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Cone beam computed tomography for evaluation of mandibular lingual canal in an Egyptian subpopulation

Rabab Amin Elmasry^{1*} , Mona Mahmoud Abu El-Fotouh², Shaimaa Mohamed Abu el Sadat³ and Wael Aboelmaaty^{4,5}

Abstract

Background: A sample of three hundred cone beam computed tomography (CBCT) scans was evaluated. Median lingual canals (MLC) were identified and classified according to their anatomical location. Evaluation of the canal diameter, length, thickness of the buccal cortical plate, and the remaining bone above and below the canal was performed. The results were assessed twice with 2 weeks interval and statistically analyzed. The study was designed to evaluate MLC in an Egyptian subpopulation by the use of CBCT.

Results: Most of the scans presented with one MLC, with a maximum number of four canals, the mean diameter was 1.68 ± 1.27 mm, with a statistically significant difference in the length from the canal opening to the alveolar crest between females and males.

Conclusions: As the study detected a high prevalence of the MLC with a vast majority of the canals supra-spinosum, a vigilant examination is required using CBCT to avoid subsequent bleeding and airway obstruction.

Keywords: Lingual mandibular canal, Egyptian population, Retrospective study, Cone beam computed tomography

Background

The safe zone was a description for the region located anterior to the mental foramen. This term was applied due to the absence of the neurovascular defects at the lip and chin sites after surgical manipulation as compared with the region posterior to the mental foramen. It is now clear that additional considerations are needed during surgery in this area based on the presence of critical structures [1, 2]. The branches of the sublingual and submental arteries that supply the lingual zone of the mandible are located close to the lingual cortical plate. This implies an increased risk of bleeding if the lingual cortical bone is damaged during drilling or surgery such as implant placement. The lingual mandibular foramina are accessory foramina on the anterior lingual surface of the mandible, where the median lingual canal (MLC)

pierces the lingual cortex at the region of the central incisors [3, 4]. The median lingual canal can be detected above (supra-spinosum), below (infra-spinosum), or in the genial tubercle (intra-spinosum) [5]. Anatomical and radiographic studies have recognized lingual vascular canals (lingual mandibular canals) in the anterior area of the mandible where the sublingual artery penetrates the lingual cortical plate [4, 6, 7]. It is difficult to detect the lingual foramen, canal location, and extension with conventional 2D imaging modalities such as periapical and panoramic radiograph due to many limitations as overlapping anatomical structures and difficulty in standardization [8]. Computer-based imaging systems like cone beam computed tomography, as a 3D imaging modality, provide superior advantages over the 2D imaging systems, by removing superimposition, correct estimation of surgical sites, reducing the possibility of surgical complications, and providing standardized images [8, 9].

* Correspondence: Rabab-Amin-Ali@eru.edu.eg

¹Faculty of Dentistry, Egyptian Russian University, Cairo, Egypt
Full list of author information is available at the end of the article

Several studies utilized cone beam computed tomography as an imaging technique in the evaluation of normal anatomic structures such as the lingual mandibular canal; but, up to our knowledge, there are a limited number of studies that were performed on the evaluation of the lingual mandibular canals in the Egyptian population. Thus, the objective of this cross-sectional study was to evaluate the presence, location, and dimensions of the lingual mandibular canal (LMC) in an Egyptian subpopulation by the use of CBCT.

Methods

Patients' data

The sample enrolled in the current observational cross-sectional study presented as three hundred (300) CBCT scans of patients seeking dental treatment (implant, orthognathic surgery, root canal treatment, surgery for removal of impacted third molar, etc.) from the year 2015 to 2019. Scans were collected from two demographic areas in the Arab Republic of Egypt divided as follows: one hundred and seventy (170) patients from Cairo governorate, Department of Oral and Maxillo-Facial Radiology in a Faculty of Dentistry, and one hundred and thirty patients (130) from a dental radiology center in Mansoura City the capital of Daqahliyah governorate. Patients' age ranges from 18-70 years with randomized sample distribution between males and females showing 121 males and 179 females. All the patients' data were anonymous and only the gender and age were known. The exemption was approved at the committee meeting number 79 on 21 March 2018, FDASU-REC IM031839.

