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Original Article

Assessing the anatomical variations of lingual foramen and its bony canals with CBCT taken from 102 patients in Isfahan

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ABSTRACT

Background: Some studies have been performed on assessing the anatomical variations of lingual foramen and its bony canals, in many different countries but no study has been performed in Iran yet. The purpose of this study is to assess the anatomical variations of lingual foramen and its bony canals with cone-beam computed tomography (CBCT) imaging in Isfahan.

Materials and Methods: This was a cross-sectional study in which CBCT images taken from 102 patients referred to the Radiology Department of Head and Neck in Esfahan (Iran) University between 2010 and 2011. The presence of the lingual foramen and its bony canals, the locations, sizes, and length were assessed. The distances between the terminal end of lingual canal at the buccal and lingual side from the inferior border of the mandible and alveolar crest were measured. We also evaluated the effect of patient age and gender on the dimensional measurements of the anatomical landmark mentioned above *t* test, analysis of variance (ANOVA), and pearson's correlation were used for statistical analysis and *P* value lower than 0.05 was considered significant.

Result: All of the CBCT images taken showed the presence of lingual foramen. Of all the participants, 52% of them had two foramens in their images. The mean diameters of the upper and lower lingual foramen were 1.12 and 0.9 mm, respectively.

Conclusion: These anatomical landmarks in Isfahan population vary from previous studies. All of the images had at least one lingual foramen which demonstrates high prevalence of this anatomy among Isfehanian population. Therefore, it is recommended to use CBCT imaging for preoperative evaluation prior to installing dental implants.

Key Words: Anatomy, cone-beam computed tomography, lingual canal, lingual foramen

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INTRODUCTION

It is well known that the anterior mandible contains several anatomical landmarks such as intra bony vascular canal, which is named the mandibular incisive canal (MIC) and lingual foramen.[1-3] The lingual foramen is situated in the midline of the mandible, at the level of, superior or inferior to the mental spines.[4] These anatomical landmarks in the anterior jaw have regained attention for optimizing surgical planning and avoiding complications.[5]

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The mandibular intermental foramen region is generally considered as a safe area, involving few risks of damage to vital anatomic structures during surgical procedure. However, these safety recommendations are not based on knowledge of the position and course of some anatomical landmarks.[6] The descriptions of lingual foramen and their bony canals dimensions and locations are important to consider during anterior dental surgery (implant placement, genioplastic, or grafting procedures) for avoiding various complications.[7] Some of these complications are as follow: intraoperative bleeding, nerve injury, pulp canal obliteration, and neuropraxia of the mandibular incisive nerve. The reported short- and long-term neurosensory disturbances include alteration or loss of pulp sensitivity in the lower front teeth.[8,9]

Nowadays, dental implants are regarded as a standard option for the prosthetic rehabilitation of edentulous patients. In most cases, implant placement is a routine and predictable technique.[10] In some situations, life-threatening hemorrhagic episodes may occur, due to perforation of the lingual cortex while placing dental implants in the anterior third of the mandible. Several studies indicated that if the lingual periosteum is ruptured an extensive hematoma develops within this region and progressive swelling of the floor of the mouth may cause upper airway obstruction.[10-13] Thus, it is necessary to do careful preoperative planning, including radiological imaging.[14] Cone-beam computed tomography (CBCT) has been shown to be superior to panoramic radiographs in displaying the mandibular lingual foramen and their bony canals variations. Image quality of CBCT systems and their relatively lower dose and cost when compared to conventional computed tomography have allowed more accessible three-dimensional assessment of craniofacial structures in dental practice.[15] CBCT allows comparatively higher resolution (spatial resolution of 0.1 mm homogeneous voxel) than spiral CT,[16] which Liang *et al.* performed an assessment of the superior and inferior genial spinal foramina and canals in a study.[17]

The purpose of this study was to assess the course and anatomical variations of lingual foramen and its bony canals with CBCT imaging in Iranian population.

