

Prevalence of lingual canals and their foramina in a group of Thai people using cone-beam computed tomography

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Objective: Lingual canals and their foramina are one of the concerned structures that should be carefully evaluated prior to the procedure of implant placement. This retrospective study aimed to determine their prevalence in a group of Thai people and their characteristics by using cone-beam computed tomography (CBCT).

Materials and Methods: A total of 240 patients who had received CBCT in the mandible at the Faculty of Dentistry, Mahidol University, from January 2012 to July 2021 were studied. Lingual canals and their foramina were classified by their location into two groups. The foramen located in the center of symphysis is the median lingual foramen (MLF), which its canal called the median lingual canal (MLC). The other located laterally from the midline is the lateral lingual foramen (LLF), which its canal called the lateral lingual canal (LLC). The number, location, and distance related to the alveolar crest of MLF and LLF were recorded. The courses of MLC and LLC were also analyzed. A Chi-square test was used to compare the prevalence between groups.

Results: The study showed that each patient had at least one lingual canal and its foramen. The prevalence was 100% in MLC&MLF and 91.7% in LLC&LLF. The location of MLF was commonly superior position followed by inferior position. The course of MLC was commonly anteroinferior, anterosuperior, and horizontal, respectively. The LLF was most common in the premolar areas and its LLC course was usually anterior direction. The overall mean distance from the top border of lingual foramina to the highest point of the alveolar crest was 23.64 ± 5.17 mm.

Conclusion: This study revealed that LLC and LLF are common anatomical structures that could be detected from CBCT. As far as mandibular implant placement procedure is concerned, operators should bear in mind LLC&LLF in the premolar areas.

Keywords: cone-beam computed tomography, lingual canal, lingual foramen

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Introduction

The area between the mandibular mental foramina or the interforaminal zone had been told to be a safe area for implant placement. The interforaminal zone is defined as the area of 4 incisors, 2 canines, and 2 first premolars. But nowadays, the concept of anatomical structures has proved the contrary. Since there were reports

about the complications, mainly severe hemorrhage in the floor of the mouth resulting from lingual cortex perforation after the implant placement, this area should be operated with special caution [1-6].

Many recent studies indicate that the structures in this area, such as mandibular incisive canals, concavity of lingual bones, or lingual canals, may affect the complications. One of the most complications is bleeding caused by

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injuring vessels in the area, emphasizing the ones approaching the lingual foramina of the mandible [1,2,7]. Lingual canals, therefore, are one of the concerned structures that should be carefully evaluated prior to the procedure of implant placement.

Lingual foramina are the accessory foramina in the lingual surface of the mandible, typically found between the mental foramina. The term “accessory” in the mandible indicates all openings except mandibular foramina, mental foramina, and alveolar sockets. Lingual foramina can be allocated by their location into median lingual foramina and lateral lingual foramina. Their associated canals are median lingual canals and lateral lingual canals, respectively [8-10].

Median lingual foramina are the lingual foramina located in the mandible’s midline. It can be divided by the level of genial tubercles into superiorly, same level, or inferiorly. In the axial view, median lingual canals almost course perpendicular direction to the lingual border of the mandible. In the cross-sectional view, superior median lingual canals mostly course anteroinferior direction, while inferior median lingual canals mostly course anterosuperior direction. The superior median lingual canals can rarely course horizontal or upwards, while inferior median lingual canals can rarely course horizontal or downwards [8-9].

Lateral lingual foramina are the lingual foramina that are not located in the midline of the mandible. Their location can be ranged from the central incisor to 3rd molar. In the axial view, lateral lingual canals mostly tend to course anterior direction from the foramen, but some can also course perpendicular direction to the lingual border of the mandible [8].

There were many techniques to study the lingual canals and their foramina, such as cadaveric studies, panoramic radiographs, CT, CBCT, etc [8]. A panoramic radiograph is useful in

viewing overall the anatomical structures of the jaws. However, it contains limitations such as its appearance only in two dimensions, distortion of the image, lack of image sharpness, and no information in a buccolingual direction. Lingual foramina on panoramic radiographs are of poor visualization compared to CBCT. A previous study confirmed that lingual foramina could be observed with a panoramic radiograph with only 6.1% [2,8].

