

# Reliability of Ultrasound in the Identification and Measurement of Blood Supply to the Anterior Part of the Mandible

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## ABSTRACT

**Objective:** The aim of this study is to identify *in vivo* the main blood supply to the bony chin and to determine the efficacy of ultrasound Doppler in determining this aspect and then compare it with radiograph.

**Materials and methods:** The study was carried on 50 subjects divided into two equal groups. In the first group, the lingual foramen was identified on intraoral periapical (IOPA) radiograph of the mandibular incisor region. Ultrasound Doppler identification of blood supply to the anterior part of the mandible was carried out. In the second group of 25 subjects, the procedure was reversed. This was done to avoid procedural bias.

**Discussion:** In our patients, the midline artery entering the lingual foramen was seen by ultrasound and radiograph. Their average diameters and velocities were measured. It was identified in 46 cases by the ultrasound Doppler examination. The IOPA radiographic examination was successful in identifying the foramen in 30 cases. The average diameter of the midline artery entering the lingual foramen was found to be 0.14 cm. The average velocity of blood flow in this artery was found to be 25.5 cm/second.

**Conclusion:** The ultrasound Doppler is a reliable tool to visualize and measure the blood supply to the anterior part of the mandible.

**Keywords:** Blood supply, Lingual foramen, Radiograph, Ultrasound Doppler.

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## INTRODUCTION

The anterior segment of the mandible is of special interest for orthognathic surgery and implantology. In this region, implants are frequently placed in the mandibular interforaminal region it is also often used in oral surgery. However, knowledge of the quantitative arterial blood supply to this area is still poor. Literature states that this arterial network is formed by three components:

1. The medullar network, located in the mandibular cancellous bone, is supplied by the incisive branch of the inferior dental artery and by a branch of the sublingual artery;
2. Gingivoperiosteal network composed of the attached gingiva zone is supplied by the sublingual and ranular arteries on the lingual side and the facial and mental branch of the inferior dental artery on the buccal aspect; and
3. The muscular and periosteal network, made up of tributary arterioles to the muscle and end branches that penetrate the bone through minute foramina and anastomose with vessels, is included in the periosteum.

These end arteries are supplied on the buccal side by collaterals of the facial arteries and by the sublingual arteries on the lingual aspect. Richbourg emphasized that the main arterial supply to the bony chin is made up of a single terminal branch of the sublingual artery that penetrates the lingual aspect of the mandible through the lingual foramina located between the two upper genial tubercles.<sup>1</sup>

In many cases, implants are placed in the mandibular interforaminal region, and this area is also often involved in oral surgery as a bone donor site. Clinically, the potential risk of a critical life-threatening hemorrhage due to the perforation of the lingual cortical plate and arterial trauma of the terminal branches of the sublingual artery must be considered.<sup>2</sup>

Ultrasound Doppler provides a comfortable, noninvasive, inexpensive, easily available diagnostic tool that has previously been used to identify and measure blood flow in different regions, such as the carotid artery and for identification of vascular pathologies in the limbs.

The present study utilizes ultrasound Doppler to clinically identify *in vivo* the artery penetrating the lingual

foramen, measure its diameter, and determine the direction of blood and flow velocity.

## MATERIALS AND METHODS

The study consisted of 50 healthy adult volunteers who were dentate and who did not have any known systemic disease affecting the vasculature or bone morphology. Written informed consent of all volunteers was taken before the procedures were carried out. They were examined with an ultrasound Doppler and with periapical radiographs taken of the mandibular incisor region. Subjects were randomly divided into two equal groups. For each group, gender and age were recorded. In the first group, the lingual foramen was identified on periapical radiographs and then ultrasound Doppler measurements were taken. In the second group, procedures were reversed, i.e., ultrasound Doppler measurements were made first followed by intraoral periapical (IOPA) radiograph next.

Periapical radiographs were taken in the standard long cone technique using a commercial film holder (XCP Instrument, Rinn Corporation Elgin, III USA). Standard periapical films (EktaSpeed; Eastman Kodak, NY) were used. The X-ray unit was Explor tube head, type Endos, Japan having 70 KVp, 8 mA, and 1.5 mm equivalent aluminum filtration.