MATERIALS AND METHODS

This was a cross-sectional study and CBCT images were obtained from patients who were referred to Esfahan School of Dentistry for preoperative implant placement planning between 2010 and 2011. The sampling method was consecutive and the sample size was 102 (d = 0.25, α = 0.05, and β = 0.2). Inclusion criteria include age above 18 years old and exclusion criteria include bone pathology in the mandible region and syndromic patients. All patients had informed consent for participation in this study.

All CBCT (GALILEOS, version 1.7) images were taken using a standard exposure and patient positioning protocol. The acquisition parameters were as follows: tube volume, 85 kV; tube current, 10–42 mA; acquisition period, 14 s; effective radiation time was between 2 and 6 s; reformatted imaging time 2.5 min; and voxel size was 0.3 × 0.3 × 0.3 mm.

Basic observations consisted of the number of lingual foramina and characteristics of its bony canal including the buccal and lingual canal diameters, the canal length, and canal slope. The distance between the terminal end of lingual canal at the buccal and lingual sides from the inferior border of the mandible and alveolar crest were measured [Figures 1 and 2].

In this study, we divided participants into three age groups for statistical analysis: under 35, 35–55, and above 55 years. Afterward, we evaluated the effect of patient age and gender on the dimensional measurements of the anatomical landmark mentioned above. All data were gathered and statistically analyzed by SPSS version 16. A five percent level of significance was used. The t test and analysis of variance (ANOVA) were used to determine the effect of age and sex on gathered data and pearson correlation was applied to obtain the relation between age and measured dimensions.

RESULTS

CBCT imaging of the mandible, from 102 patients which included 57 males (54%) and 55 females (46%), were investigated. The mean age was 52.37 (SD: 13.33) years, range 21–91 years. 73.5% of patients showed a dentate anterior mandible, and 26.5% of the patients who were referred for CBCT imaging were edentulous.

From the 102 mandibles investigated, 102 (100%) had at least one lingual foramen.

54 mandibles (52.9%) had two foramina at the lingual side of the mandibular midline and 20 mandibles (19.6%) showed three foramina in the mandibular

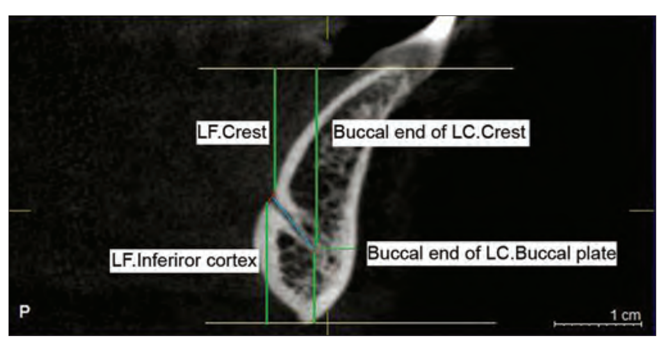

Figure 1: Dimensional measurements on a reformatted cross-sectional image of mandibular CBCT

