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ORIGINAL ARTICLE

EVALUATION OF THE PREVALENCE AND MORPHOMETRIC CHARACTERISTICS OF THE LATERAL LINGUAL CANAL IN THE INTER-FORAMINAL MANDIBLE OF THE MELMARUVATHUR POPULATION: A RETROSPECTIVE CBCT STUDY

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ABSTRACT

Objectives: Lateral lingual canal (LLC) is a critical anatomical landmark for presurgical assessment of dental implants. Data on the prevalence and morphometry of the LLC in varying population shows a lot of variability. The purpose of this cross-sectional Cone Beam Computed Tomography (CBCT) study was to assess the frequency, distribution, location , and morphometric variations of the LLC of Melmaruvathur population in South India.

Materials and Methods:A retrospective cross-sectional study was conducted using 200 CBCT scans of partially edentulous individuals aged 21–72 years from the Department of Radiology at Adhiparasakthi Dental College and Hospital. Inter-foraminal region of mandibular scans were assessed for the presence, location, course, and morphometric parameters of the LLC. Statistical analysis was performed using Chi-square and Mann-Whitney tests with a significance threshold of $p<0.05$.

Results: LLCs were observed in 22% of participants, with 20% showing a single canal and 2% exhibiting double canals. The most common location was the canine region (50%), followed by the premolar (41.66%) and lateral incisor (8.33%) region, with a significant gender-based association ($p=0.048$). Cephalic course was the most frequent (66.66%), and 31.25% of canals crossed a critical diameter of 1 mm. No significant gender differences were observed in morphometric measurements.

Conclusion: LLCs exhibit notable anatomical variability in the Melmaruvathur population, particularly in their prevalence, location, and course. Given their potential to cause intraoperative complications, especially during implant surgery, routine and thorough preoperative CBCT evaluation is recommended to ensure surgical safety and precision in implant surgery.

Keywords**:** Lateral Lingual Canal, Inter-foraminal mandible, Cone-beam Computed Tomography (CBCT), Morphometric variability, Mandibular Anatomy

INTRODUCTION

The human mandible is a highly complex and varied anatomical structure with significant clinical implications, particularly in fields of implantology, oral surgery, and radiology. A key landmark in this region is the Median Lingual Canal and Lateral Lingual Canal (LLC), which harbor anastomosing blood vessels . Lingual surface of mandible shows a high frequency of foramina which can be classified as median lingual foramina and lateral lingual foramina[1]. Vascular canal emerging from lingual foramina in the midline in and around genial tubercles is known as Median Lingual Canal or median Vascular Canal which have shown a prevalence of 90-100%. Accessory Vascular canals originating from the lingual foramina on the lingual mandibular surface other than the midline are called as LLC. The LLC is frequently identified during routine CBCT scans, but its clinical significance is often underestimated[2]. Misinterpretations or failure to recognize variations in LLC morphology can result in unintended complications during procedures such as implant placement, bone harvesting, and surgical extraction[3].

Numerous case reports have documented life-threatening complications due to profuse bleeding, edema, and hematoma formation during or immediately after surgical procedures in the inter-foraminal region[2,3,4]. Understanding the typical and atypical features of the LLC is vital for clinicians to reduce such risks.

Studies on the morphology of the lateral lingual canal have shown significant variability in terms of its prevalence, distribution, and morphometric characteristics[5]. Moreover, while studies have explored the LLC in various populations restricting to urban population, limited research has been conducted on specific regional populations like Melmaruvathur. The Melmaruvathur population presents unique anthropological and genetic characteristics that could potentially result in distinct morphometric features compared to other populations. This study addresses the gap by providing population-specific data, thus enriching the literature.

In context to this subpopulation, a previous study evaluated the morphological variability of the median lingual canal using Cone Beam Computed Tomography (CBCT) shedding light on the anatomical peculiarities specific to this region[6]. Extending this knowledge to the LLC offers a more comprehensive understanding of the variability in lingual canal anatomy within the same population.

The primary objective of this study was to evaluate the prevalence, distribution, and morphometric variability of the lateral lingual canal in the inter-foraminal region of mandible in the Melmaruvathur population, using CBCT imaging. By providing detailed insights into the anatomical variations of this vascular structure, the study aims to enhance the safety and precision during surgical interventions in the inter-foraminal region in this Indian Subpopulation.

