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International Journal of Current Research
Vol. 9, Issue, 08, pp.55882-55886, August, 2017

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

ISSN: 0975-833X

RESEARCH ARTICLE

ASSESSMENT OF ANATOMIC VARIATION WITH THE FREQUENCY, LOCATION, AND MORPHOLOGY OF MANDIBULAR LINGUAL FORAMINA USING CONE BEAM COMPUTED TOMOGRAPHY

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ARTICLE INFO

Article History:
Received 05th May, 2017
Received in revised form
30th June, 2017
Accepted 14th July, 2017
Published online 31st August, 2017

Key words:

CBCT,
Implant,
Lingual Foramina,
Mandible

ABSTRACT

Purpose: To assess the anatomic variation with the frequency, location, and morphology of mandibular lingual foramina using Cone Beam Computed Tomography.
Methods: A retrospective study from CBCT examination of 200 subjects was conducted. The canal frequency (number), location, and travel direction were assessed by selecting images of the mandible. Also, linear dimensions such as the diameter of lingual foramina (D), the distance between the alveolar crest and the lingual foramina (L1), the distance between the tooth apex and the lingual foramina (L2) and the distance between the mandibular inferior border to the lingual foramina (L3) were examined. The differences in gender and age with respect to lingual foramina were also evaluated.
Results: High frequency of lingual foramina (99.5%) in 200 subjects have been noted. Most subjects had two canals (44%) with mostly Medial Lingual Canal (97.14%). 2.57% canals were vertical in direction. 6.29% foramina were >1mm in diameter. In 14.85% subjects, the distance from apical crest to the lingual canal (L1) was found to be <12mm. No significant difference was found between various age groups in values of L1 and L2 and in the diameter of lingual foramina in male and female subjects ($p>0.05$).
Conclusion: As the variations were shown in lingual foramina characteristics, it is mandatory to be aware of the structures present in anterior mandible to prevent the surgical complications. CBCT plays a pivotal role during the surgical phase of implant placement.

Citation: Dr. Pratul Kumar Agrawal, Dr. Anupama, Dr. Shilpa Shetty and Dr. Nalinakshamma Muniswamy Reddy, 2017. "Assessment of anatomic variation with the frequency, location, and morphology of mandibular lingual foramina using cone beam computed tomography", *International Journal of Current Research*, 9, (08), 55882-55886.

INTRODUCTION

The lingualforamen is a small opening present at the lingual surface of the mandibular anterior region which can vary in its position and number (Denny *et al.,* 2016). The mandibular anterior region is considered to be a safe area for implant surgery because of the absence of any neurovascular structures (He *et al.,* 2016). But, recent reports have indicated life threatening haemorrhage on the floor of the mouth due to the injury to the vessels passing through the lingual foramen during implant surgery. Surgery in this area can also affect the branches of the mylohyoid nerve, causing paresthesia or hypoesthesia (Kawai *et al.*, 2006; Niamtu, 2001; Mraiwa *et al.*, 2003). Lingual foramina are classified into two types according to their location: either in or near the midline [Median Lingual Canal (MLC)] or laterally [Lateral Lingual Canal (LLC)] in both premolar and molar regions (Tagaya *et al.,* 2009; Liang *et al.,* 2007; Katakami *et al.,* 2009; Babiuc *et al.,* 2011). So to avoid any neurovascular complications, it is necessary to establish the frequency, location, travel direction, and morphology of mandibular lingual foramina. These analyses are carried out by using Panoramic and Computed Tomographic radiograph. However, these radiographs appear only in two dimensions, and the extent of magnification (10% to 30%) obscures the key elements in the image. In recent times, cone-beam computed tomography (CBCT) is being used widely for the planning of implant surgeries (Kim *et al.,* 2013). CBCT provides high resolution, fast image acquisition, and low-dose radiation requirements and the error rate of displaying bony structures is less than 1%. Therefore, CBCT can offer an accurate and a high-resolution visualization of the structures of the jaw and dental measurements for quantitative analysis (Ludlow *et al.,* 2007; Stratemann *et al.,* 2014).

