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Original Article

Characterization of anatomical structures using panoramic X-rays: Part II: Mandibular incisive canal

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ABSTRACT

Introduction: The mandibular incisive canal (MIC) is the anterior extension of the mandibular canal which contains the mandibular incisive nerve and blood vessels that provide blood supply and innervation to the mandibular anterior teeth.
Methods: In order to determine the detectability, extent, and position of the MIC, conventional panoramic radiographs of 215 Chilean patients were analyzed.
Results: The MIC was detected in 35.9% of cases, and was more frequently observed in male patients (37.5% in males and 34.7% in females) and on the right side of the mandible (44.6% in the right side and 27.4% in the left side). The results showed a tendency for the detectability of the MIC to decrease with age. The average extensions of the MIC on the right and left sides of the mandible were found to be 8.16 mm and 5.58 mm, respectively. The average minimum and maximum distances from the lower limit of MIC to the lower margin of the mandible were 11.7 mm and 13.2 mm, respectively.
Discussion: Panoramic radiographs have limited effectiveness when being used to determine the presence, extent, and precise location of the MIC. Since there are significant differences in detectability, length, and path of the MIC between panoramic radiographs and anatomical studies, the use of cone beam (CT) scans is recommended for invasive treatments of the interforaminal jaw area.

1. Introduction

Various surgical procedures involve the interforaminal area of the mandible, such as dental implants, bone grafts, and bone block extraction, among others. Usually, it is considered a safe area for this type of treatment, as it is supposedly free of anatomical structures that might be damaged. However, there have been reports of altered sensation after these types of treatments, in addition to bruising, edema, and failure of implant osseointegration.[1–3]

The exact anatomy of the anterior portion of mandible is still controversial. In 1928, Olivier[4] first described the anatomical course of the inferior alveolar nerve (IAN), which travels

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the mandibular canal, heading in the anterior direction and then becomes divided into two terminal branches: mental nerve, which emerges from mental foramen and the incisive nerve located in the mandibular incisive canal (MIC), which also contains blood vessels.[5] However, other studies refute the existence of an incisive canal as such.[6]

Studies using CT scans to detect the presence of the incisive canal have detected it in over 80% of cases[7–9] and in some cases recommend it (the use of CT scans) over panoramic radiographs, which have limitations in identifying this structure.[10,11] However, Mardinger et al.[5] report the partial or complete presence of bony cortical walls of the mandibular canal in most cases, and that the correlation of this phenomenon with two-dimensional radiographic findings is statistically significant.

Moreover, it should be noted that panoramic radiographs are still one of the most frequently used methods in clinical practice, and that their economic cost is significantly lower than CT scans. Consequently, it is essential to determine the ability of conventional panoramic radiography to detect this structure. Thus, the objective of this research was to study the effectiveness of panoramic radiographs in identifying the MIC and its anatomical relationships.

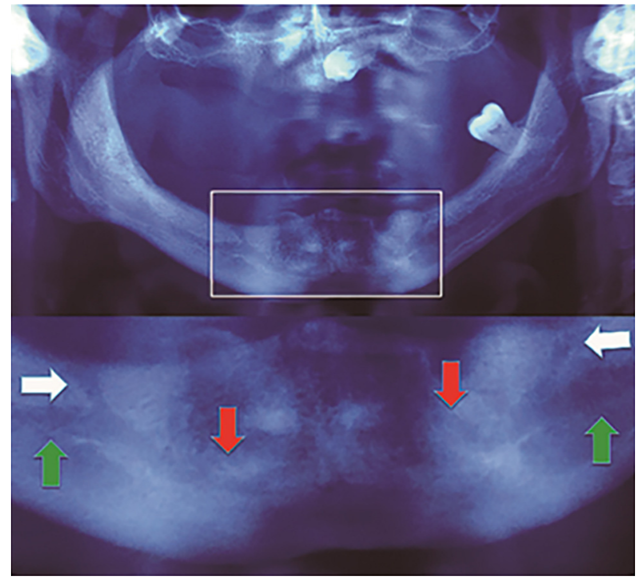

Fig. 1 – Visualization of MIC in panoramic radiograph. The presence of the mandibular canal (green arrow), mental canal (white arrow), and the MIC (red arrow) is observed.

