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| ORIGINAL

Anatomical evaluation of the medial lingual foramen using cone-beam computed tomography: a retrospective study

Avaliação anatômica do forame lingual medial usando tomografia computadorizada de feixe cônico: um estudo retrospectivo

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ABSTRACT

Objective: To evaluate the frequency of medial lingual foramina present in the cortex of the mandible using cone beam computed tomography (CBCT). **Methods**: A total of 953 CBTC exams of the mandible were evaluated to determine the presence of canals in the mandibular midline, canal location in relation to the mental spine, canal diameter, distance to the base and alveolar crest of the mandible, trajectory of the canal, and coincidence measurements of the panoramic image containing the location of the canal in relation to the mental spine. **Results**: Foramina were located in three positions: above the mental spine (FSS) 89.2%, below the mental spine (FIS) 67.9%, and other positions (FOP) 21.3%. Non-edentulous individuals had a significantly higher number of FSS than did edentulous individuals (P<0.001). Male individuals presented a significantly greater distance from the FSS (P=0.001), FIS (P=0.045) and FOP (p=0.002) to the base of the mandible than female individuals. Younger individuals presented a significantly higher distance from the FSS (P=0.001) and FIS (P=0.001) to the alveolar crest of the mandible. Male individuals had a significantly greater FIS (P=0.002) and FOP (P=0.001) diameter than female individuals. Male individuals had a significantly higher number of bifurcations in FOP than female individuals (P=0.017). **Conclusion**: CBCT supplies the provider with a detailed assessment of the foramina and canals, which improves the quality of surgical planning and mitigates the chances of surgical intercurrences.

Indexing terms: Accessory foramen; cone-beam computed tomography; lingual foramen; anatomy; mandible.

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RESUMO

***Objetivo**: Avaliar a frequência dos forames linguais mediais presentes na cortical da mandíbula por meio da tomografia computadorizada de feixe cônico (TCFC). **Métodos**: Um total de 953 exames de TCFC da mandíbula foram avaliados para determinar a presença de canais na linha média mandibular, localização do canal em relação ao tubérculo geniano, diâmetro do canal, distância à base e crista alveolar da mandíbula, trajetória da canal e medidas de coincidência da imagem panorâmica contendo a localização do canal em relação ao tubérculo geniano. **Resultados**: Os forames localizaram-se em três posições: acima do tubérculo (FSS) 89,2%, abaixo do tubérculo (FIS) 67,9% e outras posições (FOP) 21,3%. Indivíduos não edêntulos apresentaram um número significativamente maior de FSS do que indivíduos edêntulos (P <0,001). Indivíduos do sexo masculino apresentaram distâncias significativamente maior do FSS (P = 0,001), FIS (P = 0,045) e FOP (p = 0,002) até a base da mandíbula do que indivíduos do sexo feminino. Os indivíduos mais jovens apresentaram uma distância significativamente maior do FSS (P = 0,001) e FIS (P = 0,001) até a crista alveolar da mandíbula. Indivíduos do sexo masculino tiveram um diâmetro de FIS (P = 0,002) e FOP (P = 0,001) significativamente maior do que indivíduos do sexo feminino. Indivíduos do sexo masculino tiveram um número significativamente maior de bifurcações no FOP do que indivíduos do sexo feminino (P = 0,017). **Conclusão**: a TCFC fornece ao profissional uma avaliação detalhada dos forames e canais, o que melhora a qualidade do planejamento cirúrgico e diminui as chances de intercorrências.*

***Termos de indexação**: Forame acessório; tomografia computadorizada de feixe cônico; forame lingual; anatomia; mandíbula.*

INTRODUCTION

The determination of the characteristics of different foramina with computed tomography is essential for preventing injury to the vessels and nerves that emerge from these structures [1]. The medial lingual foramen (MLF) located in the midline of the mandible has been described in previous articles as a structure that may be located in a superior or inferior position or inside the mental spine [2,3]. Textbooks on dental anatomy also fail to consistently note the presence of the MLF. However, the MLF is well identified in textbooks related to oral radiographic anatomy because of its cortical contour [4,5].

