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Research Article

Investigation of the Bifid Mandibular Canal Prevalence in the Central Anatolian Population: A Retrospective CBCT Study

Melike Gulec[1], Elif Esra Ozmen[2]

[1]Karamanoğlu Mehmetbey University, Ahmet Keleşoğlu Faculty of Dentistry, Department of Dentomaxillofacial Radiology, Karaman, Türkiye
[2]Karamanoğlu Mehmetbey University, Ahmet Keleşoğlu Faculty of Dentistry, Department of Oral and Maxillofacial Surgery, Karaman, Türkiye

Abstract

Aim: This study aims to retrospectively examine cone beam computed tomography (CBCT) images obtained for various reasons to determine the prevalence of bifid mandibular canal (BMC) in the Central Anatolian population.
Material and Method: A total of 518 mandibular canals (right and left sides evaluated separately) from 259 CBCT images (145 female, 114 male) that met the inclusion criteria were included in the study. BMCs were categorized as retromolar canal, forward canal, dental canal, and buccolingual canal. Individuals were grouped into age ranges of 15-34, 35-54, and 55-75 years. Statistical analysis was performed using IBM SPSS version 25.0. The data were then compared based on side (right/left), gender, and age.
Results: BMC was observed in 35.9% of the total participants. The most common subtype was the forward canal (Type 3) at a rate of 41.9%, followed by the retromolar canal at 35.4%, the dental canal at 31.1%, and the buccolingual canal at 26.8%. While there was no significant difference in BMC prevalence by gender, the prevalence was found to be higher in the second age group.
Conclusion: In conclusion, regardless of subtype, determining the presence of BMC in patients undergoing mandibular procedures is extremely important for informing the clinician, especially to avoid complications such as local anesthesia failure, postoperative paresthesia, or bleeding. If present, it should be noted in the CBCT report.

Keywords: Bifid mandibular canal, cone-beam computed tomography, mandibular anatomy

INTRODUCTION

The mandibular canal, which extends bilaterally from the mandibular foramen in a downward and forward direction towards the mental foramen and lingual foramen in the anterior region, is an anatomical curve that carries the mandibular artery, vein, and nerve bundle, providing innervation and vascularization to the mandible (1). Radiographically, the mandibular canal is typically observed as a linear radiolucency accompanied by a thin cortical bone opacity on the inferior and superior sides. Identifying variations of the mandibular canal is critical in reducing and preventing complications in procedures such as impacted third molar extractions, implant placements, and orthognathic surgeries in this region. These complications may include paresthesia, iatrogenic nerve damage, local anesthesia failure, and unexpected intraoperative bleeding (2).

Among the variations of the mandibular canal, the bifid mandibular canal (BMC) is a commonly observed condition. The term "bifid" originates from Latin and refers to a structure divided into two branches or parts. In 1996, Chávez-Lomeli et al. (3) conducted a study on cadaveric hemi-mandibles. They found that the mandibular canal could be observed as three distinct canals corresponding to the anterior, premolar, and molar teeth, respectively. They further noted that these canals later fused into one or two branches, and in cases where fusion was incomplete, bifid or even trifid canal variations could be observed.

Since the first case was described in the 1970s (4), numerous studies have been conducted on the prevalence and classification of BMC. Although some studies have utilized panoramic radiography, its limitations in assessing BMC prevalence have been noted due to the two-dimensional nature of panoramic radiography. These limitations include insufficient cross-sectional information, high magnification values, and anatomical superimpositions such as the pharyngeal airway, uvula, and soft palate (5). In contrast, cone beam computed

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Corresponding Author: Melike Gulec, Karamanoğlu Mehmetbey University, Ahmet Keleşoğlu Faculty of Dentistry, Department of Dentomaxillofacial Radiology, Karaman, Türkiye
E-mail: mlkakd92@gmail.com

tomography (CBCT), which is frequently used in preoperative imaging for dentomaxillofacial surgeries, has been commonly employed in BMC research due to its ability to provide high-resolution volumetric images with a significantly lower radiation dose compared to medical computed tomography (6-8).