Nowadays, cone-beam computed tomography (CBCT) has been used widely in implant surgery. CBCT has overcome the limitations of panoramic radiographs. But depending on the CBCT protocol, radiation doses were 4-20 times higher than traditional radiography such as panoramic radiograph. It creates high-quality and three-dimensional images with unique cross-sectional views that offer higher visualization of the anatomy of the jaws. CBCT reveals more details of the jaws’ vulnerable structure, including intrabony canals that may contain significant arteries or other structures to be avoided, such as mandibular canal, mental foramina, incisive canal, or lingual canal. We can visualize the lingual foramina and the canals up to 100% in many studies [2, 8, 12, 13, 16, 17].

Thus, to confirm the existence of lingual canals and their foramina, CBCT images of the mandible were evaluated to determine the prevalence of lingual canals and their foramina and their characteristics in a group of Thai people.

Materials and Methods

Ethical approval for this retrospective study was obtained from the Faculty of Dentistry/ Faculty of Pharmacy, Mahidol University, Institutional Review Board, with the certificate of approval COA.No.MU-DT/PY-IRB 2021/094.0511.

The patients who had received CBCT in the mandible at the Faculty of Dentistry, Mahidol University, from January 2012 to July 2021 were studied. The inclusion criteria were Thai patients with a minimum age of 20 years. The exclusion criteria were patients who had a history of jaw fracture or jaw surgery in the mandible, history of permanent tooth extraction for orthodontic treatment, pathological conditions or diseases affecting the bone in the mandible, and micrognathia or underdeveloped mandible.

The included CBCT images with a field of view (FOV) of 10 cm × 10 cm, or 14 cm × 10 cm, or 17 cm × 12 cm with 0.25 mm voxel size were taken from a 3D Accuitomo 170 CBCT machine (J. Morita Mfg. Corp., Kyoto, Japan) and analyzed by using one volume viewer software.

Lingual canals and their foramina were classified into two main groups, median lingual canals & median lingual foramina (MLC&MLF) and lateral lingual canals & lateral lingual foramina (LLC&LLF). MLC&MLF were located in the center of the symphysis, and their number was recorded.

The level of genial tubercle subclassified the position of MLF into superiorly, same level, and inferiorly. From the cross-sectional view, the MLC course was subclassified into the anteroinferior, horizontal, anterosuperior directions, and two projections (Figure 1).

The LLC&LLF were located laterally from the midline area, and their number was recorded. The LLF location was subclassified into left or right sides and the tooth position from the central incisor to the third molar area. From the axial view, the LLC course was subclassified into an anterior direction, perpendicular direction, and two projections (Figure 2).

Furthermore, the distance from the top border of lingual foramina to the highest point of the alveolar crest was recorded.

All statistical tests were carried out using IBM SPSS Statistics for Windows Version 25.0. (IBM Corp., Armonk, New York, 2015). A Chi-square test was used to compare the prevalence between groups, with the statistical analysis at $\alpha=0.05$.



Figure 1 Classification of the position of the median lingual foramina (MLF) and the course of the median lingual canals (MLC). a: MLF in the superior position (1) and its MLC coursed in an anteroinferior direction (green line), MLF in the inferior position (2) and its MLC coursed in a horizontal direction (blue line), b: MLF in the same level as genial tubercle (3) with its MLC coursed in an anteroinferior direction (orange line), c: Both MLF in the inferior position (4) and their MLC coursed anterosuperior direction (red lines).

