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Detection of Mandibular İncisive Canal by Panoramic Radiographs

Selin Ergün[1*], Pelin Güneri[2] and Hayal Boyacıoğlu[3]

*[*1]Karşıyaka Oral and Dental Health Center, Karşıyaka, İzmir, Turkey*

[2]Department of Oral and Maxillofacial Radiology, School of Dentistry, Ege University, Bornova, İzmir, Turkey

[3]Department of Statistics, Faculty of Science, Ege University, Bornova, İzmir, Turkey.

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ABSTRACT

Introduction: The aim of this study was to visually assess the presence of mandibular incisive canal (MIC) that is defined as the anterior extension of the mandibular canal on digital panoramic images.

Materials and methods: In total, 221 panoramic radiographs were obtained by using ORTOPANTOMOGRAPH® OP200 D X-ray unit and applying a standardized exposure protocol. Two experts evaluated the presence/absence of MIC independently. In addition to the prevalence of MIC, the agreement between the observers was analyzed with Kappa test ($p=0.05$).

Results: The incisive canal was observed in 16.74% on the right and 14.48% on the left of the patients. The agreement between the observers was almost perfect for the right ($k=0.843$, $p=0.000$) and substantial for the left sides ($k=0.809$, $p=0.000$). Patients' dental status has not influenced the agreement ($p>0.05$). Mandibular canal was not clearly traced on panoramic images of 25.79% and 18.55% of the patients (right and left sides, respectively).

Conclusion: In this study, the prevalence of MIC was similar to the literature. In order to avoid any damage to this anatomical variation, exact localization of MIC should be identified prior to surgery using appropriate radiographic techniques.

Keywords: Radiography, Panoramic, Mandibular nerve, Anatomic variation

INTRODUCTION

Knowledge of anatomy in the region of any surgical intervention is important for the success of surgical procedures [1,2]. The presence of a neurovascular bundle within the region may present risks during surgery and therefore a preoperative radiographic identification is considered of most importance [2-5].

The mandibular division of the trigeminal nerve enters the mandibular foramen [6]. The mandibular canal (MC) extends bilaterally from the mandibular foramen to the mental foramen carrying the inferior alveolar nerves, arteries and veins [7]. As the inferior alveolar nerve proceeds anteriorly in the mandibular canal, it traverses the mandible from the lingual to the buccal side [6]. The mental nerve (MN) is a terminal branch of the inferior alveolar nerve which generally emerges from the mental foramen in three branches in the mental canal [1,4,6,8] **(Figure 1)**. The first branch gets the sensory impulses from the skin of the mental region, while the other branches get the sensory impulses from the lip skin, mucous membranes and gingival up to the second premolars [1,6,8]. Medial to the mental foramen, studies confirmed an anatomic variation of the mandibular canal, which is the incisive branch of the mandibular canal [1,6,9-11]. This canal is referred to as the mandibular incisive canal (MIC) which is an anterior extension of the mandibular canal [11-14]. It contains one of the terminal branches of the inferior alveolar nerve which provides innervation to the lateral and central incisors, canine and mandibular first premolar [10,15,16] **(Figures 2a and 2b)**.

Corresponding author: Dr. Selin Ergün, Karşıyaka Oral and Dental Health Center, Karşıyaka, İzmir, Turkey, Tel: 90-0232 4443543; Fax: 90-0232 3622354; E-mail: seling77@yahoo.com; selin.gogus@hotmail.com

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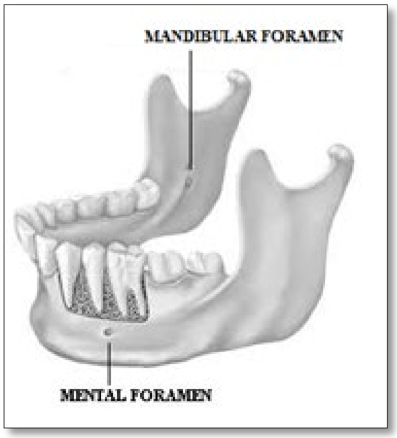

Figure 1. The anatomical localization of the mandibular foramen and mental foramen.

