mandibular foramen on the medial surface of the ascending mandibular ramus. It runs obliquely downward and forward in the ramus, and then horizontally forward in the body till mental foramen. It transmits the inferior alveolar nerve, a branch of the third division of the trigeminal nerve, and the associated vessels [1,2] The MC is of particular importance to the dentist and dental specialist as it carries both the dental division of the mandibular nerve and the nerve supply for the lower lip [2,3]

The knowledge of the morphology and topography of the MC is important for performing dental interventions in the jaw; therefore it involves preservation of the anatomic structures that pass through it. In the surgical approach to the jaw, the MC isomical structure used as reference [4].

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Extraction of mandibular third molars, implant surgeries, orthognathic surgeries and those to reduce and to fix of fractures in the different regions of the jaw, are examples of the procedures that can be done close to the mandibular canal, increasing the risks of injuries to the inferior alveolar nerve [5,6]

The mandibular foramen is a useful anatomic point for positioning the needle in inferior alveolar nerve anesthesia, and for planning surgical procedures in the mandibular ramus region. Injecting anesthetic solution in the pterigomandibular space, region where the inferior alveolar nerve is found in the mandibular foramen, is an anesthetic technique frequently used in the dental clinic. The failure indices of this technique range from 29% to 35% because of the lack of precision in locating the anatomy of this foramen [7]

The mental foramen, the place where the mesial portion of the mandibular canal is exposed, is a reference structure with a great clinical applicability, being the place where the mental nerve passes through. Injecting anesthetic solution in the region of this foramen allows the mental nerve and inferior alveolar nerve to be effectively blocked in the mandibular premolar region[8]

Panoramic radiography is a widely used technique because it has the advantage of providing, in a single film, the image of both jaws, with a relatively low radiation dose, in a short period of time, and at lower cost if compared to more sophisticated techniques. This technique can offer information about the localization of anatomic structures vertical and horizontal bony diamentions. [9] However, a panoramic radiograph is a two-diamentional image, lacking information in the bucco-lingual direction and magnifying in both vertical and horizontal directions. The magnification factors are different to each unite so the resultant magnification is specific for each panoramic x-ray machine. [10] Nevertheless, the fact that the availability of panoramic imaging in the dental office and its widely use for evaluation of the jaws, justifies the interest in determining the visibility of anatomical structures on these films**.** [11]

SUBJECTS AND METHODS

The study sample was 300 Iraqi patients from both genders, (150 male & 150 female), attending to the Maxillofacial Radiology Department at Al-Karkh Hospital in Baghdad, referred for digital panoramic radiographs for various purposes, These participants were evaluated according to age and gender, they were divided to 3 groups according to age: first group: Subjects from (20-29) years of age (50 male & 50 female); second group: Subjects from (30-39) years of age (50 male & 50 female); and third group: Subjects from (40-49) years of age (50 male & 50 female). Sample individuals should have no history of any systemic disease that might affect bone metabolism, Alveolar crest resorption would have to be absent, Patients with extracted mandibular second molar and/or third molar, presence of crowding and spacing in the mandibular arch, past history of orthodontic treatment for mandibular arch, any pathology or congenital anomaly in the mandible that could affect the interpretation of radiographic image were excluded.

Methods

Panoramic image was taken for each subject using Dimax-3 digital X-ray machine, all subjects were positioned in the machine according to the manufacturer manual.

All images were examined on the monitor and the resolution was enhanced to what was considered optimum. The selected radiographic images are imported by (the DIMAX3 digital software) with specific tools for making linear measurements on images of the mandibular jaw. Six linear vertical measurements (D1, D2, D3, D4, D9 & D10) were performed on all radiographic images to describe the course of the mandibular canal and its relations with the anatomic structures of jaw according to Amorim et al, [12] , and four linear vertical measurements (D5, D6, D7 & D8) were performed to describe the vertical position of the mandibular canal in relation to the root apecis of the mandibular second molar tooth and mandible base according to Sato et al, [13]. These measurements were done on the right and left sides of the mandible image.

The following measurements were taken, figure (1):

D1 – Vertical distance of the most inferior point of the image of the inferior edge of the mental foramen to the image of the inferior limit of the mandible base at the shortest line connecting the alveolar crest and the inferior limit of mandible base, passing through the center of the mental foramen.

D2 – Vertical distance of the most superior point of the image of the superior edge of the mental foramen to the image of the superior limit of the alveolar crest at the shortest line connecting the alveolar crest and the inferior limit of mandible base, passing through the center of the mental foramen.

