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ORIGINAL ARTICLE

The Accuracy and Interobserver Reliability of Identification of Interalveolar Foramina in the Mandible Using Dental Radiography

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Background: The evaluation of periapical radiographic evidence of these foramina might be helpful to avoid hemorrhaging of the highly vascularized regions of the floor of the mouth. Accuracy and reliability of the dental radiography in depicting the interalveolar medial foramina on 28 dry mandibles was tested in this study. **Materials and Methods:** The 28 mandibles were radiographically examined for the presence of median and lateral foramina that were interalveolar. The foramina diameters and the distance of the foramen to the cementoenamel junction, and to the alveolar bone crest, were measured. Two radiographic images of the symphysis areas were obtained, with and without the insertion of metal wires into the foramina. On the radiographic films, the presence of the foramina was identified and marked by two periodontists. The accuracy, sensitivity, specificity, interobserver reliability and the agreement of the readings between the diagnostic films and the films with wire insertions were analyzed. **Results:** Two to four foramina were observed on the lingual surfaces in the symphysis areas in 27 dry skulls. Among the 52 median foramina, 22 and 21 foramina were identified by observers 1 and 2, respectively. The accuracy, sensitivity, and specificity for the identification of the foramina were 41.1%, 42.3%, and 25.0%, respectively, for observer 1, and 37.5%, 40.4%, and 0.0%, respectively, for observer 2. The interobserver reliability was 0.57 (Kappa value). The readings for the diagnostic films and those for the films with wire insertions showed no agreement, regardless of the observer. **Conclusions:** Dental radiography revealed the presence of interalveolar foramina in 28 skulls; nonetheless, this result should be interpreted cautiously, as the accuracy was <50%.

Key words: Mandible, dental, radiography, anatomy, oral radiology, accuracy, foramina

INTRODUCTION

Surgical procedures performed on the anterior mandible usually have a minimal clinical risk.[1,2] However, the incidence of massive internal hemorrhaging of the highly vascularized regions of the floor of the mouth can result from arterial trauma induced by instrumentation.[3] There have been reports outlining the course of several alveolar artery branches that originated from the sublingual artery.[4,5] In addition, the occurrence of accessory foramina was also observed on the lingual surface of the anterior mandible, and they are believed to offer access to these branches.[4-9] The occurrence of interalveolar medial and lateral foramina were observed proximal to the crest of the alveolar ridge and were situated at the location between the central and lateral incisors, and between the lateral incisors and the canines, respectively.[4] The small vascular branches of the sublingual arteries entering these foramina were observed on the cadaver mandibles.[6] A high prevalence (79%–83%) of medial foramina in the interalveolar region has been reported.[4,10]

Although computerized tomography has been used in dentistry, routine radiography is still frequently used as the first choice diagnostic modality for assessment. The interpretation of radiographs can be influenced by many factors, including

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anatomical complexity, the delay between the development of symptoms and signs and the radiographic confirmation of the disease, as well as the limitations of the imaging system itself.[11] There is scarce information on the utility of routine periapical radiography for the identification of interalveolar foramina in mandibles. Therefore, the evaluation of periapical radiographic evidence of these foramina might be helpful. The aim of this study was to evaluate the reliability of dental radiography for the identification of interalveolar foramina in 28 dry mandibles.

MATERIALS AND METHODS

Twenty-eight adult, dried Indian mandibles were procured from the Department of Anatomy, National Defense Medical Center, Taipei, Taiwan, ROC. On the lingual surfaces of the individual, dry mandibles, the interalveolar medial and lateral foramina were examined close to the crest of alveolar ridge [Figure 1].[4] The interalveolar medial foramen is defined when the foramen is located between the central and lateral incisors, whereas the interalveolar lateral foramen is between the lateral incisors and the canines. The study protocol was reviewed and approved by the Appropriate Institutional Review Board (TSGHIRB: 100-05-093).

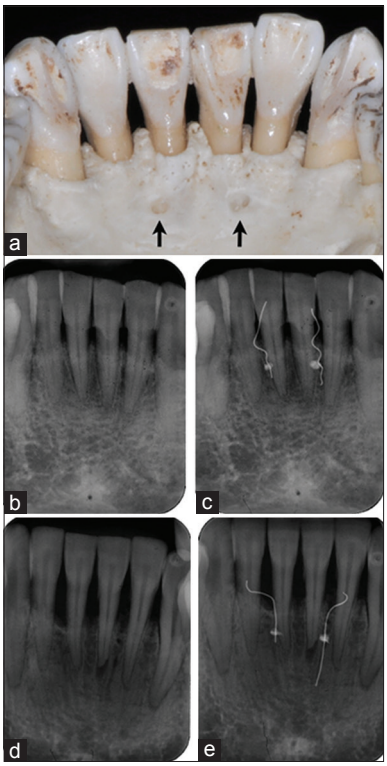

Figure 1: Anatomy of mandibular interalveolar medial foramina and the radiographic evaluation of the foramina. The lingual anatomy of mandible viewed from a dry skull (black arrows indicate the right and left interalveolar medial foramina). (a) Two radiographic films were taken from each mandibular skull (b and c or d and e), with (b and d) and without wire (c and e). For B, no clear radiolucency was observed to reveal the interalveolar medial foramen, while a radiolucent shadow with a canal shape (indicating by a white arrow) was easily observed on the film D

