Localization of the Mandibular Canal in a Turkish Population: a Retrospective Cone-Beam Computed Tomography Study

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ABSTRACT

Objectives: The aim of this study was to determine the location of the mandibular canal at the mental foramen region that is essential in order to prevent injuries to the inferior alveolar neurovascular bundle during mandibular surgical procedures.
Material and Methods: The position of the mandibular canal was analysed using cone-beam computed tomography images from 300 Turkish patients, who were referred to Department of Oral and Maxillofacial Radiology, Faculty of Dentistry, Izmir Katip Celebi University for various complaints. The distances of the mandibular canal to the outer superior (D1), inferior (D2), buccal (D3), and lingual (D4) cortical margins were measured at 2 mm distal to the mental foramen.
Results: There were 148 (49.3%) males and 152 (50.7%) females with ages ranging from 15 to 74 years (39.15 [SD 17.8]). D1 was significantly greater than D2 and D3 was significantly greater than D4 on both left and right sides. While the mean D1, D2, and D4 in males were significantly greater than in females on both left and right sides. There was no significant difference between D3 in males and females on both left and right sides.
Conclusions: The results showed that the mandibular canal was vertically located nearer to the inferior cortical border and horizontally nearer to the lingual cortical border of the mandible at the mental foramen region. Knowledge of the distances of mandibular canal to the outer cortical margins at this region of the mandible will be helpful for surgical procedures.

Keywords: cone-beam computed tomography; inferior alveolar nerve; mandible.

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INTRODUCTION

The mandibular canal (MC) is located within the internal aspect of the mandible that is beginning in the mandibular foramen on the medial surface of the ascending mandibular ramus. It runs obliquely downward and forward in the mandibular ramus, and then horizontally forward in the body of the mandible, and it ends at the mental foramen (MF) [1].
The MC transmits the inferior alveolar neurovascular bundle that contains the inferior alveolar nerve (IAN), inferior alveolar artery, and inferior alveolar vein. The IAN provides sensory innervation to the teeth and mucoperiosteum of mandibular teeth. It also supplies sensory innervation to the chin and lower lip [2]. The MC is vulnerable during surgical procedures, orthodontic treatment, and endodontic treatment involving the mandible due to an involvement of the neurovascular bundle [1,3]. Therefore, it is highly important to know its intraosseous position, course, and branches of the IAN for clinical dental procedures in terms of aiding in diagnosis, treatment planning, and surgical procedure [1,4]. Moreover, if IAN and the MF are not properly identified, some complications, such as altered sensation, numbness, and pain often occurred [5].
Currently, three-dimensional imaging techniques give more detailed information for the MC [6]. Cone-beam computed tomography (CBCT) typically imposes a lower dose to patients compared to conventional medical computed tomography (CT) [7].
There have been many studies on anatomic variations, morphologic evaluation, the location of the MF and MC [1,4,8-13]. Various patterns of MF and its location have been described. Furthermore, an average prevalence of the anterior loop was reported 47% in the literature [14]. MC has various courses in different regions of the mandible [15]. However, there is not enough information about the location of MC at the MF region. Therefore, the aim of this study is to determine the location of MC at MF region.

MATERIAL AND METHODS

This retrospective study was approved by the Izmir Katip Celebi University Non-Interventional Clinical Studies Institutional Review Board (No. 2018-GOKAE-0611). Previously obtained 300 CBCT images for various reasons were selected from the archive of the Department of Oral and Maxillofacial Radiology, Faculty of Dentistry, Izmir Katip Celebi University and retrospectively analysed. The sample was composed of 152 females and 148 males with ages ranging from 15 to 74 years. As a routine protocol, all patients in our CBCT archive had been informed and provided written consent regarding the use of their data for scientific research.
All images were obtained in the supine position, using a NewTom 5G CBCT machine (QR srl, Verona, Italy), operating at 110 kVp, 1 - 20 mA with a 15 x 12 field of view (FOV) and standard resolution mode (0.2 mm voxel size). Exclusion criteria were determined as:

- < 15 years of age.
- Presence of missing mandibular premolars.
- Presence of any pathological and developmental conditions in the region of the MF (i.e., tumours, cysts, fractures, or malformations).
- Presence of impacted or partially erupted teeth in the anatomic region.
- Presence of poor image quality with severe artefacts.