With the ultrasound Doppler technique, the machine used was the GE Voluson PRO 730. Patients were positioned with the head in an overextended position, the chin pushed forward and upward. A 7 to 12-MHz linear high-resolution transducer was used. The left and the right branches of the sublingual arteries were identified and followed toward the midline where they anastomosed, forming a single short vessel oriented perpendicular to the midsagittal plane of the mandible. The widths of the right and left sublingual arteries and the artery entering

the lingual foramen were measured along with the direction of flow and the velocity of blood flow. In the Doppler, the vessels were evaluated on pulse wave Doppler. Any smaller vessels that were not detectable by this method were subjected to power Doppler.

## RESULTS

In the first group, intraoral radiographs of the mandibular central incisor region for visualization of the lingual foramen by paralleling technique were carried out first followed by ultrasound Doppler for identification of the midline artery entering the lingual foramen on the IOPA radiograph. The lingual foramen was identified in 19 cases (Fig. 1). In six cases, the lingual foramen was not identified on the radiograph. By the ultrasound Doppler identification method, the right and the left sublingual arteries and the midline artery entering the lingual foramen were identified in 24 cases (Figs 2 and 3). In one case, the sublingual arteries were identified, and the diameter of the arteries and the velocity of blood flow in the arteries were identified, but the midline artery entering the lingual foramen was not visualized. In this case, the IOPA radiograph too failed to visualize the lingual foramen.

In five cases, where the foramen was not visualized on the IOPA radiograph, ultrasound Doppler identification of the artery was possible, and measurement of the diameter of the blood vessel and velocity of blood flow in the vessel was also possible.

In the second group, ultrasound Doppler measurements of the artery were carried out first, followed by IOPA radiograph of the mandibular central incisor region for visualization of the lingual foramen. In 22 cases, ultrasound Doppler identified both the right and the left sublingual arteries and the midline artery entering the lingual foramen, and the diameters of the arteries

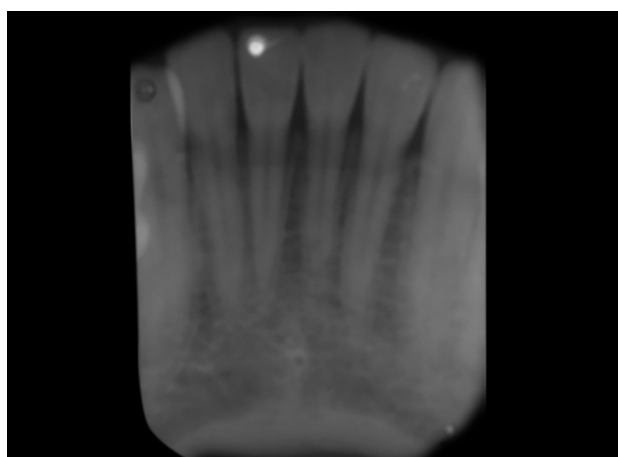


Fig. 1: The IOPA radiograph of the mandibular incisor region showing lingual foramen

