

## ORIGINAL COMMUNICATION

# Lingual Foramina on the Mandibular Midline Revisited: A Macroanatomical Study

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The purpose of the present study was to determine the incidence, size, location, course, and content of the foramina and bony canals located on the lingual side of the mandibular midline. Fifty dry human mandibles were morphometrically analyzed by measuring the distances of these midline foramina from the mandibular base and the dimensions of these foramina and their bony canals. In addition, macro- and microanatomical dissection was performed on 12 intact cadaver mandibles. The macroanatomic midline foramina were classified into superior and inferior genial spinal foramina according to their vertical location with respect to the genial spines. This study showed that out of 50 dry mandibles, 49 (98%) had at least one midline lingual foramen; only one lacked a true midline foramen. Evaluation of the microanatomical dissections indicated a clear neurovascular bundle in both superior and inferior genial spinal foramina and canals. For the superior canal, the content was found to derive from the lingual artery and the lingual nerve. For the inferior canal, however, the arterial origin was submental and/or sublingual, while the innervation derived from a branch of the mylohyoid nerve. In conclusion, different kinds of lingual foramina have been identified according to their location. The superior and inferior genial spinal foramina have different neurovascular contents, determined by their anatomical location above or below the genial spines. Clin. Anat. 20:246–251, 2007. © 2006 Wiley-Liss, Inc.

**Key words:** lingual foramina; macroanatomy; mandibular midline; trigeminal nerve

## INTRODUCTION

When performing surgical procedures in the anterior mandible, such as implant placement, the lingual foramina and canals are often neglected or considered as having little clinical risk associated with them. When reviewing anatomical textbooks, a consistent description of the mandibular lingual foramina is not given (McMinn and Hutchins, 1988; Woodburne and Burkel, 1988; Williams et al., 1989; Agur, 1991). Dental anatomy textbooks equally fail to note the presence of the foramen as a consistent finding (Longman and McRae, 1985). However, in oral radiology textbooks, a lingual foramen is often mentioned (Whaites, 2002; White and Pharoah, 2004).

There may be two or more foramina at the mandibular midline and their location and dimensions are quite variable. Ennis (1937) demonstrated a foramen located superior

to the genial spines, while Novitsky (1938) reported a foramen inferior to the genial spines. Suzuki and Sakai (1957) mentioned that the bony canals of these foramina coursed perpendicular to the inner surface of the mandible. Their reported frequency was 87% for the foramen supra-spinosum, 68% for the foramen interspinosum (superior genial spinal foramen), and 26% for the foramen infraspinosum (inferior genial spinal foramen). McDonnell et al.

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(1994) reported that the foramina are in the midline on the lingual side of the mandible, at or above the genial spines. Only Gahleitner et al. (2001) characterized the diameter of the canals and the distance between their foraminal openings and the mandibular border.

In a review of the literature, contradictory descriptions regarding these macroanatomic foramina and their canal structure are found. The canal content also remains a matter of debate. Ennis (1937) stated that the lingual foramen transmits a branch of the incisive artery to anastomose with the sublingual artery. A branch of the sublingual artery was reported by Suzuki and Sakai (1957), McDonnell et al. (1994), and Hofschneider et al. (1999). Novitsky (1938) demonstrated by blunt dissection, the passage of branches of the mylohyoid nerve through a foramen inferior to the genial spines. Then, Sutton (1974) reported that branches of the mylohyoid nerve and vessels were present in the foramen. Finally, Percinoto et al. (1977) and Madeira et al. (1978) reported that the canal content was neurovascular with branches of the mylohyoid nerve and sublingual artery.

Based on previous reports, we know that in the anterior region of the mandible on its lingual side, there are not only midline foramina but also lateral foramina as reported by Hofschneider et al. (1999). The present study was designed to revisit the midline lingual mandibular foramina and their bony canals, describe their characteristic macro- and microanatomical appearance, and establish the true canal content.