2. Materials and method

This study is a descriptive study. Conventional panoramic radiographs taken in a private clinic in the city of Temuco, Chile were analyzed. The radiographs were taken using the standard technique with *Orthopantomograph* (Proline CC, Planmeca, Helsinki, Finland) and the developing process was done in an automatic processor (Dürr XR 24 pro, Bietigheim-Bissingen, Germany), Image plate Kodak, T–MAT G/RA (New York, USA). All radiographs analyzed in the study were from patients with known age and gender. Radiographs of patients under age 21 and/or evidencing distortions or alteration in contrast were excluded. The sample consisted of 215 films, of which 73 were men and 142 women, aged from 21 to 82. The unit of analysis was the side (right and left) of the jaw. All cases showing presence of pathologies and/or impacted teeth were excluded. A total of 212 right and 208 left sides were analyzed.

The presence of MIC and its differentiation into mental canal and loop of the mandibular canal were determined as outlined in Fig. 1.

To take measurements on the panoramic radiographs, a negatoscope was used. The lines were made manually on a transparency overlaid on the image plate. A line (line L1) tangential to the lower margin of the mandible, parallel to the horizontal (Fig. 2)[12] was plotted. Another line was drawn perpendicular to L1 and tangential to the most medial point of the mental foramen (line L2). A third line was drawn tangential to the most anterior point of the MIC visible on the panoramic radiograph (line L3). Finally, a line (L4) was drawn through the midsagittal plane determined by the anterior nasal spine (Fig. 2). Next, the following parameters were measured:

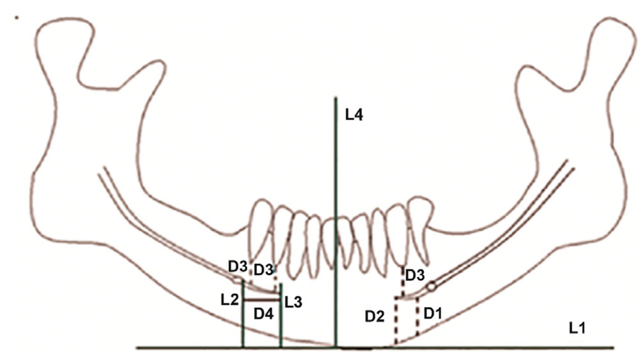

Fig. 2 – Drawing based on a panoramic radiograph, with MIC paths and distance measurements. The location of the measurement of the D1, D2, and D3 distances varies, depending on the position of measurement of minimum distance (D1), maximum distance (D2), and teeth in relation to the path of the MIC location (D3).

(1) Minimum distance (D1) from the lower limit of the MIC to the lower margin of the mandible (Fig. 2). To determine the shortest distance, all mandibular margin distances to the MIC were measured at intervals of 1 mm.
(2) Maximum distance (D2) from the most anterior lower limit of the MIC to the lower margin of the mandible (Fig. 2). To determine the greatest distance, all mandibular margin distances to the MIC were measured at intervals of 1 mm.
(3) Extension of the canal (D4), from L2 to L3 (Fig. 2) [9].

Furthermore, the distance from the upper limit of the canal to the root apex (D3) of all related teeth was measured, tracing lines perpendicular to L1 (Fig. 2).

Measurements were taken with a Mitutoyo digital caliper (Mitutoyo America Corporation, IL, USA) with an accuracy ± 0.02 mm. These were performed by a single operator who performed the measurements twice (7 days between the first and second measurement). In cases where there was no correlation between the first and second measurement, a third measurement was taken, which was established as definitive.

Statistical analysis was performed using SPSS/PC (20.0, Chicago, IL) software. Descriptive statistics were calculated for the different measurements. Levene Test was used to determine the homogeneity of variance, and Chi-square test and one-way ANOVA test were also used. In all statistical analyses, a significance level of $p \leq 0.05$ was used.

3. Results

The MIC was detected in 35.9% of cases, with a higher frequency observed in male patients (37.5% in males and 34.7% in females) and on the right side of the mandible (44.6% in the right side and 27.4% in the left side). The results showed a tendency for the detectability of MIC to decrease with age. The results of identification of MIC by gender and age are described in Tables 1 and 2.

The average MIC extension (D4) in the right and left sides of the mandible was 8.16 mm and 5.58 mm, respectively ($p = 0.00$). The minimum distance from the lower limit of the MIC to the lower margin of the mandible (D1) was 11.6 mm (right side of the mandible) and 11.9 mm (left side). The maximum distance from the lower limit of the canal to the lower margin of the mandible (D2) was 13.3 mm and 13.2 mm for the right and left side, respectively. The results of the mean size and minimum and maximum distance from the lower limit of the MIC to the lower margin of the mandibular body are described in detail in Table 3.

The teeth which were most closely related with the path of the MIC were the first premolar of the right (64.5%) and left side (79.1%). The distances from the upper limit of MIC to the teeth apex relative to the course are detailed in Table 4.