D3 – Vertical distance of the image of the inferior cortical wall of the mandibular canal to the inferior limit of the mandible base, in the height of the image of the anterior edge of the mandibular ramus.

D4 - Vertical distance of the image of the superior cortical wall of the mandibular canal to the inferior limit of the image of the oblique line in the height of the image of the anterior edge of the mandibular ramus.

D5 - Vertical distance of the most inferior point of the image of the inferior cortical wall of the mandibular canal to the inferior limit of the mandible base, at the shortest vertical line connecting the inferior point of the apex of mesial root of mandibular second molar and the inferior limit of the mandible base.

D6- Vertical distance of the image of the superior cortical wall of the mandibular canal to the inferior point of the apex of mesial root of mandibular second molar at the shortest vertical line connecting the inferior point of the apex of mesial root of mandibular second molar and the inferior limit of the mandible base.

D7 - Vertical distance of the most inferior point of the image of the inferior cortical wall of the mandibular canal to the inferior limit of the mandible base at the shortest vertical line connecting the inferior point of the apex of distal root of mandibular second molar and the inferior limit of the mandible base.

D8 - Vertical distance of the image of the superior cortical wall of the mandibular canal to the inferior point of the apex of distal root of mandibular second molar at the shortest vertical line connecting the inferior point of the apex of mesial root of mandibular second molar and the inferior limit of the mandible base.

D9 - Vertical distance of the most inferior point of the image of the mandibular notch to the image of the most superior point of the image of the superior edge of mandibular foramen at the line connecting the most inferior point of the image of the mandibular notch and the inferior edge of the mandibular ramus, passing through the center of the mandibular foramen.

D10 - Vertical distance of the most inferior point of the image of the mandibular notch to the image of the inferior edge of the mandibular ramus, passing through the center of the mandibular foramen.

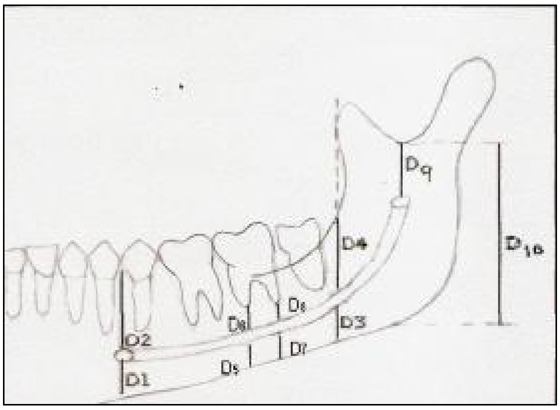

Figure 1: Measurements used to describe mandibular canal course and position.

Based on these ten measurements, the following ratios were calculated: R1 - Ratio between the measurements D1 and D2; R2 - Ratio between the measurements D3 and D4; R3 - Ratio between the measurements D5 and D6;R4 - Ratio between the measurements D7 and D8; and R5 - Ratio between the measurements D9 and D10.

The proximity of the image of the MC to the roots of mandibular posterior teeth was classified according to Madeira [14] in to three types of relation: **a.** There is a relation of proximity of the MC image only with the image of the root of the mandibular third molar, and from this point, there is a gradual removal of the MC in relation to the roots of other mandibular posterior teeth; **b.** There is an absence of proximity between the MC and the roots of mandibular posterior teeth; **c.** There is a relation of proximity between the MC and the roots of all the mandibular posterior teeth. This relation was determined by visual examination for both the right and left sides of the mandible image.

Statistical analysis:

Statistical analyses were computer assisted using SPSS (Statistical Package for Social Sciences). The bony measurements were normally distributed variables and thus conveniently described by mean, while ratios of two bony measurements are non-normally distributed and such variables are described by median and interquartile range (25^{th} to 75^{th} percentile). Independent samples t-test was used to test the statistical significance of difference in mean between 2 groups, Kappa statistics was used to assess the magnitude of agreement beyond chance. The statistical significance, direction and strength of linear correlation between age and a quantitative normally distributed variable was measured by Pearson's linear correlation coefficient. P- value less than the 0.05 level of significance was considered statistically significant.

RESULTS

Inspit of slight discrepancies in measurements, it was revealed that the mean of total values on the right side of the mandible was almost concordant with that on the left side for each linear measurement, no statistically significant differences existed between sides measurements, which justify using sides instead of subjects as the original unit of sampling (600 sides).

The difference in the mean of total values of linear measurements between the right and the left sides of the mandible was illustrated in table 1. Also, There was a bilateral concordance in the mandibular canal morphology in relation to the roots of posterior teeth, as illustrated in table 2.

