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Morphological assessment of the mandibular canal inferior to the mandibular second molar in an Arab Iraqi population using cone beam computed tomography

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ABSTRACT

Background: The mandibular canal (MC) serves as the pathway for the inferior alveolar neurovascular bundles, which terminate at the mental foramen.

Objective: The aim of the study was to compare the shape, size, and location of the MC inferior to the mandibular second molar of an Arab Iraqi population according to gender.

Materials and Methods: The study involved 200 CBCT images (100 males and 100 females) of the Arab population in Iraq, which were examined for the morphology of MC inferior to the mandibular second molar The measurements were shape and size. The location of MC includes distance from the MC to the buccal and lingual alveolar ridges, distance from the MC to the root, distance from the MC to buccolingual borders, and distance from the MC to the inferior border of the mandible.

Results: Mandibular second molars present in 71 males and 60 females on the right side and 55 males and 64 females on the left side. The shape of MC was oval and irregular, with a significant difference between the genders on the right side but no significant difference on the left side. The size and location measurements were larger in males than in females, except for the distance from the MC to the lingual border, which was significantly higher in females. The distance from the MC to the root was zero in one case.

Conclusion: Before performing endodontic or surgical procedures involving the mandibular second molar, it is crucial to accurately identify the MC morphology particularly its location to avoid MC injury. This precise anatomical knowledge is not only essential for successful dental procedures but also plays a vital role in forensic investigations. Dentists, with their knowledge in craniofacial anatomy, are increasingly sought as experts in forensic and legal cases.

Keywords: mandibular canal, CBCT, mandibular second molar, Iraqi population

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INTRODUCTION

The underlying cause of 63% of dental cases with neuropathy is due to invasive treatment.[1] If implant surgery and endodontic operations are not performed appropriately, they might result in neurological impairments, including pain, paresthesia, or anesthesia.[2,3]

The inferior alveolar nerve (IAN) is very susceptible to injury. Before conducting surgical intervention on such affected regions, it is crucial for the surgeon to have a comprehensive understanding of the anatomical landmarks and structures in close proximity to the area.[4] The use of cone beam computed tomography (CBCT) can provide precise readings. However, the availability of CBCT may be limited at times.[5]

There are three recognized ways that implants and endodontic operations can cause injury to the IAN: mechanical, chemical, and thermal.[6] The IAN may sustain mechanical damage due to an injection, drilling method, or implant implantation in close proximity to the nerve,[7] excessive instrumentation and overextension, or an iatrogenic error such as nerve severance.[8] An irrigation solution, an endodontic intracanal medicament, or a sealer can chemically damage IAN.[9] Thermal injury to the IAN can occur due to excessive heat generated by the implant drill, the prolonged use of ultrasonic devices, or the placement of an overheated gutta-percha in a canal that has been excessively prepared.[10]

The mandibular canal (MC) encloses the IAN, which splits into the mental and incisive nerves at the mental foramen. This usually occurs in the space between the two premolars or close to the apex of the second premolar.[9] Before performing a surgical operation that involves penetrating the posterior mandible, it is crucial to know the exact location of the IAN.

Research has shown that CBCT is a reliable and accurate method for clinical assessments, such as determining the height and thickness of the buccal bone.[10,11] Recent investigations using CBCT have examined the correlation between the root tips and the thickness of the MC and the buccal bone.[12–14]

The objective of this study was to use existing CBCT scans to measure the location of the MC, the thickness of the buccal and lingual bone above the MC, the size of the MC, and the shape of the MC below the second molar tooth. These findings contribute to the knowledge base of dentists.

