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Original Article

Prevalence of bifid mandibular canal according to gender, type and side

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Abstract *Background/purpose:* An awareness of mandibular canal variations may help prevent complications due to nerve damage that can occur during surgery. The aim of this study is to evaluate the variations of mandibular canal distribution and frequency via cone beam computed tomography (CBCT), retrospectively, in a Turkish population.
Materials and methods: The study population comprises 500 (250 female, 250 male) randomly selected participants between the ages of 14 and 79 years. The study was conducted in Marmara University, Faculty of Dentistry, in the Department of Dentomaxillofacial Radiology. The distribution and frequency of mandibular canal variations were evaluated using the Naitoh classification, which includes retromolar canal, forward canal, dental canal, and buccolingual canal. The trifid canal was also included in this study. The data were analysed using IBM SPSS statistics 20.0. The data were then compared based on age group and gender.
Results: Bifid mandibular canals (BMCs) were found in 200 (40%) of the 500 subjects, and in 248 of the 1000 sides (24.8%). Mandibular canal variations were observed in 71.5% of patients on the right side, 52.5% on left side and 24% bilaterally. The forward canal was the most common type (48.8%), followed by the retromolar canal (26.2%), the dental canal (12.9%), the buccolingual canal (9.7%), and the trifid canal (2.4%).
Conclusion: BMCs were detected at a high rate in the Turkish subpopulation. Moreover, CBCT appears to be an appropriate method to assess the entity and shape of BMCs.

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Introduction

The mandibular canal extends bilaterally from the mandibular foramen to the mental foramen, carrying the inferior alveolar neurovascular bundle.[1–4] Knowledge of the location and shape of the mandibular canal is crucial for surgical processes involving the mandibula. Although the mandibular canal has been shown to be a single formation, anatomical variations have also been described.[1,5–7]

The term bifid has its origins in Latin and means cleft into two parts. Chavez et al.[8] has proposed that three diverse inferior dental nerves are fused together during embryonic maturation to make a single nerve. Thus, the bifid and trifid mandibular canals consist as a consequence of the unfinished fusion of these three nerves.[1]

The presence of these anatomic structures has crucial clinical implications. Indeed, an awareness of the mandibular canal variations can help prevent complications that may arise due to damage of the BMC during surgery. Traumatic neuroma, paraesthesia, anaesthesia and bleeding are all possible complications.[6,9]

Some authors have classified the pattern of BMCs based on their anatomic location and shape. While Nortje et al.[10] and Langlais et al.[11] performed panoramic radiography, Naitoh et al.[2] performed cone beam computed tomography (CBCT).

Studies in which panoramic radiography was used to describe BMCs have declared incidence rates between 0.08% and 0.95%.[10–14] Detecting the mandibular canal and its variations using panoramic radiography might be difficult due to ghost images that may be formed by the opposing side of the mandible and superposition of the adjacent structures.[1,2,6] Due to the limitations of panoramic radiography, the ratios reported by prior studies may have been underestimated.[6] Compared to panoramic radiography, CT and CBCT are excel at illustrating the mandibular canal and variations, and can provide high-quality 3D images.[3,6,15] Although it is possible to perform CT, its application has been limited in dentistry due to cost, access and the risk of high radiation doses.[16,17]

Thus, CBCT is a new technology for imaging the dentomaxillofacial region. This method is capable of providing accurate, submillimetre-resolution images and low radiation dose.[29] The BMC can be defined accurately using the multiplanar images obtained via CBCT.[8] Nevertheless, several reports have found obvious differences between different populations with regard to the existence rate, type, length, diameter, and angle of the BMCs.[1,2,5,6] Therefore, the aim of this research is to evaluate the frequency of mandibular canal variations in a Turkish population via CBCT.

Materials and methods

In this retrospective research, 500 patients (250 female, 250 male) underwent CBCT imaging for different indications in the Department of Dentomaxillofacial Radiology at the Marmara University Faculty of Dentistry. The patients' mean age was 38.24 years (age range 14–79 years). Approval for the study was obtained from the Department of Non-invasive Clinical Research Ethics Committee, Marmara University Faculty of Medicine (Project No: 092015140). Only high-quality images were included and pathologies effecting the mandibular canal were excluded.

