Original Article

Assessment of the Mandibular Canal and Mental Foramen Variations Using Cone Beam Computed Tomography

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Abstract

Statement of the Problem: It is crucial to have sufficient knowledge about inferior alveolar canal variations in mandibular surgeries. Anatomic imaging of the mandibular canal prior to surgical procedures such as implant placement and sagittal split osteotomy is essential for achieving the best results and confronting minimal complications.

Objectives: The aim of this study was to determine normal variations of the mandibular canal and mental foramen in a selected Iranian population.

Material and methods: This cross-sectional study was conducted on 334 cone beam computed tomography (CBCT) of patients , comprising of 119 males and 215 females , aged between 15-75 years (mean age, 45±7.5 years). The prevalence of anterior loop, the level of mandibular canal cortication, and mental foramen variations were recorded on CBCT images.

Results: Statistical analysis showed no significant differences in the prevalence of the anterior loop and mental foramen variations in both sides regarding the age and gender (p>0.05). Anterior loop was detected in 90.5% of cases, while accessory mandibular canals were observed in 4.6% of the patients. More than one mental foramen was detected in 5 (4.2%) men and 17 (7.9%) women in the right side and in the left side; this was detected in 11(9.2%) men and 10 (4.7%) women. No significant differences were found in the number of mental foramen regarding to gender and age in both sides (p>0.05). A non-significant relationship was observed between the age groups, the gender, and the prevalence of accessory canals. Moreover, statistical analysis did not demonstrate a significant relationship between gender and mandibular canal cortication in both sides.

Conclusions: This study demonstrated that there were numerous anatomical variations of the mandibular canal, mental foramen and, anterior loop.

Introduction

The inferior alveolar canal transmits the inferior alveolar nerve and vessels supplying the mandibular teeth and adjacent structures. It is a hollow space surrounded by bony tissue extending from the mandibular foramen posteriorly toward the mental foramen anteriorly [1]. Knowledge about the accurate position and course of the mandibular canal within the mandible and identifying the anatomical variations are very important for preventing potential complications such as neurosensory disturbances that may occur during surgical dental procedures such as endodontic therapy and implant placement [2]. Injury to inferior alveolar nerve may occur frequently due to the proximity of the lower first and second molar roots to the inferior alveolar canal during extraction of these teeth [3]. Paresthesia of the inferior alveolar nerve after obturation of the teeth during endodontic treatment was also reported [4]. In previous studies, different imaging modalities have been applied for assessment of the normal variation of the anatomy of the mandibular canal including conventional radiographs [1, 5, 6], computed tomography (CT) [7-10] and cone beam computed tomography (CBCT) [11-15]. Conventional radiographs have several limitations including limited reproducibility, magnification and distortion [9]. These techniques only represent two- dimensional (2D) position of the canal and do not demonstrate the buccolingual position of the canal [16]. CBCT is a new accurate modality for three-dimensional (3D) reconstruction of the imaging of dental and maxillofacial structures without any superimposition or magnification [17-20]. A few studies have evaluated the anatomic variations of the mandibular canal and mental foramen using CBCT [21-24]. The purpose of the present study was to evaluate the variations of the mandibular canal and mental foramen in a selected Iranian population using CBCT.

Materials and Methods

The present study was approved by the Institutional Review Board. This cross-sectional study was conducted on CBCT images of 334 patients (119 males and 215 females) aged between 15-75 years

(mean age, 45±7.5 years) who were referred to a private oral and maxillofacial radiology center for various reasons from 2012 to 2016. Patients with maxillofacial deformities, pathologic conditions or positive history of fracture or any previous manipulation, which could change the position of inferior alveolar canal, were excluded. All images were taken by Planmeca Promax 3D MID (Helsinki/ Finland). The adjusted scan parameters were 60-90 KVp and 1 -14 mA depending on the size of the patients. The exposure time was 14 seconds, effective exposure time was 2–6 seconds, and voxel size was 150µm. The CBCTs were analyzed by an oral and maxillofacial radiologist on LG LED computer viewer (E2042C, Korea) using Romexis viewer software. The prevalence of anterior loop, the accessory canals, the level of corticalization of the mandibular canal, and the mental foramen variations were identified in cross-sectional and axial views. Statistical analyses were carried out using SPSS 18 (SPSS, Chicago, IL, USA). Fisher exact test was used to analyze the relationship between age and recorded items. Pearson Chi-square at the significance level of $p<0.05$ was used to evaluate the relationship between gender and the anatomical variations of the inferior alveolar canal.

Results

The prevalence of the anterior loop regarding gender in the left and right side is presented in Table 1. There were no significant differences in the prevalence of anterior loop regarding gender in both sides of the mandible. The prevalence of the number of mental foramen in the left and right sides is presented in Table 2. Single right mental foramens were found in 114 (95.8%) men and 198 (92.1%) women. More than one foramen (Figure 1) was detected in 5 (4.2%) men and 17 (7.9%)

Table 1: The prevalence of anterior loop regarding gender in the left and right sides

| Side | Gender | | P-value |
	Male	Female	
Left	108(90.8%)	194(90.2%)	0.876
Right	107(89.9%)	196 (91.2%)	0.707

Table 2: The anatomic variation of the mental foramen in the left and right sides