MATERIALS AND METHODS

The study included a total of 200 CBCT images, with an equal distribution of 100 males and 100 females from the Arab Iraqi population aged 20–50 years. These images are recorded in the data archive of a CBCT device located in a private clinic called Baghdad GAMA clinics. The study was conducted in accordance with the ethical approval of the School of Dental Sciences at Universiti Sains Malaysia. An examination and measurement of both sides of the mandible was conducted while the sound second molar (M7) was present and the MC was visible without any distortion. The image was viewed with the reliable RadiAnt DICOM viewer software used in previous research.[15,16]

The measurements were performed by the first author. Two weeks elapsed between the applications of the same measures in 10% of subjects to assess intra-examiner reliability. Similarly, 10% of subjects were chosen for inter-examiner reliability between two examiners. The second examiner had expertise in CBCT readings and was an oral and maxillofacial radiologist. The Kappa test was used to assess the reliability of shape, and the intra-class correlation coefficients (ICC) test assessed MC size and location reliability. All indicators showed good intra- and inter-examiner agreement.

The measurements taken were as follows:

1. Distance from the most superior aspect of MC to the apex of the root (MC-R).
2. Distance from the most superior aspect of MC to the most superior aspect of the buccal ridge crest (MC-BC).
3. Distance from the most superior aspect of MC to the most superior aspect of the lingual ridge crest (MC-LC).
4. Distance from the most buccal aspect of MC to the buccal border of the mandible parallel to the horizontal reference line (MC-BB).
5. Distance from the most lingual aspect of MC to the lingual border of the mandible parallel to the horizontal reference line (MC-LB).
6. Distance from the most inferior aspect of MC to the inferior boder of the mandible parallel to the vertical reference line (MC-IB).
7. By selecting the “closed polygon” option in the “measurements and tools” feature of RadiAnt DICOM, the width, length, and area of the MC below the root was calculated, as shown in Figures 1–3.

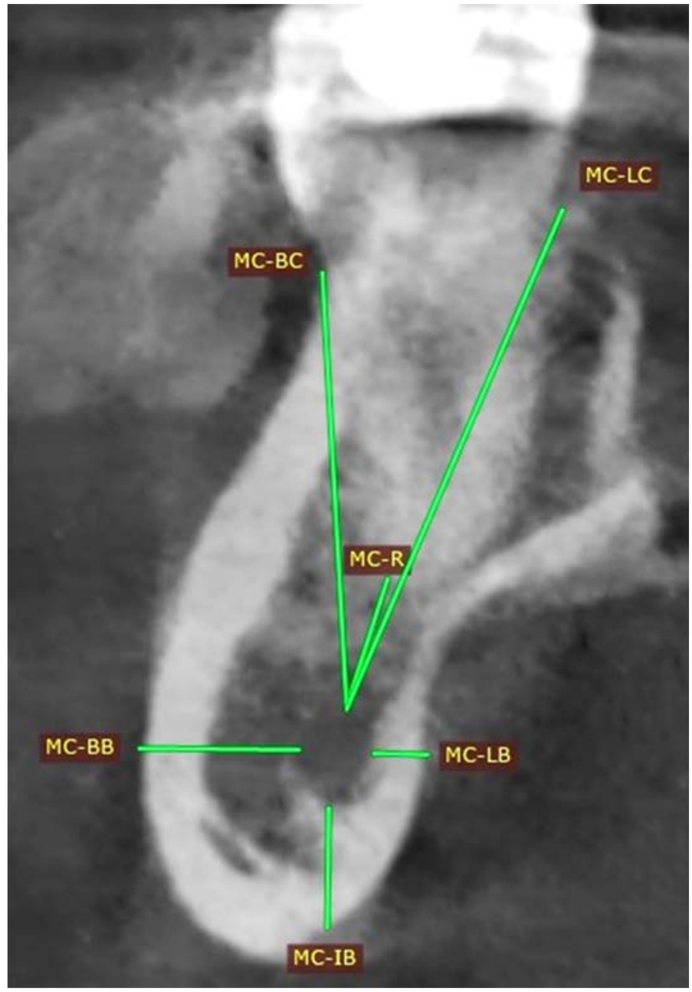

Figure 1. Measurements of the location of the MC in cross section.

8. The MCs located under each root can be categorized as oval (when the width is not equal to the length of the MC), round (when the width is equal to the length of the MC), or irregular in shape.

