Evaluation of the Mandibular Canal Visibility on Cone-Beam Computed Tomography Images of the Mandible

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Background: The mandibular canal (MC) is an important and necessary landmark that should be considered before any surgery in the posterior region of the mandible. This study is aimed to evaluate the visibility and position of the MC in an Iranian population using cone-beam computed tomography.

Methods: In this cross-sectional study, cone-beam computed tomography images of 69 patients, which were available as soft copies in the archives of the databases in the Department of Oral Radiology at Hamadan University of Medical Sciences (Hamadan, Iran), were analyzed. The visibility, corticalization, and position of the MC were assessed by 2 expert oral radiologists independently. The χ² test, unpaired t test, and 1-way analysis of variance were used for analysis.

Results: The right and left MCs were clearly visible in 89.6% and 84.7% of the cases, respectively. Among 87.5% of cases, the MC was observed simultaneously in 2 sides. Position of the MC in relation to surrounding structures showed lowest asymmetry at the second premolar area. There were no statistically significant differences between sex and the evaluated parameters.

Conclusions: Cone-beam computed tomography was successful in most cases in displaying the MC. The areas with most MC visibility in the right and left sides were the second and third molar regions, respectively. This visibility declined forwardly in both sides.

Key Words: Mandibular canal, cone-beam CT, inferior alveolar canal

The mandibular canal (MC) is an important and necessary landmark that should be noted before any surgery in the posterior region of the mandible.1,2 Common surgical procedures that are performed in close proximity to the neurovascular bundle include the following: placement of intraosseous implants (ie, the most common procedure), bone harvesting from the chin, genioplasty in orthognathic surgery, placement of screws, bilateral sagittal split osteotomy, and extraction of third molar.3,4 Interestingly, the most commonly affected nerve is the mandibular nerve (ie, reports indicate up to 64.4% of complications are related to this nerve), followed by the lingual nerve.5 Encroachment into this vital structure is a most unpleasant experience for both the patient and the dentist.6 Clinician errors and failure to properly identify this landmark can result in injuries to this vital structure, and the patient could ultimately suffer significantly because of such errors. Complications, such as changes in sensation, numbness, pain, and excessive bleeding, can affect the patient’s overall quality of life. The iatrogenic nature of this condition significantly increases the psychological effects related to this damage.7–8

Clearly, prevention of such events is rather important. During these surgeries, clinicians should not rely solely on probabilities for the locations of important anatomical structures, when they can use advanced imaging techniques to pinpoint exact locations of such structures. The best way to prevent issues arising from encroachment into the MC is having a crisp, clear, three-dimensional view of the jaws. Radiographic examination is one of the most important aspects of the diagnostic and preoperative evaluation.3,9–11 Among the possible radiographic procedures, a cross-section image is the radiographic method of choice for preoperative evaluation; in fact, it is strictly recommended for the provision of visual aids for preoperative evaluation examinations.12

The evolution of computed tomography (CT) provides the possibility of obtaining a three-dimensional assessment of the head and neck structures, but CT is not truly ideal for most routine dental applications, because of the high exposure to radiation, high cost, and limited availability.4 Currently, the most commonly used diagnostic cross-sectional imaging is cone-beam CT (CBCT).12–16 Cone-beam CT is a very familiar technology and procedure, and the data can be examined in sufficient quantity, which was previously not possible with other methods. By introducing this new technology, three-dimensional images for dental applications such as study of root resorption, tooth impaction, implant insertion, and so on have become more easily available than before.3,17–20 Such advantages as optimal image quality, excellent geometric precision, low-dose radiation, and easy handling make CBCT an excellent system for preoperative evaluation and treatment planning.21–23

Yet, to date, most research has concentrated on how dental implants properly and rapidly integrate with the bone, and few studies have been done on the anatomy of the implant area.24 The location of canal has been variably reported.25,26 However, the detailed anatomy of the inferior alveolar canal zone and its potential clinical complications still remain controversial, and visibility of this structure may vary considerably, even individually.27–32

Previous reports have revealed that sufficient image quality and adequate detection of anatomical data can be achieved with CBCT.33 In our study, we performed a study in an Iranian population to confirm the reliability of CBCT in the evaluation of the MC. This study was conducted to determine the visibility of the MC on CBCT; rather, the ability of this technique more than ever is judged.

MATERIALS AND METHODS

This study was a descriptive cross-sectional study, and the statistical population was 69 CBCT scans including the mandible that were available as soft copies in the archives of the databases in the Oral Radiology Department of Hamadan Dental School in Iran. The inferior alveolar nerve canal region was examined in the CBCT scans. The data were used from the patients who were referred to this department between 2010 and 2012. Cone-beam CT images
were randomly selected from the patients older than 20 years. The scans have been taken as part of a clinical diagnostic procedure for various reasons such as planning before orthodontic treatment, implant insertion, or extraction of the third molar and have been prescribed as a diagnostic workup rather than the investigation of the inferior MC. Therefore, it was not necessary to seek ethical approval.