Inclusion and exclusion criteria

All the mandibular scans that revealed the whole mandible till the area of the third molar region were included in the study. Scans that showed any pathological conditions or missing teeth anteriorly as well as traumatic injuries and surgeries were excluded. Reconstructed CBCT images were transferred as DICOM files to be analyzed using On-Demand 3D Cybermed Inc. (OnDemand3DApp 1.0.10.7510) software program. Scans incorporated in the study were performed using the i-CAT Next Generation machine (Imaging Sciences International, Hatfield, Pennsylvania, USA) and with the following scanning parameters: Tube voltage of 120 kVp, tube current of 36.12 mA/s, and 26.9 seconds scanning time. Among 600 scans, a total of 300 scans were excluded from the study because of one or more of the exclusion criteria, leaving a final sample of 300 scans.

Measurements

In the present study, identification of the presence and location of the lingual mandibular canal in the midline,

and linear analysis were done. The midline lingual canals (MLC) were further categorized into 1-supra-spinosum, 2-intra-spinosum, and 3-infra-spinosum (Fig. 1). Linear measurements were done on the canals showing a diameter of more than 1 mm [10]. The following measurements were performed: diameter of the opening of the canal, the diameter of the end of the lingual canal, the length of the canal, the distance between the end of the canal and the buccal cortical plate, distance from the opening of the lingual foramen to the alveolar crest, and distance from the opening of the lingual canal toward the inferior border of the mandible (Figs. 2, 3, 4, and 5). Assessment of the measurements was performed two times; all the images were examined using the same screen 32-inch large screen size with high resolution under dim lighting conditions by an oral radiologist with 4 years' experience. The second radiologist with 14 years' experience provided advice on the interpretation of the images with unusual variations. Measurements were assessed twice with 2 weeks intervals between the two sessions. The data obtained were recorded using an Excel 2013® table (Microsoft Corporation, Redmond, Washington, USA), monitored, statistically analyzed, and no consents were needed as patients' data were anonymous.

Statistical analysis

Data were fed to the computer and analyzed using IBM SPSS software package version 20.0 (Armonk, NY: IBM Corp). Qualitative data were described using number and percent. The Kolmogorov-Smirnov test was used to verify the normality of the distribution (Kolmogorov-Smirnov statistic (D) = 0.18). Quantitative data were described using the median (minimum and maximum), the mean, and the standard deviation. The significance of the obtained results was judged at the 5% level. The relevance of all data was assessed and analyzed statistically using the chi-square test, Student t tests, Mann Whitney test, and a P value of ≤ 0.05 was considered statistically significant.

Results

The results represented the prevalence of the canals in the studied cases in relation to the gender, age, and the presence of the (MLC) in the total sample ($n=300$). According to the gender, the study included 121 males (40.1%) and 179 females (59.66%) with a mean age of 35.42 ± 13.20 years. The canals were present in 296 scans with a percent of 98.7% and absent in 4 scans with a percentage of 1.3%. The MLC were present in 175 scans (97.76%) of the female sample, and in 121 scans (100.0%) of the male sample, with a statistically non-significant difference between groups ($P=0.276$), and the data were listed in Table 1.

Fig. 1 Sagittal CBCT showing anatomical classification of the MLC

As regards to the MLC distribution, the cases with two median lingual canals showed the largest number in the total sample with a percentage of 49.33%, which presented as 51.24% of the male scans, and 48.04% of the female scans, while the scans with four median lingual canals showed the smallest number of canals, representing 1.0% of the total sample, with 1.7% of the male scans, and 0.56% of the female scans, and the results were displayed in the Table 2.

The total number of the median lingual canals in the supra-spinosum, intra-spinosum, and infra-spinosum locations were 534 canals. The largest number of the three types was in the supra-spinosum location with 283 canals and the smallest number of the three types was in the intra-spinosum location with 59 canals. The supra-spinosum, intra-spinosum, and infra-spinosum canals were detected in the form of single canals or two canals in their location regarding the genial spine, with the single supra-spinosum canal represented 99.3% of the total number of the supra-spinosum canals, and the double supra-spinosum canal represented 0.7% of the total supra-spinosum canal number, and the data were represented in Table 3.

The distribution of the MLC, regarding the canal's diameter, showed that the canals with a diameter of the opening larger than 1 mm were 28.0% in the total sample, 30.73% in the females, and 24.0% in the males with no statistically significant difference between the female and the male samples. The results were displayed in Table 4.