The MC and MF were detected using NNT software (QR srl, Verona, Italy) on a medical monitor (Radiforce MX270W; Eizo Radiforce, Ishikawa, Japan) in a dark room by a calibrated oral and maxillofacial radiologist. At first, a panoramic image with a 30 mm thickness and cross-sectional images perpendicular to the mandibular dental arch with a 1 mm section interval, and a 1 mm section thickness were obtained from each CBCT data. MC was detected on the cross-sectional slice that 2 mm distal to the MF. This cross-sectional slice was used to measure the following distances (Figure 1):

- Upper distance (D1) - the distance from the superior border of the MC to the superior border of the alveolar process.
- Lower distance (D2) - the distance from the inferior border of the MC to the inferior mandibular border.
- Buccal distance (D3) - the distance from the buccal border of the MC to the outer buccal margin of the mandible.
- Lingual distance (D4) - the distance from the lingual border of the MC and the lingual margin of the mandible.

Statistical analysis

Statistical analysis was carried out using SPSS v.22 (SPSS Inc, IBM, USA). Descriptive statistics including the means and standard deviations for each measurement were calculated for both side and gender. Parametric data were expressed as mean and standard deviation (M [SD]). Independent samples t-test was used to calculate differences between gender and differences between left and right sides.

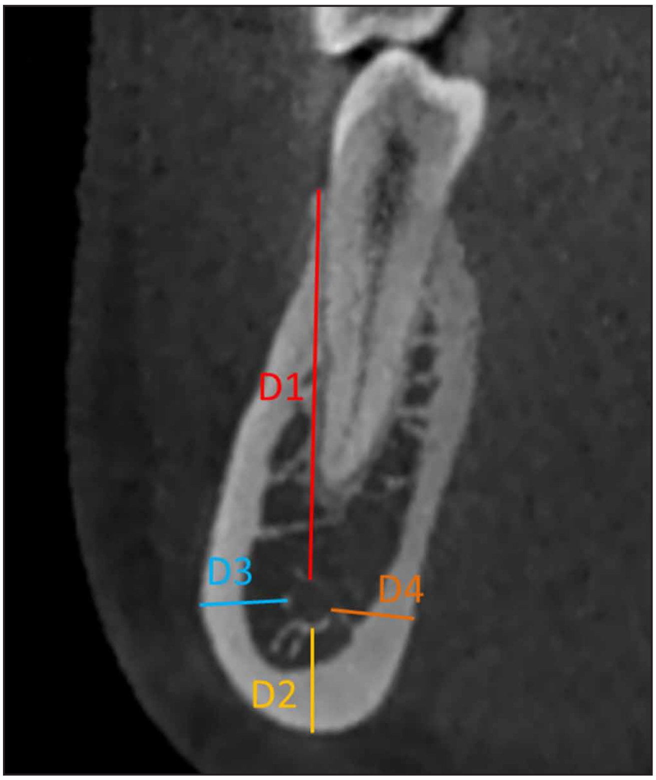

Figure 1. D1 = The distance from the superior border of the mandibular canal (MC) to the superior border of the alveolar process (upper distance).
D2 = The distance from the inferior border of the MC to the inferior mandibular border (lower distance).
D3 = The distance from the buccal border of the MC to the outer buccal margin of the mandible (buccal distance).
D4 = The distance from the lingual border of the MC and the lingual margin of the mandible (lingual distance).

Paired samples t-test was used to determine vertical and horizontal position of the MC. Statistical significance level was defined at P = 0.05. Seventy-five CBCT images (25% of the images) were randomly selected and re-evaluated by the same investigator 2 weeks after the first evaluation to determine intra-examiner reliability using the intraclass correlation coefficient.