The mandibles under investigation were fully dentate in posterior regions of 2 sides including the second premolars and first, second, and third molars. Existence of mandibular pathology, absence of second premolars and 3 molars in each side of the mandible, and presence of bifid MC or accessory mental foramen were considered as the exclusion criteria for the samples. Cone-beam CT scans displaying the entire mandibular bone on both sides were included. The scans having positioning errors that the inferior border of the mandible was not recorded well and the images that did not have the perfect quality were excluded during the selection process.

Two oral radiologists experienced in interpreting CBCT scans reconstructed and interpreted the CBCT images simultaneously and independently for the MC, and all measurements were carried out by them. For the visibility rating of the MC, the interpretation of CBCT was based on a consensus between 2 professionals, as a criterion standard. The CBCT images were processed and observed with NNT viewer software (NNT Viewer software, Verona, Italy). In fact, this software was used to reconstruct two-dimensional multiplanar reformatted images.

For assessing the MC, continuous cross-sectional images were reconstructed in 2 directions from the original mandibular axial images at the midroot reference. These included projections, parallel to the dental arch (reconstructed panoramic), with thickness of 1 mm and distance of 2 mm and perpendicular to the dental arch (the cross section), according to the following protocols: 0.5-mm slice thickness, width of 30 mm, and 2-mm interval. The observers carefully examined these images, scrolling the consecutive cross-sectional images under standardized viewing conditions and reduced room lighting. Brightness and contrast were adjusted according to the examiners’ individual preference.

First, the MC was evaluated in consecutive reconstructed panoramic images. If both sides of the canal were not visible in a single panoramic image, other panoramic images were searched to view both sides of the canal. Slice thickness of panoramic reconstructions varied in each hemimandible, ranging from 5 to 20 mm, so that the entire course of the canal could be visualized, including the mental foramen, without impairing image superimposition.

The characteristics of the MC were defined according to the following criteria. Visibility of the MC in 5 regions in both sides (which will be explained in the following) was recorded using a 2-item grading scale (present or absent), corticalization of the MC (present or absent), and the MC’s position.

Mandibular canal’s position was defined through the quantification of the distance of the MC from the lingual cortical bone, buccal cortical bone, and the inferior cortex of the mandible, which were measured as the distance from the point where the MC is present to the internal border of the corresponding side of the mandibular body.

Reformatted panoramic and cross-sectional images were carefully evaluated to study MC’s visibility as well as position in its course from the mandibular foramen to the mental foramen in 5 distinct areas of the hemimandibles:

1. the beginning of the MC: distal of third molar
2. third molar area: below the third molar furcation
3. second molar region: below the second molar furcation
4. first molar region: below the first molar furcation
5. second premolar area or end of the canal: below the second premolar apex

These values were measured in the left and right sides of each patient. All these measurements were carried out using the measurement tools on the accompanying NNT viewer software. Because multiplanar reformation images are shown in the actual size, the measured values were used as stated.

The collected data were entered in a spreadsheet (Excel 2007; Microsoft, Richmond, VA) and were analyzed using statistical analysis software (SPSS version 17; SPSS Inc, Chicago, IL). Descriptive statistical analysis was carried out. The χ² test, unpaired t test, and 1-way analysis of variance were used for analysis. In addition to descriptive statistical tests, the effect of sex on the visibility of anatomical landmarks was investigated using χ² test. For all the observations, Fisher and χ² tests were applied to compare the right and left sides. Significance level was considered at P < 0.05. Weighted κ index was calculated to assess agreement between observations. In this study, the κ coefficient for interexaminer reliability in measurements was 0.72 with 95% confidence interval.

RESULTS

Visibility Rating of the MC

In the current study, MC visibility was studied in 5 points. The areas with most MC visibility in the right and left sides were the second and third molar regions, respectively. This visibility declined forwardly in both sides (Figs. 1 and 2). Right MC was detected in 89.6% of the cases. Left MC was also observed in 84.7% of the cases. There was no significant difference between 2 sides of the mandible in canal visibility (P > 0.05).

In 87.5% of cases, the MC was observed on both sides simultaneously.

MC Corticalization

On cross-sectional and reconstructed panoramic images of the MC region, the corticalization of the MC was observed in 56.3% of hemimandibles. In 43.7% of the cases, the canal was not corticalized.

