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Visibility of the Mandibular Canal: From Two-Dimensional Radiography to Three-Dimensional Imaging

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

The mandibular canal (MC), located within the mandible, carries the inferior alveolar nerve and the inferior alveolar vessels. This neurovascular bundle is at risk during mandibular surgical procedures. Therefore, an adequate preoperative evaluation of the MC could lead to safer treatment with fewer postoperative complications. The purpose of this paper was to review the most commonly used radiographic techniques in dentistry (periapical, panoramic, and cone-beam computed tomography (CBCT)) as well as their benefits and drawbacks in terms of MC visibility and, as a result, better preoperative planning in dentistry. Although panoramic radiography and CBCT technology are useful for the MC assessment, CBCT exposes the MC image more accurately and is thus regarded as the best technique for pre-surgery radiographic planning.

Keywords: Mandibular canal; cone-beam computed tomography; panoramic radiography; three-dimensional image; two-dimensional radiograph.

1. INTRODUCTION

The mandibular canal (MC), located within the mandible, carries the inferior alveolar nerve (IAN), which is a branch of the mandibular nerve, the third division of the trigeminal nerve, and the inferior alveolar vessels (artery and vein) [1,2]. The IAN supplies sensation to the mandibular

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teeth and gingivae and branches into: a) the mental nerve which exits the MC through the mental foramen supplying sensory innervations to the chin and lower lip and b) the mylohyoid nerve providing motor innervations to the mylohyoid muscle [2,3].

According to its location and path, the IAN is at risk during mandibular surgical procedures [4,5]. Any aggression to the nervous bundle or ramifications may lead to a temporary/permanent loss of tactile sensation of the lower lip and chin [4]. In a study with shocking results performed in 2005, Robert et al. stated that 94.5% of surveyed California oral and maxillofacial surgeons reported instances of injury to the IAN during mandibular surgeries in a 12-month period [4]. Dimensions and paths of the MC are important parameters which decisively contribute to correct planning. Thus, an adequate preoperative visibility of the MC can yield safer treatments with less IAN morbidity [6,7].

In a study investigating the vertical positioning of the IAN in 39 edentulous human cadaveric mandibles, Kieser et al. found 30.7% (12 out of 39) of IAN located in the superior part of the body of the mandible, and 69.2% (27 out of 39) half- way or closer to the inferior border of the mandible [8].

On the other hand, Kane et al. who assessed the bucco-lingual position of the MC in 20 patients using computed tomography (CT) found that the IAN and accompanying vessels are situated more or less at 4.7mm from the buccal aspect and at 1.8mm from the lingual side of the mandible at the level of the mandibular first molar [9].

The bucco-lingual position of the MC and the topography of the IAN were investigated using three-dimensional reconstruction by Kim et al. on sixty-two mandible sides. The researchers conclude that 70% of the canals followed the lingual aspect at the ramus and the mandibular body, 15% were located at the middle of the ramus behind the second molar and lingually when passing through the second and first molars, and the last 15% followed the middle or the lingual third of the mandible from the ramus to the body. On the other side, also according to Kim et al., the inferior alveolar vessels were above the IAN in 80% and in 20% lateral to it [10].

Usually the MC is unique but sometimes it may be bifid [6,11,12] and rarely trifid [13]. According to Nasseh and Aoun, bifid MC can be found in every patient even if considered uncommon and hence must be assessed effectively [6].

In fact, bifurcation of the MC was investigated by many authors via different radiographic techniques. Panoramic radiographs were used by Nortje et al. [11] and Langlais et al. [12] who found, respectively, a prevalence of bifid MC of 0.91% (33 out of 3612) and 0.95% (57 out of 6000).

Other authors used other imaging technology such as CT and cone-beam computed tomography (CBCT) [14,15].

Usually the MC exits the mandible buccally at the mental foramen located at the apical region of the premolars [16-23].

The aim of this article was to review different visibility methods of the MC, their advantages and disadvantages, as well as their clinical application in the dentist's everyday practice.

2. RADIOGRAPHIC TECHNIQUES USED IN DENTISTRY

In daily dental practice, the radiographic evaluation of the MC is mostly performed on periapical, panoramic and CBCT images with a percentage of visibility of 28%, 32% and 98% respectively [24]. On conventional two-dimensional (2D) radiography, the MC appears as a radiolucent image, with two well-defined radiopaque borders, inferior to the mandibular molars and premolars roots [25]. This typical appearance is mainly due to the principle of the radiographic lines formation. A radiopaque radiographic line is visible whenever the primary X-ray beam is perpendicular to the surface of separation of two different densities. In the case of the MC, the two different densities are due to the trabecular bone and the inferior neurovascular bundle.

