

RADIOGRAPHIC ASSESSMENT OF THE COURSE AND VISIBILITY OF THE MANDIBULAR CANAL BY PANORAMIC RADIOGRAPHY**ABSTRACT**

Background and Objectives: The mandibular canal is a canal within the mandible that contains the inferior alveolar nerve, the inferior alveolar artery and the inferior alveolar vein. The anatomy and variations of the human mandible are very important for planning various surgical procedures such as extraction of the third molar, dental implants and mandibular reconstruction. This study was conducted to determine the frequency of the different courses of the mandibular canal and to investigate the visibility of the mandibular canal by panoramic radiography, among a sample of Yemeni adults. **Subjects and Methods :** A retrospective cross-sectional study was conducted in Sana'a city on a sample of Yemeni adults. The study consisted of panoramic radiographs of 928 patients; the number of males was 340 (36.6%) and 588 females (63.4%). The mandibular canal course, as shown in the panoramic radiographs, was classified into four types: linear, elliptical, spoon-shaped, and turning curves. The visibility of this canal from the first to the third molar region was assessed through visual determination of whether the lower canal was clearly visible, possibly visible, or invisible. **Results:** Elliptical curves were the most observed along the mandibular canal course at 62.2% of the total, followed by the linear curve (24.8%) while the lower rate curve spoon (7.9%) and the turning curve (5.2%). There were no statistically significant differences between the distribution of the mandibular canal courses between males and females except in the spoon curve where the ratio was 10.8% in males versus 6.1% in females ($p < 0.05$). The percentage of clearly visible mandibular canals was the highest among the spoon-shaped curves (49.9% in the first molar, 63% in the second, 78.1% in the third molar) and the lowest among the linear curves (10.9% in the first, 18.7% in the second and 33.5% in the third molar). In panoramic radiographs, invisible mandibular canals were found in 198 (21.3%) of the examined sites in the first molar region, in 85 (11%) in the second molar region, and in only 6 (0.64%) in the third molar region. **Conclusion:** It was observed that elliptical curves along the path of the mandibular canal were the most present, while a decrease in the ratio of the two types of spoon curve and turning curve was observed. It was found that spoon curve was significantly more common among males than females. It was also found that the visibility of this canal is less in the first molar region than in the third molar region.

KEY WORDS: Radiography, Panoramic; Mandible; Nerve, Inferior Alveolar

INTRODUCTION

The mandibular canal is a canal inside the mandible that contains the inferior alveolar nerve, the inferior alveolar artery and the inferior alveolar vein. It runs obliquely down and forward into the branch, then laterally forward into the body, where it is placed under the alveoli and communicates with it through small openings. On reaching the incisive teeth, it turns back to connect with the mental foramen, giving rise to a small canal known as the mandibular incisive canal, which extends into the cavities containing the incisor teeth¹. The mandibular canal is fairly close to the tops of the second molar in 50% of the radiographs. In 40% the canal is distant from the root apices, and in only 10% of the radiographs, the root crests appeared to penetrate the canal. In root canal treatment of the second molar, care must be taken to extend the perforator expander or root canal filling material because there is a potential risk of injury to the inferior alveolar nerve¹⁻⁴. The mandibular canal is an important milestone to consider before performing any posterior mandibular surgery²⁻⁴. Preoperative radiological diagnosis can provide the precise location of the mandibular canal and thus prevent complications during any surgical procedures⁵. The mandibular canal pathway has been investigated in several studies, and frequent anatomical differences have been found in the intrabony course of the inferior alveolar nerve⁶⁻⁸. Moreover, the radial profile of the mandibular canal can be variable⁹. The visibility of the mandibular canal may vary significantly¹⁰⁻¹². Wadu *et al.* found that in a reasonable number of cases, the radiopaque boundaries are disrupted in radiographs, and it is invisible in some other cases. The mandibular canal usually consists of a thin trabecular bone with many circumferential spaces, and there is a thin layer of cortical bone in just a few of the mandibles^{13,14}.

In panoramas, the mandibular canal is usually seen as a well-defined radiopaque area, lined with a radiopaque superior and inferior boundaries⁵. Understanding the anatomical contrast of the pathway and the visibility of the mandibular canal will be helpful in planning treatment for procedures involving the posterior mandible¹⁵. This study was conducted to determine the frequency of the different courses of the mandibular canal and to investigate the visibility of the mandibular canal by panoramic radiography, among a sample of Yemeni adults.