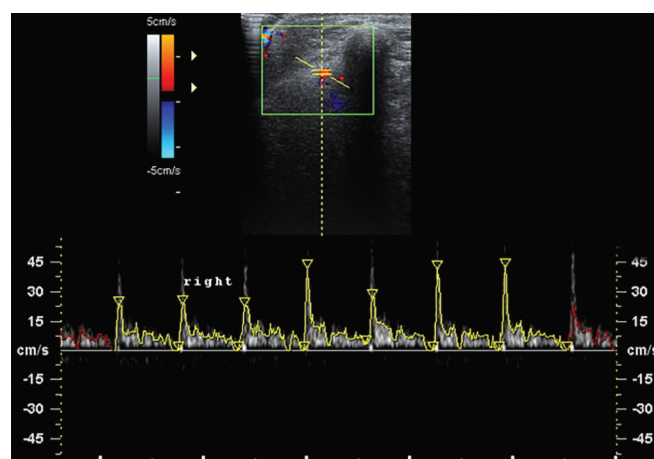


Fig. 2: Measurement of blood flow velocity in right sublingual artery

**Fig. 3:** Measurement of blood flow velocity in midline artery entering lingual foramen

and the velocity of blood flow in them were measured. In three cases, the midline artery entering the lingual foramen was not visualized. In these three cases, the right and left sublingual arteries were identified, but not the midline artery entering the lingual foramen. In these three cases, the velocity of blood flow in one sublingual artery was found to be relatively higher than its contralateral counterpart. By the IOPA radiograph method, in 11 cases, the lingual foramen was identified on the radiograph. In 14 cases, the lingual foramen was not identified on the IOPA radiograph. In the three cases in which the midline artery entering the lingual foramen, was not identified by ultrasound Doppler investigation, the IOPA radiograph too failed to visualize the lingual foramen.

Overall, out of 50 subjects, the lingual foramen was identified by the radiograph method in 30 subjects, while the midline artery entering the lingual foramen was identified by ultrasound Doppler in 46 cases. In three out of the four cases, where the midline artery entering the lingual foramen was not identified, the velocity of blood flow in one sublingual artery was found to be significantly higher than the other. The average diameter of the midline artery entering the lingual foramen was found to be 0.14 cm, and the average velocity of bloodflow in the midline artery entering the lingual foramen was found to be 25.5 cm/second (Table 1 and 2).

By the ultrasound Doppler method, in all the subjects where the vessel entering the lingual foramen was identified, the blood flow was identified as an arterial one. The

midline artery entering the lingual foramen, the lingual foramen artery, was identified as a single midsagittal vessel, which resulted from the anastomosis of the right and left sublingual arteries.

## DISCUSSION

Henry Gray's epic textbook of anatomy describes the bony architecture and arterial network in this area as superior to the mental spine. Most mandibles display a lingual (genial) foramen that opens into a canal, which traverses the bone to 50% of the buccomandibular dimension of the mandible. It contains a branch of the lingual artery. As yet, its development is uncertain, although it is a useful radiological landmark. The sublingual artery arises at the anterior margin of the genioglossus and mylohyoid, and it supplies the gland, mylohyoid muscle and the buccal and gingival mucous membrane. One branch pierces the mylohyoid and joins the submental branches of the facial artery. Another branch courses through the mandibular gingiva to anastomose with its contralateral fellow. A single artery arises from this anastomosis and enters a small foramen (lingual foramen) on the mandible, situated in the midline on the posterior aspect of the symphysis immediately above the genial tubercle.<sup>3</sup>

Ultrasound Doppler is a popular, noninvasive diagnostic tool frequently used for the assessment of blood supply to different regions of the body. It has been used previously to examine whether color Doppler imaging can be used to assess vascular patency after use of pedicle pelvic bone grafts in the operative treatment of avascular necrosis of the femoral head, where color Doppler imaging and selective angiography were performed, and it was found that it is suited for the same.<sup>4</sup>

It has also been used in the diagnosis of renal vascular lesions; to evaluate diameter, flow volume, and time-averaged mean velocities of angiographically verified normal vertebral arteries; for the investigation of carotid abnormalities; to provide the guidelines with respect to the location of the facial vessels, observe the potential reversed flow of the facial artery, salivary gland measurements, and blood inflow responses to salivary stimulation for evaluating rituximab effects in patients with primary Sjögren's syndrome and in many other cases.<sup>5-9</sup>

The present study was undertaken to evaluate the reliability of ultrasound in the identification and measurement

**Table 1:** Comparison of Doppler and radiograph

Presence of artery/ lingual foramen	Ultrasound Doppler	Radiograph	Total
Yes	46	30	76
No	4	20	24
Total	50	50	100

**Table 2:** Statistically significant difference between the proportion of samples diagnosed for artery using ultrasound and radiograph techniques in both the methods ( $p < 0.05$ )

Method	Ultrasound	Radiograph	Z	p-value
Method 1	24	19	2.04	0.042
Method 2	22	11	3.28	0.001

of blood supply to the anterior part of the mandible. The presence, content, structure, and importance of the lingual perimandibular foramina and vasculature have been an area of much study, interest, debate, and controversy.