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MATERIALS AND METHODS

A total of 200 subjects [111 female subjects and 89 male patients] who underwent CBCT examination were randomly selected and they were divided into 3 age groups: Group A: 15-25 years, Group B: 26-49 years and Group C: ≥50 years. The study was assessed retrospectively. Lingual Foramina was assessed in terms of canal frequency; Canal location by classifying into two categories: MLC(Median Lingual Canal), LLC(Lateral Lingual Canal);linear dimensions such as the diameter of lingual foramina(D), the distance between the alveolar crest and the lingual foramina(L1),the distance between the tooth apex and the lingual foramina (L2),the distance between the mandibular inferior border to the lingual foramina (L3) (Fig. 1); direction of travel of lingual foramina by classifying into three types : inclined, horizontal and vertical. The differences in gender and age with respect to lingual foramina were also evaluated.

Statistical Analysis

Data were expressed as the mean ± standard deviation (SD). For comparison of two groups, an independent t-test was used. One-way analysis of variance (ANOVA) and ad hoc Fisher's Least Significant Difference (LSD) tests were used to determine the significant differences among age groups once ANOVA was found to be significant. Values of $p \leq 0.05$ were considered significant.

RESULTS

Frequency (Number) of Lingual Foramina

A total of 350 lingual foramina were found in 200 CBCT examination out of which one subject did not demonstrate any lingual foramina (0.5%). Number of lingual foramina ranged from 0-4 and 88 subjects (44%) had two foramina,83 subjects (41.5%) had one foramen.

Diameter of Lingual Foramina

The diameter of lingual foramina was classified based on the risk of severity of hemorrhage. Diameter ≤1mm is at low risk and diameter > 1mm is at high risk. Out of total 350 lingual foramina identified, 328 (93.71%) were ≤ 1mm and 22(6.29%) were >1mm. In male patients, 144(41.14%) foramina were ≤ 1mm and 12(3.42%) were >1mm.In female patients 184 (52.57%) were ≤ 1mm and 10(2.86%) were >1mm (Table 1).

Travel direction of Lingual Foramina

According to the travel direction, the lingual foramina was classified into 3 types: inclined to the horizontal plane of the inferior border of the mandible (Inclined), parallel to the horizontal plane of the inferior border of mandible (Horizontal) and perpendicular to the horizontal plane of the inferior border of the mandible (Vertical) (Fig 2). From a total of 350 lingual foramina, 280(80%) foramina were inclined, 61(17.42%) were horizontal and 9(2.57%) were vertical. In the male patient 123(35.14%) foramina were inclined, 26(7.43%) foramina were horizontal and 7(2%) foramina were vertical. In female subjects 157 (44.86%) foramina were inclined, 35(10%) foramina were horizontal and 2(0.57%) foramina were vertical (Table 2).

Table 1. Diameter of lingual foramina

Male subjects		Female subjects		Total	
≤1mm	>1mm	≤1mm	>1mm	≤1mm	>1mm
144(41.14)	12(3.42)	184(52.57)	10(2.86)	328(93.71)	22(6.29)

Table 2. Travel Direction of Lingual Foramina

	Inclined		Horizontal		Vertical	
	n	%	n	%	n	%
Male	123	35.14	26	7.43	7	2
Female	157	44.86	35	10	2	0.57
Total	280	80	61	17.43	9	2.57

Table 3. Regional Frequency of Lingual Foramina

	MLC	LLC
Male	154(44%)	4(1.14%)
Female	186(53.14%)	6(1.71%)
Total	340(97.14%)	10(2.85%)