4. Discussion

The MIC is the anterior extension of the mandibular canal,[5] which contains the mandibular incisive nerve[13] and blood

Table 1 – Detailed findings on mandibular incisive canal by gender and age on the right side of the jaw. Xi^2 test for statistical significance.

	Gender				Age (years)							
	Male		Female		21–35		36–50		51–65		>65	
	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*
Visible	45.2	33	43.2	60	41.9	13	51.3	40	38.2	26	40	14
Non visible	54.8	40	56.8	79	58.1	18	48.7	38	61.8	42	60	21
p-value	0.7				0.4							

Table 2 – Detailed findings on mandibular incisive canal by gender and age on the left side of the jaw. Xi^2 test for statistical significance.

	Gender				Age (years)							
	Male		Female		21–35		36–50		51–65		>65	
	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*
Visible	29.6	21	26.3	36	32.3	10	28.9	22	28.9	19	17.1	6
Non visible	70.4	50	73.7	101	67.7	21	71.1	54	71.1	47	82.9	29
p-value	0.6				0.4							

Table 3 – Average extension (D4), minimum (D1), and maximum (D2) distance (mm) from the lower limit of the mandibular incisive canal to the lower margin of the mandible.

	Right side of the mandible			Left side of the mandible		
	Extension (D4)	D1	D2	Extension (D4)	D1	D2
Mean	8.16	11.6	13.29	5.58	11.91	13.15
SD	5.6	2	2.4	3.94	2.06	1.96

Table 4 – Average distance (mm) and standard deviation of tooth apex to the upper limit of the mandibular incisive canal (D3).

Distance/tooth	D3 (45)	D3 (44)	D3 (43)	D3 (42)	D3 (35)	D3 (34)	D3 (33)	D3 (32)
Mean	7.7	8.3	6.6	9.7	10.2	6.6	5.3	–
SD	2.29	3.26	1.73	9.7	1.2	2.67	1.77	–
N	12	40	9	1	2	19	3	0

vessels that provide blood supply and innervation to the mandibular anterior teeth.[7,14] Originally, Olivier[4] reports that the IAN is divided at the level of the mental foramen into two branches: the mental nerve and incisive nerve. Subsequently, some studies showed that IAN is divided at the level of the molar region into its two terminal branches, noting that each branch is wrapped in different epineural sheaths.[14]

The present study established detectability of MIC in 35.9% of cases, which is higher than the values reported by Pires et al. (11%)[8] and Jacobs et al. (15%)[15] based on panoramic radiographs. Mardinger et al.[5] used conventional radiographs of anterior dry jaws, and identified the MIC clearly in 24% of cases, and with difficulty in another 32% of cases. Anatomical studies on dry jaws detect the MIC in 90% of cases,[5,7,10,15] while cone beam CT scans detect MIC in over 80% of cases.[7,8]

The difficulty in visualizing the MIC in panoramic radiographs can be explained by several reasons: absence or partial presence of bony cortical walls of the canal,[5,10] narrow diameter of the MIC,[15] inherent distortion and magnification in panoramic radiographs, and overlapping teeth and cervical spine.[8] The angle of the jaw when taking panoramic radiographs plays an important role. Jacobs et al.[15] studied 22 jaws in which MIC was found in 20 samples and was observed in 11 of the panoramic radiographs. When the radiograph was taken with the jaw facing down (-5 to -8° below the Frankfurt plane), the canal was observed in 17 cases. On the other hand, one must keep in mind that the quality and definition of conventional panoramic radiographs has improved over time, which could also explain the variation in the results of panoramic radiographs in various studies.

The detection of MIC in the panoramic radiographs examined was slightly higher in males (45.2% male vs. 43.2% female on the right side, and 29.6% vs. 26.3% on the left, respectively), evidencing a trend to decreasing detection as age increases.

The study observed an average canal length of 8.16 mm on the right side and 5.58 mm on the left side, and none of the MIC reaches the midline. Such distances were established by CT scan,[8] where the average length was 7.1 mm on the right side and 6.6 mm on the left. Makris et al.[9] established greater lengths (15 and 13 mm) after analyzing 100 CT scans, concluding that in 18.6% of cases, the canal reached the mandibular symphysis. De Andrade et al.[16] determined the length of the mandibular incisive nerve in 12 jaws, finding an average length of 20.58 mm on the right side and 21.45 mm on the left.