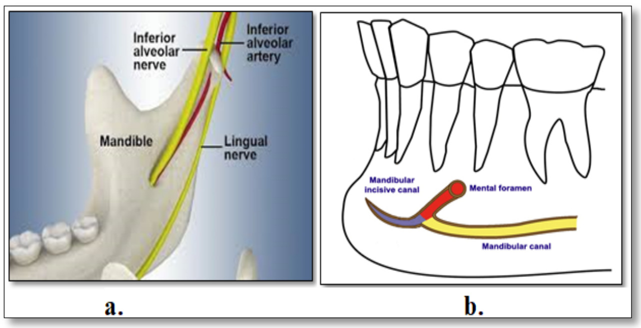

Figure 2. a) The entrance of inferior alveolar nerve into the mandibular canal. **b)** The schematic view of the mandibular incisive canal.

MC and mental foramen are important anatomical structures that may be vulnerable during surgical procedures involving the mandible, such as orthognathic surgeries, jaw reconstructions, mandibular anesthesia, third molars removal or endosseous implant placements [7,15]. Complications can be observed due to anatomical variation in the inferior alveolar nerve [1,2]. Neurosensory alterations in the chin and lower lip are one of the inadvertent complications that occur during any surgical procedure [4,5,7].

Panoramic radiographs are routinely used to examine the dental and bony structures, to locate anatomical landmarks for presurgical planning and may be useful in dental management because they provide broad coverage of the jaws [2,3,5,17,18]. On the other hand, cone-beam computed tomography (CBCT) replaced panoramic radiography especially in implantology because it allows three-dimensional analysis of the structures [2,11,19]. Nevertheless, many dental surgeons use only panoramic radiographs for the surgery of mandibular implant-supported prosthesis, mainly because the anterior region has always been considered relatively safe for this procedure [2,20]. Additionally, considering the high radiation exposure, high cost and unavailability in all dental centers, a three-dimensional examination and cross-sectional analysis are not routinely recommended [2,4,18,21].

The fact that panoramic imaging is widely used for evaluation of the jaws justifies the interest in determining the visibility of anatomical structures on these films [3]. Therefore, the aim of this study was to investigate the visual assessment and the presence of the mandibular incisive canal on digital panoramic radiographs.

MATERİALS AND METHODS

A total of 221 panoramic radiographs of patients which were taken for dental diagnostic purposes were examined in this study. The patients received written information regarding the procedure and they signed the consent forms. All panoramic radiographs were taken by using ORTOPANTOMOGRAPH® OP200 D X-ray unit (tube potential: 57-85 kV, tube current: 2-16 mA, focal spot size: 0.5 mm, exposure time: 14.1 s and magnification factor of 1:1.25) (Instrumentarium Dental, Tuusula, Finland). All images were examined by two oral and maxillofacial radiologists who had a minimum of 10 years clinical experience.

The observers scored the presence of mandibular incisive canal (MIC) at the right and left sides of the mandible on the images (present/absent) **(Figures 3a and 3b)**. When the observers could not observe the related region of the canal, they have also recorded those accordingly. Thus, all images were classified into three groups: a) MIC was not present, b) MIC was present, and c) Mandibular canal and mental foramen were not visible. The dentition status of each patient was also recorded as 1) dentate, 2) partially dentate and 3) edentulous.