MC Position

In the current study, the distance of visible MC from inferior, buccal, and lingual borders of the mandible was measured in 5 points in reformatted cross-sectional images.

FIGURE 1. Anatomic region distribution of inferior alveolar canal visibility in the right mandible in CBCT scans.

FIGURE 2. Anatomic region distribution of inferior alveolar canal visibility in the left mandible in CBCT scans.
Distance From the Inferior Border of the Mandible

The distance of visible MC from the lower border of the mandible was investigated in 5 areas in CBCT scans and concluded that the maximum distance from the lower border of the mandible was in the 4th order of third molars on both sides. In 4 of the 5 areas of study, distances of MCs from the lower border were significantly different between 2 sides, and the only area where symmetry or similarity could be observed was at the second premolar area ($P > 0.05$) (Table 1).

Distance From the Buccal Wall of the Mandible

According to Table 2, the second molar area on each side showed the maximum distance from the mandibular buccal wall. Just similar to the distances from the lower border, in 4 of the 5 main areas of study, distances of MC from the buccal wall were significantly different between 2 sides, and the only area where symmetry is shown was the second premolar area ($P > 0.05$).

Distance From the Lingual Wall of the Mandible

Investigation of visible MC distance from lingual wall showed that second premolars on both sides had maximum distance from the lingual wall. It was also concluded that MC position forward along the canal in both sides is without symmetry as the lingual wall, and the only area where symmetry or similarity is shown was the second premolar area ($P > 0.05$) (Table 3).

In general, it can be concluded that the position of the most anterior part of the MC, the area of the second premolar, had the most symmetry to surrounding structures.

Appearance of MC Canal in Relation to Gender

Sex segregation of reviewed CBCT scans was reported as 63.8% of men and 36.2% of women. In the group of men, cortical canals were observed in the 60.3% of cases, and noncortical canals in 39.7%. These proportions in women were 48.4% and 51.6%, respectively. In 84.6% of men in the study group, bilateral MC was observed. This proportion in women is recorded 90.8%.

No significant differences between sexes were observed for all parameters assessed.

DISCUSSION

It is important to identify the MC before performing surgery that involves the posterior area of the mandible. Mandibular canal identification is critical and requires skill. The MC usually appears as a radiolucent zone surrounded by a radiopaque upper and lower border on images. Cortication of the canal is diverse and may explain why the MC is not always visible by imaging. In 87.5% of the scans in this study, the canal was visible on both sides. Thus, CBCT provides an effective method to identify the MC. This result was similar to the findings of Heurich et al. who was able to accurately reconstruct the inferior alveolar canal in 75 (93%) of 81 cases using CBCT before the extraction of the third molars. In addition, Suomalainen et al. concluded that, using CBCT scans, the MC can be correctly identified and properly located in relation to the third molar, but in using conventional tomography, the MC was considered imperceptible (invisible), or the identification of its location was considered unreliable in a number of cases.

Neugebauer et al. also reported that using CBCT scans, only 1% of the vertical position and 8.2% of the horizontal position of the mandibular third molar root tip to the MC were not specifically identified.

These results indicate the high potential of CBCT in detection of anatomical structures in the posterior mandible. However, identification of anatomical structures in all the studies in this field is not as simple as presumed, and the reported results can have diverse outcomes. For example, in a study by de Oliveira-Santos et al., only 53% of all MCs were clearly visible, and in 25% of the cases, viewing was associated with problems. In an additional 22% of the cases, it was extremely difficult to view the anatomical structures. There are various results reported in the ability of CBCT to visualize...
different structures, and the image quality depends on factors such as the type of device, field of view, size of the voxel, tube voltage and current, and other technical factors. The first, and perhaps the most important factor among this, is the type of device that is used. So, considering the physical and structural properties of each of these devices, the ability to view the anatomical structures is quite diverse.39 Kamburoğlu et al40 showed that the subjective quality of images and their visibility in 10 different structures (mental foramen, MC, teeth, caries, restorations, amalgam fillings, root canal filling, trabecular pattern, soft tissue, metal crowns, and the final implant drills) were quite different from the perspective of 5 expert observers. When 4 brands were compared, Morita Veraview 3D was found to give the best quality, and Iluma had the lowest quality for the assessment of investigated structures.40