MATERIALS AND METHODS

Study Design

A retrospective cross-sectional study was conducted to evaluate the frequency, localisation, course and morphometric variation of LLC in the inter-foraminal mandible among individuals from the Melmaruvathur region in South India using cone-beam computed tomography (CBCT). The study protocol received ethical approval from the Institutional Review Board of Adhiparasakthi Dental College and Hospital, Melmaruvathur (Approval No: IRB/27/ Prostho-02/APDCH/2025). Written informed consent was taken from all the participants before surgery in accordance with NABH guidelines. All procedures were performed in accordance with the ethical principles of the Declaration of Helsinki.

Participant Selection and Imaging Protocol

CBCT scans from 200 participants were retrospectively selected from the archives of the Department of Radiology, APDCH. Based on the lateral lingual foramen prevalence of 13.3%[7], the sample size calculated was 178 using OpenEpi, version 3 (www.OpenEpi.com). No scan was performed exclusively for this study. Participants included were partially edentulous adults aged 21–72 years with at least one missing mandibular tooth for whom CBCT had been taken for planning implant surgery from the period of January 2023 to December 2024. Patients having taken CBCT for wisdom tooth extraction were also included in the study. All CBCTs were of medium FOV. Exclusion criteria included a history of craniofacial trauma, jaw surgery, congenital anomalies, orthodontic treatment, systemic diseases like osteoporosis, edentulous mandibular arch, syndromic conditions, unclear scans, and small or large FOV CBCT . All CBCTs were obtained using a Dentsply Sirona CBCT unit operating at 85 kVp and 6 mA, with a medium field of view (8 × 8 cm) and 1 mm slice thickness.

Image Analysis

CBCT scans were independently reviewed by two implantologists with over 5 years of experience, using CareStream 3D Imaging Software (Version 3.10.38; Carestream Dental LLC, Atlanta, USA). Observers adjusted brightness and contrast to enhance visualization. All measurements were recorded to a single decimal point. In cases of interobserver disagreement, an oral radiologist re-evaluated the scan, and their interpretation was taken as final.

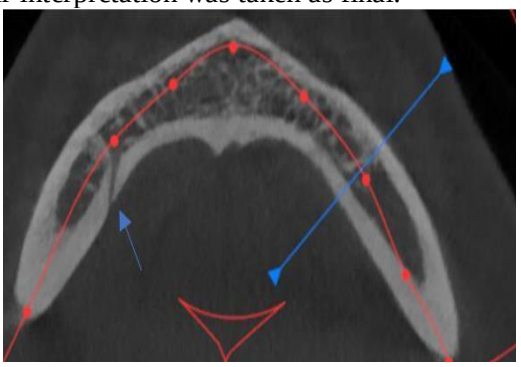

Figure.1 Axial view depicting lateral lingual canal (arrow)

The mental foramen was used as a starting reference point, and scans were cropped from mental Foramen on either side. The LLC was identified by distinct cortication and analyzed in both axial and cross-sectional views (Fig 1). Canal seen in the midline in genial tubercle region were named as MLC and ones identified away from midline of mandible were named as LLC as classified by Sanomiya *et.al* [8]. The interobserver agreement for the identification and classification of the mandibular lingual canal was substantial, with a Cohen's kappa (κ) value of ≥ 0.70,

reflecting a high level of consistency between the evaluators. The LLC was assessed for number and location relative to the tooth region(Lateral Incisor, Canine and Premolar) and its supero-inferior course was categorized as caudal, transverse, or cephalic in cross section. Course Localisation of canals were done by drawing a vertical line across the centre of the tooth. The LLC foramina nearest to the central line determined the location of the canal designated as Lateral Incisor region, Canine region and Premolar region. Morphometric parameters measured included:

- LLC diameter at emergence on the lingual mandibular plate
- LLC diameter at exit(intraosseous)
- Distance from LLC emergence to buccal cortical plate
- Distance from LLC exit to buccal cortical plate
- Distance from LLC emergence to the inferior border of the mandible (IBM)
- Distance from LLC exit to the IBM

All measurements were taken from standardized cross-sectional slices.

RESULTS

Analysis of 200 CBCT scans was done with a Male to Female ratio of 1:1. Study included 100 males and 100 females with mean age of 45.3 ± 13.1 years. Mean age of females and males was (42.8 ± 14.9) years and (47.8 ± 13.2) years respectively. LLC was seen in 44(22%) patients and 156(78%) patients had no LLC. Prevalence of LLC and no association with gender is shown in **Table1**. 40(20%) patients showed single accessory canal and 4(2%) patients had double accessory canal in interforaminal region . Total Number LLC present were 48.(**Table2**). Total Number LLC present were 48.