RESULTS

A total of 300 patients were included in the study. There were 148 (49.3%) males and 152 (50.7%) females with ages ranging from 15 to 74 years (39.15 [17.8]). The coefficients of reliability for all measurements were > 0.96. The results of the paired-sample t-test revealed no significant difference between the two sets of readings (P > 0.05).
The mean D1, D2, D3, and D4 on the right side were 15.65 (3.54), 8.95 (1.68), 4.09 (1.33), and 2.37 (0.8) mm respectively. The mean D1, D2, D3 and D4 on the left side were 15.73 (3.59), 8.96 (1.68), 4.11 (1.37), and 2.33 (0.78) mm respectively. D1 was significantly greater than D2 and D3 was significantly greater than D4 on both left and right sides. These results mean that MC was vertically located nearer to the inferior cortical border and horizontally nearer to the lingual cortical border of the mandible (Table 1). While the mean D1, D2, and D4 in males were significantly greater than in females on both left and right sides. There was no significant difference between D3 in males and females on both left and right sides (Table 2).
The mean D1, D2, D3, and D4 on the right side were compared with on the left side in males, females, and all patients. There was no significant difference in the mean D1, D2, D3, and D4 between on the right and left sides of the mandible in both genders and all patients (Table 3).

Table 1. Comparison of the measurements (mm) between D1 and D2, and between D3 and D4 on both left and right sides

	Right		Left	
	Mean (SD)	**P**	**Mean (SD)**	**P**
D1 (n = 300)	15.65 (3.54)	0.000[a]	15.73 (3.59)	0.000[a]
D2 (n = 300)	8.95 (1.68)		8.96 (1.68)	
D3 (n = 300)	4,09 (1.33)	0.000[a]	4.11 (1.37)	0.000[a]
D4 (n = 300)	2.37 (0.8)		2.33 (0.78)	

[a]Significant, paired samples t-test (significance level P < 0.05).
D1 = upper distance; D2 = lower distance; D3 = buccal distance; D4 = lingual distance; n = number of cases; SD = standard deviation.

Table 2. Comparisons the distances (mm) between males and females

	Males	Females	All cases	P
	Mean (SD)	**Mean (SD)**	**Mean (SD)**	
Right				
D1	16.59 (3.25)	14.74 (3.58)	15.65 (3.54)	0.000[a]
D2	9.41 (1.65)	8.49 (1.57)	8.95 (1.68)	0.000[a]
D3	4.11 (1.43)	4.06 (1.23)	4.09 (1.33)	0.747[b]
D4	2.52 (0.84)	2.22 (0.74)	2.37 (0.8)	0.001[a]
Left				
D1	16.71 (3.24)	14.78 (3.66)	15.73 (3.59)	0.000[a]
D2	9.55 (1.65)	8.38 (1.51)	8.96 (1.68)	0.000[a]
D3	4.17 (1.42)	4.06 (1.33)	4.11 (1.37)	0.511[b]
D4	2.43 (0.83)	2.24 (0.71)	2.33 (0.78)	0.042[a]

[a]Significant, independent samples t-test (significance level P < 0.05).
[b]Not significant, independent samples t-test (significance level P < 0.05).
D1 = upper distance; D2 = lower distance; D3 = buccal distance; D4 = lingual distance; n = number of cases; SD = standard deviation.

Table 3. Comparisons the distances (mm) between on right and left sides

	Males		Females		All	
	t	P	t	P	t	P
Right D1 - left D1	-0.317	0.751[a]	-0.088	0.93[a]	-0.267	0.79[a]
Right D2 - left D2	-1.146	0.253[a]	0.628	0.53[a]	-0.943	0.346[a]
Right D3 - left D3	-0.326	0.745[a]	0.004	0.996[a]	-0.238	0.812[a]
Right D4 - left D4	0.946	0.345[a]	-0.252	0.801[a]	0.537	0.592[a]

[a]Not significant, Independent samples t-test (significance level $P < 0.05$).
D1 = upper distance; D2 = lower distance; D3 = buccal distance; D4 = lingual distance; n = number of cases; SD = standard deviation.

DISCUSSION

The awareness of the location of various anatomical structures such as mandibular foramen, the MC and MF and the course of the mandibular neurovascular bundle is obligatory to achieve the desired surgical outcome of the procedures performed at different levels of the mandible. Knowledge of these vital anatomical structures facilitates to achieve various surgical complications [16].