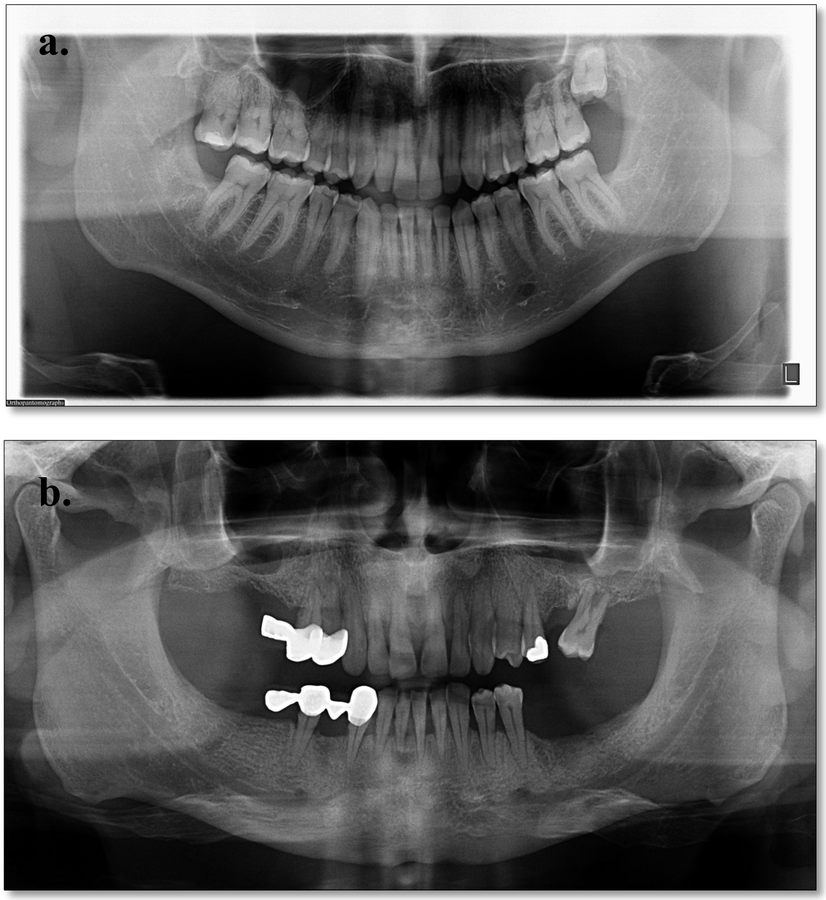

Figure 3. a) Common appearance of mandibular canal and mental foramen on a panoramic radiograph bilaterally. **b)** Identifiable mandibular incisive canal on a panoramic radiograph bilaterally.

The films which had optimum diagnostic quality, clearly showed visible and traceable borders of mandible, had acceptable density and contrast, with minimal positioning errors and minimum or no superimposition of structures were included into the study. Radiographs with a radioopaque/radiolucent pathological lesion within the area extending from right third molar to the left third molar which obstructs the related region were excluded. A radiolucent canal within the trabecular bone that is surrounded by a radiopaque cortical bone representing the canal walls, and extending to the anterior portion beyond the mental foramen was considered as MIC **(Figure 4)**.

Kappa statistics were applied for assessment of inter-observer agreement and Kappa coefficient was interpreted as being poor (0), slight (0.01-0.20), fair (0.21-0.40), moderate (0.41-0.60), substantial (0.61-0.80) and almost perfect (0.81-1.0). In all tests, p was set as 0.05.

RESULTS

The observers examined right and left sides of 221 patients and a total of 442 half of panoramic images were inspected. The patients were consisted of 91 males and 130 females whose ages were ranging between 14 and 81 years. The number of dentate patients was 138 whereas that of the partially dentate patients was 83. None of 221 patients was edentulous.

When the right sides of the patients were considered

Both observers stated that MIC was absent in 106 of the patients (47.96%). Of those, 59 were females and 47 were males. Also, 34 were partially dentate and 72 were dentate patients. According to the scores of both observers, MIC was present in 37 of the patients (16.74%) **(Figures 5a and 5b)**. These patients were mostly males (15 females and 22 males); 16 patients were partially dentate whereas 21 patients were dentate.