The linear measurements included the following: the canal diameter, the length of the canal, the length from the canal opening to the alveolar crest and to the inferior border of the mandible, and the length from the canal end to the buccal cortical plate. All the previous measurements were performed for the total sample and in the males and the females. The results showed no statistically significant difference between both genders in all the measurements except for the distance between the canal openings toward the alveolar crest. The length of the canal in the female sample was slightly larger than the males with 8.22 ± 2.34 mm. The length from the opening to the inferior border of the mandible in the female sample was slightly larger than the male sample with 12.18 ± 4.76 mm. The length from the canal end to the buccal cortical plate in the male sample was slightly

Fig. 2 CBCT measurements in 21-year-old male patient

Fig. 3 CBCT measurements in 31-year-old male patient

Fig. 4 CBCT measurements in 60-year-old female patient

larger than the females with 8.9 ± 2.7 mm, and the results were listed in Table 5.

Concerning the intra-observer reliability in the first and the second measurements, the intra-class correlation coefficient for the total sample and for the male and female samples was 1,000 and the level of agreement was excellent in all parameters.

Discussion

Awareness of the anatomy in the anterior region of the mandible is crucial in the field of dental surgery. Wide ranges of operations are performed for example: implants, autogenous chin grafts, and orthognathic surgeries. These surgeries may be accompanied by life-threatening conditions such as hemorrhage, which may lead to airway obstruction and suffocation ending in death [5, 10].

Although there were studies performed on dry mandibles or in vitro concerned with the existence of the lingual foramina, yet the presence of the 3D imaging modalities such as CT and later CBCT improved the understanding of the prevalence, location, and the number of the mandibular lingual foramen in vivo [11, 12].

In this study, CBCT scans were used due to the three-dimensional accuracy in detection of vital anatomical structures, besides its low radiation exposure and simple handling compared to CT scans [6, 10, 13].

The current study showed approximately 99.0% of MLCs within the examined sample presenting the prevalence of MLC, with close proximity to Wang et al. [10] and Zhang et al. [14], who showed a percentage of 97.0%, and 99.3% respectively using CBCT scans with a voxel size comparable to the current study. On the contrary, Scaravilli et al. [15], who used MDCT scans with 1.5 mm slice thickness observed a low prevalence of the canals. Also, the study performed by Yilmaz et al. [8] found 92% of MLC in a sample of 200 patients, and this might be due to a relatively smaller sample size compared to the present study.

Regarding the number of MLC in each examined case, the current findings were consistent with Rosano et al. [4], who recorded that the majority of cases with MLC in a sample of 60 dry mandibles were two canals, followed by the single canals, three canals, and cases with no canals; however, they showed no cases with four canals, and this might be attributed to the use of cadaver

Fig. 5 CBCT measurements in 40-year-old female patient

study. On the other hand, Kilic et al. [16] and Scaravilli et al. [15], using CT scans, found a high percentage of the single canals with the absence of cases showing four canals in the central incisor region. Also, Kung et al. [17] showed the same results as the aforementioned studies but found two cases with four canals out of 215 patients representing 1.0%.

In the present study, the classification proposed by Wang et al. [10] was used, dividing MLC based on their location regards the genial tubercle as 1.supra-spinosum, 2.intra-spinosum, and 3.infra-spinosum. The MLC was distributed as follows: a high percentage of the median canals (94.33%) were located in the supra-spinosum region, followed by 64.0% canals located in the infra-spinosum, and finally 19.67% canals located in the intra-spinosum region. The current findings were supported by the findings of G. Arun Kumar [18], Zhang et al. [14],

and Yilmaz et al. [8], who performed their studies on CBCT scans using i-CAT, Planmeca, and Carestream machines.

Lustig et al. [19], who performed an ultrasound study, showed that the lingual canals with the average arterial diameter of 1.41 ± 0.34 mm may show profound bleeding upon injury, and based on the former study measurements were done on canals with a diameters larger than 1 mm. Regarding the diameter of the MLC, the current results were comparable to Yagmur et al. [20], with a study using spiral and cone beam CT scans, which identified the number of the MLC as 24.4% out of 639 of the studied cases. Also, Wang et al. [10], who identified 24.8% of the MLC out of 101 cases, using the same imaging protocol used in this study. On the other

Table 1 Presence of the MLC

	Total (n=300)	Females (n = 179)	Males (n = 121)	Test of significance	P
Presence					
Absent	4 (1.33%)	4 (2.23%)	0 (0.0%)	$\chi^2=2.7404$	0.276
Presence	296 (98.67%)	175 (97.76%)	121 (100.0%)		