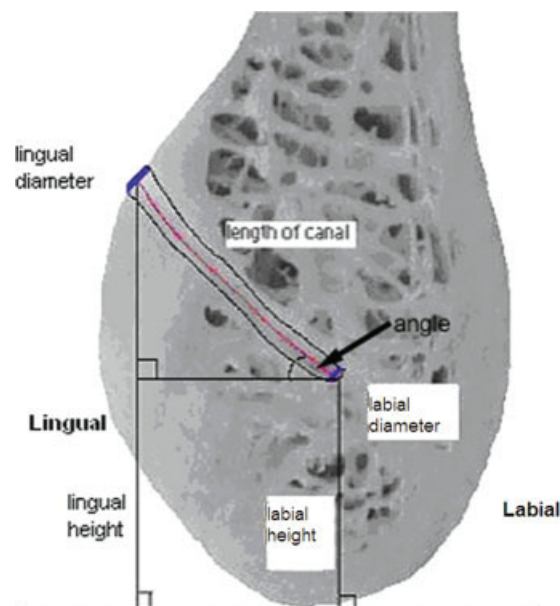
## MATERIALS AND METHODS

### Materials

Fifty Caucasian dry human mandibles and 12 formalin-perfused cadavers were used for the present investigation. These mandibular bone specimens were derived from patients who had donated their bodies for research and were provided with ethical approval from the Department of Anatomy at the Faculty of Medicine (K.U.Leuven) and the Department of Morphology (University Centre Limburg, Belgium).

### Methods

**Macroanatomical assessment.** For macroanatomical evaluation, 50 dry human mandibles from the Department of Anatomy at the Faculty of Medicine (K.U.Leuven) were evaluated to determine the number of foramina and canals and their respective locations. Afterwards, these mandibles were cut through the midline of the foramina to produce specimens that were further analyzed to assess the dimensions of the mandibular midline foramina and their bony canals. Dimensional measurements were made using a Mitutoyo® digital sliding caliper (Mitutoyo, Andover, UK; accuracy, 0.01 mm) and included labial and lingual heights of the canals in relation to the mandibular base, respective diameters of the foraminal openings and bony canal endings, and lengths and angles of the canals (Fig. 1). All data were gathered and statistically analyzed by means of Statistica for Windows® Software version 5.1. (Statsoft, Tulsa, OK). In addition to descriptive statistics, inferential analyses utilized the Mann-Whitney *U* Test for establishing the relation between location and number of canals, and the Kolmogorov-Smirnov Test for relating the number of midline and lateral lingual foramina. A 5% level of significance was chosen.



**Fig. 1.** This drawing illustrates measurements made of the superior or inferior genial spinal foramina and their bony canals. [Color figure can be viewed in the online issue, which is available at [www.interscience.wiley.com](http://www.interscience.wiley.com).]

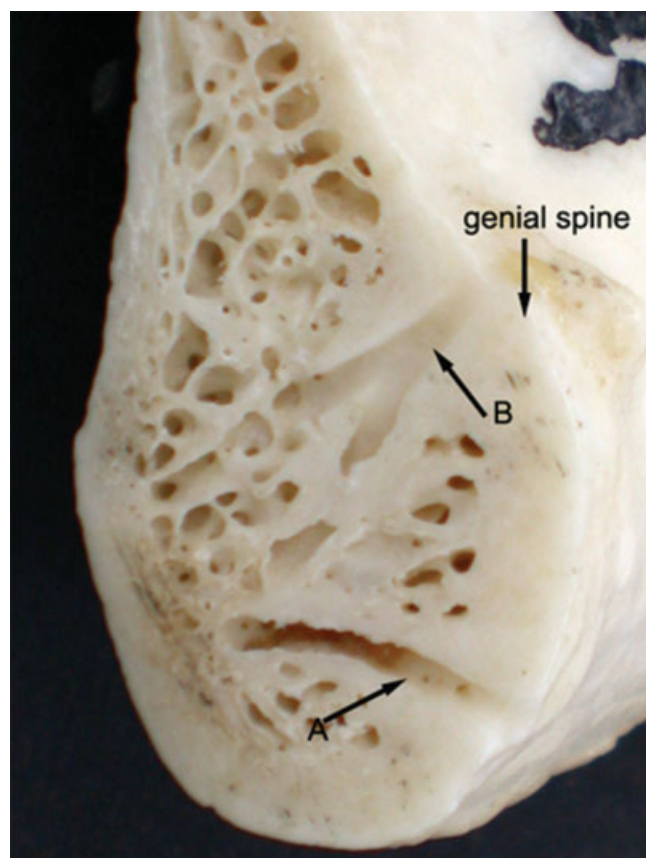
**Macro and microanatomical dissection to assess canal content.** Twelve intact mandibular specimens were obtained from the Department of Morphology (University Centre Limburg, Belgium) and dissected to macro- and microanatomically (dissection under the microscope) investigate the true canal contents associated with the foramina.