This study aims to retrospectively examine CBCT images obtained for various reasons to determine the prevalence of BMC in the Central Anatolian population. This study contributes significantly to identifying anatomical variations in the mandibular canal, particularly BMC. Accurately defining the type and morphological variations of the mandibular canal is critical for preventing complications that may arise during procedures such as impacted tooth extractions, implant placements, and other surgical interventions in the mandibular region.

Considering the limitations of panoramic radiography, using three-dimensional, high-resolution imaging techniques like CBCT enables more reliable and precise evaluations. The significance of this study lies in its investigation of BMC prevalence in the Central Anatolian population using the detailed data provided by CBCT, thereby elucidating the impact of these anatomical variations on surgical and dental treatment planning. These findings are expected to contribute to developing safer and more effective treatment protocols for dentists and surgeons.

MATERIAL AND METHOD

This study was approved by the Local Scientific Medical Research Ethics Committee of Karamanoğlu Mehmetbey University Faculty of Medicine with decision number 01-2024/09 and was conducted by the principles of the Helsinki Declaration.

Sample Group and Study Design

Within the scope of the study, CBCT images obtained for various purposes between August 2022 and August 2024 at Karamanoğlu Mehmetbey University Faculty of Dentistry were retrospectively and randomly reviewed. From the 400 CBCT images evaluated, images of individuals with a history of trauma, surgery, or pathology in the maxillofacial region, craniofacial anomalies, or images with artifacts that hindered radiological assessment (such as metallic artifacts or artifacts due to patient movement), and CBCT images in which the mandibular canal could not be traced, as well as those not meeting diagnostic criteria, were excluded from the study. Consequently, 518 mandibular canals (evaluated separately for the right and left sides) from 259 CBCT images (145 females, 114 males) that met the inclusion criteria were included in the study. The participants were grouped by age into the following categories: 15-34, 35-54, and 55-75 years.

The mandibular canals examined for BMC prevalence were classified according to the classification system proposed by Naitoh et al. (9) based on this classification:

- **Type 1 Retromolar Canal:** A branch that exits the mandibular canal and reaches the retromolar region.
- **Type 2 Dental Canal:** A branch that exits the main canal and terminates at the roots of the molar teeth.
- **Type 3 Forward (Anterior) Canal:** A canal originating from the mandibular canal's upper wall. The forward canal has two subtypes based on whether it merges with the main mandibular canal:
  - ***Without confluence:*** A forward canal that diverges from the main mandibular canal in the mandibular ramus region and advances towards the second molar region.
  - ***With confluence:*** This type of forward canal separates from the mandibular canal and advances anteriorly, later merging with the main mandibular canal.
- **Type 4 Buccolingual Canal:** This canal branches off the main mandibular canal's buccal or lingual wall. There are two variations of the buccolingual canal:
  - ***Buccal Canal:*** A canal type that separates from the mandibular canal in the mandibular ramus and advances bucco-inferiorly.
  - ***Lingual Canal:*** A canal that separates from the mandibular canal in the mandibular ramus, advances in the lingual direction, and then perforates the lingual cortical bone (Figure 1).

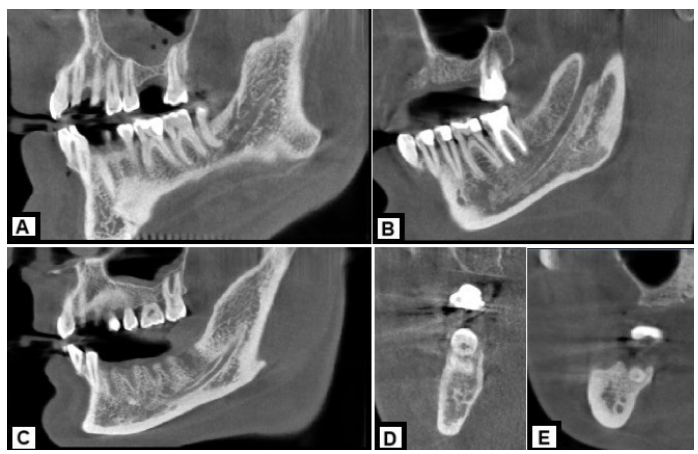

Figure 1. A. Type 1 retromolar canal; **B.** Type 2 dental canal; **C.** Type 3 forward canal (with confluence); **D.** Type 4 buccal canal; **E.** Type 4 lingual canal

Imaging Protocol

All CBCT images were obtained using Kavo OP 3D Pro (PaloDEx Group Oy, Tuusula, Finland) with 90 kVp, 8 mA dose setting, 4.5 seconds irradiation time, and 8x15 cm imaging area exposure parameters.