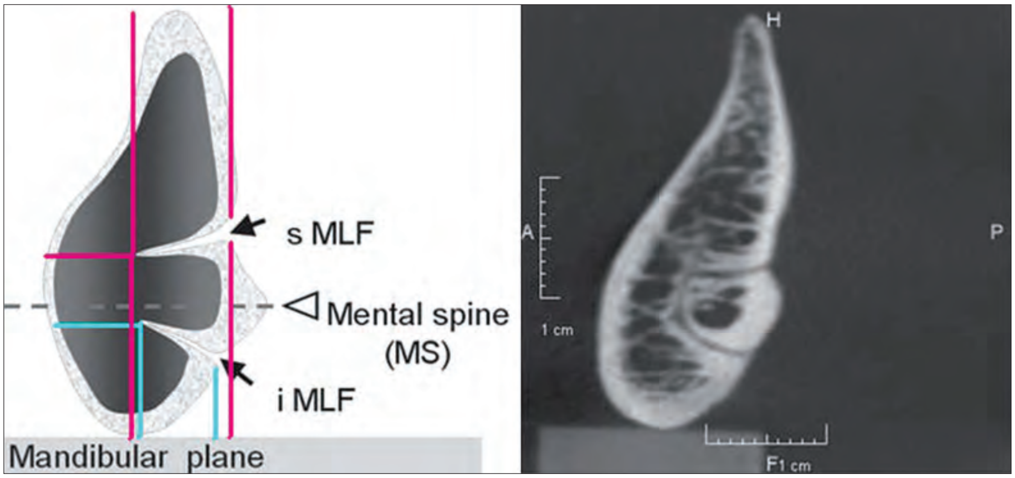

Figure 2: Scatterplot diagram between age and lower lingual foramen distance to crest. This plot shows a negative linear effect between age and distance of lower lingual foramen to crest ($P = 0.031$, $r = -0.248$)

midline and three mandibles (2.9%) showed four foramina in the mandibular midline. The remaining 25 mandibles (24.5%) had a single foramen and canal.

The average length of the superior lingual canals was 7.83 (SD 2.25) mm. The mean diameter of the opening of the superior lingual canals at the lingual side (superior lingual foramen) was 1.12 (SD 0.31) mm and at the labial side, it was 0.68 (SD 0.17) mm. The mean distances between the openings of the superior lingual canals at the labial side and lower border of the mandible, mandibular crest, and buccal plate were 10.08 (SD 2.06), 18 (SD 5.63), and 4.73 (SD 1.85) mm, respectively.

The average length of the inferior lingual canals was 6.33 (SD 1.65) mm. The mean diameter of the opening of the inferior lingual canals at the lingual side was 0.9 (SD 0.39) mm and at the labial side, it was 0.57 (SD 0.18) mm. The mean distances between the opening of the inferior lingual canals at the labial side and lower border of the mandible, mandibular crest, and buccal plate were 6.43 (SD 2.07), 21.89 (SD 4.12), and 4.8 (SD 1.87) mm, respectively.

The mean distances between the superior and inferior lingual foramina from lower border of the mandible were 14.12 (SD 2.49) and 4.27 (SD 2.65) mm, respectively. Also the mean distances between the superior and inferior lingual foramina from mandibular crest were 14.39 (SD 4.82) and 24.27 (SD 5) mm.

In our study, 96% courses of the superior lingual canals were running downward to the labial and 3% of the canals were running horizontally and 1% of the canals were directed upward to the labial side. From all the inferior lingual canals, 21.47% of them had courses running downward to the labial, 2.68% of the canals were running horizontally, and 77.8% of the canals were directed upward to the labial side.

Tables 1 and 2 show the distinctive dimensional measurements of the superior and inferior lingual foramina and their bony canals regarding to age and sex of the patients. As it can be seen in Table 1, the distance between lingual foramen and alveolar crest was significantly larger in less than 35 years old group. Also males had significantly larger distances between buccal end of lingual canal from inferior and buccal plate [Table 2].

Furthermore, we evaluated the correlation between the mentioned measurements and patient's age. As a result, we did not find any significant correlation rather than a correlation between age and lower lingual foramen distance to crest with P value = 0.031 and a –0.248 pearson correlation [Figure 3].

DISCUSSION

With the increasing use of implants and grafting procedures for anterior jaw bone, the number of reported postoperative complaints has been rising.[5] Dental anatomy textbooks equally fail to report on the existence of the lingual foramen. However, the lingual foramen is well identified on oral radiographs and thus clearly described in textbooks related to radiographic anatomy.[18] Knowledge of lingual foramen could be important for presurgical considerations of implant installation in the midline of the mandible. The content of this foramen has been

Table 1: The differences between dimensional characteristics of lingual foramen and canal with age groups