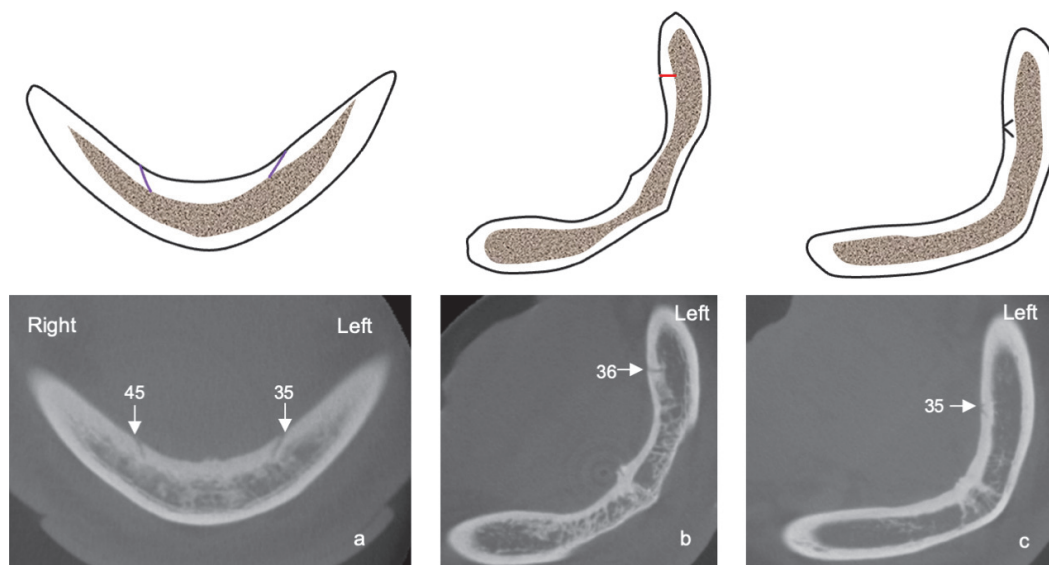


Figure 2 Classification of the position of the lateral lingual foramina (LLF) and the course of the lateral lingual canals (LLC). a: LLF in the areas of teeth 35 and 45 and their LLC coursed in an anterior direction (purple lines), b: LLF in the area of tooth 36 and its LLC coursed in a perpendicular direction (red line), c: LLF in the area of tooth 35 and its LLC coursed into two projections (black lines).

Results

Demographic general data

Two hundred forty patients met the requirement: 131 females (54.6%) and 109 males (45.4%). The mean age was 59.17 ± 12.18 years; 132 patients (55.0%) were ≥ 60 years old group, followed by 89 patients (37.1%) in the 40 - 59 years old group and 19 patients (7.9 %) in the 20 - 39 years old group, respectively.

Prevalence of lingual canals and their foramina

The total number of lingual foramina was 1,019, of which 510 were MLC&MLF, and 509 were LLC&LLF. Prevalence of lingual canals and their foramina occurred in all patients (100.0%), categorized as MLC & MLF occurring in all cases (100.0%), and LLC&LLF was 91.7%, with statistically significant differences at level 0.05 ($P < 0.001$) (Table 1).

Median lingual canals & Median lingual foramina (MLC&MLF)

The total number of median lingual foramina was 510, categorized as superiorly in 225 (44.1%), same level in 22 (4.3%), and inferiorly in 263 (51.6%). When divided by the course of 510 median lingual canals, most were anteroinferior 55.7 %, followed by anterosuperior 27.3%, horizontal 15.9%, and two projections 1.2 %, respectively. The overall prevalence of MLC & MLF occurred in all cases (100.0%), being superiorly at 90.0%, followed by inferiorly at 80.8% and the same level at 9.2%, respectively, with statistically significant differences at level 0.05 ($P < 0.001$) (Table 2, Figure 1).

Lateral lingual canals & Lateral lingual foramina (LLC&LLF)

The total number of lateral lingual foramina was 509, divided into 239 on the right side (47.0%)

and 270 on the left side (53.0%). When divided by the course of the 509 lateral lingual canals, most were anterior 91.6%, followed by perpendicular 8.1% and two projections 0.3%, respectively. The overall prevalence of LLC & LLF was 91.7%, being 72.9% on the right side and 74.2% on the left side, with no statistically significant difference ($P=0.836$). On the right side, the prevalence was highest in the tooth

45 at 29.2%, followed by the tooth 46 at 16.3%, and the tooth 44 at 15.4%, respectively. On the left side, the prevalence was highest in the tooth 35 at 27.9%, followed by the tooth 34 at 17.1% and the tooth 32 at 16.3%, respectively. When comparing the prevalence of LLC & LLF in each tooth, it was statistically significantly different at level 0.05 ($P<0.001$) (Table 3, Figure 2).