χ^2 , chi square test; P value, statistically significant at $P \leq 0.05$

Table 2 Number of MLC

Canals number	Male (n=121)	Female (n=179)	Total number (n=300)
0 canal	0 (0.0%)	4 (2.23%)	4 (1.33%)
1 canal	36 (29.75%)	59 (33.0%)	95 (31.67%)
2 canals	62 (51.24%)	86 (48.04%)	148 (49.33%)
3 canals	21 (17.4%)	29 (16.2%)	50 (16.67%)
4 canals	2 (1.7%)	1 (0.56%)	3 (1.0%)

Table 3 Distribution of MLC

	MLC		
	Supra-spinosum	Intra-spinosum	Infra-spinosum
No. (%)	283 (94.33%)	59 (19.67%)	192 (64.0%)
1 canal	281 (99.3%)	56 (94.9%)	175 (91.1%)
2 canals	2 (0.7%)	3 (5.1%)	17 (8.9%)

hand, Kung et al. [17] identified the MLC with a percentage higher than the current study showing 37.2% out of 215 cases in the Taiwanese population, with a significant difference between the males and the females which was disagreeing with the current results, and this difference might be related to the different racial type of the sample.

In the study by Wang et al. [10], using CBCT scans of Taiwanese patients, they identified the mean diameter of the (MLC) opening with 1.20 ± 0.25 mm, which was slightly smaller than the present results that showed the mean diameter with 1.68 ± 1.27 mm. Also, the study performed by Moro et al. [21], in Japan, mentioned that the mean diameter of the MLC opening was 1.05 ± 0.59 mm, which was still smaller than the reported measurements.

Regarding the mean diameter of the canal end, the study performed by Ahmed et al. [22], in the Egyptian population using CBCT scans from 50 patients, showed the mean diameter to be 0.5 ± 0.2 mm, with proximity to the present study.

In the implant surgeries, the minimum length used for the fixture is about 6 mm below the crestal bone, with a 2 mm safety margin between the implant and the vital structure to avoid the tendency of bleeding, so a total length of 8 mm is needed for the alveolar crest before performing implant surgery. Alveolar ridge resorption increases after extraction of permanent teeth, so careful evaluation is essential before these kinds of surgeries [5, 19, 20]. Regarding the distance from the canal opening to the alveolar crest, the results of the current study were close to Yagmur et al. [20], who found the distance to be 18.33 ± 5.45 mm in the total of 639 cases and showed a statistically significant difference between the males and the females, this agreement might be due to a large sample size gathered from different demographic areas all over the world including an Arab country. Also,

Georges Aoun et al. [23] showed a significant difference in the distance between the lingual foramen and alveolar crest between the male and the female groups, which was similar to the current study. On the other hand, G. Arun Kumar [18] who carried out his study on the South Indian population showed no significant difference between both genders.

Measurements performed from the canal end to the buccal cortical plate were important to avoid any risk of bleeding during chin grafting procedure [21, 22]. Concerning the distance from the end of the canal to the buccal cortical plate, the current results were close to Kung et al. [17], with a distance of 5.44 ± 1.36 mm, but their result showed a statistically significant difference between the female and male groups which was contradictory with the present study.

It was crucial to measure the bone thickness between the MLC and the inferior border of the mandible to exclude the possibility of hemorrhage with orthognathic surgeries [4, 22]. Regarding the distance from the canal opening to the inferior border of the mandible, Wang et al. [10] identified the distance to be 11.50 ± 4.33 mm, which was close to the reported results, with a statistically non-significant difference between the males and the females agreeing with the current results. On the other hand, Rosano et al. [4] and Kung et al. [17] gave the following results: 12.2 ± 3.0 mm and 12.68 ± 3.02 mm respectively, which were slightly larger than the current results.

The current study of the Egyptian sub-population showed some limitations. Although all the measurements were taken with high reliability, the limited number of canals assessed makes further investigations of a larger group necessary which may provide accurate results, besides different demographic areas inside the Arab Republic of Egypt should be included to provide a more representative sample.