The mandibular canal was proximal to the mandibular third molar tooth in most of the subjects (83.7 %), both for male and female and there were gradual removal of the canal from other molar teeth, as shown in table 3.

Details on the ten linear vertical measurements and their ratios variations in relation to age groups and gender are illustrated in tables 4,5&6. Age had no evident linear correlation with any of study measurements and their ratios. The means of overall values for D1, D2, D3, D4, D9 & D10 were significantly higher in male in comparison to female. The measurements D5, D6, D7 and D8 were almost higher in male than female measurements, however, these differences have no evident statistical significance. The position of the canal varies with respect to the lower border of the mandible and the apices of the roots of mandibular molar teeth. The MC relative vertical position tends to be closer to the mandibular teeth roots apices than to the mandible lower border.

The median value of R1 seem to be equal to that of R2, both for male and female, although the median of overall values for R1 & R2 were slightly higher in male (0.6) in comparison to female (0.58), this difference had no evident statistical value. R3 & R4 median values were significantly higher in male than female that means the MC in female tends to be relatively lower than that in male independent on age. There was no statistically significant difference between male and female in the median value of R5 as it was almost (0.5), that means that the mandibular foramen was almost located in the middle of the mandibular ramus independent on age or gender.

Table 1: Difference in the mean of total values between the right and the left sides of the jaw for the vertical linear measurements related to the MC

Distance-1	Right(N=300)	Left(N=300)	Difference between right and left	P (paired t-test)
Mean	9.63	9.68	-0.05	0.1[NS]
Distance-2				
Mean	16.87	16.89	-0.02	0.55[NS]
Distance-3				
Mean	9.34	9.3	0.04	0.65[NS]
Distance-4				
Mean	15.27	15.33	-0.06	0.35[NS]
Distance-5				
Mean	5.49	5.49	0	0.98[NS]
Distance-6				
Mean	4.11	4.07	0.04	0.54[NS]
Distance-7				
Mean	5.85	5.79	0.06	0.41[NS]
Distance-8				
Mean	3.56	3.54	0.02	0.64[NS]
Distance-9				
Mean	24.15	24.16	-0.01	0.58[NS]
Distance-10				
Mean	48.28	48.29	-0.01	0.85[NS]

Table 2: Agreement in mandibular canal morphology between the right & left sides

Right Canal	Left Canal			
	Proximal to third Molar	Away from all Molars	Proximal to all Molars	Total
Proximal to Third Molar	250	0	1	251
Away from All Molars	1	19	0	20
Proximal to All Molars	0	0	29	29
Total	251	19	30	300

Observed agreement = 99.3%
Kappa= 97.7% P=0.017

Table 3: Mandibular Canal Morphology

Mandibular Canal Morphology	Gender				P
	Male		Female		
	N	%	N	%	
overall					0.001
Proximal to Third Molar	251	83.7	251	83.7	
Away from All Molars	20	6.7	39	13	
Proximal to All Molars	29	9.7	10	3.3	
Total	300	100	300	100	
P (Chi-square) for difference between age groups =	0.75[NS]		0.12[NS]		

Table 4: Difference in the mean values of the vertical linear measurements related to the MC between males and females stratified by age groups.