In the literature, the studies related with the localization of MC and/or MF were performed on cadaveric materials [1,17,18], dry skulls [19], panoramic radiographs [8,10,20,21], CT scans [2,11,22], and CBCT images [23-25]. Assessment the location of MC on dry skulls has some limitations such as lack of gender and age. The findings from researches using cadavers may not be generalized to patient populations due to differences in age or disease [11]. Assessment the location of MC using CBCT has certain advantages, such as accurate measurements compared with panoramic radiography [26] and high spatial resolution, low cost, and low radiation doses compared with CT [7]. CBCT is a useful and reliable tool for the presurgical measurement of the MC region that is essential for avoiding injury to the neurovascular bundle [27].

In the previous studies, the location of MC was evaluated at different regions of the mandible. Levine et al. [11] measured the distances between the buccal aspect of the IAN canal and the outer buccal cortical margin of the mandible, and the superior aspect of the IAN canal and the alveolar crest at the position of the mandibular first molar furcation. They reported that the canal was 4.9 mm from the buccal cortical margin and 17.4 mm from the alveolar crest. Safaee et al. [25] measured the distances between the center of the IAN canal and the outer buccal cortical margin, and the center of the IAN canal and the outer lingual cortical margin of the mandible on the cross-sectional images of mandibular arch at the second premolar apex, median point of two root apices of the first molar, and median point of two root apices of the second molar. They found that the position of MC was influenced by the location of the MF. The direction of MC gradually changed from lingual to buccal and from posterior to anterior. The course of MC from the posterior to the anterior was progressively changed from the lingual to the buccal. Hsu et al. [23] performed the measurements from the MC to the upper border, the buccal border, and the lingual border of the mandible at second premolar and first molar sites by using CBCT. They found that the distance from the MC to the buccal border of the second premolar was significantly smaller than that of the first molar.

In our study, we assessed the location of MC at 2 mm distal to MF. The location of MF varies among races and genders [28]. Therefore, we preferred to measure the distances of MC to the outer cortical margins on the first cross-sectional slice distal to the MF instead of measuring on the first or second mandibular premolar area. The presented results showed that MC was vertically located nearer to the inferior cortical border and horizontally nearer to the lingual cortical border of the mandible. Moreover, the mean upper, lower and lingual distances in males were significantly greater than in females on both left and right sides. While there was no significant difference in buccal distance between males and females on both left and right sides. This difference in upper, lower and lingual distances between sexes can probably be attributed to the fact that males are generally physically larger than females in most dimensions.

Kılıç et al. [1] performed a study to identify through direct measurement the position of the MC on the hemimandible specimens from human cadavers. Their measurements on the first section distal to the MF showed that the MC was located vertically closer to the inferior cortical margin of mandible while horizontally closer to the lingual cortical margin of the mandible, similar to our study. They found that the distances of MC to the outer cortical margins were slightly lower in females than males, but the differences were not statistically significant. However, we found that the mean upper, lower, and lingual distances of MC to the outer cortical margins in males were significantly greater than in females on both left and right sides. In the study of Kılıç et al. [1], the lack of significant differences in the distances of MC to the outer cortical margins can probably be explained as a result of including a smaller number of specimens compared with our study.

In a cadaveric study, Gowgiel et al. [29] examined dissected human cadaver mandibles for the determination of the precise location of the MC. They observed that the MC was located in contact with, or very close to, the lingual cortical plate until it reached the MF, consistent with our study. De Oliveira Junior et al. [4] analysed 50 partially dentulous patients and measured the distances from the MC to the surrounding mandibular cortical plates on the mandibular premolar and molar regions using CT images. Contrary to our study, they reported that the MC was localized nearer the lingual surface in the posterior mandible and then it became progressively more superficial in relation to the buccal surface of the mandible towards to the MF. Hwang et al. [18] found that the MC was quite nearer to the lingual side at the first and second molar level, but slightly nearer to the lingual side (mean buccal distance: 4.3 [1.3] mm, mean lingual distance: 4.2 [1.3] mm) at the second mandibular premolar level.

CONCLUSIONS

In the presented study, we analysed the cone-beam computed tomography image of 300 Turkish patients and revealed the location of mandibular canal at mental foramen region. Knowledge of the distances of mandibular canal to the outer cortical margins at this region of the mandible will be helpful for surgical procedures.

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