	Mental foramen		
Side	Solitary	Double	More than 2
Left	313(93.7%)	18(5.4%)	3(0.9%)
Right	312(93.4%)	16 (4.8%)	6(1.8%)

women. Solitary left mental foramen was detected in 108 (90.8%) men and 205 (95.3%) women. More than one foramen was detected in 11(9.2%) men and 10 (4.7%) women. No significant differences were found in the anatomic variation of mental foramen regarding to gender in the left (p=0.228) and right sides (p=0.191). 285 patients (93.1%) of 15-45 years old group and 29 (96.7%) of older group had one mental foramen on the right side. On the left side, 285 images (93.8%) of the15-45-year-old group and 28(93.3%) of the older group had single mental foramen. Statistical analysis did not show a significant relationship between age and the frequency of mental foramen on the right (p=0.451) and left sides (p=0.929). The incidence of accessory canals in the right and left sides regarding to gender is presented in Table 3.A non-significant relationship was also found between gender and prevalence of accessory canal on the right side (Table 3). A total of 304 patients (91%) were 15-45 (group1) years old and 30 cases (9%) were more than 45 years old (group 2). The accessory canals were not found in 288 (94.7%) patients in the 15-45-year-old group and 28 (93.3%) of the older group. A non-significant relationship was observed between the age groups and prevalence of accessory canals (p=0.745). The

Figure 1: Double mental foramen in a sample patient

upper and lower cortication of the right mandibular canal were detected in 42 (35.3%) males and 58 (27%) females, and lower or upper cortication in 42 (35.3%) male and 71 (33%) females and in 7 men (5.9%) and 16 women (7.4%) in some instances. Upper and lower cortication on the left side was observed in 47 men (39.5%) and 62 (28.8%) women. Lower or upper cortication was detected in 34 (26.8%) males and 68 (31.6%) females, and finally in 27 (22.7%) male and 64 (29.8%) female no cortication was detected. Statistical analysis did not demonstrate a significant relationship between gender and mandibular canal cortication on the right (p=0.232) and left sides (p=0.228).

Table 3: The prevalence of accessory canals regarding gender in the left and right sides

	Gender		
Side	Male	Female	P-value
Left	4 (3.4%)	14 (6.5%)	0.222
Right	6 (5%)	12 (5.6%)	0.834

Discussion

The present study provided information about the variations in the mandibular neurovascularization that must be identified to decrease the potential risk for hemorrhages and neural disturbances during surgical procedures such as implant placement and orthognathic surgeries. Verification of the existence of accessory mental foramina is important for prevention of accessory nerve damage with subsequent neurosensory impairment during periapical surgery and anesthetic applications [25, 26]. In the current research, the results showed that 12.8% of patients had accessory mental foramina that were higher than previous reports. In previous studies, the accessory mental foramen was observed in 9.2% [22], 3% [27], 6.5% [26], 7% of patients [23] in CBCT images. This variation in the prevalence of accessory mental foramen in studies, which used the same detection method (CBCT), may be due to the difference in the sample size and the racial variation of the patients studied. To avoid injuring the mental nerve, it is essential to evaluate whether an anterior loop of the mental nerve or the

incisive canal lies mesial to it [28]. Apostolakis *et al*. showed that an anterior loop could be identified in 48% of the cases with a mean length of 0.89 mm (0-5.7) [21]. In this study, the anterior loop was found in a large number of the images (on right side of 303 and left side of 302 patients).

Powcharoen and Chinkrua suggested that the absence of mandibular canal cortication has high sensitivity and specificity for predicting intraoperative IAN exposure during third molar surgery [29]. In this research, mandibular canal cortication was the prominent finding in most of the cases. Corticalization of the mandibular canal was observed in 59% of hemimandibles in the study by de Oliveira-Santos *et al*. [24]. No cortication was seen on the left sides of 27.2% patients and right side of 29.3% ones. Large variations exist in the size of mandibular accessory foramina. They may be as small as 0.1 mm or reach a width of more than 1.5 mm and often resemble the original foramina in size. Smaller foramina have seldom been measured because they are indistinguishable from the normal porous appearance. Furthermore, variations also exist in relation to their number. Some mandibles may have none, while in rare instances in one mandible up to 100 foramina were observed. Most studies agree that the majority of foramina are concentrated in the posterior areas of the mandible and to a lesser degree in the symphysis, and are much more frequent on the internal than the external surface of the mandible [30]. The incidences of accessory canals in the retromolar area of the right side were 4.8% (16 cases) and 4.5% (15 cases) in the left side (Figure 2). The frequency of retromolar canal (RMC) in CBCT images has been reported to be 8.5% in Korean, 28.1% in Turkish [31] and 52% (37% of sides) in the Japanese populations [32]. Previous studies suggested that panoramic radiograph is not a suitable imaging modality for assessment of RMC because of the superimposition of various structures over the area. CBCT images provide 3D images without any superimpositions and with higher resolution. Moreover, von Arx *et al*. reported a prevalence of 25.6% of RMC in CBCT and showed that among 31 RMC observed in CBCT, panoramic radiographs were able to identify just 7 cases (5.7% of samples) [33]. Similarly, Muinelo-Lorenzo *et al*. [34] demonstrated that only 32.5%

Figure 2: Retromolar accessory canal in a sample patient

of RMFs detected on CBCT images were found on panoramic radiographs. Furthermore, Sisman *et al*. found 253 RMC (26.7%) on 947 sides of CBCT images while only 29 RMC were seen on panoramic radiographs (3.1%) [35].

Conclusions

This study showed that that there were numerous anatomical variations in the normal anatomy of the mandibular canal and the mental foramen. Dentists should be familiar with these variations in order to prevent treatment complications. CBCT provides an effective tool for pre-surgical evaluation of the neurovascular structures and its variations.

Conflict of Interest: None declared.

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