Although the anterior region of the mandible is considered a safe surgical area, studies have reported hemorrhagic events during surgeries in this region. The cause of such events has been associated with blood vessels that emerge from the lingual foramen in an intraosseous canal [6]. Cone-beam computed tomography (CBCT) provides high-quality images for the assessment of bone canals, which are not easily seen in panoramic or periapical radiographs [1,7-9].

The precise identification of the MLF as well as its diameter and trajectory are important parameters to be considered during oral surgery [1,9]. Therefore, the aim of this research was to perform a study of the anatomical changes in the MLF of patients in Brazilian who received oral and maxillofacial radiology services.

METHODS

The study was approved by the Research Ethics Committee of the Federal University of Minas Gerais (UFMG). A retrospective study was conducted with total or partial CBCT scans of the anterior region of the mandible in individuals of both sexes who received oral and maxillofacial radiology services of the UFMG. Cases were excluded in which the presence of impacted teeth or pathological alterations precluded the assessment of the foramen. In some cases, the presence or absence of FSS, FIS and FOP could not be determined due to the edges of the images being cut-off and the size incompatibility of the FOV. These cases were excluded from the analysis.Images were obtained using a KODAK 90003D (Kodak Dental Systems, Carestream Health, Rochester, NY) with a tube voltage of 70 kVp, a tube current of 10 mA, a voxel size of 0.2 mm, and a field of view (FOV) of 50 x 37 mm. The sagittal sections obtained had a thickness of 0.2 mm. The images were reconstructed using CS 3D Imaging Software (Carestream Health, Rochester, NY, USA). To measure the variables, images were observed in full-screen mode using Implant Viewer software (Anne Solutions, São Paulo, Brazil). Information regarding the sex and age of the individuals was obtained. The variables evaluated in the CBCT were as follows: foramen (presence or absence); number of MLF; diameter of the foramen in millimeters (mm); localization of the foramen in relation to the mental spine; distance from the foramen to the alveolar crest of the mandible (mm); distance from the foramen to the base of the mandible (mm); direction of the foramen (ascending or descending); bifurcation (presence or absence); and presence or absence of teeth in the anterior region of the mandible. The presence of the foramen was evaluated in three locations: foramen immediately above the mental spine (FSS) and foramen immediately below the mental spine (FIS). The foramina in other positions (FOP) were those located in the midline of the mandible, which included those not classified in the FSS and FIS positions. The measurements were carried out from sagittal CBCT sections. An imaginary line in the Implant Viewer program was drawn vertically to the upper limit of the foramen. From this point, the diameter of the foramen, the distance from the foramen to the alveolar crest, and the distance from the foramen to the base of the mandible were measured. The coincidence of the MLF, as seen in the coronal and sagittal planes, was obtained with the software used in this study. These measurements were obtained by the same evaluator at two timepoints (T1 and T2) with a time period of 15 days between the two. For the calculation of the systematic error, the Wilcoxon test was used and comparisons between T1 and T2 were performed. The results of $p>0.05$ indicated that there were no systematic errors for any of the quantitative measurements. The random error was calculated using the Dahlberg formula [10]. The software Social Package for the Social Sciences (SPSS) for Windows (SPSS Inc., version 21.0, Armonk, USA) was used for statistical analysis. Relationships among the variables of sex, age, foramen, direction of the foramen and bifurcation were evaluated using the Pearson's chi-square test. Associations between the sex and age variables and the variables in the diameter of the foramen, distance from the foramen to the crest of the mandible, and distance from the foramen to the base of the mandible were assessed with the Mann-Whitney test and Kruskal-Wallis test. The level of significance was set at $P<0.05$.