Another important factor contributing to the variability in results is the racial and individual differences in bone structures. Therefore, the canal visibility might have a higher dependence on the anatomical features examined rather than the techniques applied. In the current study, unlike the study by de Oliveira-Santos,39 the visibility of the MC in the distal area of the third molar is lower than the visibility of other areas.34 For example, in an osteoporotic mandible, MC observation is difficult, often due to the lack of or minimum cortication of canal walls. Because the canal walls are usually not formed by dense bones and are composed of the trabecular bone, they vary from dense to very fragile structures, and trabeculation also shows variations among individuals and among the different locations in the mandible. Hence, the definition of canals with a clear border does not seem to be a constant and regular feature. In the study of de Oliveira-Santos et al,39 the visibility of canal declined toward the mental foramen. Conversely, the posterior portion of the canal, closer to the mandibular foramen and expanding into the apical third molars, was detected more frequently because of an increased density of the walls.34 These findings were consistent with the findings of Denio et al11 and Gowgiel,42 who reported unreliable radiographic visibility of the canal near the mental foramen because of the lack of specific anterior part of the canal wall. Similarly in 2008, Angelopoulos et al55 showed that the posterior one third of the canal is best seen, followed by the middle third and the anterior one third. In our study, except in the case of the distal third molars, such a pattern is evident. The anterior teeth–viewing capabilities reduced as the root, but this pattern was more obvious on the left side. Because the distal region of the third molar is in the same area of the submandibular gland fossa, a reduction in the trabeculation pattern and osteoporotic appearance is probably responsible for the decreased visual capabilities of the MC. In the study by de Oliveira-Santos,39 an involvement and relevance of such a phenomenon have been documented when the corticated canal walls are absent. Finally, in the current study, approximately 56.3% of the MC was cortical, and these findings are consistent with the results reported by de Oliveira-Santos et al40 that showed 59% of the MCs were cortical.

In the current study, cortical canal was observed in 60% of males and 48% of females. Cortical structures in women have a lower density because of osteoporotic conditions accounting for the higher percentage of noncortical canals.

Cone-beam CT almost in most cases (87.5%) was successful in displaying the MC. The only area where similarity or symmetry was shown was the second premolar area. The authors point out the importance of presented results in everyday practice, especially in oral and maxillofacial surgery.

REFERENCES

Massive Thrombosis of Bilateral Superior and Inferior Ophthalmic Veins Secondary to Ethmoidal Rhinosinusitis: Imaging Findings

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Abstract: Ophthalmic vein thrombosis (OVT) is a rare condition occurring secondary to varied etiologies that commonly present with proptosis, globe dystopia, ophthalmoplegia, periorbital edema, and occasionally diminished visual acuity. It may be related to inflammation of the orbit or paranasal sinuses.

We herein report imaging findings of thrombosed superior and inferior ophthalmic veins in bilateral involvement in a 20-year-old male patient without cavernous sinus thrombosis. He presented with pain, swelling, and blurred vision in both eyes. Magnetic resonance (MR) imaging, cerebral MR angiography, and susceptibility weighted imaging were performed. Bilateral superior and inferior OVT due to a complication of ethmoidal sinuses was diagnosed in the patient. Anticoagulant and systemic broad-spectrum antibiotic therapy was started. His symptoms were recorded at the end of 14 days of the treatment.

Key Words: Superior and inferior ophthalmic veins thrombosis, ethmoidal sinuses, MR imaging, susceptibility weighted imaging

Ophthalmic vein thrombosis is considered to be an early sign of cavernous sinus thrombosis. Clinically, it is characterized by ptosis, chemosis, ocular motility restriction, and normal fundus examination findings.1 Bilateral massive thrombosis of both superior and inferior ophthalmic veins is an uncommon condition. In this article, we presented the imaging findings of bilateral superior and inferior ophthalmic vein thrombosis (OVT) secondary to ethmoidal sinuses.

CLINICAL REPORT

A 20-year-old male patient presented to our emergency department with history of progressive bilateral orbital swelling, pain, and blurred vision in both eyes. He had previously been treated for sinusitis about 5 to 6 days before and had a history of purulent nasal discharge, but was on no regular medications. There was no history of neurological disorder.

On examination, the body temperature was 39.0°C, and he was slightly tachycardic. All his blood investigations were within the normal ranges. Blood pressure was normal. Ophthalmological examination revealed bilateral periorbital swelling with bilateral proptosis. Extraocular movements restricted in all directions. Visual acuity of both eyes was 20/30, and there was no evidence of a relative afferent papillary defect. Fundus examination of both eyes was normal. Neurological examination was unremarkable.

As the ophthalmic findings suggested the possibility of ophthalmic vein and cavernous sinus lesion, MR imaging of the brain and orbits was performed. T2-weighted MR imaging showed bilateral proptosis with dilated and thrombosed superior and inferior ophthalmic veins with hyperintense signal (Figs. 1A, B). T1-weighted MR imaging with gadolinium enhancement and fat suppression revealed a low-intensity signal in the markedly enlarged bilateral superior and inferior ophthalmic veins, consistent with inflammation of the orbit or paranasal sinuses.

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