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A Review of the Accuracy of CBCT in the Analysis of Lingual Foramen Anatomical Variations

Nuhad A. Hassan[1], Amal Raouf S. Mohammed[2], Abeer A. Aljoujou[3]

[1]Department of Oral Medicine, College of Dentistry, Mustansiriyah University, Baghdad, Iraq. E-mail: nuhad_alshammery@yahoo.com, nihadalwan@uomustansiriyah.edu.iq, ORCID: https://orcid.org/0000-0002-5601-0924.

[2]Department of Oral Medicine, College of Dentistry, Mustansiriyah University, Baghdad, Iraq. E-mail: amalraouf@uomustansiriyah.edu.iq , ORCID: https://orcid.org/0000-0002-2169-7199.

[3]Department of Oral Medicine, College of Dentistry, Damascus University, Damascus, Syria, E-mail : abeer79.aljoujou@damascusuniversity.edu.sy, , ORCID: https://orcid.org/0000-0001-8606-3122.

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Abstract

Vascular and neural components, including the lingual artery, the submental artery, and its anastomoses, in addition to mylohyoid nerve branches, all pass via the lingual foramina (LF), which are located on the lingual midline of the mandibular symphysis of the jaw. Numerous procedures, such as implantation, tori excision, and genioplasty, are performed in the anterior mandibular midline, where the LF is commonly present. Cone-beam computed tomography (CBCT), a more current scanning modality, offers 3-D images with great spatial resolution, minimal irradiation dose, and precise assessments of the anterior mandible's bone structures on a variety of planes. Bleeding, tongue elevation, and edema of the mouth floor are common surgical complications of anterior mandibular implants. This review is designed to see if the anatomical variations of the LF can be properly evaluated for implant and surgery using CBCT. Scopus, PubMed, Web of Science, Google Scholar, and the Iraq Virtual Library employ them for database searches. The identification of up to four LFs and a similarly low proportion of accessary LFs are notable.

Keywords: lingual foramina, Cone beam CT, accessory foramina, symphysis, mandible.

Introduction

Nowadays, cone-beam CT (CBCT), the more recent scanning technology [1,2], provides valuable 3-dimensional radiography (3-D) and measuring software to provide images with high spatial resolution, a relative low irradiation dosage, and accurate measurements of significant bony structures of the anterior mandible (AM) on a variety of planes [3,4].

Using the CBCT, the surgeon can carefully prepare for operations while keeping in mind the anatomical structures in AM. For instance, during dental implant surgery, orthognathic surgery, or osteodistraction, there is a possibility of damaging the structures in this area, resulting in severe bleeding [5]. A large hematoma in the floor of the mouth caused by this haemorrhage may not be noticed right away, causing obstruction [6,7].

The increased use of implants and grafting techniques in the front jaw bone has led to an increase in postoperative problems [8]. Oral radiographs may reveal that the lingual foramen (LF) is well-defined [9]. Prior to the insertion of implants in the mandible's midline, understanding the LF is a crucial pre-surgical consideration. Numerous anatomical features, including the mandibular incisive canal (MIC) and the LF, are found in the anterior jaw [10,11]. The LF is in the middle of the mandible, at the same level as the mental spines, either below or above them [12]. These parts of the jaw's anatomy in the front play a big role in making the best plans for dental surgeries and preventing more problems [13].

This review is designed to see if the anatomical variations of the lingual foramen can be properly evaluated for implant and surgery using CBCT.

Materials and methods

Scopus, PubMed, Web of Science, Google Scholar, and the Iraq Virtual Library employ them for database searches. The review covered publications from 2000 through 2022, beginning in September 2022. Throughout the search, the phrases lingual foramina, mandible, cone beam CT, accessory foramina, and symphysis were utilized. Only English-language articles were examined. Selection criteria for studies: Radiological research in three dimensions. We omitted case reports, abstracts, and panoramic studies. Frequency, diameter, number, length, position, and lateral foramen were the main evaluated factors. Researchers recorded information about anatomical variances from prior investigations.

Results

The database search enabled the screening of 44 studies. After screening and eligibility, 27 studies were selected.