RESULTS

In total, 953 CBCT exam images were assessed. Of the 953 individuals who participated in the study, 299 (31.4%) were male and 628 (65.95%) were female. There were 26 (2.7%) participants with no data regarding sex. The mean age of the participants was 46.7 years (± 20.2). Eight individuals had no data regarding their age. Regarding the canal trajectory (ascending or descending), 95.9% of the FSS had a descending trajectory. For FIS and FOP, there were higher occurrences of an ascending trajectory, with 75.8% and 77.3% respectively. The coincidence with the coronal plane was seen as the association of the foramen to the mental spine in both the coronal and sagittal planes. Sixty-eight foramina were not seen in the coronal section. A total of 705 visible foramina corresponded to FSS, 128 corresponded to FIS, and 16 corresponded to FOP. In 37 images, it was possible to identify two or more foramina in the coronal section. The results of the other variables studied are shown in tables 1, 2, 3, 4, 5, and 6.

Table 1 – Association of presence and absence of foramen with individuals' sex and edentulism.

MLF	Present n (%)	Absent n (%)	Not viewed** n (%)	Sex		*p value	Teeth present		*p value
				M n (%)	F n (%)		No n (%)	Yes n (%)	
FSS	851 (89.2)	76 (8.0)	27 (2.8)	277 (32.5)	574 (67.5)	0.527	199 (22.7)	676 (77.3)	0.001
FIS	648 (67.9)	275 (28.8)	31 (3.3)	198 (30.6)	450 (69.4)	0.077	174 (26.1)	492 (73.9)	0.189
FOP	203 (21.3)	719 (75.4)	32 (3.4)	68 (33.5)	135 (66.5)	0.734	58 (27.8)	151 (27.8)	0.319

Note: MLF: medial lingual foramen; M: male; F: female Note. The number of participants (N) in each variable is different depending on the possible visualization or determination of the foramen in each exam. *Pearson's chi-square test, significant at $p<0.05$. **There was doubt about the presence of the canal.

Table 2 – Association of individuals' sex with distance from the foramen to crest and the base of the mandible and association of edentulism with angle of canal trajectory.

MLF	DFB (mean)		*p value	DFC (mean)		*p value
	M	F		M	F	
FSS	14.7	13.6	0.001	14.1	14.6	0.077
FIS	6.21	5.7	0.045	21.8	22.1	0.311
FOP	4.0	3.3	0.002	22.3	23.7	0.179

Note: MLF: medial lingual foramen; DFB: distance foramen to mandibular base in millimeters; DFC: distance foramen to crest of the mandible in millimeters; M:

Table 3 – Association between individuals' ages and distance from the foramina to the crest and the base of the mandible

MLF	Distance from the foramen to the crest of the mandible in millimeters				Distance from the foramen to the base of the mandible in millimeters			
	≤45 years	46-58 years	≥59 years	*p value	≤45 years	46-58 years	≥59 years	*p value
FSS								
Mean	15.3	13.9	13.6		13.6	14.0	14.5	
Median	16.1	15.0	14.1	0.001	16.6	13.9	14.6	0.166
Min	3.2	1.9	2.8		10.2	11.9	7.9	
Max	24.8	26.0	20.1		17.0	16.2	18.2	
FIS								0.783
Mean	22.2	21.9	21.4		6.0	5.9	5.8	
Median	22.1	23.1	22.3	0.001	5.4	5.2	5.7	
Min	10.9	6.4	12.1		1.7	2.2	2.9	0.882
Max	30.7	29.0	29.9		12.1	16.2	11.3	
FOP								
Mean	24.6	24.1	24.3		3.6	2.9	4.1	
Median	25.5	25.4	24.2	0.527	2.5	2.6	2.8	
Min	7.2	10.5	14.8		0.6	0.9	0.9	
Max	33.9	32.7	31.8		9.9	38.0	38.0	

Note: MLF: medial lingual foramen *Kruskal Wallis test. Significant at P<0.05.

Table 4 – Association of individuals' sex with foramen diameter and bifurcation.