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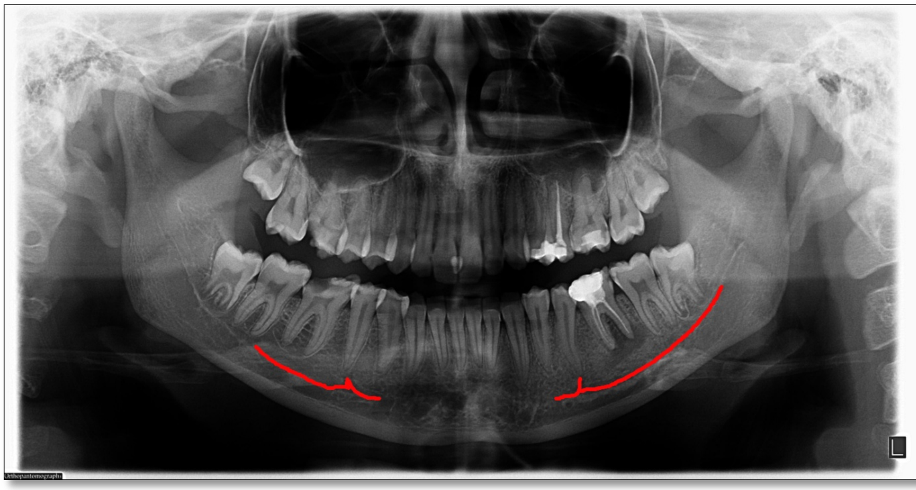

Figure 4. Traceable mandibular incisive canal on a panoramic radiograph bilaterally.

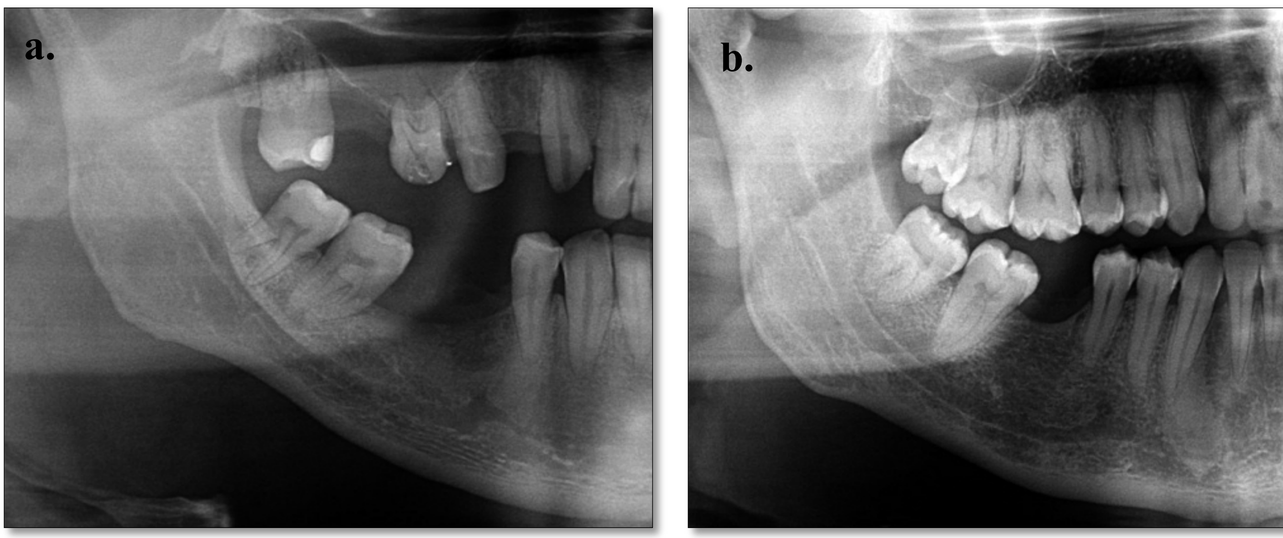

Figure 5. a&b) MIC detected on the right sides of different patients; according to the scores of both observers, it was present in 37 of the patients (16.74%).

On the other hand, the mandibular canal and foramen mentale were not clearly traceable in 57 patients (25.79%). Of those, females constituted the majority (41 were females and 16 were males). In this group, 24 patients were partially dentate and 33 patients were dentate. The agreement between the observers was almost perfect for the evaluation of the right sides (Kappa=0.843, p=0.000).

When the left sides of the patients were investigated

MIC was considered as "absent" in 125 patients (56.56%) by both observers. Of those, 72 were females and 53 were males. In this group of patients, 42 were partially dentate and 83 were dentate. According to both observers, MIC was present in 32 patients (14.48%); of those, 14 were females and 18 were males (**Figures 6a and 6b).** In this group, 14 were partially dentate whereas 18 were dentate patients.