## RESULTS

### Macroanatomical Assessment

From the 50 dry mandibles investigated, 49 (98%) had at least one lingual foramen. One mandible lacked a true midline foramen. Eleven mandibles (22%) had two foramina at the lingual side of the mandibular midline (Fig. 2) (Table 1) and two mandibles (4%) showed three foramina in the mandibular midline (Table 1). The remaining 36 specimens had a single foramen and canal (72% of these were located superior to the genial spines and 28% were located inferior to the genial spines). In the 50 cases considered, there were a total of 64 foramina observed in the midline of the mandible. Twenty four foramina (38%) were located superior to the genial spines; 16 (25%) foramina were located at the level of the genial spines. These foramina were denoted as superior genial spinal foramina. Another 24 (38%) foramina were located inferior to the genial spines. These were denoted as inferior genial spinal foramina (Fig. 2) (Table 2). Figure 3 shows the different kinds of canals on radiographs of dry mandible slices.

The mean diameter of the opening of the bony canals at the lingual side was 0.8 mm (SD 0.4 mm) and at the labial side, it was 0.4 mm (SD 0.3 mm). The mean height from the lower cortical border was 10.6 mm (SD 5.5 mm) at the



**Fig. 2.** This human mandibular bone section shows an inferior genial spinal canal (arrow A) and duplicating canals superior to the genial spine (arrow B). [Color figure can be viewed in the online issue, which is available at [www.interscience.wiley.com](http://www.interscience.wiley.com).]

lingual side and 9.8 mm (SD 3.3 mm) at the labial side. The mean length of the canals was 6.5 mm (SD 2.4 mm). Seventy two percent of the canals had courses running downwards to the labial side with an average slope of  $-37.5^\circ$  (SD  $20.1^\circ$ ); 28% of the canals were directed upwards to the labial side with the average slope being  $23.7^\circ$  (SD  $18.0^\circ$ ) (Fig. 1).

Table 3 gives the distinctive dimensional measurements of the superior and inferior genial spinal foramina and their bony canals. There was a significant difference between foramen location and number of canals. If only one canal was present, the foramen was usually located superior to the genial spine (Mann-Whitney *U* Test,  $P = 0.01$ ). Furthermore, in the majority of mandibles having two midline

**TABLE 1. Frequency of Midline Lingual Foramina**

Mandible	Number	Percent occurrence (/50) (%)
With foramina	49	98
One foramen	36	72
Two foramina	11	22
Three foramina	2	4

**TABLE 2. Location of Midline Lingual Foramina**

Foramina	Number	Percent occurrence (/64) (%)
Superior	40	62
Inferior	24	38

canals, the major canal with larger dimensions (greater diameter and longer canal) was similar to single canals.