   All measurements were conducted in accordance with the research studies.[17,18]

Statistical analysis was performed using IBM SPSS version 26. The chi-square test was used to assess the shape of the MC. The Mann–Whitney U test was used to compare the size and location measures.

RESULTS

M7 was found on the right side in 71 males and 60 females and on the left side in 55 males and 64 females. The MC on the right side was oval in most subjects, with 37 males and 32 females showing a notable difference between the two genders ($p = 0.019$). The irregular type was observed in 34 males and 28 females. The observations on the left side revealed that the majority of subjects were oval in shape (32 males and 35 females; $p = 0.702$), with no significant differences. The irregular type was observed in 23 males and 29 females, as shown in Table 1.

The measures of MC size (width, length, and area) below the distal root of M7 were significantly larger in males than in females. Only the MC length differences on the right side was not statistically significant (Table 2).

The MC location beneath the distal root of M7 on the right side indicated that most measurements were higher in males than in females, although only the **MC-BC** measurement showed a significant difference. The **MC-BB** and **MC-LB** were larger in females, with a significant difference only in the **MC-LB.** On the left side, the measurements of **MC-R**, **MC-BC**, and **MC-LC** were significantly larger in males. On the other hand, females have larger measurements for **MC-BB**, **MC-LB,** and **MC-IB** with significant difference only for **MC-LB** (Table 3).

Figure 2. Measurements of the width and length of the MC in cross section.

DISCUSSION

It is well known that individuals exhibit variations in the development of their musculoskeletal system and follow diverse growth patterns. The study of sexual dimorphism in adults is facilitated by the hormonal and endocrine processes that regulate sexual differentiation.[19,20]

Occupational stress patterns vary between cultures, leading to population-specific standards for sexual differentiation in bone changes.[21]

The importance of CBCT as a pre-mortem technique is increasing due to its widespread use as a dental radiological technology, particularly due to its consistent and accurate measurement of mandibular features.[22,23]

Several recent research studies have investigated sexual dimorphism in the relative location of the inferior dental canal and its foramina in adults using CBCT scans. Some of these studies included images showing sexual dimorphism, while others did not.[24–26]

The morphology of MC exhibited significant variation, characterized by vertical dimensions exceeding the horizontal diameter, resulting in an oval shape. This is consistent with previous studies.[27,28] Furthermore, the irregular shape was also observed in other cases, confirming this finding with previous studies.[29,30] The morphology of the mandibular foramen is closely associated with the arrangement of its veins and nerves, which may adopt an oval, circular, or intermediate configuration.[31] Similarly, the shape of the MC, which is an extension of the mandibular foramen, mirrors the course of the veins and nerves inside it.

The shape of the MC showed a significant difference on the right side, whereas no significant difference was observed on the left side. Consequently, it is not possible to reliably identify gender based on the morphology of the MC. This finding is consistent with previous research studies.[27,28]

Figure 3. Measurements of the area of the MC in cross section.

Table 1. Descriptive statistics and comparison of the shape of the MC under the distal root of the lower second molar in the Arab population (right side (R) and left side (L)).

Gender	Oval	Irregular	Total	X^2	DF	p
Male (R)	37	34	71	0.019	1	0.019*
Female (R)	32	28	60			
Male (L)	32	23	55	0.147	1	0.702
Female (L)	35	29	64			

*Significant at $p < 0.05$. Chi-square for differences.

The research revealed significant differences in the measurements of MC size between males and females. As far as we know, no study has shown differences in the size of the MC between males and females.

Male individuals had greater distances from the alveolar crest compared to females, consistent with previous studies.[32]

Male MCs were further away from the root apex than female MCs. This is in line with the research efforts of previous studies.[33,34] There may be an increased susceptibility to IAN injury during dental procedures among females.[34]

There was no significant difference between genders with respect to the distance between the inferior border of the mandible and the MC. This finding is consistent with a previous study.[35]

The buccolingual distance was larger in the female group (especially the distance from the MC to the lingual border). This finding is consistent with previous studies.[36,37] This is mainly associated with

Table 2. Descriptive statistics of the size of the MC under the distal root of the lower second molar in the Arab population (right side (R) and left side (L)).