D1	Gender		P (t-test)
	Male (Mean+/-SE)	Female (Mean+/-SE)	
(20-29) years of age	9.63+/-0.172	8.81+/-0.168	**0.001**
(30-39) years of age	10.6+/-0.177	9.84+/-0.134	**0.001**
(40-49) years of age	9.96+/-0.164	9.07+/-0.173	**<0.001**
	r (linear correlation with age) =0.038 **P=0.27[NS]**	r (linear correlation with age) =0.092 **P=0.11[NS]**	
D2			
(20-29) years of age	17.8+/-0.187	15.95+/-0.232	**<0.001**
(30-39) years of age	17.88+/-0.198	16.82+/-0.164	**<0.001**
(40-49) years of age	16.65+/-0.212	15.27+/-0.22	**<0.001**
	r (linear correlation with age) =-0.091 **P=0.11[NS]**	r (linear correlation with age) =0.069 **P=0.23[NS]**	
D3			
(20-29) years of age	10.09+/-0.208	8.78+/-0.168	**0.001**
(30-39) years of age	9.46+/-0.166	9.46+/-0.214	**0.99[NS]**
(40-49) years of age	9.21+/-0.217	8.94+/-0.104	**0.27[NS]**
	r (linear correlation with age)=-0.092 **P=0.11[NS]**	r (linear correlation with age)=0.081 **P=0.16[NS]**	
D4			
(20-29) years of age	15.56+/-0.267	15.14+/-0.178	**0.2[NS]**
(30-39) years of age	15.7+/-0.169	15.43+/-0.143	**0.22[NS]**
(40-49) years of age	15.21+/-0.184	14.76+/-0.132	**0.05[NS]**
	r (linear correlation with age)=-0.061 **P=0.08[NS]**	r (linear correlation with age) =-0.03 **P=0.61[NS]**	
D5			
(20-29) years of age	6.12+/-0.187	5.56+/-0.19	**0.034**
(30-39) years of age	5.75+/-0.149	5.24+/-0.195	**0.06 [NS]**
(40-49) years of age	5.32+/-0.162	4.96+/-0.171	**0.13 [NS]**
	r (linear correlation with age) =-0.112 **P=0.06[NS]**	r (linear correlation with age) = - 0.111 **P=0.06[NS]**	
D6			
(20-29) years of age	3.67+/-0.206	3.83+/-0.25	**0.62 [NS]**
(30-39) years of age	4.66+/-0.303	4.16+/-0.229	**0.2 [NS]**
(40-49) years of age	4.21+/-0.262	4.02+/-0.184	**0.54[NS]**
	r (linear correlation with age) =0.067 **P=0.24[NS]**	r (linear correlation with age) =0.108 **P=0.06[NS]**	
D7			
(20-29) years of age	6.67+/-0.199	6.06+/-0.262	**0.07 [NS]**
(30-39) years of age	5.93+/-0.153	5.55+/-0.197	**0.13 [NS]**
(40-49) years of age	5.66+/-0.166	5.04+/-0.185	**0.013**
	r (linear correlation with age) =-0.026 **P=0.41[NS]**	r (linear correlation with age) =-0.018 **P=0.61[NS]**	
D8			
(20-29) years of age	3.08+/-0.22	3.5+/-0.456	**0.41[NS]**
(30-39) years of age	4.11+/-0.305	3.45+/-0.222	**0.08[NS]**
(40-49) years of age	3.74+/-0.263	3.36+/-0.182	**0.66[NS]**
	r (linear correlation with age) =0.096 **P=0.09[NS]**	r (linear correlation with age) =-0.091 **P=0.08[NS]**	
D9			
(20-29) years of age	25.53+/-0.162	23.36+/-0.15	**<0.001**
(30-39) years of age	24.92+/-0.232	23.19+/-0.106	**<0.001**
(40-49) years of age	24.81+/-0.204	23.08+/-0.123	**<0.001**
	r (linear correlation with age) =-0.018 **P=0.61[NS]**	r (linear correlation with age) =-0.014 **P=0.81[NS]**	
D10			
(20-29) years of age	50.9+/-0.328	46.52+/-0.284	**<0.001**
(30-39) years of age	50.31+/-0.313	46.17+/-0.24	**<0.001**
(40-49) years of age	49.91+/-0.332	45.86+/-0.223	**<0.001**
	r (linear correlation with age) =-0.081 **P=0.12[NS]**	r (linear correlation with age) =-0.051 **P=0.38[NS]**	

Table 5: Difference in overall mean values of the vertical linear measurements between males and females

Distance	Gender		P (t-test)
D1	**Male (N = 300)**	**Female (N = 300)**	
Mean+/-SE	10.06+/-0.101	9.24+/-0.095	<0.001
D2			
Mean+/-SE	17.4+/-0.119	16.01+/-0.121	<0.001
D3			
Mean+/-SE	9.58+/-0.116	9.06+/-0.098	<0.001
D4			
Mean+/-SE	15.49+/-0.122	15.11+/-0.089	<0.001
D5			
Mean+/-SE	5.73+/-0.098	5.25+/-0.108	0.07 [NS]
D6			
Mean+/-SE	4.18+/-0.151	4+/-0.128	0.38[NS]
D7			
Mean+/-SE	6.08+/-0.103	5.55+/-0.127	0.08 [NS]
D8			
Mean+/-SE	3.65+/-0.154	3.57+/-0.179	0.75[NS]
D9			
Mean+/-SE	25.09+/-0.117	23.21+/-0.074	<0.001
D10			
Mean+/-SE	50.37+/-0.188	46.18+/-0.145	<0.001

Table 6: Difference in overall median values of ratios between males and females

	Gender		P (Mann-Whitney)
R1 (D1/D2 Ratio)	**Male (N = 300)**	**Female (N = 300)**	
Median	0.6	0.58	0.12[NS]
R2 (D3/D4 Ratio)			
Median	0.6	0.58	0.17[NS]
R3 (D5/D6 Ratio)			
Median	1.54	1.36	0.026
R4 (D7/D8 Ratio)			
Median	2.1	1.59	0.03
R5 (D9/D10 Ratio)			
Median	0.5	0.5	0.09[NS]