In addition to the midline foramina at the lingual side in the dry mandibles, a total of 56 lateral foramina (located between the midline and respective canine teeth) (Fig. 4) were observed in 31 jaws (62%). Of these 31 cases, 15 had bilateral foramina, 8 had lateral foramina on the right side only, and another 8 had these only on the left side. Of the 56 lateral foramina, 35 (63%) were located on the right and 21 (37%) on the left side. Fourteen of those 56 lateral foramina (25%) were located in the upper and middle thirds of the mandible, while the others ( $n = 42$ , 75%) were located in the lower third. Analysis showed a significant difference between mandibles having one or two midline foramina and the number of lateral foramina. Mandibles having only a single midline canal had more lateral lingual foramina than did mandibles having two midline canals (Kolmogorov-Smirnov Test,  $P < 0.025$ ).

### Pilot Observations of Canal Content Using Macro and Microanatomical Dissection

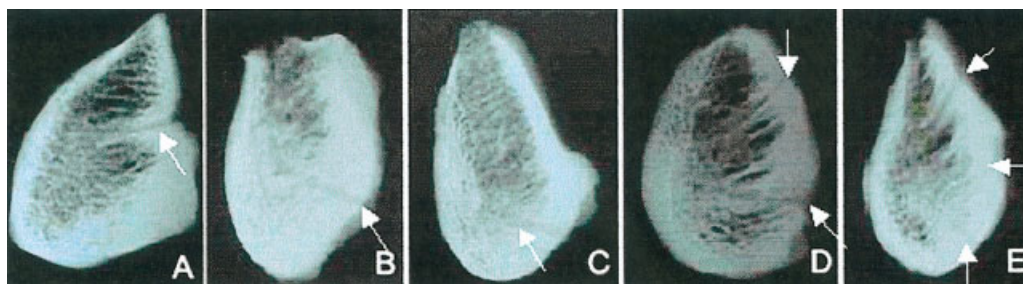
Finally, the canal content was observed by dissection of 12 intact cadaver mandibles. One specimen lacked a genial spinal foramen. Nine specimens had a superior genial spinal foramen, while two of them had an inferior genial spinal foramen. Branches of the lingual artery, vein, and nerve were found entering all nine superior genial spinal foramina (Figs. 5 and 6). Branches of the mylohyoid nerve and submental and/or sublingual artery and vein were observed entering the two inferior genial spinal foramina (Fig. 7).

## DISCUSSION

The present study further characterizes features of midline lingual foramina (superior and inferior genial spinal foramina) and their bony canals. When there was only one foramen, it was typically located superior to the genial spines. This result is in accordance with the findings of Shiller and Wiswell (1954) and Suzuki and Sakai (1957). In cases of two or more foramina, the second one was always located inferior to the genial spines, again in agreement with the results of Shiller and Wiswell (1954). The present study indicated that the average length of a single canal was similar to that of the major canal if two canals were present. Seventy two percent of these midline canals were directed downwards to the labial side over a distance of 6.5 mm.

Apart from the distances between the foramina and mandibular border, there was not a significant difference in





**Fig. 3.** Periapical radiographs of dry mandibular slices showing different kinds of canals. **A** shows a superior canal, **B** and **C** show inferior canals, **D** shows one superior and one inferior canal, and **E** shows three canals; one superior and two inferior. [Color figure can be viewed in the online issue, which is available at [www.interscience.wiley.com](http://www.interscience.wiley.com).]

the dimensional characteristics between the superior and inferior genial spinal foramina and their bony canals.

There were also many lateral foramina and canals located to the left and right of the mandibular midline. Tepper et al. (2001) reported that a number of lateral foramina and canals showed an intraosseous course in the lingual-vestibular direction and were located in the lingual region of the mandible over their entire length. One particular finding in our study was the significant relation between lateral and midline canals. Persons having only one superior or inferior genial spinal foramen had many more lateral foramina than those who had more than one midline canal.