MLF		Diameter in millimeters		*p value	Presence bifurcation n (%)				**p value
					Female		Male		
		Female	Male		Yes	No	Yes	No	
FSS	Mean	0.50	0.55						
	Median	0.48	0.52	0.055	87	488	30	246	
	Min	0.25	0.24		(15)	(84.8)	(10.9)	(89.1)	0.171
	Max	1.03	1.17						
FIS	Mean	0.41	0.44						
	Median	0.38	0.43	0.002	48	402	15	183	
	Min	0.19	0.23		(10.7)	(89.3)	(7.6)	(92.4)	0.251
	Max	1.04	0.90						
FOP	Mean	0.35	0.44						
	Median	0.34	0.42	0.001	07	126	13	57	0.017
	Min	0.15	0.21		(5.3)	(94.7)	(18.6)	(81.4)	
	Max	0.82	0.92						

Note: MLF: medial lingual foramen. Min: minimum. Max: maximum.*Mann Whitney test, Significant at P<0.05. **Pearson's chi-square test, Significant at P<0.05.

Table 5 – Association of presence / absence of teeth and distance from the foramina to the crest and the base of the mandible.

Foramen	Distance from the foramen to the crest of the mandible in millimeters			Distance from the foramen to the base of the mandible in millimeters		
	Teeth present		*p value	Teeth present		*p value
	Yes	No		Yes	No	
FSS						
Mean	15.6	10.3		13.9	13.9	
Median	15.7	10.7	0.001	13.7	14.0	0.165
Min-Max	5.5-26.0	1.8-20.1		10.2-18.2	7.9-17.8	
FIS						
Mean	23.3	17.8		5.9	5.8	
Median	23.4	17.7	0.001	5.3	5.6	0.196
Min-Max	12.9-30.8	6.4-27.9		1.7-16.2	2.9-10.5	
FOP						
Mean	25.5	20.7		3.6	3.1	
Median	26.2	20.5	0.001	2.6	2.7	0.513
Min-Max	7.2-33.9	10.5-30.6		0.9-38.0	0.6-10.0	

Note: *Mann Whitney test, Significant at P<0.05.

Table 6 – Association between edentulism and direction of the canal trajectory.

Foramen	Direction of the canal				*p value
	Teeth present		Teeth absent		
	A (%)	D (%)	A (%)	D (%)	
FSS	63.3	78.2	36.7	21.8	0.072
FIS	72.5	73.6	27.5	26.4	0.904
FOP	71.3	76.9	28.7	23.2	0.643

Note: A: Ascending; D: Descending; *Pearson's chi-square test, significant at P<0.05.

DISCUSSION

Our study divided the location of the MLF into three positions in relation to the mental spine. Of the 953 CBCT exams, 89.2% allowed the examiner to see the FSS, 67.9% allowed the examiner to see the FIS, and 21.3% allowed the examiner to see the FOP (table 1). Several studies on MLF have been performed in various countries using CBCT, or in macroanatomical studies on dry jaws [7,11,12]. The occurrence of FSS ranged from 62.0% to 86.8%, while the prevalence of FIS ranged from 13.0% to 83.8%. The differences reflected the different characteristics and populations studied, which included populations from several countries [2,8,13]. The difference between our results and those of other authors may have been because the Brazilian population has a greater miscegenation rate and because our sample was much larger than the sample of other studies. Differences between the methodologies used should also be considered. Furthermore, for the FIS analyses, most studies did not consider the foramen in other positions as this study did. However, the identification of at least one lingual foramen in the midline of the mandible was possible in most analyses [1,7,8,13].

In the present study, a higher prevalence of FSS in the anterior region of the mandible was observed in nonedentulous individuals than in edentulous individuals (table 1). A study conducted in Turkey found that in the nonedentulous group, 62.9% of the samples had two foramina, and in the edentulous group, 48.6% had two foramina [14]. In a systematic review, Van der Weijden et al. [15] found that tooth extraction was followed by a reduction in the buccolingual and apico-coronal dimensions of the alveolar ridge. The defect resulting from tooth loss may have been complicated by previous bone loss due to periodontal disease, endodontic lesions, or a traumatic episode. In our study, the lower prevalence of FSS in edentulous individuals could be explained by the shorter distance of the foramen to the alveolar crest, which was observed in these patients.