SUBJECTS AND METHODS

In this retrospective study, samples were randomly assigned from patients who visited Ammar Dental Clinics and underwent panoramic radiography in 2019, up to September 2020. The panoramic radiograph was taken as part of the clinical diagnostic procedure for various reasons, such as implant placement and extraction of the third molar or, orthodontic treatment planning. The number of patients was 340 males and 588 females, with a mean age of 27.3 years (age range: 20-58 years). Subjects with mandibular pathology were excluded from the study. All panoramic radiographs were taken using a Proline XC. These images were carefully examined by the first investigator. The mandibular canal course was classified, as in the published research by Liu *et al.*¹⁶ where they classified them into four types: linear, elliptic, spoon-shaped, and turning curves. Mandibular canal vision was assessed by visually determining whether the maxillary canal is clearly visible, possibly visible, or invisible on panoramic radiographs.

The Wilcoxon signed-rank test was used to detect statistically significant differences in the visibility of the mandibular canal between the right and the left sides using online calculators. The Wilcoxon signed-rank test is a non-parametric statistical hypothesis test used to compare two related samples, identical samples, or repeated measurements on a single sample to assess whether the ranks of the average population differ (i.e. it is a paired difference test). The Kruskal Wallis test was used to examine the difference in the visibility of this canal according to the course of the canal and the difference in visibility in the three mandibular regions. A p value of less than 0.05 was considered to indicate a statistically significant difference.

ETHICAL APPROVAL

Ethical approval was obtained from the Medical Research & Ethics Committee of the Faculty of Medicine & Health Sciences at Sana'a University. All data, including patient identification and X-rays, were kept confidential.

RESULTS

Elliptical curves were the most observed along the mandibular canal course at 62.2% of the total, followed by the linear curve (24.8%) while the lower rate curve spoon (7.9%) and the turning curve (5.2%). There were no statistically significant differences between the distribution of the mandibular canal courses between males and females except in the spoon curve where the ratio was 10.8% in males versus 6.1% in females ($p < 0.05$). The percentage of clearly visible mandibular canals was the highest among the spoon-shaped curves (49.9% in the first molar, 63% in the second, 78.1% in the third molar) and the lowest among the linear curves (10.9% in the first, 18.7% in the second and 33.5% in the third molar). In panoramic radiographs, invisible mandibular canals were found in 198 (21.3%) of the examined sites in the first molar region, in 85 (11%) in the second molar region, and in only 6 (0.64%) in the third molar region.

DISCUSSION

In this study, the mandibular canal course was examined using panoramic radiographs, the canal visibility was assessed, and our results showed the contrast and visualization of the canal course. Kieser JA *et al.* Nortjé *et al.* and Heasman^{7,8,17} classified the mandibular canal course according to vertical locations within the mandible, such as high, low and intermediate locations. In a study using 96 plain films of the dry mandible, Heasman in 1988 showed that the majority (68%) of the inferior canals passed along an intermediate pathway between the root apices and the inferior border of the mandible¹⁷. Ozturk *et al.* in 2012¹⁵ confined classification to the canal's course in the mandibular body: straight projection (12.2%), catenary-like configuration (51.1%), and progressive descent from posterior to anterior (36.7%). Also, Ozturk and colleagues' study¹⁵ classified the mandibular canal pathway into linear, spoon-shaped, elliptic, and turning curve types, similar to the study conducted 3 years earlier by Liu *et al.*¹⁶. The linear curve (24.8%) in the current study was completely different from the straight projection (12.2%) observed by Ozturk *et al.*, in 2012, and the other curves were not similar to their findings¹⁵. In the study by Liu *et al.*¹⁶ elliptic curves (48.5%) were the most common, and spoon-shaped curves (29.3%) were the next most common pathway.

The most common pathway found in the current study was the elliptical curve (62.2%), followed by the linear curves (24.8%) and the spoon-shaped curves (7.9%). In the study conducted by Jung and Cho in Korea in 2014¹⁸, elliptical curves (64.7%) were the most common, followed by linear curves (22.9%) and spoon curves (6.9%). This result is nearly similar to the current study in which the elliptic curve was 62.2%, followed by the linear curves (24.8%) and the spoon-shaped curves (7.9%). These results indicated that in Yemeni patients there is more space for implant placement, because the elliptical and spatula curves can provide more space for implant placement than the linear curves¹⁸.

