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Prevalence of Mandibular Incisive Canal and its Anatomical Relationship Using CBCT

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Aim: The objective of this retrospective study was to assess the prevalence of the mandibular incisive canal (MIC) and evaluate the morphometric parameters through the utilization of cone beam computed tomography (CBCT).

Materials and methods: Two hundred and sixty-four CBCT scans of patients aged 18 to 70 were part of this study, including both genders. After confirming the presence of MIC, its length was determined, and subsequent measurements were taken based on its extension in the canine, lateral incisor, and first premolar regions. These measurements included the lingual bony surface, the distance between the labial bony surface and the canal, inferior border, and alveolar bone crest.

Results: The prevalence of MIC was observed in 121 cases (45.8%), with an average length of 9.91 mm. The distance from the canal to the alveolar crest at the first premolar, canine, and lateral incisors were 18.44 mm, 18.99 mm, and 16.14 mm, respectively. Moreover, the distances to the inferior border were 8.79 mm, 9.39 mm, and 9.21 mm, respectively; to the labial bone surface were 3.05 mm, 3.35 mm, and 3.14 mm, respectively; and to the lingual bone surface were 4.83 mm, 4.64 mm, and 5.94 mm, respectively.

Conclusion: Greater attention is warranted from radiologists and surgeons to avoid mandibular incisive nerve damage during different dental treatments. Therefore, using CBCT to identify the existence and location of the MIC is crucial.

Keywords: CBCT, interforaminal region, mandibular incisive canal, prevalence.

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Introduction

The 5th cranial, trigeminal, is the biggest mixed cranial nerve. It has three terminal branches: maxillary, ophthalmic, and mandibular. The largest branch of the trigeminal nerve is the mandibular nerve. The inferior alveolar nerve is a significant branch of the mandibular nerve; the nerve passes through the mandibular canal and leaves through the mental foramen as an incisive nerve and mental nerve; the incisive nerve continues anteriorly within the mandibular incisive canal (MIC), providing innervation and carrying sensory fibers for sensation and nutrition to the mandibular first premolar, canine, lateral, and central incisors.[1]

Historically, it has been considered that surgeries in the anterior region of the mandible are safe to perform.[2] The designation of this area as a "safe zone" is not supported because there have been significant reports in the literature about implant surgery that have described complications related to MIC injury or damage, including bleeding in the floor of the mouth after bone graft removal, neurosensory disorders,[3] and continuous discomfort experienced during implant placement.[4] This means that during dental surgical operations, consideration must be given to the anatomical vital structures of the anterior mandible.[5]

Although numerous imaging modalities have been employed to detect the incisive canal, panoramic radiography is frequently utilized as a screening technique following dental procedures. A panoramic radiograph, on the other hand, is a two-dimensional representation devoid of buccolingual details. Additionally, it is challenging to take precise measurements due to the variable intrinsic distortion that panoramic views generate. As a result, while panoramic imaging can detect a possible anterior looping and the mental foramen, it is ineffective in identifying the MIC.[6]

Cross-sectional radiography for initial assessment has become more accessible due to recent technological and apparatus advancements. Furthermore, these pictures supply further details about MIC in three dimensions. Computer-based imaging systems like cone beam computed tomography, as a 3D imaging modality, provide superior advantages over 2D imaging systems. [7] CBCT is highly effective in identifying the MIC due to its high-resolution [8], three-dimensional imaging capabilities. This technology offers precise localization and detailed visualization of the MIC to avoid nerve damage, which is crucial for various dental procedures like implant placement, endodontic treatment, and orthognathic surgery. CBCT helps in avoiding complications, assessing anatomical variations, and planning surgical interventions accurately.Despite its benefits, CBCT comes with considerations such as higher radiation exposure, cost, accessibility, and the need for specialized expertise in image interpretation. Overall, CBCT is an invaluable tool in modern dentistry for managing the MIC, enhancing diagnostic precision and patient outcomes. [9]

Numerous studies have been conducted on different populations to identify the MIC using CBCT, in 2018, Gomes et al. [10] aimed to assess the prevalence, length, and distances associated with MIC in the Brazilian population; in 2022, Nikkerdar et al. [11] in the Iranian population, In 2023, Yuzbasıoglu et al. [12] assessed the prevalence of MIC in the Turkish population, In 2023, Nasher et al. [13] evaluate the prevalence of MIC in a sample of the Yemeni population using CBCT. Until now, based on our knowledge, the prevalence, morphological characteristics, and anatomical relationships of MIC in the Egyptian population have not been well studied in the available literature. Furthermore, oral and maxillofacial surgeries at the inter-foraminal distance of the mandible necessitate the careful detection of MIC presence.