A computer with a 21.5-inch flat panel color screen (Lenovo ThinkVision S22e-20), 8 GB RAM, Windows 10 Professional operating system, 3.10 GHz Intel 10th generation i5 processor, and 1920×1080-pixel resolution was used to examine the obtained CBCT images.

All radiologic examinations were performed in a standardized observation room under fixed imaging protocols by an observer (M.G.) with 8 years of radiology experience. For consistency of the examinations, 20% of the total measurements were recalculated by the same observer at least 14 days after the initial measurements, and intraobserver agreement was evaluated with the data obtained.

Statistical Analysis

All statistical analyses were conducted using SPSS version 25 (IBM SPSS Statistics v25.0, IBM Corp. Released 2017, Chicago, IL, USA). Continuous variables are presented as mean±standard deviation (X±SD), while categorical variables are reported as frequency and percentage (%). The relationship between gender and BMI was evaluated using the chi-square test. To measure effect size, Cramer's V coefficient was calculated and interpreted. Results with a p-value of less than 0.05 were considered statistically significant.

RESULTS

In this study, CBCT images obtained from a total of 259 individuals aged 15 to 75 were retrospectively analyzed. The Intraclass Correlation Coefficient (ICC) value used to assess intra-observer agreement was found to be excellent, with a value of 0.948.

Table 1 presents the sociodemographic information of the participants and the distribution of BMC and other canal types. The mean age of participants was 43.72±15.61 years. The largest age group, comprising 41.3% of participants, was those aged 35-54. This was followed by the 55-75 age group at 35.1% and the 15-34 age group at 23.6%. This distribution indicates a greater representation of middle-aged and older individuals in the study. Of the participants, 56% were female (145 individuals), and 44% were male (114 individuals), indicating a higher representation of females in the study.

BMC was observed in 35.9% of the total participants. It was most frequently found on the right side (15.8%), followed by the left side at 12.7% and bilaterally at 7.3%, indicating that BMC is more prevalent on the right side. Retromolar canals were absent in 87.3% of participants, with bilateral presence being quite low at 1.2%. The frequency of occurrence of the canal was equal on both sides (5.8%). Dental canals were absent in 88.8% of participants. The most frequently observed variation of dental canals was at the level of the first molar on the right side (3.1%) and at the level of the second molar on the left side (2.3%), indicating that dental canals are more common at the levels of the first and second molars.

In 93.4% of participants, no forward canals were found on the right side; however, types of forward canals merging with the main mandibular canal were identified in 6.6% on the left side and 5.4% on the right side. Non-merging types were very rarely observed (1.2% on the right, 1.9% on the left). Buccal and lingual canals were also rarely seen. Buccal canals were absent in 95% of participants, with only 3.9% on the right and 1.2% on the left showing buccal canals. Lingual canals were absent in 95.4% of cases, while they were found in 2.7% on the right and 1.9% on the left.

No significant difference was found in the presence of BMC between genders (p=0.781). BMC was observed in 35.2% of females and 36.8% of males.