Anatomical landmarks	Under 35	35–55	Above 55	Age (*P* value)
LF diameter				
Superior	0.97 (0.31)	1.15 (0.29)	1.14 (0.33)	NS (0.148)
Inferior	0.82 (0.4)	1 (0.45)	0.83 (0.32)	NS (0.15)
LF – Alveolar crest				
Superior	16.7 (2.4)	15.4 (3.9)	12.7 (5.6)	S (0.004)
Inferior	27.5 (4.1)	25.3 (4.4)	22.1 (5.1)	S (0.002)
LF – Inferior cortex				
Superior	15 (2.7)	14.49 (2.47)	13.5 (2.33)	NS (0.053)
Inferior	4 (2.47)	4.74 (2.8)	3.9 (2.57)	NS (0.417)
LC length				
Superior	8.05 (2.6)	7.55 (2.47)	8.02 (1.9)	NS (0.585)
Inferior	6.05 (1.97)	6.64 (1.32)	6.11 (1.82)	NS (0.355)
Buccal end of LC Diameter				
Superior	0.73 (0.16)	0.65 (0.19)	0.68 (0.15)	NS (0.301)
Inferior	0.51 (0.3)	0.62 (0.17)	0.55 (0.13)	NS (0.138)
Buccal end of LC – Crest				
Superior	18.47 (5.99)	19.7 (4.67)	16.4 (5.96)	S (0.023)
Inferior	22.38 (8.5)	24.12 (4.16)	19.35 (5.77)	S (0.005)
Buccal end of LC – Inferior cortex				
Superior	10.75 (2.41)	10.27 (2.9)	9.68 (1.87)	NS (0.169)
Inferior	7.05 (3.1)	6.3 (1.6)	6.3 (2.1)	NS (0.568)
Buccal end of LC – Buccal plate				
Superior	4.55 (1.96)	4.7 (2.3)	4.8 (1.3)	NS (0.879)
Inferior	4.85 (1.6)	4.3 (1.9)	5.35 (1.77)	NS (0.074)

Table 2: The differences between dimensional characteristics of lingual foramen and canal with sex

Anatomical landmarks	Male	Female	Sex (*P* value)
LF diameter			
Superior	1.11 (0.3)	1.13 (0.33)	NS (0.822)
Inferior	0.82 (0.42)	0.98 (0.38)	NS (0.086)
LF – Alveolar crest			
Superior	14.9 (5.33)	13.96 (4.34)	NS (0.335)
Inferior	25.8 (5)	23 (4.7)	S (0.014)
LF – Inferior cortex			
Superior	14.76 (2.12)	13.58 (2.8)	S (0.014)
Inferior	4.65 (2.37)	3.96 (2.86)	NS (0.255)
LC length			
Superior	8.22 (2.26)	7.5 (2.19)	NS (0.104)
Inferior	6.6 (1.7)	6.11 (1.56)	NS (0.203)
Buccal end of LC Diameter			
Superior	0.7 (0.19)	0.65 (0.15)	NS (0.08)
Inferior	0.55 (0.16)	0.6 (0.2)	NS (0.319)
Buccal end of LC – Crest			
Superior	18.7 (5.7)	17.5 (5.36)	NS (0.291)
Inferior	22.9 (6.13)	21 (5.77)	NS (0.173)
Buccal end of LC – Inferior cortex			
Superior	10.63 (1.8)	9.6 (2.2)	S (0.011)
Inferior	7 (1.8)	5.9 (2.2)	S (0.018)
Buccal end of LC – Buccal plate			
Superior	5.2 (1.9)	4.3 (1.7)	S (0.017)
Inferior	5.48 (1.7)	4.3 (1.8)	S (0.004)

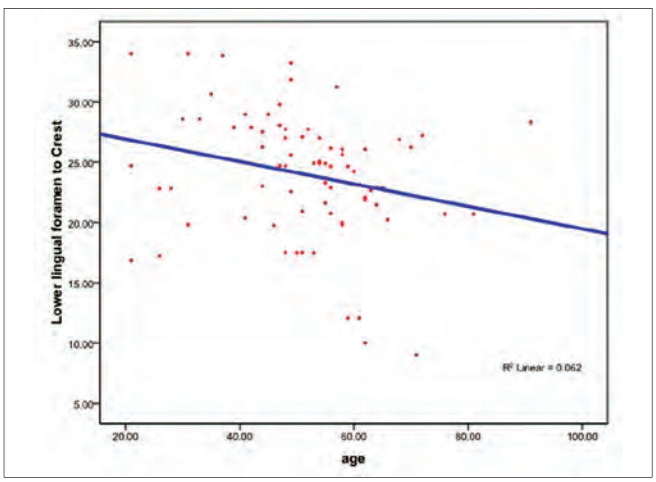

Figure 3: The differences between dimensional characteristics of lingual foramen and canal with sex