Table 1. Presence of LLC

Gender	LLC		p-value
	Absent n (%)	Present n (%)	
Male	80 (40)	20 (10)	0.495 (NS)
Female	76 (38)	24 (12)	
Total	156 (78)	44 (22)	

NS - Statistically not significant at p<0.05, Chi-square test

Table2. Number of LLC

Gender	LLC			p-value
	0 n (%)	1 n (%)	2 n (%)	
Male	80 (40)	20 (10)	0 (0)	0.129 (NS)
Female	76 (38)	20 (10)	4 (2)	
Total	156 (78)	40 (20)	4 (2)	

NS - Statistically not significant at p<0.05, Chi-square test

24 (50%) accessory canals were present in canine region, 4(8.33%) were present in lateral incisor region and 20(41.66%) were present in premolar region(**Table 3**).

Table 3. Association between location of LLC and Gender

	Canine n(%)	Lateral incisor n(%)	Premolar n(%)	p-value
Male	8 (40)	4 (20)	8 (40)	0.048*
Female	16 (57.14)	0 (0)	12 (42.85)	
Total	24 (50)	4 (8.33)	20 (41.66)	

*Statistically significant at p<0.05, Chi-square test

32(66.66%) canals were seen on right side and 16(33.33%) on left side(**Table 4**).

Table4.Association between Regional Distribution of LLC and Gender

	Left n(%)	Right n(%)	p-value
Male	4 (33.33)	8 (73.33)	0.110 (NS)
Female	12 (60)	8 (40)	
Total	16 (33.33)	32 (66.66)	

NS- Statistically not significant at p<0.05, Chi-square test

Table 5. Association between course of LLC and Gender

	Caudal n(%)	Cephalic n(%)	Transverse n(%)	p-value
Male	8 (40)	12 (60)	0 (0)	0.051 (NS)
Female	4 (14.28)	20 (71.42)	4 (14.28)	
Total	12 (25)	32 (66.66)	4 (8.33)	

NS- Statistically not significant at p<0.05, Chi-square test

32(66.66%) canals showed a cephalic course, 4(8.33%) showed a transverse course and 12 (25%) showed a caudal course. Association between the course of LLC and gender is seen in **Table 5**. 15(31.25%) canals showed a diameter greater than 1mm with no statistically significant association with gender. Mean of all the morphometric measurements of LLC and its association with gender is seen in the **Table 6**.

Table 6. Linear measurements of LLC and association with gender

		Total	Gender		p-value
			Male	Female	
Diameter at entrance of LLC	Mean±SD	0.655±0.254	0.334±0.164	0.857±0.344	0.230 (NS)
Diameter at exit of LLC	Mean±SD	0.422±0.224	0.419±0.208	0.426±0.240	0.321 (NS)
Distance from entry of LLC to inferior border of mandible	Mean±SD	4.036±2.088	4.707±2.220	3.249±1.956	0.481 (NS)
Distance from exit of LLC to inferior border of mandible	Mean±SD	4.489±2.410	4.486±2.176	4.504±2.644	0.334 (NS)
Distance of canal entry from buccal plate	Mean±SD	4.149±2.278	4.009±1.948	4.279±2.6080	0.210 (NS)
Distance of canal exit from buccal plate	Mean±SD	2.931±1.518	2.772±1.344	3.085±1.692	0.373 (NS)

NS- Statistically not significant at p<0.05, Mann Whitney test

DISCUSSION

This retrospective CBCT-based study aimed to assess the prevalence, distribution, trajectory, and morphometric characteristics of the lateral lingual canal in the inter-foraminal region of the mandible in a South Indian subpopulation. The findings offer valuable insights for clinicians performing implant placement or other surgical procedures in this anatomically critical area. In recent years, advancements in imaging technologies, particularly CBCT, have provided more precise and detailed three-dimensional views of mandibular structures. CBCT offers a clear advantage over traditional radiographic methods, providing high-

resolution images at a reduced radiation dose, making it an ideal modality for the detailed study of the lateral lingual canal[9]

The LLC was identified in 22% of the study population, which is in line with previous studies reporting prevalence rates ranging from 11.5% to 39%[7,8,5]. The variability in prevalence may be attributed to ethnic differences, imaging resolution, and methodological variations. Gender-wise distribution of the LLC showed no statistically significant difference, although double LLC were observed exclusively in females (2%), which may suggest an observation requiring further investigation. Most LLCs were unilateral and singular, with only 2% of participants exhibiting double canals. In contrast to the findings of our study, a study on Iranian population showed that LLC was 1.36 times more common in males than females[7] .