All the CBCT examinations were acquired using Planmeca Promax 3D Mid (Planmeca Oy, Helsinki, Finland) at 90 kV, 12 mA and a 36-second exposure time. The Romexis 2.92 software program (Planmeca Oy, Helsinki, Finland) was used to reconstruct and evaluate all of the projections. The images were exported and saved as single frame DICOM files. The images were assessed directly on the monitor screen (Monitor 14-inch Full HD LED 3200 × 1800 pixel Lenova Flex 2 PC).

To ensure a professional and efficient evaluation, the clinician and dentomaxillofacial radiology specialist (ÖO) evaluated the images. When disagreement occurred, it was discussed with the clinician and dentomaxillofacial radiology specialist (AD) who had been working in the Department of Dentomaxillofacial Radiology for 15 years or more and reached final consensus.

The mandibular canal and its variations were evaluated using coronal, sagittal, cross-sectional and panoramic reconstructed CBCT images for all semi-mandibles. The BMCs were classified according to the criteria proposed by Naitoh et al.[2] Based on the source site and the course by the separated canal from the mandibular canal (Fig. 1), Naitoh et al. classified into the following four categories: retromolar, dental, forward and buccolingual with CBCT. In addition, the trifid canal type also was included in this study. In the other classifications for describing mandibular canal variations, the panoramic radiography has been used so we used the classification proposed by Naitoh et al.[2]

1) Forward canal: the branch emerging from the upper border of the main canal.

A. Forward canal without confluence: It separates from the mandibular canal in the mandibular ramus and then extends to the second molar area.

B. Forward canal with confluence: It separates from the mandibular canal in the mandibular ramus, extends anteriorly and then rejoins to the main mandibular canal.

2) Buccolingual canal: the branch emerging from the buccal or lingual side of the main canal.
3) Dental canal: the end of the separated canal reaches the root apex of the first, second and third molar.
4) Retromolar canal: the branch emerging from the main canal reaches the retromolar region.

Statistical analysis

The data were analysed using IBM SPSS statistics 22 (SPSS Inc., Chicago, IL, USA). Descriptive statistical methods (mean, standard deviation and frequency) were used to evaluate the data. A Chi square test was performed to compare the qualitative data. The values of $p < 0.05$ were interpreted as significant.

Results

BMCs were observed in 248 out of 1000 sides (24.8%) and in 200 out of 500 patients (40%). These canals were identified