The importance of the study lies in the fact that there is a potential risk of critical life-threatening hemorrhage due to the perforation of the lingual cortical plate and arterial trauma of the terminal branches of the sublingual artery.

In an anatomic study of the association between lingual perimandibular vessels and life-threatening bleeding, it was discussed that lingual plate perforation, especially anterior to the canine area, can easily injure blood vessels in the floor of the mouth and cause life-threatening hemorrhage following implant placement. It was concluded that vessels in the floor of the mouth are sometimes in close proximity to the site of implant placement. Caution should be exercised when placing implants in this area.<sup>10</sup>

There are several studies to conclusively prove the importance of the lingual perimandibular vessels and the consequence of lack of identification of the same.

In all the subjects, the midline artery entering the lingual foramen was identified by ultrasound Doppler and the foramen through which the artery passes was identified by radiograph. Their average diameters and velocities were measured. The midline artery was identified in 46 cases by the ultrasound Doppler examination. The IOPA radiographic examination was successful in identifying the foramen in 30 cases. The average diameter of the midline artery entering the lingual foramen was found to be 0.14 cm. The average velocity of blood flow in this artery was found to be 25.5 cm/second.

The present study clearly established that the blood flow is directed into the bone and it is an arterial one. It also established ultrasound Doppler to be effective in identifying the vasculature in 92% of the subjects. This is in accordance with the study by Lustig et al<sup>1</sup> who also found the blood flow to be an arterial one in the region of the lingual foramen and also that ultrasound was efficacious in proving the same.

The findings in the present study are in accordance with the study by McDonnell et al<sup>11</sup> in that the content of the lingual foramen was an artery formed by the anastomosis of the sublingual branches of the right and left lingual arteries. In this study, the incidence of identifying the lingual foramen on the periapical radiographs was 49%; however, in our study, the incidence of identifying the lingual foramen on the periapical radiograph was 60%.

The percentage of identification of the midline foramen artery entering the lingual foramen was 92% in the present study. The results are in accordance with the study where the average diameter of the artery was found to be  $0.41 \pm 0.34$  mm, and the artery was identified in nearly all the subjects.<sup>1</sup>

In the present study, the lingual foramen was identified on periapical radiographs taken by the paralleling technique in 60% of the subjects. This is in agreement with a study by Lustig et al.<sup>12</sup>

A survey of 314 dried mandibles showed the foramen to be present in 99.04% specimens. The contents of the foramen were found to be an artery, which was an anastomosis of the sublingual branches of the right and left lingual arteries. This is in agreement with the results of our study.<sup>11</sup>

In the present study, the radiological identification of the lingual foramen was less reliable. A positive identification was found in 60% of the subjects radiographically. The explanation is that this technique is highly sensitive; the lingual canal has an inclined path in relation to the lingual surface of the mandible. Therefore, if the radiographic tube is not directed parallel to the long axis of the canal, the radiograph will fail to show it, and the radiopaque rim of the canal blends with the shadow of the surrounding bone. This can explain the discrepancy between the low radiological score and the higher and consistent findings by certain other methods.<sup>1</sup>

In the present study, ultrasound/Doppler has been successful in the identification of the midline foramen entering the lingual foramen and the measurement of parameters of blood flow to the region.

## CONCLUSION

Through this study, the following observations were seen and concluded as follows: The lingual foramen and its contents, namely a midline artery entering the lingual foramen, are a constant anatomical finding. The ultrasound/Doppler is a reliable tool to visualize and measure the blood supply to the anterior part of the mandible. The radiological identification of the lingual foramen is far less reliable, owing to the fact that the lingual canal has an inclined path in relation to the lingual surface of the mandible. The existence of the midline artery entering the lingual foramen has several clinical implications. The artery is of sufficient size to cause difficulty in controlling hemorrhage in procedures, such as reduction of genial tubercles in edentulous patients, in genioplastic procedures, or during insertion of dental implants. Presurgical assessment for genioplastic procedures and other surgical procedures in the anterior part of the mandible should include an ultrasound/Doppler evaluation of the midline artery entering the lingual foramen to assess the flow of blood to the chin.

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