The potential consequences of various dental procedures include the risk of harm to the mandibular incisive nerve. CBCT scans have limitations, including image noise caused by scattered radiation and electronic noise, reduced contrast resolution due to scattered radiation, artifacts caused by high-density materials like fillings and implants, and beam hardening artifacts like cupping and streak artifacts. These limitations can affect the quality of the image and make it difficult to diagnose some conditions.

Given the potential variations in mandibular incisive canal (MIC) location and size observed in other populations[14]. Is there a significant prevalence of the MIC among the Egyptian subpopulation, and what is the anatomical relationship of the canal? This study aims to assess the prevalence of the mandibular incisive canal (MIC) and evaluate the morphometric parameters including its path and position in relation to the cortical bone and the lower border of the mandible through the utilization of CBCT.

Materials and Methods

Two hundred sixty-four CBCT scans were retrospectively analyzed in this study. The MIC was evaluated on both the right and left sides during each scan. The study received ethical approval from FDASU-RecEM012101. The evaluation of the sample size was predicated on the study by Gomes et al.[15] The predicted sample size (n) was determined to be an overall of 264 cases, utilizing an alpha (α) level of 0.05 (5%), a beta (β) level of 0.20 (20%), power = 80%, and an allowance of error of 5% with limited population modification. The specimen size was determined using Epi Info for Windows version 7.2.

This retrospective study included CBCT scans of patients seeking dental treatment at Ain Shams University's Department of Oral and Maxillofacial Radiology, Faculty of Dentistry. The inclusion criteria for dentulous patients' age ranges were from 18 to 70 years old, and both genders were included. Scans with a field of view (FOV) sufficient to reveal the premolar and anterior regions in the lower jaw to display the anatomical structures for the MIC detection**.** Exclusion criteria: all scans exhibiting pathological conditions in the region of interest (tumors, cysts), fractures, and artifacts in the area of interest caused by metallic objects as a restoration were excluded from the study.

I-CAT Next Generation CBCT machine (Imaging Sciences International, Hatfield, PA, United States) was employed to obtain each scan. The scanning time is 26.9 seconds, with a tube voltage of 120 kVp, and a tube current of five mA. The voxel size was 0.2mm, and the field of view was 16 × 6 cm. Image examination was conducted as follows: The acquired Digital Imaging and Communications in Medicine (DICOM) data were analyzed using the OnDemand3DApp software developed by Cybermed Inc. Korea.

Both multiplanar reformatted (MPR) and dental modules were used to detect and assess the incisive canal on each side. The dental module used the axial plane to draw a dental arch, creating a reconstructed panorama and cross-sectional cuts. Once the existence of a MIC was verified, two observers with 4 years of experience. The observers were well trained to the interpretation of the CBCT besides, calibration sessions were completed before executing any interpretation or measurements with an experienced oral and maxillofacial radiologist (more than 10 years of experience) to ensure the accurate detection of the canal and the standardization of all measurements. (M.B) and (M.G) measured the MIC length from its origin to its complete length, as well as the distance between the MIC and the lingual bony surface, the labial bony surface, the inferior border, and the alveolar bone crest. The MIC length was assessed on the reconstructed panoramic view starting from the distal end of the mental foramen, anteriorly towards the anterior end of the canal (Fig. 1). In addition, the remaining measurements were standardized on the MPR screen.

Reference line standardization was adjusted on the primary premolar, canine, or lateral incisor according to the end of the MIC. The measurement between the most buccal point of the buccal cortex of the MIC to the labial bony surface of the mandible (Fig. 2). Similarly, the measurement between the most lingual point of the MIC and the lingual bony surface of the mandible (Fig. 3). The distance from the MIC to the inferior border of the mandible (Fig. 4). And the distance from the MIC to the alveolar bone crest was determined (Fig. 5).

Figure 1: Mandibular incisive canal (MIC) length on both sides.

Figure 2: Distance from the MIC to the labial bony surface at the first premolar (a), canine (b), and lateral incisor (c).

Figure 3. Distance from MIC to the lingual bony surface at the first premolar (a), canine (b), and lateral incisor (c).

Figure 4. Distance from MIC to the inferior border at the first premolar (a), at canine (b), and lateral incisor (c).