Anatomical and clinical findings

Implant operations require in-depth familiarity with the anatomy of the small artery structures. Submental and sublingual arteries (branches of the facial and lingual arteries, respectively), as well as branches from the anastomosis between them, provide blood supply to the LF, as shown by cadaveric studies. At the hyoid bone level, the lingual artery is the third anterior and second consecutive branch of the external carotid artery[14,15]. Since the primary supply of blood for the structures found in the mouth floor and tongue [16,17]. The deep dorsal branches that branch out of the lingual artery provide blood to both the body and the top of the tongue. In order to reach the sublingual artery, the lingual artery must first pass through the frontal border of the hyoglossus muscle. Anatomical focus provides the groundwork for understanding the submental artery's role as either a major vessel or a supplementary vessel in this region, which is necessary for comprehending the trends of hemorrhages arising from the perforation of the mandibular lingual cortical during implant surgery. A potentially life-threatening bleeding might be caused by mechanical damage to the arterial plexus's branch vessels [18].

Radiographical considerations

The CBCT diagnostic is critical for surgical planning [19-21]. This advancing technology's expanded diagnostic capabilities provide the physician with the skills essential to minimize potential challenges and promote the clinician's trust and predictability in implant dentistry [22,23].

Babiuc et al. [15] evaluated the CBCTs of 36 patients in 2011. The foramen was present in every patient examined.

The LF has been defined as a tiny opening in the midline of the lingual region of the jaw. This hole appears as a tiny radiolucent circle roughly one centimeter below the interapical line of the inferior incisors on radiographs. It varies in size, with a diameter that seldom exceeds 1 to 2 mm, as well as in number, length, and placement, all of which make it challenging to detect the LF with conventional radiography [24-31].

In their analysis of 70 individuals' mandibles, Surathu et al. [32] found lingual foramina in a variety of anatomical arrangements. It has been suggested that CBCT be used in the preoperative planning of anterior mandibular surgical operations to reduce the risk of unanticipated bleeding (Figures 1–4).

Frequency

As reported by Laisiriroengrai et al. [33] in their research of 240 patients, midline LF had a 100% frequency. Yu et al. [34] demonstrated that at least one lingual foramen was present in 80 CBCT pictures of elderly Koreans. Likewise, historically, results have shown a high incidence of LF (greater than 90%) [35-39]. Tagaya et al. [31] used CBCT to study both 5 cadavers and 200 living people. All of the cadavers had foramina, while at least one foramen showed up in 190 of the 200 living. We discovered a 99.3 % prevalence rate. 199 (99.5%) of the women and 102 (99.0%) of the men possessed foramina. Alqutaibi et al. [40] have indicated no significant difference between genders in the prevalence of LF. A review by Barbosa et al. [41] concluded that females were more likely to have it than males. While research by de Andrade Santos et al. [42] in 2020 found that both men and women had foramina (99.0% and 99.5%, respectively). LF is quite prevalent, and its occurrence has been found to be independent of factors including age, gender, and dental state.

Number

Sheikhi et al. [43] analyzed the discrepancies between the LF and bone canals of 102 individuals using CBCT. Approximately 52% of the research group had at least one foramen. In addition, the data revealed that as many as four LFs had been discovered. Abesi et al.[44] noted that during an inspection of CBCT data, the most relevant number of canals was two (53%), followed by a single canal (46.5%) and only in 6.0% of cases, three canals were identified, which is in line with de Andrade Santos et al. [42] outcome (two: 47.5%; single: 39.5%; and three: 7.5%).

Literature reported that more than three LFs were unusual, with a low prevalence of four LFs ranging from 0.15 to 4% [15,43,45,46]. Despite the fact that previous investigations have identified up to four LFs [47,48].

Previously, it was reported that a single LF was the most prevalent[10,15,49], but other researchers reported a double foramen [43,50]. According to He et al. [38], the majority of patients had 3 or 4 foramina. In addition, between 0 and 8 foramina were discovered in each subject.

Sanchez-Perez et al. [23] detected that 64% of individuals had one canal of the LF, 33% had two canals, and 3% had a triple foramen after analyzing 111 CBCTs for implant purposes. In both edentulous and dentate individuals, women exhibited marginally lower values for each variable compared to males. This indicates that the LF must be considered while considering surgery. When determining where to place the dental implant, it is essential to pay special attention to avoid complications.

Bernardi et al.[51] conducted a study of Dental CT scans on 56 individuals. Seventy-five percent had at least one foramen on the midline of the lingual mandible.