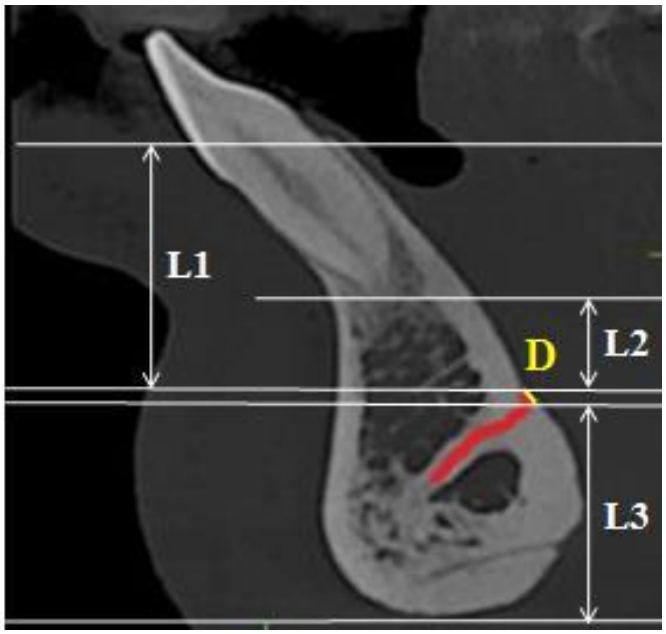

Fig. 1. Linear Measurement of lingual foramina on CBCT

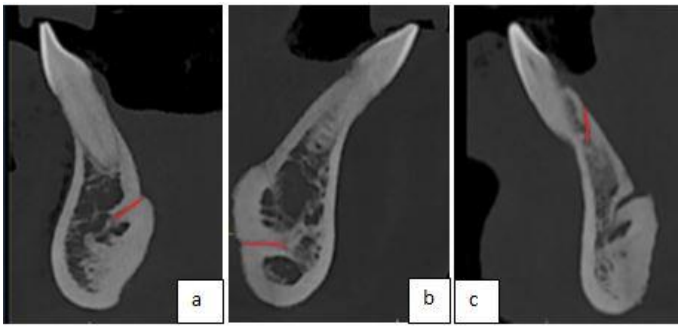

Fig. 2. CBCT showing the travel direction of lingual foramina

Distribution of Lingual Foramina

From the total 350 lingual foramina, 340(97.14%) were MLC and 10(2.85%) were LLC. In the male subjects, 154(44%) were MLC and 4(1.14%) were LLC. In the female subjects, 186(53.14%) foramina were MLC and 6(1.71%) foramina were LLC (Table 3). In relation to tooth position, most lingual foramina were observed in relation to 31 and 41 and no foramina were observed after 2nd premolars (Fig. 3)

Table 4. Measurements of lingual foramen below the tooth apex

	MLC			LLC			TOTAL		
	Male	Female	p	Male	Female	p	MLC	LLC	P
Diameter	0.53±0.32	0.48±0.23		0.85±0.47	1±0.23		0.5±0.28	0.94±0.33	<0.05*
L1	16.57±4.89	16.85±4.84		16.5±0.42	14.53±1.56	<0.05*	16.71±4.85	15.32±1.56	
L2	10.89±5.44	10.18±5.39		10.25±2.07	6.88±2.25	<0.05*	10.49±5.41	8.23±2.7	
L3	9.7±5.32	9.50±4.87		7.8±1.28	12.03±2.85	<0.05*	9.61±5.06	10.34±2.98	
*Statistically significant									

Table 5. Measurements of lingual foramina based on age groups

Group (Age)	A(15-25 Years)	B(26-49 Years)	C(≥50 Years)	p value
No. of subjects examined	29 (14.5%)	117 (58.5%)	54 (27%)	
Diameter	0.53±0.27	0.51±0.29	0.48±0.28	
L1	16.43±4.8	17.12±4.76	15.57±4.85	
L2	9.84±5.11	10.87±5.4	9.58±5.5	
L3	10.31±4.87	9.17±4.95	10.65±5.13	<0.05*
*Statistically significant				

Measurement of lingual foramina above and below the tooth apex

Two types of lingual foramina were observed with respect to tooth apex: those found above the tooth apex and those found below the tooth apex. Only one foramen (n=1; 0.29%) was found above the tooth apex in a male subject at MLC position with a mean diameter of 0.2 mm, L1 value of 3.5mm and L3 value of 22.4 mm. A total of 349(99.71%) foramina were found below the tooth apex. A significant difference was noted in the mean diameter of lingual foramina with MLC 0.5±0.28mm and LLC 0.94±0.33mm, indicating that LLC had a larger diameter than MLC ($p<0.05$). No significant difference was found between MLC and LLC in L1, L2, and L3 values ($p>0.05$). Also, a significant difference was noted in mean values of L1, L2, and L3 in LLC ($p<0.05$) [Table 4]

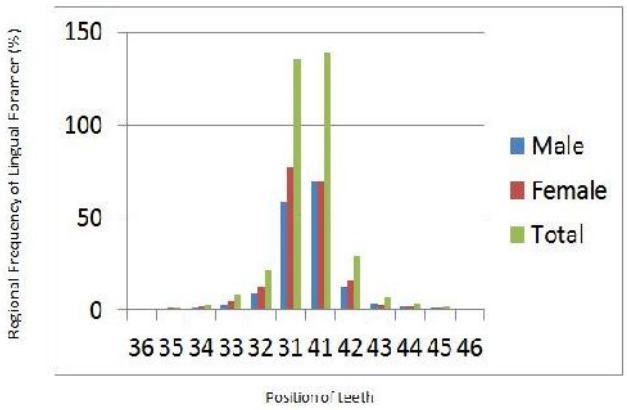

Fig. 3. Position of lingual foramina in the mandible

Measurements of lingual foramina based on age groups

Out of 200 lingual foramina evaluated, there were no significant differences among the three age groups seen in values of diameter, L1, and L2 ($p>0.05$). A significant difference ($p<0.05$) was noted among the three age groups in values of L3: A(10.31±4.87mm), B (9.17 ± 4.95mm) and C (10.65±5.13mm). (Table 5)