Conclusion

The examined Egyptian sub-population showed significant variability in the MLC anatomy and location, increasing the risk of life-threatening situations. The prevalence of MLC was 98.67%, and the canals above the genial tubercles (supra-spinosum) showed a percentage of 92.5% which mandates a thorough radiographic analysis prior to any surgical procedure conducted in

Table 4 MLC larger and smaller than 1 mm

Median lingual canal measurement	Total (n=300)	Females (n = 179)	Males (n = 121)	χ^2	P
Lingual canal diameter of the opening smaller than 1 mm	216 (72.0%)	124 (69.27%)	92 (76.0%)	1.636	>0.05
Lingual canal diameter of the opening larger than 1 mm	84 (28.0%)	55 (30.73%)	29 (24.0%)		

χ^2 , chi-square test; P value, significant at $P \leq 0.05$

*the sample is statistically significant at p value smaller than 0.05

Table 5 Linear measurements in the males and females

	Total (n=300)	Females (n = 179)	Males (n = 121)	Test of significance	P
DO					
Mean ± SD	1.68± 1.27	1.52±0.55	1.64±0.5	U= 1.142	>0.05
Median (min.-max.)		1.35 (1.06-4.06)	1.42 (1.01-2.8)		
DE					
Mean ± SD	0.39 ± 0.17	0.37±0.2	0.42±0.2	U= 0.849	>0.05
Median (min.-max.)		0.36 (0.1-0.9)	0.34 (0.16-0.78)		
OP-ALC					
Mean ± SD	18.46 ± 5.67	16.9±5.2	20.6±6.5	U= 5.514	<0.05*
Median (min.-max.)		15.73 (1.03-29.82)	19.63 (11.77-31.46)		
OP-EN					
Mean ± SD	7.86 ± 2.8	8.22±2.34	7.18±2.5	t= 0.1038	>0.05
Median (min.-max.)		7.87 (2.97-16.63)	7.99 (2.49-10.37)		
EN-BCP					
Mean ± SD	5.6±1.9	5.34±1.83	6.08±1.97	t= 3.284	>0.05
Median (min.-max.)		5.1 (2.07-10.06)	5.97 (3.03-10.01)		
OP-IBM					
Mean ± SD	11.42 ± 5.28	12.18±4.76	10.0±6.0	U= 6.879	>0.05
Median (min.-max.)		13.77 (1.29-18.38)	9.29 (1.48-18.75)		

t Student t test, U Mann-Whitney test, DO diameter of the opening, DE diameter of the end of the canal, OP-ALC distance from the canal lower cortex of the opening to the alveolar crest, OP-EN length of the canal, EN-BCP distance from the canal lower cortex of the end to the buccal cortical plate, OP-IBM distance from the canal lower cortex of the opening to the inferior border of the mandible

*Significant at $P \leq 0.05$

the anterior region of the mandible by the use of CBCT scans. Special consideration should be given to the female patients before surgeries in the anterior region, where a close relation of MLC to the alveolar crest was found within the study.

Abbreviations

CBCT: Cone beam computed tomography; MLC: Median lingual canal; LMC: Lingual mandibular canals

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Authors' contributions

RAE (corresponding author) was involved in image evaluation using the third party software, adjusting zoom, brightness, and capture images that then coded and exported to an Office Word document, performing linear measurements and submitting data to an Office Excel sheet. MMA Manuscript correcting and editing, blinded assessment, and scoring of mandibular lingual canal visibility. SMA Conceived the project and the study hypothesis, manuscript correcting and editing, blinded assessment and scoring of mandibular lingual canal visibility. WA Manuscript correcting and editing. The author read and approved the final manuscript.

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Availability of data and materials

The datasets generated and/or analyzed during the current study are not publicly available as they include DICOM files for the studied cases and cannot be uploaded on the manuscript file but are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

The exemption was approved at the committee meeting number (79) in 21 March 2018 FDASU-REC IM031839.

Consent for publication

No clinical photographs; not applicable.

Competing interests

The authors declare that they have no competing interests.

Author details

¹Faculty of Dentistry, Egyptian Russian University, Cairo, Egypt. ²Oral Radiology Department, Faculty of Dentistry, Ain Shams University, Cairo, Egypt. ³Oral and Maxillofacial Radiology Department, Faculty of Dentistry, Ain Shams University, Cairo, Egypt. ⁴Oral Radiology Department, College of Dentistry, King Saud bin Abdulaziz University for Health Sciences, Riyadh, Saudi Arabia. ⁵Oral Radiology and Diagnostic Sciences, Faculty of Dentistry, Mansoura University, Mansoura, Egypt.

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