a matter of debate. Some studies assume a vascular content, its being an anastomosis of the sublingual branch of the right and left lingual arteries. The artery could be of sufficient size to provoke a hemorrhage intraosseously or in the connective soft tissue, which might be difficult to control.[19,20] Previous studies have been performed about frequency, diameter, and other anatomical features of lingual foramen and its canals. The purpose of the present study was to investigate the prevalence and anatomical variations of lingual foramen among Iranian population.

In our study, 102 mandibles were investigated and all of the images had at least one lingual foramen. Our results support those of Tepper *et al.*,[2] Gahleitner *et al.*,[1] and Mc Donnell studies.[4] Yet, our results provide no evidence for those of Jacobs *et al.* study, in which lingual foramen was seen in 82% of the spiral CT images.[21] One possible explanation for this discrepancy is that the reformatting procedure with some CT scans lacking a reformatted cross-sectional slice exactly at the mandibular midline. Furthermore, it is possible that the 1-mm slice thickness may have masked smaller diameter structure on the mandibular midline. Recently, CBCT, which has an approach different from spiral CT, has come to be used widely. CBCT allows comparatively less radiation and higher resolution (spatial resolution of 0.3 mm homogeneous voxel) than spiral CT. Therefore, the CBCT measurements for the mandibular lingual foramen and canal are considered to be reliable.

The superior and inferior lingual foramen frequencies in present study were 99% and 74.5%, respectively. Yet, our results provide no evidence for those of Kawai *et al.*,[22] which reported that the superior and inferior lingual foramen occurred with frequencies of 86.8% and 83.8%, respectively.

The location of lingual foramen and canal is important to avoid complications during surgery in that region. For instance, the mean distances between the superior and inferior lingual foramina from lower border of the mandible were 14.12 (SD 2.49) and 4.27 (SD 2.65) mm, respectively. While Kawai *et al*.[22] on Japanese mandibles showed that distances of the superior and inferior lingual foramina from the inferior mandibular plane were 11.43 (SD 1.56) and 4.42 (SD 2.64) mm, respectively. As it can be obtained, the mean distance between the superior and inferior lingual foramina from lower border of the mandible was greater in Iranian population rather than other populations in previous studies.

The vertical distance from the alveolar crest to the opening of the superior lingual canal at labial side was 18 (SD 5.63) mm. This means that a long implant is needed to injure the blood vessels. In type A and B ridges, Lekcholm *et al.* recommended placements of implants no longer than 13 mm in atrophied mandibles (types C and D), the vertical and horizontal dimensions are shorter, and implant length should be considered carefully.[23]

Also, the mean height of the opening of the superior and inferior lingual canals at the labial side from lower border of the mandible were 10.08 (SD 2.06) and 6.43 (SD 2.07) mm, respectively, in order to their appearance, which is similar to Liang *et al.*, which reported that the mean height of the superior and inferior lingual canals from the lower cortical border were 11.5 (SD 2.8) and 7.4 (SD 2.4) mm, respectively.[14]

According to the results of the study, the mean length of the superior lingual canals was 7.83 (SD 2.25) mm and the mean length of the inferior lingual canals was 6.33 (SD 1.65) mm.

From the 50 dry mandibles investigated by Liang *et al.*, they showed that the mean length of the superior and inferior lingual canal was 6.8 (SD 2.3) and 6.1 (SD 2.6) mm, respectively.[14]

In a previous study performed by Liang *et al.*, they showed that 72% of the canals had courses running downwards to the labial side and 28% of the canals were directed upward to the labial side.[14] In the study we conducted, the majority of the superior lingual canals were running downward to the labial side. And most of the inferior lingual canals were directed upward to the labial side, which is similar to Kawai *et al.* study.[22] These canal directions may explain the slightly vertical-oval morphology of midline lingual foramina. Thus, it is probable to realize in intraoral radiographs depending on differences in the angle of the projected X-rays. In images of the anterior region of the mandible obtain using the intra oral bisecting method, the mental spine is generally observed as a radio opaque region and occasionally a radio lucent pit can be observed near the spine.[24,25] In our result, the course of the superior and inferior lingual canal was approximately constant. We recommend that one can confirm the mandibular lingual canal from intra oral bisecting images when the course of the mandibular lingual canal parallels the projection angle of the X-rays.