DISCUSSION

In most of the studies, the frequency of lingual foramina was high (58.8%-99.0%). A study had reported that out of 500 subjects, 85 (17%) had one lingual foramen, 141 (28.2%) had two foramina, 265 (53%) had more than two foramina and nine(1.8%) had no foramina (Sekerci *et al.,* 2014). In another study it was found that 72% of subjects had a single foramen, 22% had two foramina and 4% had three foramina (Liang *et al.,* 2007).While one study had reported one canal in 71.9% of subjects, two canals in 9.4%, three canals in 15.6% and four canals in 3.1% (Babiuc *et al.,* 2011). In the present study, lingual foramina were noted in 99.50% of subjects, which is a high frequency. The number of lingual foramina in the mandible ranged from 0 to 4 in each individual. Most subjects had two canals (44%) and one canal (41.5%).

Lingual foramina with large diameters (>1mm) may be involved in severe hemorrhage on the floor of the mouth associated with implant surgery as described by previous studies. The diameters of lingual foramina ranged from 0.64 to 0.84mm (Yildirim *et al.,* 2014; Sahman *et al.,* 2014; Romeo *et al.,* 2006). One study has found 21.23% canal were >1mm but in the present study, 6.3% canal were >1mm (He *et al.,* 2016).

Lingual foramina are classified into two types based on their location: either or near midline (MLC) or laterally (LLC).Most of the studies mentioned that frequency of MLC ranged from 73.9% to 100% (Liang *et al.,* 2007; Katakami *et al.,* 2009; Babiuc *et al.,* 2011). However,one study has found the frequency of MLC ranged upto 20% and LLC upto 80% using CT imaging (Tagaya *et al.,* 2009). In the present study, 97.14 % of lingual foramina were MLC and 2.85 % were LLC. A study had reported the presence of lingual foramina till second molar(He *et al.,* 2016) while in the present study, the lingual foramina were not found beyond second premolars.

Lingual foramina were classified into two types based on above or below the tooth apex. Because of anatomic variation, foramina above the tooth apex have high chances of injury during the surgical phase of implant placement. Severe, life-threatening hemorrhage and respiratory obstruction were reported in different studies because of injury of the sublingual and submental arteries contained in lingual foramina (Kalpidis *et al.,* 2015; De Vera *et al.,* 2008). In the present study, one lingual foramen (0.29%) was found above the tooth apex which was less in diameter (0.2mm). This result suggests that although the lingual foramen found above the tooth apex was smaller and less in number, attention should be paid to prevent any surgical complications because of their anatomic variations.

The distance between the lingual foramina and the alveolar ridge crest (L1) is clinically relevant to implant surgery as it may limit the length of the implant to be placed (Kilic *et al.*, 2014). Currently, the length of standard implants is 10 mm and a safety margin of 2 mm (total >12mm) between a dental implant and neurovascular structures is recommended to prevent any injury (Romeo *et al.*, 2006; Monje *et al.*, 2013). In the present study, L1 values of ≤12 mm were observed in 39 (11.14%) foramina in MLC position and 13 (3.71%) foramina in LLC position. These findings indicate that MLC are at more risk of injury than LLC.

Differences in the foramina between male and female patient were also studied. Studies have shown that male subjects had a larger diameter of the lingual foramen (He *et al.*, 2016). In the present study, no significant difference was noted in gender with respect to the diameter of lingual foramina. A study has reported the changes in the values of L2 with advancing age (He *et al.*, 2016). However, in the present study, there was no significant difference found between the age groups in the values of L2.

Conclusion

As the present study shows the anatomic variation in lingual foramina position, diameter, the path of travel and also with respect to gender, it is important to have CBCT examination prior to treatment planning to prevent any surgical complication.

Abbreviations

CBCT:Cone Beam Computed Tomography
CT: Computed Tomography
MLC: Median Lingual Canal
LLC : Lateral Lingual Canal
D: Diameter of the lingual foramina
L1: Distance between the alveolar crest and lingual foramina
L2: Distance between the tooth apex and the lingual foramina
L3: Distance between the inferior border of mandible to the lingual foramina

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