Table 1 Prevalence of lingual canals and their foramina

	Total	MLC&MLF	LLC&LLF	P-value
Number of lingual foramina	1,019	510	509	
Number of cases with lingual canals and their foramina existed, n (%)	240 (100.0)	240 (100.0)	220 (91.7)	<0.001*

* Statistically significant at the 0.05 level ($\alpha=0.05$)

Table 2 The number and percent of the median lingual canals (MLC) and median lingual foramina (MLF)

MLC and MLF	Number (%)	Superiorly	Same level	Inferiorly	P-value
Number of MLF, n (%)	510 (100.0)	225 (44.1)	22 (4.3)	263 (51.6)	
Number of MLC & MLF cases, n (%)	240 (100.0)	216 (90.0)	22 (9.2)	194 (80.8)	<0.001*
Number of course, n	510	225	22	263	
Anteroinferior, n (% within the group)	284 (55.7)	207 (92.0)	16 (72.7)	61 (23.2)	
Horizontal, n (% within the group)	81 (15.9)	12 (5.3)	5 (22.7)	64 (24.3)	
Anterosuperior, n (% within the group)	139 (27.3)	3 (1.3)	1 (4.5)	135 (51.3)	
Two projections, n (% within the group)	6 (1.2)	3 (1.3)	0 (0.0)	3 (1.1)	

* Statistically significant at the 0.05 level ($\alpha = 0.05$)

Table 3 The number and percent of lateral lingual canals (LLC) and lateral lingual foramina (LLF)

LLC and LLF	Right & left sides	Right side	Left side
Number of LLF, n (%)	509 (100.0)	239 (47.0)	270 (53.0)
Number of LLC & LLF cases, n (%)	220 (91.7)	175 (72.9)	178 (74.2)
Number of course, n	509	239	270
Anterior, n (% within the group)	466 (91.6)	217 (90.7)	249 (92.2)
Perpendicular, n (% within the group)	41 (8.1)	21 (8.8)	20 (7.4)
Two projections, n (% within the group)	2 (0.3)	1 (0.5)	1 (0.4)

Distance from the top border of lingual foramina to the highest point of the alveolar crest

The mean distance from the top border of lingual foramina to the highest point of the alveolar crest had an overall mean of 23.64 ± 5.17 mm, divided into MLC&MLF 23.91 ± 5.56 mm and LLC&LLF 23.36 ± 4.74 mm. While the superiorly MLF held the mean of 19.44 ± 3.26 mm, at the same level as genial tubercle 22.93 ± 3.31 mm, and the inferiorly 27.82 ± 4.19 mm. The right LLF had a mean distance of 23.46 ± 4.71 mm, and the other left mean was 23.27 ± 4.77 mm (Figure 3).

Discussion

The present study showed that everyone had at least one lingual canal and the foramen. The prevalence was MLC&MLF at 100% and LLC&LLF at 91.7%, with a statistically significant difference at level 0.05 ($P < 0.001$) between the two types. The prevalence of MLC&MLF was according to many previous studies [9, 11, 14, 20]. However, the prevalence of LLC&LLF was higher

than in many previous studies, 58.8% by Kim *et al.* [7], 80% by Tagaya *et al.* [9], and 52.9% by Tepper *et al.* [14], and others [18, 21].

Prevalence of median lingual canals and their foramina was most at superiorly, followed by inferiorly and same level, respectively, with a statistically significant difference at level 0.05 ($P < 0.001$) between groups. However, when focused on the frequent location in the total number of MLF, being most at inferiorly, followed by superiorly and the same level, respectively. Xie *et al.* concluded that a single median lingual foramen with the supraspinous type was the highest frequency among lingual foramina. When the 2nd and 3rd foramina were presented, they were mostly the infraspinous type [19]. Tagaya *et al.* said that the foramina supraspinosum held the highest appearance and were generally more prominent than the other levels [9]. Soto *et al.* also reported that the highest frequency was superior to the mental spine (88%), followed by inferior to the mental spine (85%) [20]. When pointed at the courses of MLC, being most in anteroinferior, followed by anterosuperior, horizontal, and