Anatomical considerations of the interalveolar foramina on the skull

The number and distribution of the foramina, as well as their diameters and locations, were recorded in a similar manner consistent with the previous studies.[12] In brief, the diameter of the foramina and the distance from the foramen to the cementoenamel junction (CEJ-F), and to the alveolar crest (AC-F), were recorded [Figure 1a]. The distribution of the interalveolar foramen/foramina in the 28 dry skulls is presented in Table 1.

Radiographic examination of the interalveolar foramina on the skulls

In the present study, the skulls routinely underwent periapical radiography around the anterior mandible using the parallel technique (XCP kit, 54-2001, Dentsply, Illinois, USA); the images were developed on the films (CEA DI, size 2, E-speed, Eastman Kodak Co., Rochester, NY, USA). In this study, the radiographic image was also obtained after placing a thin metal wire into the interalveolar foramen of the lingual, which was subsequently fixed with premixed calcium hydroxide paste with iodoform, to evaluate the orifice as described in a previous study.[13] The presence of foramina/canals was evaluated, again, on each radiographic film with/without the wire insertion (the radiopacity of the wire made the identification of the foramina easier). In this study, a wire was successfully inserted into 52 median foramina [Figure 1c and e]. Each radiograph was mounted in a standard, opaque film mount and coded with a random case number.

Evaluation of the radiographs of the foramina

In this study, two periodontal specialists (YDY and CGL), both with 2 years of similar training and experience, acted as the case observers. Each observer was informed about the purpose of the study and was asked to note the location of the mental foramina. Subsequently, they were instructed to rate the confidence of their diagnoses. The observers worked independently and evaluated each case, once, in a random order. They had no information regarding the clinical signs or symptoms for the evaluation of the periapical films. Observers were instructed to limit their review sessions to approximately 1 h and were required to complete the reviews on the forms provided. Films were read under ideal viewing conditions, and a magnifying glass was made available to the observers. The gold standard used for the evaluation of radiograph accuracy

Table 1: The distributions of the inter-alveolar median and lateral foreman/foramina in 28 dry skulls

Dry Mandibles	Distribution of Inter-alveolar Foramina					No. of Foramina per Skull
	Right Lateral	Right Medial	Central	Left Medial	Left Lateral	
1		+		+		2
2		+		+		2
3		+		+		2
4		+		+		2
5		+		+		2
6		+		+		2
7	+			+		2
8		+		+		2
9		+		+		2
10		+		+		2
11		+		+		2
12		+		+		2
13		+ (*n*=2)[a]		+		3
14		+		+		2
15			+			1
16		+		+		2
17	+	+		+	+	4
18		+		+		2
19		+		+		2
20		+		+		2
21		+		+		2
22		+ (*n*=2)		+ (*n*=2)		4
23	+	+		+	+	4
24		+		+		2
25		+		+		2
26		+			+	2
27	+	+		+ (*n*=2)		4
28		+		+		2
Summary	3[b]	26	1	26	3	

[a]= Presence of two medial foramina; [b]= No. of mandible with foramina

Table 2: The diameters and the locations of the inter-alveolar median and lateral foramina in 28 mandibular dry skulls

	Median Foramina	Lateral Foramina
Diameter of Foramina (mm)		
	0.9±1.2 (*n*=56)	0.6±0.2 (*n*=9)
Location of Foramina		
AC-F (mm)	3.4±1.8 (*n*=56)	4.5±1.8 (*n*=9)
CEJ-F (mm)	6.7±2.6 (*n*=22)	6.6±2.3 (*n*=9)

(CEJ-F and AC-F: the distances of the foramen to the cement-enamel junction and to the alveolar crest, respectively) (Mean±SD)

was based on the radiographs that were marked using the wires.

Statistical analysis

Kappa statistics were used to evaluate the agreement between the observers for the identification of the interalveolar foramina on the diagnostic radiographic films, and on the films with the radiopaque shadowing of the wire. The interobserver reliability for identifying the presence of foramina was also evaluated with a Kappa value. The SPSS software (SPSS Inc., Chicago, IL, USA) was used, and $P < 0.05$ was defined as statistically significant.