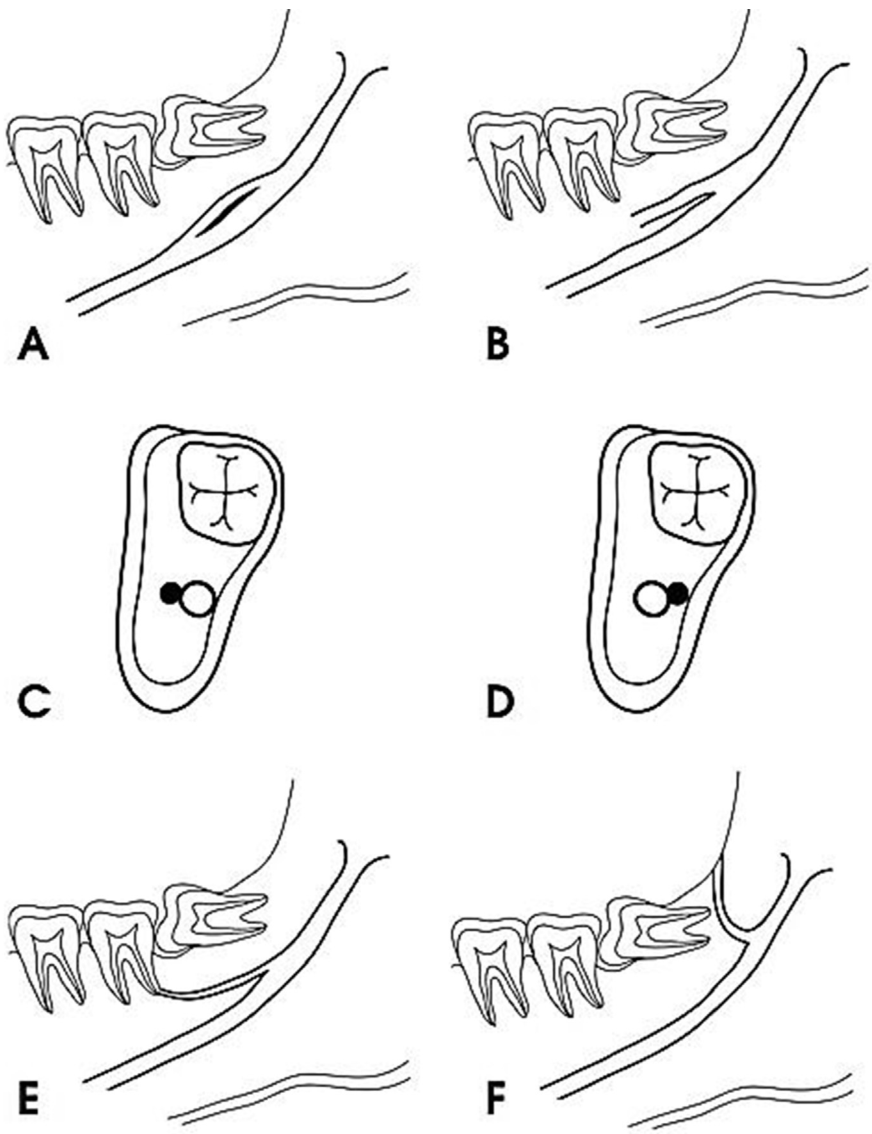

Figure 1 Naitoh classification. The forward canal subdivided into with confluence (A) or without confluence (B). The bucco-lingual canal from the buccal or lingual wall (C and D). The dental canal reached to the root apex (E). The retromolar canal opened to the retromolar region (F).

in 106 females (53%) and 94 males (47%). Thus, there is no significant difference between males and the females with respect to the incidence of BMC ($p < 0.05$) (Table 1). The incidence of BMC according to age was 14.5% in those aged 25 years and under, 28.5% in participants aged 26–35 years, 26.5% in the age group 36–45 years, and 30.5% in those aged 45 years and over. Based on the pairwise comparisons, the incidence of BMC in those aged 25 years and under was significantly lower than in the other age groups ($p < 0.05$) (Table 2).

Table 1 Prevalence of bifid mandibular canal according to gender.

		Bifid Mandibular Canal (n = 200)		p
		n (%)	%	
Gender	Female	106	53.0	0.396
	Male	94	47.0	

Chi-square test $p < 0.05$.

Table 2 Prevalence of bifid mandibular canal according to age.

		Bifid mandibular canal (n = 200)		p
		n (%)	%	
Age groups	≤25	29	14.5	0.006**
	26–35 years	57	28.5	
	36–45 years	53	26.5	
	≥45	61	30.5	

Chi-square test **$p < 0.05$.