Some researchers have performed dissections to identify blood vessels and nerves entering the foramina, but their findings were often contradictory. This confusion may be explained by the fact that no study evaluated the contents of the superior and inferior genial spinal foramina separately. In our study, we found the contents entering the superior genial spinal foramen to be branches of the lingual artery, vein, and nerve. This is in agreement with the observation by Ennis (1937) that a terminal branch of the inferior alveolar artery passed through the lingual foramen to anastomose with the lingual artery. We also found that branches of the mylohyoid nerve and submental and/or sublingual arteries entered the inferior genial spinal foramen, as reported previously (Novitsky, 1938; Suzuki and Sakai, 1957; Sutton, 1974; Madeira et al., 1978; McDonnell et al., 1994; Hofschneider et al., 1999). To our knowledge,

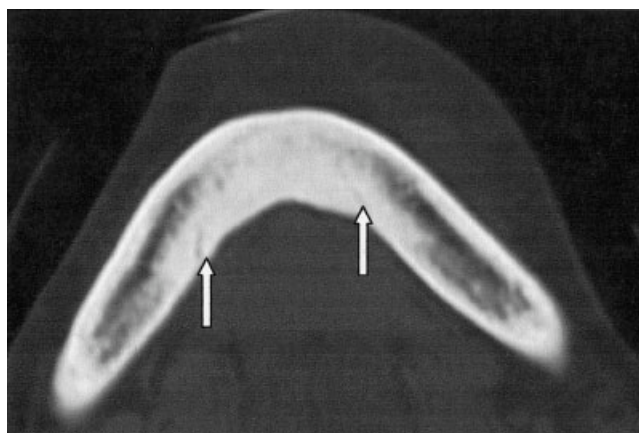
none of these reports were based on microanatomical dissections. Hence, the findings from the present dissection study using microscopic guidance may prove to be useful. To verify the microanatomic content of the foramina, more cadaveric material will be evaluated in further studies. This will allow us to distinguish normal anatomy from anatomical variability and determine potential racial, gender, and evolutionary differences.

The presently reported descriptions of canal dimensions and locations are important to consider during anterior dental surgery, such as implant placement, genioplasty, or grafting procedures, since the potential damage to these canals cannot be excluded. Because of extreme bone resorption, some preprosthetic procedures, such as vestibuloplasty, may also present a risk for trauma. Only those patients with a single inferior canal (28% occurrence in our study) will benefit from the inferior location of this canal, allowing deeper flap surgery or implant placement without risk of damage to the canal.

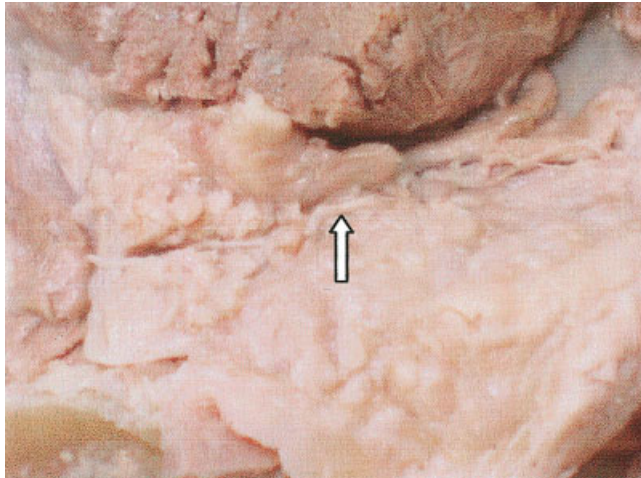
Considering the neurovascular content, trauma to the canal may lead to bleeding complications or neurosensory disturbances. Thus, it is necessary to do careful preopera-

**TABLE 3. Dimensional Measurements of the Superior and Inferior Genial Spinal Foramina and Their Bony Canals**

Measurement	Superior (SD)	Inferior (SD)
Lingual height	12.6 mm (5.6)	7.0 mm (3.1)
Labial height	11.5 mm (2.8)	7.4 mm (2.4)
Lingual diameter	0.9 mm (0.4)	0.8 mm (0.4)
Labial diameter	0.4 mm (0.3)	0.5 mm (0.3)
Canal length	6.8 mm (2.3)	6.1 mm (2.6)
Canal angle (coursing upwards)	10.9° (7.3)	21.8° (11.4)
Canal angle (coursing downwards)	34.4° (8.3)	15.5° (14.2)



**Fig. 4.** Axial CT image of a 54-year-old female showing two lateral canals (arrow) at the lingual side of an edentulous mandible.