Location

Several approaches were used to assess the anatomical location of the LF. Marzook et al. [52] categorized it based on the position of the canal opening as upper, middle, and lower, which might be lingual or buccal. As a reference, He et al. [38] utilized the tooth apex (above or below). Another often used genial tubercle has characterized the LF location as superior, medium, or inferior [38,53,54]. Additional research based on the genial tubercle categorizes it as either upper or lower LF [52,55-57] Laisiriroengrai et al.[33] and Moshfeghi et al.[49] clarified that the location of LF was commonly in the superior position, followed by the inferior position. Concerning the mandible, 7.7 mm was the average distance between the LF and inferior border of the mandible [49]. This number was somewhat less than what was recorded for this distance (11.5 and 14mm, respectively)[14,48].

The work of Kawai et al. [58], which discovered that the distance between the inferior LF and the inferior mandibular plane was 4.42 mm while the distance between the superior LF and the inferior mandibular plane was 11.4 mm, supported these findings.

Diameter

The diameter (D) of the LF was identified to vary from 0.25 to 1.90 mm (mean 0.61 ±0.33 mm) by Wang et al. [36], who were more interested in the bone canals of the mandible within the evaluation, which included 303 CBCT pictures in total. The supraspinosum canals measured an average of 0.87_ 0.03 mm in D at the lingual terminus [41]. According to prior studies, the mean D of the superior LF falls between the ranges of 0.71 and 1.05 mm. In general, the D of the superior LF was bigger than that of the lower LF, and the majority of them ran downward [14,21,35,36,38,37]. Nevertheless, prior outcomes found no link between the magnitude of LF and gender or age [21,43]

Lateral lingual foramen (LLF)

Several investigations have found different LLF frequencies. Many studies demonstrated that the premolar area was the most common location for LLF [28,50,53,58,59]. Accordingly, Laisiriroengrai et al.[33] found similar results, and its canal course was usually in the anterior direction. There was a greater incidence of LLF in males. Conversely, a study of Indian cadavers found that LLF was more prevalent in the canine area [60].

Recommendation

The lingual foramen and the LLF identification are useful in that they may aid in the prevention of surgical problems during surgery. Recently, dental implants have been recognized as the principal choice for the prosthetic rehabilitation of individuals with missing teeth. In many instances, implant implantation is a regular and predictable procedure. However, surgery in the anterior mandible may cause rupture of the lingual periosteum, forming a hematoma in this location, followed by enlargement of the floor of the mouth and obstruction of the upper airway. Thus, pre-operative planning should incorporate radiological imaging to minimize complications. Especially, the literature recorded that LLF communicated with the mandibular canal in the premolar area.

Conclusion

The LF and canal must be evaluated before surgery to avoid intra-operative and postoperative problems such as bleeding. The LLF and its canal can be identified by CBCT. In the premolar locations, operators should take LLF into account while placing mandibular implants. The identification of up to four LFs and a similarly low proportion of the accessary LFs are notable.

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Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this manuscript.

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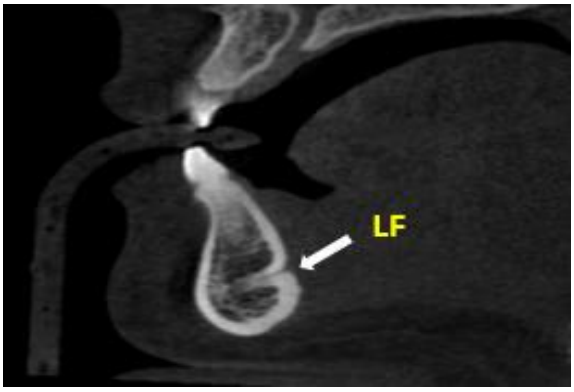
Figure 1. Sagittal plane of CBCT showed lingual foramen (LF).

Figure 2. CBCT sagittal plane showed superior and inferior lingual foramen (SLF & ILF).

Figure 3. The CBCT axial plane displays the lingual foramen (LF).

Figure 4. Lingual foramen (LF) coronal CBCT imaging.



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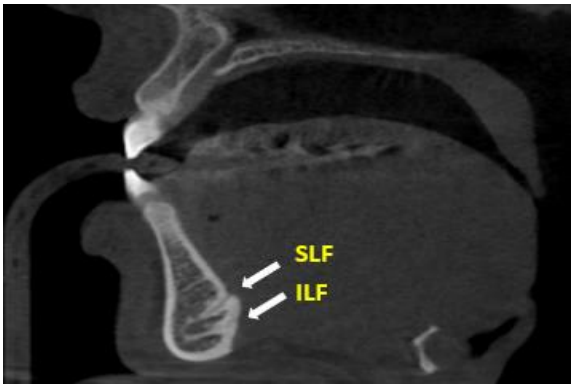

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