Regarding the vertical angulations of the X-ray beam in anterior bisecting images (–15°), the probability projection of the superior lingual canal section and its distal end (inferior lingual foramen) is more than inferior lingual canal, because the X-ray beam is parallel to cortical border of canal.

The inferior lingual foramen had smaller diameter in comparison with superior lingual foramen. The mean diameter of the superior and inferior lingual foramen in our observation were 1.12 (SD 0.31) and 0.9 (SD 0.39) mm, respectively, while in a previous study they were 0.9 (SD 0.4) mm and 0.8 (SD 0.4) mm, respectively.[14] Although smaller canals with a diameter of less than 1 mm are rare in causing a major hematoma, larger canals could be mentioned in the radiologic reports and considered during the preoperative planning procedure.[17] Our results showed that the mean diameter of the superior lingual foramen was more than 1 mm. So the superior lingual foramen must be encountered with greater caution during operations to avoid bleeding complication.

In our study, two lingual foramens were more frequent (52.9%), this has also been shown in the previous studies.[26,27] However, the results are in disagreement with those of Liang *et al.* and Tepper *et al.* studies, in that, they found single foramen was most frequent.[14,2] Only those patients with a single lingual foramen (24.5% occurrence in our study) will benefit from the inferior location of this foramen, allowing deeper flap surgery or implant placement without risk of damage to the canal. Our study demonstrated that up to four lingual foramens have been detected, which support those of Katakami *et al.* studies.[28] The data indicate that when there was only a single midline lingual foramen (24.5%), it was normally above the genial spine. From a clinical view, the location, not the number, of the midline lingual foramina is important to avoid complications.

In this study the mean diameter of the opening of the superior and inferior lingual canals at the labial side was 0.68 (SD 0.17) and 0.57 (SD 0.18) mm, respectively. A previous study demonstrated that the mean diameter of the opening of the superior and inferior lingual canals at the labial side was 0.4 (SD 0.3) and 0.5(SD 0.3) mm, respectively.[14] From these data, we can suggest that may be there is no significance difference of the mean diameter of the opening of the superior and inferior lingual canals at the labial side between various studies.

Of 389 consecutively taken cone-beam computed tomograms of the mandible by Arx *et al.*, there was no statistically significant influence on the vertical diameter of the lingual foramina by gender (P =0.34) or age (P = 0.45).[26] Also according to the results of our study, there were no significant difference on the diameter of lingual foramen by sex and gender. But we demonstrated that there is greater distance between the inferior lingual foramina to the alveolar crest and also superior lingual foramina to the inferior cortex in male population. Furthermore, the results indicated that the distance of buccal end of lingual canal to inferior and buccal plate was also greater in size in male population. We showed that there is a significant difference between gender and distance of lingual foramen to alveolar crest. One possible explanation for this is mandible is larger in size in male population.

The results indicated that we did not find any moderate or strong correlations between age of the participants and the obtained measurements. But we only found a weak negative correlation between age of the participants and the distance of lower lingual foramen to crest in our study. This indicates that with increase in age the distance of lower lingual foramen to crest decreases. The most probable explanation for this correlation is that the crest has atrophied due to aging.

CONCLUSION

In this present study, we found some variations in mentioned anatomical landmarks in Isfahan population in comparison with previous studies. Due to these findings, we suggest that according to different anatomical positions and measurement for lingual foramen and its bony canal in every individual, it is important to consider this point during preoperative planning for surgery and especially, for implant placement in the anterior mandible. Furthermore, CBCT imaging was able to show the anatomical features of the lingual foramen and its bony canal, to avoid post operative complications.

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