	Gender	*N*	IQR	Median	Z score	*p*
Width MC-(R) (mm)	Male	71	0.78	2.29	2651.50	0.016*
	Female	60	0.91	2.03		
Length MC-(R) (mm)	Male	71	0.89	2.84	2547.00	0.054
	Female	60	0.73	2.59		
Area MC-(R) (mm^2)	Male	71	2.22	5.39	2679.00	0.011*
	Female	60	2.55	4.38		
Width MC-(L) (mm)	Male	55	0.61	2.65	2452.50	< 0.001**
	Female	64	0.71	2.09		
Length MC-(L) (mm)	Male	55	0.59	2.80	2140.50	0.043*
	Female	64	0.62	2.60		
Area MC-(L) (mm^2)	Male	55	1.42	5.74	2411.50	0.001*
	Female	64	1.70	4.29		

*Significant at $p < 0.05$, **significant at $p < 0.001$. Mann–Whitney U test for differences. MC: mandibular canal, IQR: interquartile range.

Table 3. Descriptive statistics and comparison of the position of the MC under the distal root of the lower second molar in the Arab population (right side (R) and left side (L)).

	Gender	*N*	IQR	Median (mm)	Z score	*p*
MC-R (R)	Male	71	2.30	5.40	2410.50	0.195
	Female	60	4.56	4.28		
MC-BC (R)	Male	71	3.97	15.40	2880.50	0.001*
	Female	60	4.68	14.00		
MC-LC (R)	Male	71	4.32	17.40	2545.50	0.055
	Female	60	4.67	16.80		
MC-BB (R)	Male	71	1.99	5.30	1966.00	0.449
	Female	60	1.16	5.74		
MC-LB (R)	Male	71	1.46	1.68	1387.00	0.001*
	Female	60	1.45	2.10		
MC-IB (R)	Male	71	2.52	7.33	2258.50	0.553
	Female	60	2.30	6.89		
MC-R (L)	Male	55	3.98	4.79	2215.50	0.015*
	Female	64	4.65	3.28		
MC-BC (L)	Male	55	4.00	15.40	2568.00	<0.001**
	Female	64	3.50	13.60		
MC-LC (L)	Male	55	4.20	17.90	2306.50	0.004*
	Female	64	4.38	16.60		
MC-BB (L)	Male	55	1.42	5.55	1716.50	0.817
	Female	64	1.50	5.68		
MC-LB (L)	Male	55	0.75	1.68	1162.00	0.001*
	Female	64	1.19	2.0		
MC-IB (L)	Male	55	3.05	7.37	1548.00	0.258
	Female	64	1.91	7.77		

*Significant at $p < 0.05$, **significant at $p < 0.001$. Mann–Whitney U test for differences. IQR: interquartile range.

hormonal effects such as postmenopausal estrogen deprivation or hyperthyroidism, which affect calcium metabolism.[38,39]

CONCLUSION

This study provides important information about the shape, size, and location of the MC below the distal root of M7, particularly for clinical and forensic dentistry. It was also revealed that females are more likely to sustain an IAN injury because their MC is closer to the root apex. However, the study found that the measurements were not reliable enough to distinguish between genders.

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CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

AUTHORS' CONTRIBUTIONS

Omar Basheer Taha: Conceptualization (Equal), Formal analysis (Lead), Methodology (Equal), Investigation (Lead), Supervision (Lead), Validation (Lead), Writing – Original draft (Lead). **Mohamad Arif Awang Naw:** Formal analysis (Supporting). **Johari Yap Abdullah:** Validation (Supporting), Writing – Review & editing (Equal). **Asilah Yusof:** Conceptualization (Equal), Methodology (Equal), Supervision (Supporting), Validation (Supporting), Writing – Review & editing (Equal).

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