The anatomical region most frequently associated with the LLC was the canine region (50%), followed by the premolar (41.66%) and lateral incisor (8.33%) regions in our study. A statistically significant association was observed between gender and regional distribution ($p = 0.048$), with females showing more frequent LLCs in the canine region. These results highlight the need for careful radiographic evaluation of the canine region, particularly in females in the population of Melmaruvathur in South India . A cadaveric study conducted in South India also reported the canine region as the most common region for the presence of LLC[10] . In contrast to our study other studies targeting different ethnicity have shown premolar region as the commonest site for the presence of LLC[1,5,7] .One probable reason for this variation could be the area scrutinised for the presence of LLC in various studies. Our study targeted only the inter-foraminal region, whereas the study done on Iranian population assessed the presence of LLC from second molar on either side[7]. Sahman *et.al* have targeted 2nd Premolar on either side to assess the presence of accessory foramen[5]. This variation in methodology could have also led to differences in the prevalence of LLC in the studies. This finding underscores the importance of careful planning and technique when placing implants in this region to minimize the risk of hemorrhagic events. In consensus to our study a systematic review identified that the mandibular canine region is the area most susceptible to bleeding complications during dental implant procedures[11] **.** A similar CBCT study assessing accessory canals in mandible of 50 Indian subjects showed the presence of 89% canals in the interforaminal region and 11% canals present in posterior to mental foramen[12]**.**

Regarding the canal trajectory, a cephalic course was most commonly observed (66.66%), followed by caudal (25%) and transverse (8.33%) orientations. These findings are comparable to those reported in the study by Kawai et al[13]; who noted a predominance of cephalic trajectories. However; Liang et.al[14] found 72% of the canals in his study had courses running downwards. Clinically, cephalic and transverse orientations may pose a higher risk of neurovascular injury during implant osteotomy. 31.25% LLC demonstrated a diameter of ≥1 mm in our study. Critical diameter of 1mm is considered clinically relevant due to higher risk for bleeding during osteotomy[15]. A similar study done in South India showed that 61% of the lingual vascular canals had a diameter of greater than 1mm[16]. A wide difference in the percent could be attributed to the methodology and regional difference in the population. While the mean diameters and linear measurements did not differ significantly between males and females, the wide range in values observed underscores the high anatomical variability of these canals. This reinforces the necessity for individualized radiological assessment rather than reliance on generalized anatomical assumptions.

The morphometric parameters including distances from the buccal cortical plate and the inferior border of the mandible showed no significant gender-based differences, though they revealed a broad distribution, further emphasizing the variability in the course and emergence of the LLC.

Knowledge of the prevalence, location, and trajectory of the LLC is essential for minimizing complications during surgical procedures in the anterior mandible. Injury to the LLC can result in persistent bleeding, hematoma formation, or neurosensory disturbances. The findings support the routine use of CBCT imaging for accurate preoperative planning and risk mitigation. This study was limited by its retrospective design and reliance on medium field-of-view CBCT scans, which, although sufficient, may not have captured finer canal details compared to micro-CT. Furthermore, the sample was derived from a single geographic region, potentially limiting the generalizability of results. Prospective studies with larger and more diverse populations are recommended to validate these findings.Canal course studied was only in cross sectional view. Course in the axial view was not studied. Parametric association with the edentulous state of the patient and age was not done in this study.

CONCLUSION

This CBCT-based study demonstrated that the lateral lingual canal is present in 22% of individuals in the Melmaruvathur population, most frequently in the canine region and often with a cephalic trajectory. Although the LLC showed no significant gender-based morphometric differences, its variable presence and dimensions highlight the importance of individualized preoperative assessment. The findings underscore the need for careful planning during surgical procedures in

the inter-foraminal region to avoid neurovascular complications. Routine use of CBCT imaging is strongly recommended to enhance surgical safety in implantology and other mandibular interventions.

DECLARATIONS

Ethical approval and consent to participate

Not Applicable

Availability of data and material

All data generated or analyzed during this study are included in the published article.

Competing interest

The authors declare that there are no competing interests.

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