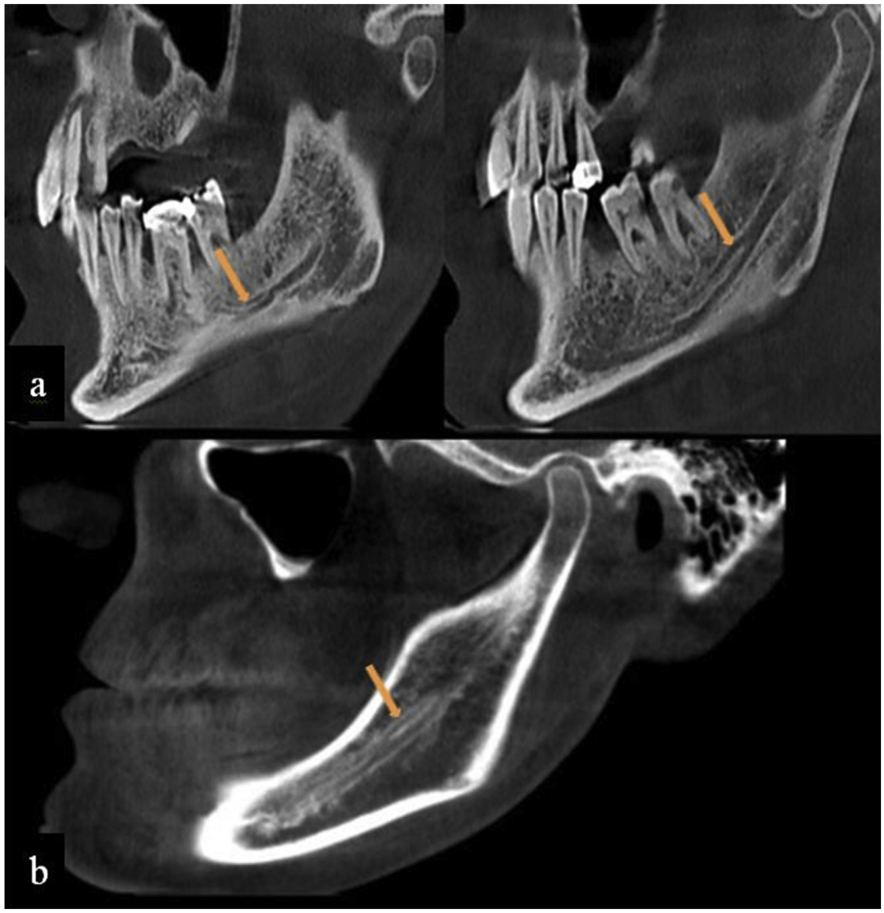

Figure 2 a: Forward canal without confluence (arrows). b Forward canal with confluence which bifurcated from the mandibular canal and then joined up with the main canal (arrow).

The forward canal was the most common type (n = 121, 69 right sides (27.8%), 52 left sides (21%) (Fig. 2), followed by the retromolar canal (n = 65, 38 right sides (15.3%), 27 left sides (10.9%) (Fig. 3a), the dental canal (n = 32, 21 right sides (8.5%), 11 left sides (4.4%) (Fig. 3b), the buccolingual canal (n = 24 sides, 11 right sides (4.4%), 13 left sides (5.2%) (Fig. 4) and the trifid canal (n = 6 sides, 4 right sides (1.6%), 2 left sides (0.8%) (Fig. 5).

Of the 121 forward canals observed, 19 (1.9%) consisted with confluence and 102 (10.2%) without confluence. Of the 32 dental canals detected, 15 (1.5%) reached the root apex of the first molar, 6 (0.6%) reached the second molar and 11 (1.1%) reached the third molar. Of all 24 buccolingual canals, 12 (1.2%) were considered buccal and 12 (1.2%) lingual (Table 3).

Discussion

The bifid mandibular canal is one of the most common variations of the mandibular canal, although it is usually neglected in clinical practise. However, researchers have begun to pay more attention to the presence of BMCs since the first case was reported.[10] The existence and morphology of BMCs are evaluated using different tools, instruments, and techniques, such as panoramic radiography, histopathology, CT, and CBCT.[2,12,18,19] Nevertheless,

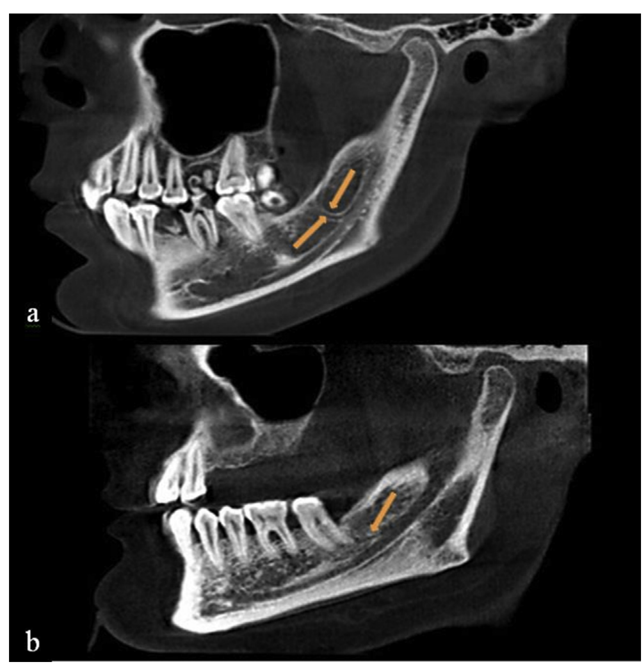

Figure 3 a: Sagittal image showing retromolar canal type which bifurcated from the main canal to retromolar region (arrows). b dental canal type which bifurcate from the mandibular canal and extended to the apex of the second molar (arrow).

several reports have found obvious differences between different populations with regard to the existence rate, type, length, diameter, and angle of the BMCs.

The knowledge of the morphology and topography of the mandibular canal is substantial for the practise of surgical procedures of the mandible due to carrying vessels and nerves.[20—22] Mandibular canal variations have been defined via panoramic radiography,[10—13,23]CT imaging[19,23—25] and CBCT imaging (Table 4).[1—3,5,6,25—27] When previous studies were examined, the highest frequency was observed in the Turkish population. The reason for this difference may be due to differences in the sample groups.