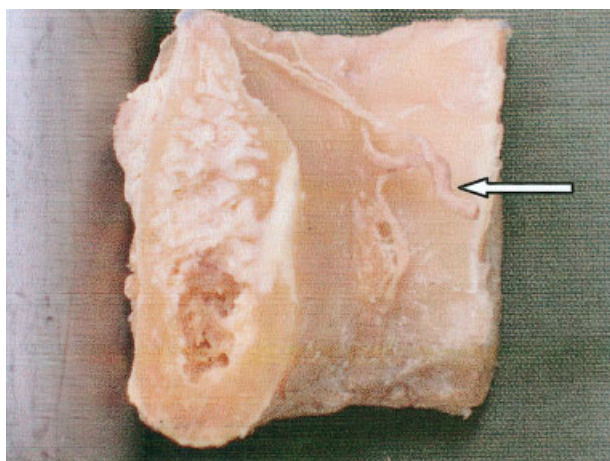


**Fig. 5.** Photograph of the dissection of the floor of the mouth. A branch of the lingual nerve is entering the superior genial spinal foramen (arrow). [Color figure can be viewed in the online issue, which is available at [www.interscience.wiley.com](http://www.interscience.wiley.com).]

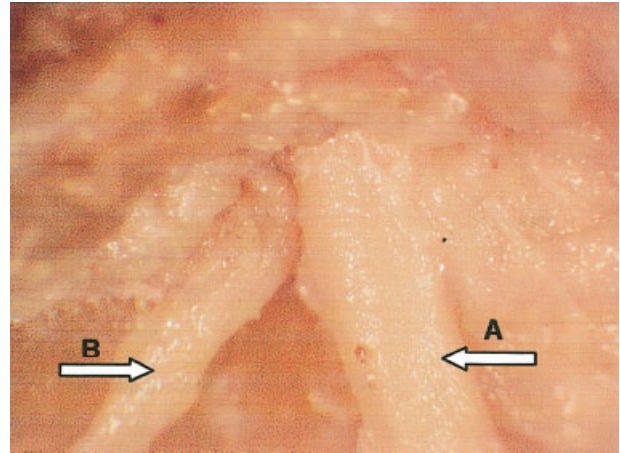
tive planning, including radiological imaging. Lustig et al. (2003) also suggested that an ultrasound/Doppler evaluation be included in the presurgical plan, which may assess the flow of blood to the chin via lingual foramina and give some information of their location.

## CONCLUSION

Lingual foramina were identified in most of the mandibles. These midline canals showed a neurovascular content, which was not only related to their anatomical location, but also subject to anatomical variation. Careful preoperative



**Fig. 6.** The middle part of the mandible visualized after dissection. There is a lingual blood vessel (arrow) entering the superior genial spinal foramen. [Color figure can be viewed in the online issue, which is available at [www.interscience.wiley.com](http://www.interscience.wiley.com).]



**Fig. 7.** Photograph of the dissection of the floor of mouth, illustrating the submental artery (arrow A) and mylohyoid nerve (arrow B) entering the inferior genial spinal foramen. Occasionally, the artery arises from the anastomosis of the sublingual and submental arteries. [Color figure can be viewed in the online issue, which is available at [www.interscience.wiley.com](http://www.interscience.wiley.com).]

planning of surgical procedures involving the mandibular midline, such as lowering genial spines in edentulous patients, genioplastic procedures, or oral implant placement, might help avoid complications due to damage of the lingual foramina and canals and their content.

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