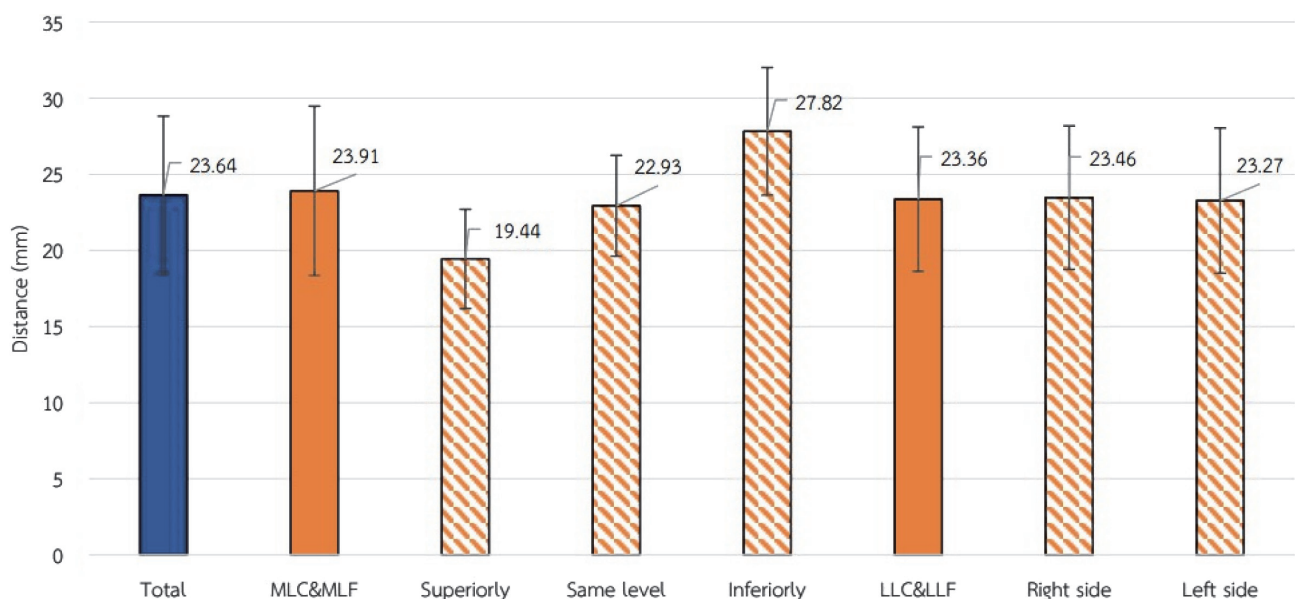


Figure 3 Distance from the top border of lingual foramen to the highest point of the alveolar crest

two projections, respectively. Tagaya *et al.* said that when exploring the intraosseous courses, the supraspinosum progressed anteroinferior direction, the interspinosum routed anterior horizontal direction, and the infraspinosum traveled anterosuperior direction [9]. However, the courses of MLC in the present study were focused on the cross-sectional view of CBCT so it might be difficult compared with the many previous studies. When looked at in the axial view, it might see in anterior or perpendicular courses. Tepper *et al.* examined that the median lingual canals traveled through the entire buccolingual direction of the mandible in many cases [14]. The reports of Von Arx *et al.* and Sekerci *et al.* said that median lingual canals are mostly perpendicularly coursed into the symphysis [15, 21].

Prevalence of lateral lingual canals and their foramina in each tooth number of each side, the right side was highest in tooth 45, followed by tooth 46 and tooth 44, respectively. The left side was highest in tooth 35, followed by tooth 34 and tooth 32, respectively, which was a statistically significant difference between teeth at level 0.05 ($P < 0.001$). Most finding of LLF in the premolar areas was in agreement with previous studies [7, 9, 15, 19, 21]. When pointed at the courses of LLC, being most in anterior, followed by perpendicular and two projections. Von Arx *et al.* and Sekerci *et al.* also reported that most lateral lingual canals showed an anteriorly directed course [15, 21]. Tepper *et al.* said that lateral lingual canals always presented an intraosseous coursed in the ventral direction and were in the lingual region of the mandible over the entire length [14].

It's necessary to differentiate fracture lines from the lingual canals. In the radiograph, fracture lines may present the cortical and trabecular bone discontinuity, displacement of the osseous fragment, increased medullary density, depressed articular surface, etc. However, patients with a

history of jaw fractures were not included in the present study [22].

Conclusion

The lingual canal and its foramen are divided into the median lingual canal (MLC) and its foramen (MLF) and the lateral lingual canal (LLC) and its foramen (LLF). They are common anatomical structures that could be visualized from CBCT. It could be concluded that the high prevalence of LLF and LLC in Thai people (91.7%) was higher than in other races. However, there were few studies on this subject in Thai people. Further studies should be done on Thai people or in a larger population where prevalence between races could be compared.

As far as mandibular implant placement procedure is concerned, operators should consider LLC&LLF in the premolar areas. Distance from the top border of the lingual foramina to the highest point of the alveolar crest is beneficial for an operator to estimate the safe zone in terms of implant length selection. This study confirmed that CBCT was recommended for presurgical evaluation before implant placement.

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