RESULTS

The distribution of the interalveolar foramen/foramina in the 28 dry skulls is shown in Table 1. The occurrence of foramina was

Table 3: Calculation of percent accuracy, sensitivity and specificity of radiographic diagnosis of the inter-alveolar mandibular median foramina/canals by the two observers

	Diagnostic Films (Wire-less)				
	Observer one		Observer two		Total
	+	-	+	-	
The wired films					
+	22	30	21	31	52
-	3	1	4	0	4
Subtotal	25	31	25	31	56

Observer 1: Accuracy=41.1%, Sensitivity=42.3%, and Specificity=25.0%; Observer 2: Accuracy=37.5%, Sensitivity=40.4%, and Specificity=0.0%; +=Finding of foramen; -=No finding of foramen

evident in all specimens; the occurrence of two to four foramina was evident in 27 skulls, and the presence of a central foramen was noted in one skull at the symphysis area. The mean distance of CEJ-F and AC-F and the diameter of the foramina were 6.7, 3.4, and 0.9 mm, respectively, for the interalveolar median foramina [Table 2]. An analysis evaluating the distribution of the foramina locations showed that the medial foramina were more prevalent than lateral foramina. In approximately, 86% (48/56) of the hemimandibles, the medial foramen was selected to determine the reliability of the radiographic diagnosis.

Among the 52 median foramina with wire insertions, the presence of 22 and 21 median foramina were identified by observers 1 and 2, respectively [Table 3]. The accuracy, sensitivity, and specificity for the identification of the foramina were 41.1%, 42.3%, and 25.0%, respectively for observer 1, and 37.5%, 40.4%, and 0.0%, respectively, for observer 2. The Kappa value for the interobserver reliability of foramina without wire labeling was 0.57.

DISCUSSION

A previous study placed the anatomical position of the foramina between the right and left central and lateral incisors in approximately 79% of the specimens.[10] In the present study, the presence of the medial foramina that were interalveolar was observed in 96% of the subjects (27/28) and in 90% (52/56) of the mandibles. In addition, a central foramen that was interalveolar was observed to be located between two central incisors was also observed in one skull, whereas six lateral foramina that were interalveolar were observed in five skulls. A high prevalence of interalveolar foramina has also been reported.[4,10] In the present study, wires were inserted into the lingual plates through the foramina. Nonetheless, the nature of these insertions remains uncertain. Based on our clinical observations, the vasculature was observed to be associated with the interalveolar foramina. The literature has shown that the branches of the sublingual artery form a complementary blood supply, through the foramina, in the lingual cortical plate of the anterior mandible.[4,6,14] In human anatomy, the lingual artery gives rise to the sublingual artery at the anterior border of the hyoglossus muscle.[15] The sublingual artery, with a mean diameter of approximately 2 mm, supplies the anatomical structures of the floor of the mouth, including the lingual gingival.[15] This artery has several alveolar branches that form a complementary blood supply to the lingual anterior cortical plate of the mandible.[4,15,16] Two small vessels or branches of the sublingual arteries enter the foramina on the lingual cortical plate in the lateral incisor region, close to the crest of the alveolar ridge.[4,6]

Periapical radiography is a diagnostic modality that has been frequently used for periodontal and periapical diagnoses. The accuracy, sensitivity, specificity, and reliability of periapical radiographic diagnoses for periapical inflammatory diseases have been evaluated, and the mean percentage of accuracy was reported at 70.2%.[11] Periapical radiography involves less radiation exposure, and is low cost and more widely available when compared with computerized tomography. Nonetheless, computerized tomography allows for high resolution and image quality.[17,18] The incidence of "nutrient canals" refers to the occurrence of radiographic shadowing that can be observed around the mandibular arterial region.[19] However, further studies are required on nutrient canals. It is suggested that the shadows may reveal the internal plexus of vascular vessels from the incisive artery of the mandibular body.[19]

In the present study, 52 median foramina were identifiable on the radiographic films of the 28 dry, mandibular skulls with wire insertion; however, only 22 and 21 median foramina were identified by observers 1 and 2, respectively. The accuracy, sensitivity, and specificity of foramina identification were 41.1%, 42.3%, and 25.0%, respectively, for observer 1, and 37.5%, 40.4%, and 0.0%, respectively, for observer 2 [Table 3]. Although the interobserver reliability (κ = 0.57) was moderate, the diagnostic yield for the identification of the foramina differed between the diagnostic films and the films with the wire insertion, regardless of the observer. [11] The factors contributing to the low accuracy and the differences in the diagnostic yield remain unclear; however, the narrow diameter, with a mean diameter of 0.9 mm, of the foramina made identification, by routine dental radiography, difficult. Second, the complex anatomy of the mandible, such as the numerous trabeculae, the double-layered cortex, and the teeth roots, may interfere with the radioopaque shadowing of the image for the visualization and identification of the foramina.[5] In our unpublished data, the interalveolar foramina, as well as the bony canals

originating from the foramina into the bony structures of the mandible, were observable using cone-beam computerized tomography.

CONCLUSION

The interalveolar foramina were observable in the 28 dry skulls; however, the accuracy of using dental radiography to identify the foramina was low (41.1% or 37.5% for the median foramina, as determined by the two periodontists). Therefore, based on the periapical dental radiographs of the interalveolar medial foramina, we recommend that the presence of the medial interalveolar foramina should warrant particular attention from clinicians.

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Conflicts of interest

There are no conflicts of interest.

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