In the literature, the mean values of the distance from the foramen to the base of the mandible range from 4.4 mm to 18.5 mm [11,16-18]. In the present study, the mean distances took into account the distance of the foramen to the base of the mandible in relation to the MLF location, as well as the sex of the individual (table 2). The values of this distance varied from 3.30 mm to 14.70 mm, which is consistent with the mean values reported in the literature. In contrast with the study by Aoun et al. [18], which was performed among Lebanese individuals, the findings presented herein demonstrated that the distance from the foramen to the base of the mandible was greater in male individuals than in female individuals. This difference may be explained by the differences in sample size and ethnicity of the sample population. As expected, the distance from the foramen to the base of the mandible was greater for FSS than for FIS.

Regarding the distance from the foramen to the alveolar crest of the mandible, the literature shows values ranging from 14.2 mm to 25.49 mm [18,19]. In the present study, this measure had a similar range from 14.13 mm to 23.70 mm. There were no statistically significant differences between male and female individuals. However, in a study performed with Lebanese individuals, the distance from the foramen to the alveolar ridge was significantly greater among males than among females [18]. The difference in this result may have been due to the differences in sample sizes and ethnicity of the populations studied. Our results showed that there was a correlation between the age of the participants and the distance of the foramen to the alveolar crest of the mandible (table 3). The distance was shorter among older individuals than younger individuals, which was probably due to resorption of the alveolar process.

The mean value of the MLF diameter found in literature ranges from 0.80 to 0.89 mm [7,12,16]. The present study also compared the diameter of the foramen to the sex of the individual (table 4). For FIS, the foramen diameter was 0.44 mm among men and 0.41 mm among women. For FOP, the foramen diameter was 0.44 mm among men and 0.35 mm among women. Wang et al. [11] found larger MLF values for male than for female individuals. The results showed that there was a relationship between foramen diameter and sex, with larger diameters found among male individuals than among female individuals. An MLF diameter between 1.0 mm and 3.2 mm has been reported elsewhere [17,20]. In our sample, foramina with a diameter greater than 1.0 mm were observed.

Tooth absence significantly influenced the distance of the foramina to the alveolar crest of the mandible (table 5); therefore, surgeons should be attentive when planning the placement of implants in the anterior region of the mandible in edentulous patients. The distance from the foramen to the base of the mandible was not influenced by tooth absence in the anterior region.

Another study evaluated 20 human mandibles with computed tomography; 21% of the foramina had an ascending direction, 51% of the foramina had a descending direction, and 28% were parallel [11]. In the present study, the direction varied greatly in relation to the foramen position. For the FSS, 95.9% of the foramina had a descending direction, and for the FIS, 75.8% of the foramen had an ascending direction. For the FOP, 77.3% had an ascending direction. The canal direction was not influenced by the presence or absence of teeth (table 6).

Our study showed that most canals did not have bifurcation and that the occurrence of bifurcation was not associated with the sex of an individual for FSS and FIS. However, a significant association between bifurcation and the sex of an individual was observed for FOP. Bifurcations occurred more often in male patients (table 4). Literature data regarding this issue are scarce.

Evaluations of the coincidence of the foramen observed in the panoramic image and the coronal section of the CBCT are also scarce in literature. The MLF is often visualized in panoramic and periapical radiographic exams [4, 7]; however, these exams do not allow one to identify which foramen is being observed. With the coronal image, our results were able to more greatly confirm the FSS. These data corroborate the importance of the use of tomographic evaluations to determine the existence, quantity and dimensions of foramina and their canals.

CONCLUSION

Evaluating the existence of the foramina and their canals is important for the planning of surgical procedures in the anterior region of the mandible. The determination of the quantity and location of these structures may guide the surgeon and be helpful in preventing surgical accidents. The success of surgical techniques is closely related to predictability and planning, as well as the correct indication and interpretation of imaging tests and computed tomography exams in particular.

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