In the current study, invisible mandibular canals were found in 198 (21.3%) of the examined sites in the first molar region, in 85 (11%) in the second molar region, and in only 6 (0.64%) in the third molar region. This finding is consistent with the fact that the visibility of the mandibular canal may differ between patients and between different areas of the lower jaw as described by Oliveira Santos *et al.*². The current incidence of invisible mandibular canals (21.3%) was lower than that reported by Klinge *et al.*¹⁹ as the mandibular canal were not visible in 36.1% of the panoramic radiographs. Our rate (21.3%) is also lower than that of Naitoh *et al.*²⁰ who reported that in panoramic images, the canal was completely invisible in 32% of the examined sites in the molar region. While our rate was roughly similar to that reported by Jung and Cho¹⁸ in that the mandibular canal was not invisible in 22.7% of the sites examined in the first molar region on panoramic radiographs. In

addition, Lindh *et al.*²¹ in Sweden reported that the mandibular canal of the specimen cadavers was clearly visible in 25% of the panoramic radiographs. In this study, on the panoramic radiographs, the mandibular canal was clearly visible in 13.5% of the examined sites in the first molar region, 19.3% of the sites examined in the second molar region and 47% of the sites examined in the third molar region.

Imaging of the mandibular canal wall on the panoramic images was related to the bone density in the alveolar region²⁰. Decreased visibility of the mandibular canal wall on a panoramic radiograph may indicate decreased integrity of the mandibular canal wall and reduced bone trabeculation²². Moreover, the extent of mandibular canal vision differed according to the the mandibular canal pathway on the panoramic radiographs in the present study. The percentages of clearly visible mandibular canals were highest in spoon-shaped curves (47.9% in first, 37% in second, 78.1% in third molar) and lowest in linear curves (10.9% in first, 18.7% in second, and 33.5% in the third molar). Our result is similar to that reported by Jung and Cho¹⁸. Also, our results showed that visibility of the mandibular canal in the third molar region was better than that in the first molar region (Table 2). This result is similar to that reported previously¹⁸⁻²¹.

CONCLUSION

In conclusion the elliptical curves along the path of the mandibular canal were the most present, while a decrease in the ratio of the two types of spoon curve and turning curve was observed. It was found that spoon curve was significantly more common among males than females. It was also found that the visibility of this canal is less in the first molar region than in the third molar region, that's mean the visibility of the mandibular canal increased in more distal regions of the canal.

AUTHOR'S CONTRIBUTION

This research work is part of a research work under the direction of Al-Kasem Mohammed Abbas. The panoramic radiography images were carefully examined by Nashwan Yahya Al-Shamahi, the professor of radiology, with the help of other authors. All authors assisted with editing the manuscript.

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CONFLICT OF INTEREST

"No conflict of interest associated with this work".

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Table 1: Frequency of the course of the mandibular canal on panoramic radiographs

	Linear curve		Elliptic curve		Spoon curve		Turning curve		Total	
	N	%	N	%	N	%	N	%	N	%
Male	73	21.5	211	62.1	37	10.8*	19	5.6	340	36.6
Female	157	26.7	366	62.2	36	6.1*	29	4.9	588	63.4
Total	230	24.8	577	*62.2	73	7.9	48	5.2	928	100

Table 2. Relationship between the course and the visibility of the mandibular canal on panoramic radiographs

	Visibility of mandibular canal	Linear curve		Elliptic curve		Spoon curve		Turning curve		Total	
		N	%	N	%	N	%	N	%	N	%
First molar region	Invisible	61	26.5	121	17.3	9	12.3	7	14.5	198	21.3
	Probably visible	144	62.6	399	69.2	29	39.7	33	68.8	605	65.2
	Clearly visible	25	10.9	57	9.9	35	47.9	8	16.7	125	13.5
Second molar region	Invisible	30	13	49	8.5	0	0	6	12.5	85	9.2
	Probably visible	157	68.2	443	76.8	27	37	37	77.1	664	71.6
	Clearly visible	43	18.7	85	14.7	46	63	5	10.4	179	19.3
Third molar region	Invisible	5	2.2	1	0.17	0	0	0	0.0	6	0.64
	Probably visible	148	64.3	292	50.6	16	21.9	30	62.5	486	52.4
	Clearly visible	77	33.5	284	49.2	57	78.1	18	37.5	436	47
	Total	230	100	577	100	73	100	48	100	928	100