Although panoramic radiographs are routinely used for the pre-operative assessment of such surgical procedures, there are several drawbacks when using these to assess the entity and shape of BMCs.[3] Lindh et al.[28] have reported that the mandibular canal was only obviously distinguished in just 25% of panoramic radiography. Therefore, the frequency determined by previous studies that have used panoramic radiography might be incorrect.[6] In contrast to panoramic radiography, CBCT can more accurately detect bifid canals.

Based on research conducted using panoramic radiography, the frequency of mandibular canal variations is between 0.08 and 0.95%. Moreover, in research using CBCT, the BMCs frequency has been found to be in the range of 15.6—64.8%.[6] Prior researches have determined that the BMC frequency obtained using CBCT was significantly higher than that acquired via panoramic radiography. In this study, the BMC frequency was 24.8%, which was lower than the frequency declared by Naitoh et al.,[2] Naitoh et al.[27] and Orhan et al.[1] although it was higher than what was found by other studies using CBCT.

Several authors[2,10,11] have used various classifications for bifid mandibular canals. This research used the classification proposed by Naitoh et al.,[2] with the addition of the trifid canal. Naitoh et al.[2] used CBCT imaging to categorize BMC into four types based on the route of the separated canal from the mandibular canal. The buccal or lingual type of BMC can be only categorized according to Naitoh's classification, as they cannot be categorized in other classifications using panoramic radiography.[6]

Based on the research conducted by Naitoh et al.,[2] the forward canal is the most common type of BMC (27.9%), while the buccolingual canal is the least common (0.8%). Orhan et al.[1] used the same classification on a Turkish population and also found that the forward canal was the most common type (17.8%), although the dental canal was