2.1 Periapical Radiography

Due to their small size and short coverage, periapical radiographs, although having the best 2D image resolution, are not advised for MC evaluation [25].

2.2 Panoramic Radiography

Unlike periapical radiographs, the panoramic 2D X-ray offers a full teeth/oral structures overview. Concerning the MC, in the majority of cases, it can be detectable without difficulty allowing the practitioner to evaluate the risk of IAN injury

during invasive interventions (Fig. 1). Liu et al. had classified its path into four categories of curves: a) linear, b) arc-elliptic, c) spoon-shaped, and d) turning [26].

However, this 2D technology lacks 3D information and may not visualize the small details of the MC [24]. Additionally, the MC visibility decreases when its borders become undetectable due to poor bone density or a non-perpendicularity between the canal and the principal beam [27]. Less resolution, elevated distortion and the risk of phantom images are also main disadvantage of this technique [28].

2.3 Cone-Beam Computed Tomography

CBCT has been referred to as the "gold standard" for maxillofacial imaging. This three-dimensional technology exposes the MC image more accurately. De Oliveira-Santos et al. concluded that among 41% of the MCs not detectable on 2D radiographs, a large majority was visible on CBCT [29].

On CBCT, the MC can be seen and traced manually. The operator must be careful in mapping the reconstruction and following the MC path (Fig. 2).

Kim et al. developed a new automatic technique to isolate the MC with no intervention from the user. In early experimental results by means of 10 clinical DICOM files, this technique could exactly recognize the MC. This technique possesses, additionally, the utmost segmentation precision [30].

Fig. 1. Digital panoramic radiograph showing the path of the MC (arrows)

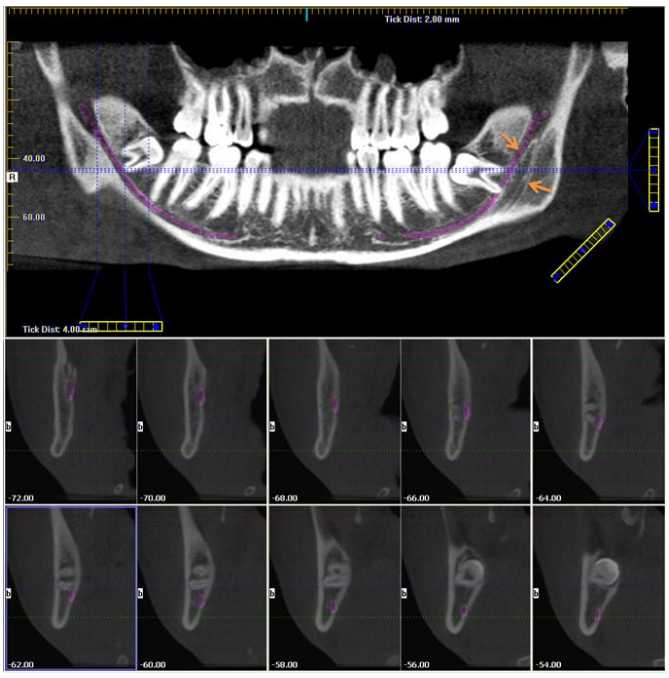

Fig. 2. A CBCT panoramic reconstruction and cross sectional cuts showing the path of the MC; to note the left double MC (arrows)

For Başa and Dilek, the average density and thickness of the bone surrounding the MC is not sufficient to resist the action of drilling, especially during implant placement; consequently, the operator must carefully approach the canal [31].

The location and the anatomical variations of the MC (bifid canal, double and accessory mental foramina, the incidence of an anterior loop, etc.) as noticed on CBCT have been largely assessed in the literature [5-8,11-15].

3. CONCLUSION

The neurovascular bundle located in the MC is at risk during invasive surgical interventions in the mandibular regions. Therefore, thorough clinical and radiological assessments before any procedure are essential. Both panoramic radiography and CBCT are useful techniques for MC evaluation; however, CBCT exposes the MC image more accurately and is thus regarded as the best technique for pre-surgery radiographic planning.

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CONSENT AND ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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