The mandibular canal and foramen mentale were not identifiable in 41 patients (18.55%) (29 were females and 12 males); of those, 19 were partially dentate and 22 were dentate. There was a substantial agreement between the observers (Kappa=0.809, p=0.000). According to statistical analysis, the presence of teeth in the related region did not influence the agreement between the observers (p>0.05) (**Table 1**).

DİSCUSSİON

The mandibular incisive canal (MIC) is increasingly been recognized as an important anatomical structure that needs to be taken into consideration when planning surgical procedures in the interforaminal region of the mandible [9,10,13,18]. Olivier was the first to describe the incisive canal as an extension of the inferior alveolar canal [12]. Studies have confirmed the existence of a true incisive canal medial to the mental foramen which is a continuation of the mandibular canal [9,13,22]. It may also appear to be ill-defined, and neurovascular bundles may run through a labyrinth of intertrabecular spaces [1,5,9].

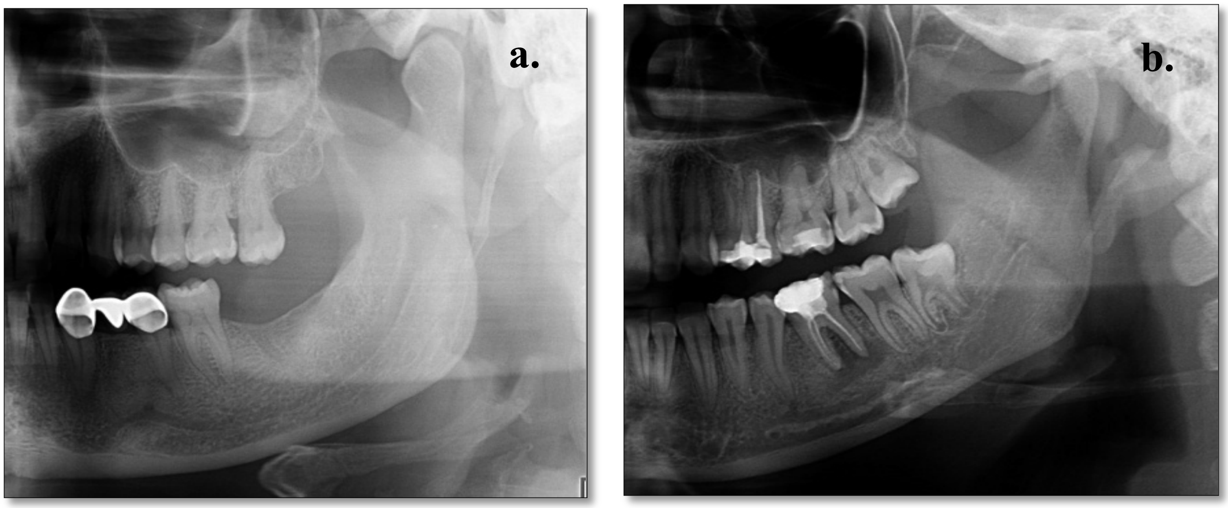

Figure 6. a&b) MIC detected on the left sides of different patients; according to both observers, it was present in 32 patients (14.48%).

Table 1. Distribution of patients and presence of mandibular incisive canal.

Total number of patients	Mean age	Number of cases with MIC	Percentage of MIC	Gender
221	40.33	37 (right side) 32 (left side)	16.74% (right side) 14.48% (left side)	15 female, 22 male (right side) 14 female, 18 male (left side)

Several studies have focused on the visualization of the mandibular incisive canal on panoramic images [3,5,17,18], since panoramic imaging has several advantages including visualization of many anatomic features, low cost, and availability [5]. However, a panoramic radiograph is a two-dimensional (2D) image, lacking information in the bucco-lingual direction and magnifying in both vertical and horizontal directions [3]. The panoramic X-rays can offer little information on the presence of the accessory canals, due to the superimpositions and to the orientation of the X-ray beam in relation to the trajectory of the canals. If the X-ray beam is not parallel to the canal, it cannot be depicted [5]. Furthermore, images can vary widely as they depend on both operator and position of the patient [2]. Panoramic radiograph's accuracy to identify the anterior extension of the mental nerve has been described as being limited [1,3,14,15,18].