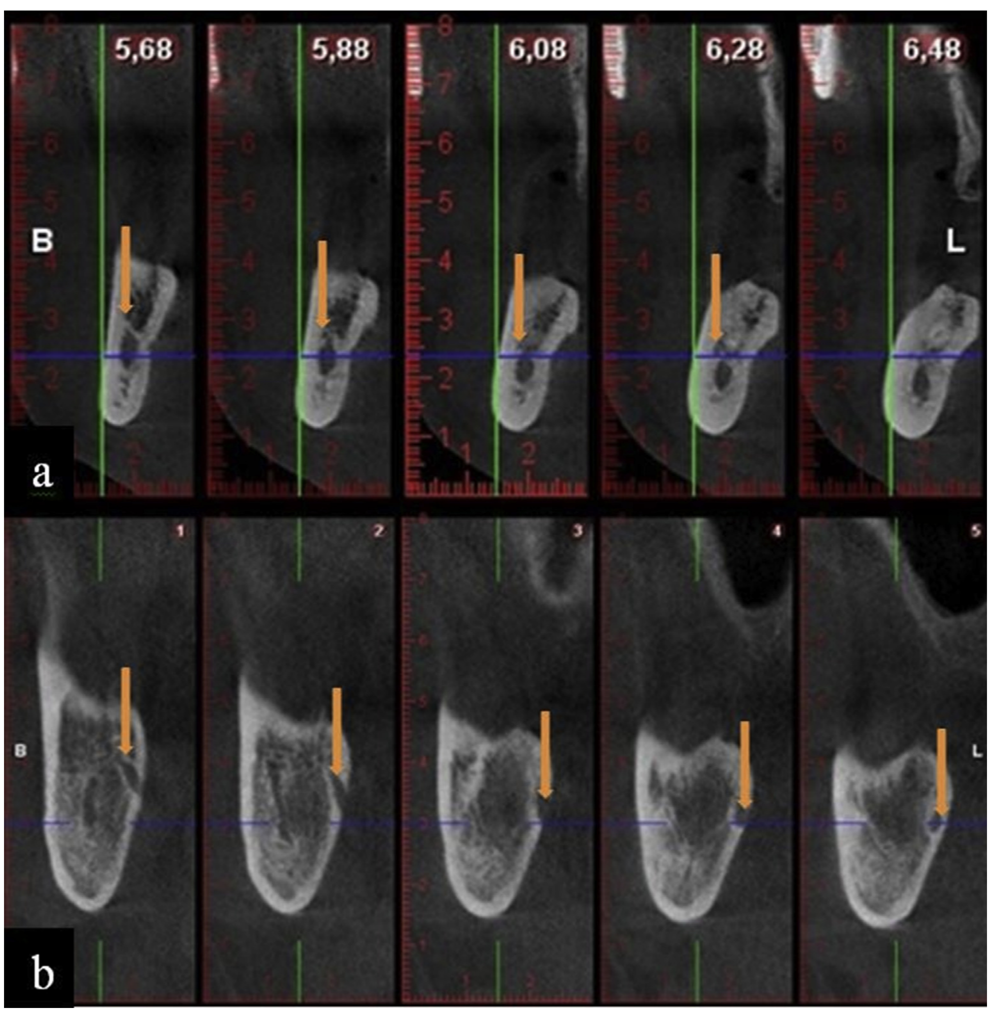

Figure 4 a: Bukkal. b Lingual canals bifurcated from the main canal and course lingual and buccal side of the mandible (arrows).

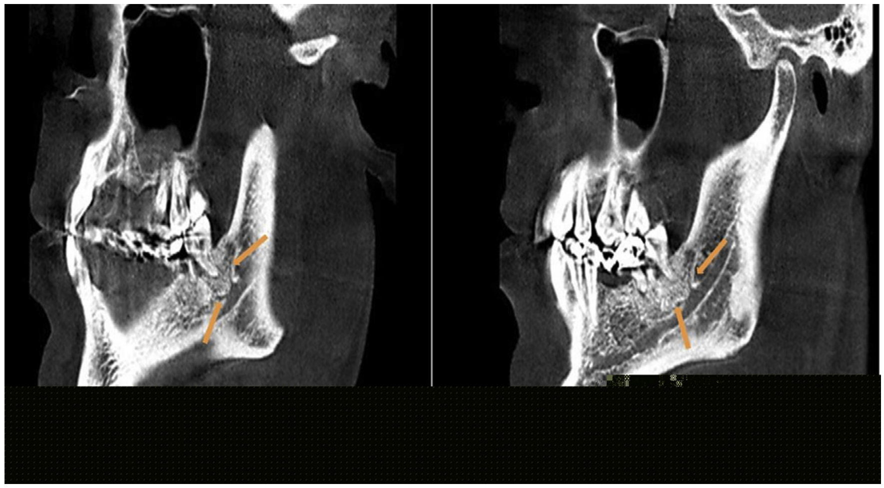

Figure 5 a,b Trifid canal (retromolar canal and forward canal) (arrows).

found to be the least common (4.3%). Similarly, in our study, the forward canal was the most common type of BMC (12.1%), followed by the retromolar canal (6.5%), the dental canal (3.2%), the buccolingual canal (2.4%); The trifid canal was found to be the least common type (0.6%). Conversely, in studies conducted by Kang et al.[6] and Rashsuren et al.[5] on a Korean population, the retromolar canal was found to be the most common type. Moreover, Rashsuren et al.[5] also found the trifid canal to be the least common.

In another study, Yang et al.[29] evaluated 280 CBCT images and classified BMC according to Natioh's classification and they found the occurrence rate of 31.1% of BMC. Similar to our study, their results indicate that the forward canal exhibits the highest occurrence rate, followed by the retromolar canal. However, unlike the present study, the dental canal was not observed.

In another study, Shen et al.[30] used two different classifications of bifid canals by defined Nortje et al.[10] and Naitoh et al.[2] They evaluated 135 CBCT images and 173 multi slice CT images and reported that 170 (27.6%) bifid canals were found in 616 hemimandibles and 127 (41.2%) bifid canal in a total of 308 subjects.

As in a number of previous studies,[1,3,11,27,31] there was a slightly higher prevalence of BMC in the female population. However, the difference between genders was not significant (53%). Other studies[5,6,19,29] have reported a higher prevalence of BMC in males. Fue et al.[19] have stated that gender difference is more likely due to the population studied rather than the type of imaging employed.

In the previous studies, the incidence of the BMC according to age was evaluated. Kang et al.[6] reported that there was no significant difference in the incidence with respect to age but the incidence was more frequently for patients in 3rd decade. Rashsuren et al.[5] reported that the incidence was more frequently for patients in 2nd decade. In our study, the incidence of BMC in those aged 25 years and under was significantly lower than in the other age groups. The reason for this difference may be due to differences in the sample groups.