This study found that the postero-anterior MIC path was parallel to the lower margin of the mandible; it descends from the mental foramen, rising at its terminal portion, as reported in some previous studies.[5,13] The minimum and maximum average distance from the lower limit of MIC to the lower margin of the mandible was 11.7 mm and 13.2 mm, respectively. We cannot make a comparison of these results with the studies reviewed in the literature, as the points from which the distance measurements are performed vary. Makris et al.[9] measured the distance from the MIC to the lower margin of the jaw at 6, 9, 12, and 15 mm from the mental foramen and establish distances 11.15 mm, 10.1 mm, 9.4 mm, and 9.5 mm, respectively. Pires et al.[8] report the distance to the lower jaw margin, at the MIC initial and terminal portions, as 10.4 mm and 10.1 mm, respectively. Mraiwa et al.[10] made measurements in the canine region, and establish a distance of 9.7 mm. Panoramic radiographs have limited effectiveness when used to determine the presence, extent, and precise location of the MIC.

This study detected the MIC in 35.9% of cases, and the average length of the MIC was 5.58 mm and 8.16 mm in the left and right side, respectively. Because there are significant differences in detectability, length, and course of the MIC between panoramic radiographs and anatomical studies, the use of CT scans is recommended for invasive treatments in the interforaminal jaw area. Finally, in implants and surgical procedures, one should take into consideration the fact that the teeth which are most related to the path of the MIC are the first premolars of the corresponding side.

Conflicts of interest

The authors have none to declare.

REFERENCES

1. Kohavi D, Bar-Ziv J. A typical incisive nerve: clinical report. *Implant Dent*. 1996;5(4):281–283.
2. Jacobs R, Lambrichts I, Liang X, et al. Neurovascularization of the anterior jaw bones revisited using high-resolution magnetic resonance imaging. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod*. 2007;103(5):683–693.
3. Romanos GE, Greenstein G. The incisive canal. Considerations during implant placement: case report and literature review. *Int J Oral Maxillofac Implants*. 2009;24(4):740–745.
4. Olivier E. The inferior dental canal and its nerve in the adult. *Br Dent J*. 1928;49:356–358.
5. Mardinger O, Chaushu G, Arensburg B, et al. Anatomic and radiologic course of the mandibular incisive canal. *Surg Radiol Anat*. 2000;22(3–4):157–161.
6. Haribhakti VV. The dentate adult human mandible: an anatomic basis for surgical decision making. *Plast Reconstr Surg*. 1996;97(3):536–541.
7. Jacobs R, Mraiwa N, van Steenberghe D, et al. Appearance, location, course, and morphology of the mandibular incisive canal: an assessment on spiral CT scan. *Dentomaxillofac Radiol*. 2002;31(5):322–327.
8. Pires C, Bissada N, Becker J, et al. Mandibular incisive canal: cone beam computed tomography. *Clin Implant Dent Relat Res*. 2012;14(1):67–73.
9. Makris N, Stamatakis H, Syriopoulos K, et al. Evaluation of the visibility and the course of the mandibular incisive canal and the lingual foramen using cone-beam computed tomography. *Clin Oral Implants Res*. 2010;21(7):766–771.
10. Mraiwa N, Jacobs R, Moerman P, et al. Presence and course of the incisive canal in the human mandibular interforaminal region: two-dimensional imaging versus anatomical observations. *Surg Radiol Anat*. 2003;25(5–6):416–423.
11. Juodzbalys G, Wang HL, Sabalys G. Anatomy of mandibular vital structures. Part II: Mandibular incisive canal, mental foramen and associated neurovascular bundles in relation with dental implantology. *J Oral Maxillofac Res*. 2010;1(1):e3.
12. Fuentes R, Prieto R, Silva H, et al. Morfometría mandibular en adultos a través de una radiografía panorámica. *Int J Morphol*. 2008;26(2):415–418.

13. Beltrán V, Cantín M, Fuentes R, et al. Presencia Bilateral del Canal Incisivo de la Mandíbula. Una Estructura Anatómica con Relevancia Clínica. *Int J Morphol*. 2011; 29(2):543–549.
14. Kqiku L, Weiglein AH, Pertl C, et al. Histology and intramandibular course of the inferior alveolar nerve. *Clin Oral Investig*. 2011;15(6):1013–1066.
15. Jacobs R, Mraiwa N, Van Steenberghe D, et al. Appearance of the mandibular incisive canal on panoramic radiographs. *Surg Radiol Anat*. 2004;26(4):329–333.
16. De Andrade E, Otomo-Corgel J, Pucher J, et al. The intraosseous course of the mandibular incisive nerve in the mandibular symphysis. *Int J Periodontics Restorative Dent*. 2001;21(6):591–597.