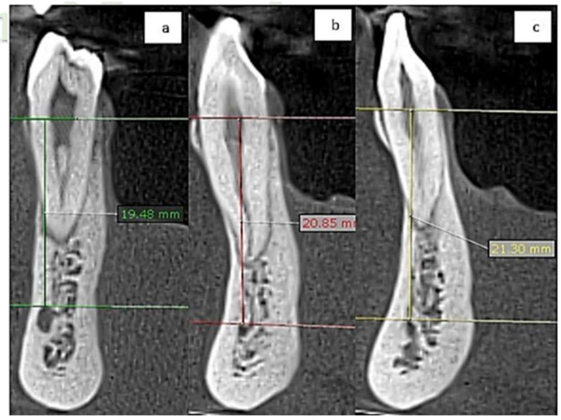

Figure 5. Distance from MIC to the alveolar bone crest at the first premolar (a), canine (b), and lateral incisor (c).

Statistical analysis

Ordinal and categorical data were introduced as frequency and percentage values, while mean and standard deviation values were used to represent the numerical data. Shapiro-Wilk's test was employed to assess their normality. Age data were generally distributed, while linear measurement data were not parametric. Associations between linear measurements and gender were examined with the Mann-Whitney U test, and Spearman's rank-order correlation coefficient was used to assess correlations between linear measurements and age. Inter-observer reliability was analyzed using the intraclass correlation coefficient (ICC). For each test, the significance level was established at $p < 0.05$. Statistical analysis was conducted using version 4.3.1 of the R statistical analysis software for Windows.

Results

This study included an equal number of males and females (132 participants in both sexes), with an average age of 37.03±10.04 years. A strong agreement between both observers was statistically significant (ICC= 0.905, $p<0.001$). The prevalence of MIC was observed in 121 cases (45.8%). Descriptive statistics of the study focus on linear measurements of the MIC's length on both sides (Mean±SD = 9.91±2.58) and the distance from the MIC to the alveolar bone crest at the lower first premolar (Mean±SD = 18.44±2.92). Additionally, measurements were taken for the following: distance from MIC to the inferior cortex 8.79±1.94, labial bony surface 3.05±1.32, lingual bony surface 4.83±1.47, alveolar bone crest mean±SD 18.04±2.76 at the lower first premolar; and distance from MIC to the alveolar bone crest mean±SD 18.04±2.76, to inferior cortex 9.39±2.92, to labial bony surface 3.35±1.21, to lingual bony surface 4.64±1.56 at the lower canine; and distance from MIC to the alveolar bone crest mean±SD 16.14±6.58, to inferior cortex 9.21±2.05, to labial bony surface 3.14±1.13, to lingual bony surface 45.94±1.38 at the lower lateral incisor.

The association between linear measurements and gender MIC length did not reach statistical significance ($p = 0.645$). However, In the region of the lower first premolar area (MIC to the alveolar bone crest), (MIC to the inferior cortex), and (MIC to the lingual bony surface), compared to females, males possessed significantly greater values ($p < 0.001$). While for the MIC to the labial bony surface, no statistically significant distinction existed regarding the sexes. ($p = 0.894$). In the lower canine form (MIC to inferior cortex), males had a significantly greater value than females ($p = 0.009$). Additionally, for other measurements, there was no significant difference between the genders ($p > 0.05$). At the lower lateral incisor for all measurements, no statistically significant distinction was observed among the sexes ($p > 0.05$) (Table 1).

There was no statistically significant correlation between linear measurements and age regarding MIC length. ($p = 0.573$). However, in the region of the lower first premolar (MIC to the alveolar bone crest), a negative relationship existed. ($r_s = -0.224$, $p = 0.001$). Meanwhile, there was no statistically significant relationship ($p > 0.05$) at the lower canine for other measurements. A negative correlation existed between the MIC and the alveolar bone crest ($r_s = -0.415$, $p = 0.002$). The correlation was weakly positive for MIC to the lingual bony surface ($r_s = 0.286$, $p = 0.036$). However, for other measurements, no statistically significant correlations were observed ($p > 0.05$) at the lower lateral incisor. Statistically, none of the correlations were significant ($p > 0.05$) (Table 2).