DISCUSSION

In this study, the mean values of the distances between the image of the mental foramen and the mandible base (D1), and of this foramen to the alveolar crest (D2) had no statistically significant differences between the analyzed age groups, confirming the stability of this relation throughout the individual's adult life, that agreed with Amorim et al, [12] and Sahin et al, [15] .The median value of R1 (D1/D2) did not differ statistically between the studied groups indicating that it is constant, which was in conformity with Spaltenholz et al, [16] ; Neder & Arruda[17]; Wang et al [18];Oguz & Bozkirn[19]; Teerijoki-Oksa et al, [5]**;** Souaga et al, [20]; Freitas [21] ; Yesilyurt et al, [22] ; Amorim et al,[12] ; Junior et al, [23] and Sahin et al, [15] .

Although some authors have affirmed that mental foramen is located in mid point between the alveolar crest and the mandible base [16,18,19]. The results of this study agree with other authors [5, 12,15,22,23] who showed that the mental foramen presents a position closer to the mandible base than to its superior border.

The median values of R2 (D3/D4), both in the height of the mandibular ramus, presented no statistically significant differences between the studied groups, suggesting that this relation also remains constant throughout the individual's adult life, independent of gender. The mean values of R2 are similar to the mean values of R1, indicating that during the course of the canal in the body of the mandible, it maintains constant relations between the canal/mandible base and canal/alveolar crest distances.

The relative vertical position of the mandibular canal was determined by (R3) - the ratio between the measurements D5 & D6 and (R4) - the ratio between the measurements D7 & D8. The results of this study have revealed that the median values of both R3 & R4 had no evident linear correlation with age in the studied groups, but there was a statistical significant difference ($P<0.05$) in the median values of R3 between male (1.54), which was higher than that of female (1.36), also, there was a statistical significant difference in the median values of R4 between male (2.1), which was higher than that of female (1.59).

It was obvious from these findings that the position of the canal varies with respect to the lower border of the mandible and the apices of the roots of the 2nd molar tooth and that the vertical position of MC was closer to the apices of the second molar than that to the inferior border of mandible. The present study results agree with Nortjé et al, [24], Littner et al, [25], Denio et al, [26], Sato et al, [13] , Kovisto et al, [27]. The results of this study showed that median values in male were higher than those in female for both (R3& R4). These findings indicate that the MC in female tends to be relatively lower than that in male independent of age. Nortjé et al, [24] found that bilateral single low mandibular canals were more common in females (50.5 per cent) than in males (46.5 percent). This finding agrees with the results of the present study.

The distance from the image of the mandibular foramen to the image of the mandibular incisure (D9) and the image of the total length of the mandibular ramus (D10) presented no statistically significant differences in relation to the studied age groups, however, both distances were higher in males, confirming the results founded by other authors, Afsar et al, [7], Amorim et al, [12] and Jalili [28]. In the present study, the ratio R5 (D9/D10) did not differ statistically between the studied groups, indicating that vertically, the foramen is in the middle portion of the mandibular ramus, at a point located approximately in the half of its length. This result is an important data for planning surgery that involves the mandibular ramus. Moreover, from these median value it can be estimated in which region the needle for the anesthesia to block this nerve must be located.

D1, D2, D3, D4, D9 and D10 were significantly higher in male, confirming the results of previous study conducted by Enlow & Hans [29], they affirmed that in the adult phase, the rate and speed of growth are bigger in men, with the result that craniofacial dimensions in this gender are from 5 to 9% bigger when compared with those of women. Bone growth in the adult phase can be controlled by multiple factors. Sex hormones, such as estrogen and progesterone can influence in the speed of bone growth in this phase, contributing to the development of craniofacial morphologic differences betweenthe genders. Furthermore, the muscular tension is considered an inductive factor of bone formation, and in the mandible, the contraction of the elevating muscles during masticatory movements exerts tension throughout the mandibular ramus. In general, men have stronger masticatory muscles than the women [30]. The two factors mentioned above can explain the differences found between the genders in all of the ten linear measurements in the present study.

The measurements (D5, D6, D7 & D8) were anatomically individualistic, independent of variation of gender or age. The mandibular canal presented a close relation with the mandibular third molar, with a gradual removal of the roots of other mandibular teeth, this anatomic relation of proximity of the mandibular canal with the roots of the mandibular third molar can justify the index of 0.5% to 5% of risk for damage to the inferior alveolar nerve during the extraction of this tooth [6].

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