In panoramic radiography examination studies, the identification rates of the MIC were reported between 2.7%-51.7% [3,5,14,17,18]. Jacobs et al. [3] reported that the MIC was identified only in 15% of the 545 panoramic radiographs. Romanos et al. [18] found the presence of MIC in routine panoramic radiographs only 2.7% of cases. Whereas, Jalili et al. [17] reported the MIC was considered 51.7% of cases on panoramic radiographs which is more than those of other researchers. Also, Singh et al. [5] detected incisive canal in 33% of the cases. It is possible that the reason for the lower rate of the MIC identification by the examiners is that it becomes thinner as it approaches to middle line [9,22]. Also, this might be explained by the fact that the incisive canal is less corticalized and has a smaller diameter than the mandibular canal which would make its identification difficult [3,23]. In many cases, the canal gradually narrows until the neurovascular bundle enters a labyrinth of medullary spaces without strictly forming a canal [2]. In addition, the angulation of the X-ray beam in panoramic radiography is about 7-8° from below, resulting in distortion of the actual mandibular anatomy and may lead to misinterpretation [3]. In clinical situations, the incisive canal could also be better visualized when there was a straighter neck position during downward tipping, with less overlap of the cervical spine [3].

The results of studies using CT [9,24,25] and CBCT [2,11,14-16,19,20,22,23,26] were compared with others that utilized panoramic radiography [1,3,5,17,18]. CT and CBCT imaging provided better visualization of the specific anatomical structures than panoramic radiography, due to inferior visualization of these structures on panoramic films. It has been shown that cross-sectional imaging offers a better alternative for the precise visualization of anatomical structures in oral region [1,16,19,23].

Previous studies revealed that MIC could be identified on 83.1%-94% of CBCT and CT images [9,14,22,25,26]. Pires et al. examined 89 CBCT and panoramic images and detected MIC 7.4 times more frequently on CBCT images (83.1% with CBCT, 11.2% with panoramic radiography) [14]. They also found no significant differences between the images regarding the side and gender separately. Similarly, MIC was identified on 83.3% [22] and 91% [26] of CBCT images, whereas it was observed in 94% of the patients with spiral CT [9,25].

According to the anatomical observation of dissected dry mandible studies, a well-defined mandibular incisive canal appears as an intraosseous extension of the inferior alveolar canal [13,27,28]. Other authors compared the prevalence of MIC in dissection material with those obtained from radiological evaluations [1,13]. Mardinger et al. anatomically observed MIC in 80% of mandibles, but with conventional radiography, the canal was well defined only on 24%, poorly defined on 32% or undetectable on 44%of the images [13]. Correspondingly, Mraiwa et al. confirmed the existence of MIC in 96% of the mandibles [1]. Nonetheless, intraoral, panoramic, and tomographic images of the dissected mandibles showed that conventional radiographic images may not accurately identify the incidence or extent of incisive canal.

According to the data presented in this study, we were able to detect the presence of MIC on the panoramic radiographs in 16.74% (right side) and 14.48% (left side) of the examined population. This finding was similar with the studies of Pires et al. who identified MIC on 11.2% of panoramic images and Jacobs et al. who detected MIC on 15% of the panoramic images [3,14]. Also, the side and the presence of teeth did not influence presence of MIC, and this was partially in accordance with Pires et al. who declared that side had no significant effect on the detection of MIC [14].

CONCLUSION

In conclusion, panoramic radiography is the standard and most prevalent radiographic method for implant treatment planning in the anterior part of the mandible, probably because of the high costs of CBCT and the problems of health insurances covering their costs [2]. However, the present study indicates that the panoramic radiography appears less suitable for detecting the incisive canal, and for thorough preoperative planning in the interforaminal region, a more precise radiographic examination such as CT or CBCT may be particularly appropriate.

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