Table 1: Associations between linear measurements of MIC various anatomical landmarks and gender

Side	Tooth	Measurement	Correlation coefficient	p-value
Both sides	Length of the canal		-0.038	0.573ns
	Lower first premolar	MIC to the alveolar bone crest	-0.224	0.001*
		MIC to the inferior cortex	0.097	0.157ns
		MIC to the labial bony surface	0.008	0.908ns
		MIC to the lingual bony surface	0.056	0.421ns
	Lower canine	MIC to the alveolar bone crest	-0.415	0.002*
		MIC to the inferior cortex	0.048	0.730ns
		MIC to the labial bony surface	-0.025	0.858ns
		MIC to the lingual bony surface	0.286	0.036*
	Lower lateral incisor	MIC to the alveolar bone crest	-0.018	0.969ns
		MIC to the inferior cortex	0.145	0.784ns
		MIC to the labial bony surface	0.044	0.934ns
		MIC to the lingual bony surface	0.319	0.538ns

NA: Not Applicable, *; significant (p<0.05) ns; non-significant (p>0.05).

Table 2: Correlations between linear measurements of MIC various anatomical landmarks and age.

Side	Tooth	Measurement	Mean±SD		p-value
			Male	Female	
Both sides	Length of the canal		9.97±2.56	9.84±2.62	0.645ns
	Lower first premolar	MIC to the alveolar bone crest	18.98±2.71	17.77±3.06	<0.001*
		MIC to the inferior cortex	9.64±1.82	7.71±1.51	<0.001*
		MIC to the labial bony surface	3.11±1.48	2.99±1.10	0.894ns
		MIC to the lingual bony surface	5.16±1.46	4.42±1.39	<0.001*
	Lower canine	MIC to the alveolar bone crest	19.84±3.04	18.28±2.88	0.053ns
		MIC to the inferior cortex	9.91±1.92	8.97±3.51	0.009*
		MIC to the labial bony surface	2.96±1.04	3.66±1.27	0.083ns
		MIC to the lingual bony surface	4.90±1.85	4.44±1.28	0.444ns
	Lower lateral incisor	MIC to the alveolar bone crest	19.34±1.52	13.74±8.20	0.377ns
		MIC to the inferior cortex	11.00±0.52	7.42±0.78	0.081ns
		MIC to the labial bony surface	3.17±0.82	3.12±1.59	0.825ns
		MIC to the lingual bony surface	6.97±1.17	4.92±0.46	0.081ns

NA: Not Applicable, *; significant (p<0.05) ns; non-significant (p>0.05).

Discussion

Although genioplasty, implant insertion, and symphysis bone harvesting are often performed surgically on the frontal mandible, in addition to other surgical procedures, including apical surgery, tooth extraction, bone disease removal, and the extraction of root fragments, could also be carried out in the anterior part of the mandible. [16] The MIC is frequently disregarded as a neurovascular bundle, so; the present study estimated the prevalence of MIC and analyzed its morphometric parameters using cone beam computed tomography.

An appropriate methodology was used in this study to confirm the standardization used for the detection and assessment of the incisive canal. The imaging modality used for assessing the mandibular incisive canals, CBCT, is used because conventional radiography exhibited limited capability in visualizing the MIC.[17] In CBCT scans, different screens could be used to detect the incisive canal. CBCT provides a 3D representation of the anatomical structures, allowing for a comprehensive visualization of the mandibular incisive canal from multiple angles. This helps in accurately determining the location, course, and dimensions of the canal, which is not possible with 2D radiographs.[18]This allows surgeons to plan the surgical approach precisely and ensure that any drilling or bone manipulation stays away from the canal.

Gomes et al. 2018.[15] and Almeida et al. 2020 [19] used cross-section cuts only to detect the MIC, which has a limited view that results in an incomplete assessment of the canal.[20], also it depends on the operator's interpretation efficiency in drawing the dental arch on the axial plane, [15] and it may not achieve the best results. So, in this study, we minimize the drawbacks of the previous methods by using cross-section cuts to trace the nerve, reconstructed panoramic view to measure the length of the canal, and sagittal view for linear measurements of MIC to ensure the clear visibility of the whole canal.

According to the current findings, the MIC prevalence was 45.8%, present in 121 cases. Poornima et al. (2020) [21] observed a prevalence of the canal of 43.89%, which agrees with the current study's results. On the contrary, this finding contradicts the results of Kong et al. (2016),[17] who documented that 63.6% of the scans exhibited visibility of the MIC; Gomes et al. (2018)[15] detected that 78% of MICs were visible among 100 patients. These observed variations may be attributed to variations in sample size. Additionally, Nafiseh et al. (2022) and [11] Neslihan et al. (2023)[12] assessed the canal with a high prevalence ranging from 68% to 75.6%. These observed variations may be attributed to the variability of MIC visibility on radiographs depending on the degree of cortication of its borders and the trabecular quantity and arrangement around the MIC. [22]

Differences in the ethnic composition of the population may account for variations in the prevalence of the MIC. When comparing the current findings in the Egyptian population to those of other reputable publications, Ayesha et al. (2020)[21] reported a prevalence of 43.89% in the Indian population, which is nearly identical to the present findings. Additionally, Gomes et al. (2018)[15] researched the Brazilian population and reported a prevalence of 78%, surpassing the values observed in this study.