Classifying BMC type, especially retromolar and dental canal, is clinically crucial.[2,5] The retromolar canal may be

Table 3 Prevalence and rate of bifid mandibular canal according to gender, type and side.

	Of all sides (%) (n = 1000)	Right side			Left side		
		Female	Male	Total	Female	Male	Total
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Retromolar canal	65 (6.5%)	21 (8.5%)	17 (6.9%)	38 (15.3%)	15 (6%)	12 (4.8%)	27 (10.9%)
Dental canal type	32 (3.2%)	14 (5.6%)	7 (2.8%)	21 (8.5%)	8 (3.2%)	3 (1.2%)	11 (4.4%)
1st molar	15 (1.5%)	4 (1.6%)	4 (1.6%)	8 (3.2%)	5 (2%)	2 (0.8%)	7 (2.8%)
2nd molar	6 (0.6%)	4 (1.6%)	1 (0.4%)	5 (2%)	1 (0.4%)	0 (0%)	1 (0.4%)
3rd molar	11 (1.1%)	6 (2.4%)	2 (0.8%)	8 (3.2%)	2 (0.8%)	1 (0.4%)	3 (1.2%)
Forward canal	121 (12.1%)	38 (15.3%)	31 (12.5%)	69 (27.8%)	24 (9.7%)	28 (11.3%)	52 (21%)
With confluence	19 (1.9%)	5 (2%)	2 (0.8%)	7 (2.8%)	7 (2.8%)	5 (2%)	12 (4.8%)
Without confluence	102 (10.2%)	33 (13.3%)	29 (11.7%)	62 (25%)	17 (6.9%)	23 (9.3%)	40 (16.1%)
Buccolingual canal	24 (2.4%)	5 (2%)	6 (2.4%)	11 (4.4%)	8 (3.2%)	5 (2%)	13 (5.2%)
Buccal	12 (1.2%)	4 (1.6%)	2 (0.8%)	6 (2.4%)	4 (1.6%)	2 (0.8%)	6 (2.4%)
Lingual	12 (1.2%)	1 (0.4%)	4 (1.6%)	5 (2%)	4 (1.6%)	3 (1.2%)	7 (2.8%)
Trifid	6 (0.6%)	0 (0%)	4 (16%)	4 (1.6%)	0 (0%)	2 (0.8%)	2 (0.8%)

Table 4 The findings of bifid mandibular canal prevalence in previous studies.

Author	Population	Method	Prevalence
Naitoh et al.[2]	Japan	CBCT	64.8%
Kuribayashi et al.[3]	Japan	CBCT	15.6%
Orhan et al.[1]	Turkish	CBCT	66.5%
Fue et al.[19]	Taiwanese	CT	30.64%
Kang et al.[6]	Korean	CBCT	10.2%
Rashsuren et al.[5]	Korean	CBCT	22.6%
Shen et al.[30]	Taiwanese	CBCT, CT	41.2%
Villaça et al.[31]	Brazilian	CBCT	26.67%
Yang et al.[29]	Chinese	CBCT	31.1%

especially at risk of injury during the extraction of an impacted third molar due to its adjacent position to the tooth. Damage to the neurovascular bundle that passes through this canal can cause excessive bleeding or post-operative anaesthesia.[6,32] Retromolar canals may also be at risk of injury when harvesting bone blocks, because this area is often used as a donor site.[33] Additionally, knowledge of the presence of a dental canal is crucial in the extraction and root canal treatment of teeth.[1,2,5] Insufficient anaesthesia in the mandible is a common problem for patients with a BMC, owing to the difference between the position of separation and the injection point.[6] Indeed, the location of separation in the mandibular ramus is often superior to the injection point.[34] Therefore, in the presence of a BMC, the Gow-Gates method or the Akinosi method can be performed to apply local anaesthesia to high inferior alveolar nerve blocks.[6] However, these methods should only be used when there is certain radiographic indication of BMCs and when traditional local anaesthesia is found to be insufficient.[6]

In conclusion, bifid and trifid mandibular canals in the Turkish population were found at a relatively high incidence through CBCT evaluation, and the most common type was the forward canal. Therefore, CBCT is an appropriate method to conduct an exhaustive assessment of the entity and configuration of BMCs.

Conflicts of interest

The authors declare no conflicts of interest.

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