In this study, the linear measurements of the length of the MIC for both sides where the longest canal extends are 9.91 mm, which is nearly similar to Zhang et al. (2019) [23], who reported that the MIC has a length of 9.97 mm, in contrast to Apostolakis et al.(2013) [24], who obtained lower values than this study with a MIC length of 8.9 mm. According to our study, the MIC terminates either at the first premolar or canine, while a small number of cases have observed its termination at the lateral incisor, which was agreed with Kim H et al. (2007) [25], Sahman et al. (2014) [26]

When the gender was considered in this study on both sides, the distance separating the MIC and the lingual cortex, the lower border of the mandible, and the alveolar bone crest displayed a significant difference between genders at the first premolar area. Thus, the current discovery aligns with the research examined by Pires et al (2012).[6] and Maciel et al. (2015). [27] In contrast, the span separating the MIC and the lower cortex is the only area where males exhibited a substantially greater value than females in this canine subject study. These results may be attributable to the variation in the bone morphology of males and females since women's mandibles are smaller than men's in size or perhaps because women are more susceptible to osteoporosis than men.[28]

In this study, on both sides, the alveolar crest distance from the canal at the area of the first premolar and canine was negatively related to age, with correlation coefficients of -0.224 and -0,415, respectively. This indicates that the referred distance tends to decrease with age. These findings are consistent with those of Almeida et al. (2020) [19]. It has previously been documented that there is negative collinearity between age and the distance between the alveolar bone crest and the MIC, demonstrating that as people age, physiological bone resorption occurs in the alveolar region.[29]

The interforaminal region of the jaw has long been thought to be a reasonably safe place to place implants. However, injury to the MIC and its related incisive branch might result in consequences like hemorrhage and neurosensory problems.[30] A case of bleeding caused by an incision of the blood vessels within the incisive canal while performing an implant osteotomy was presented by Lee et al. (2012) [31]

In their retrospective study, Kütük et al. evaluated nerve pain resulting from placing an implant in the mandibular interforaminal area. They noticed that among the ten patients evaluated for neurosensory problems, nerve-related pain caused by implant placement in the mandibular region was more significant than the MIC.[32]

Lee et al. (2012) explained that complications can happen when an implant comes into contact with the MIC. The implant may not integrate due to the soft tissue migration surrounding the implant. When diagnosing and treating anterior mandibular and periapical pathology, significant consideration must be devoted to the positional assessment of the prevalence of the MIC.[33]

A multitude of dental procedures have the potential to cause harm to the mandibular incisive nerve. Therefore, surgeons must give greater attention to this aspect to avoid nerve injury. This study thus emphasizes the significance of the CBCT as the recommended imaging technique for regular evaluation during operations in the mandibular anterior region.

The retrospective nature of this study also presents limitations. The CBCT scans were obtained from a database, and the indications for which these scans were initially performed might not be uniformly relevant to the research objectives. Consequently, the sample might not be fully representative of the general population, potentially affecting the generalizability of the findings. However, prospective studies with standardized data collection protocols could provide more robust and comprehensive insights into the prevalence and anatomical relationships of the mandibular incisive canal.

Another limitation of this study is the potential for observer bias. Observer bias can occur when the interpretation of CBCT images. This can lead to inconsistencies in identifying and measuring anatomical structures such as the mandibular incisive canal. To mitigate this risk, it is essential to ensure that observers are well-trained. However, even with this precaution, eliminating observer bias is challenging. Future studies could benefit from employing multiple observers and calculating inter-observer reliability to assess and improve consistency.

Conclusion

When premeditating and strategizing for maxillofacial and oral surgical interventions conducted in the anterior mandibular area, it is critical to account for the incisive branch of the IAN as a significant anatomical element. CBCT must be utilized as the primary radiographic imaging technique whenever feasible, as it exhibits greater efficacy in detecting the existence of the MIC than conventional radiographs.

Declarations

Ethical approval

Ethical approval was granted by the local Ethics Committee of the faculty of dentistry, Ain Shams University (FDASU-RecEM012101) in view of the retrospective prevalence nature of the study.

Informed consent

For this type of study, formal consent is not required

Competing interests

The authors declare they have no conflict of interest.

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Availability of data and materials

All data included in this study are available from the corresponding author upon request.

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