Table 1. Sociodemographic data of participants

Variable	X±SD / n (%)
Age (years)	43.72±15.61
Gender	
Male	114 (44.0)
Female	145 (56)
Age range	
15-34	61 (23.6)
35-54	107 (41.3)
55-75	91 (35.1)
Bifid mandibular canal	
Absent	166 (64.1)
Right	41 (15.8)
Left	33 (12.7)
Bilateral	19 (7.3)
Type 1 retromolar canal	
Absent	226 (87.3)
Right	15 (5.8)
Left	15 (5.8)
Bilateral	3 (1.2)
Type 2 dental canal	
Absent	230 (88.8)
1st molar right	8 (3.1)
1st molar left	4 (1.5)
2nd molar right	7 (2.7)
2nd molar left	6 (2.3)
3rd molar right	2 (0.8)
3rd molar left	0
Other	
Type 3 forward canal right	
Absent	242 (93.4)
With confluence	14 (5.4)
Without confluence	3 (1.2)
Type 3 forward canal left	
Absent	234 (90.3)
With confluence	17 (6.6)
Without confluence	5 (1.9)
Type 4 buccal canal	
Absent	246 (95.0)
Right	10 (3.9)
Left	3 (1.2)
Type 4 lingual canal	
Absent	247 (95.4)
Right	7 (2.7)
Left	5 (1.9)

X: mean, SD: standard deviation, n: frequency, %: percentage

Table 2 illustrates the relationships between age groups and the presence of BMC and other mandibular canal variations. A significant difference was found in the presence of BMC among age groups (p=0.004). Notably, the prevalence of BMC is higher in the 35-54 age group (47.7%). The Cramér's V value is 0.206, indicating a weak yet significant relationship.

A significant difference was also identified in the presence of Type 1 retromolar canal among age groups (p=0.021). Retromolar canals are more frequently observed in the 35-54 age group (18.7%), while this rate is notably low in the 55-75 age group (5.5%). The Cramér's V value of 0.173 suggests a weak relationship.

No significant difference was found in the presence of Type 2 dental canals among age groups (p=0.139). However, it is noteworthy that the dental canal is more frequently observed in the 35-54 age group compared to other age groups (15%).

A significant difference was found regarding the Type 3 forward canal among age groups (p=0.046). The presence of forward canals is particularly higher in the 35-54 age group (18.7%), indicating a greater prevalence in this age group compared to others. The Cramér's V value of 0.154 also shows a weak relationship.

No significant differences were found in the presence of Type 4 buccal and lingual canals among age groups (p>0.05). However, the presence of buccal canals is higher in the 35-54 age group (18.7%).

Table 2. Relationship between age group and variations of subtypes

Age groups	15-34	35-54	55-75	p	Cramer' V
Bifid mandibular canal					
Absent	44 (72.1%)	56 (52.3%)	66 (72.5%)	**0.004***	0.206
Present	17 (27.9%)	51 (47.7%)	25 (27.5%)		
Type 1 retromolar canal					
Absent	53 (86.9%)	87 (81.3%)	86 (94.5%)	**0.021***	0.173
Present	8 (13.1%)	20 (18.7%)	5 (5.5%)		
Type 2 dental canal					
Absent	58 (95.1%)	91 (85%)	81 (89%)	0.139	0.123
Present	3 (4.9%)	16 (15%)	10 (11%)		
Type 3 forward canal					
Absent	57 (93.4%)	87 (81.3%)	82 (90.1%)	**0.046***	0.154
Present	4 (6.6%)	20 (18.7%)	9 (9.9%)		
Type 4 buccal canal					
Absent	60 (98.4%)	87 (81.3%)	82 (90.1%)	0.363	0.088
Present	1 (1.6%)	20 (18.7%)	9 (9.9%)		
Type 4 lingual canal					
Absent	59 (96.7%)	100 (93.5%)	88 (96.7%)	0.472	0.076
Present	2 (3.3%)	7 (6.5%)	3 (3.3%)		

p<0.05, Chi-square, n: frequency, %: percentage

DISCUSSION

Determining the type and shape of mandibular canal variations is crucial for preventing potential complications during planned surgical procedures in the relevant areas and for providing patients with the most effective treatment options. Various imaging protocols, including panoramic radiography, computed tomography, and CBCT, have been utilized in studies examining the mandibular canal. It has been reported that the dense trabeculation observed around the mandibular canal in panoramic radiography may lead to misinterpretations, highlighting that prevalence studies planned with CBCT would be more reliable (9).

In a study conducted in our country in 2010 (6), it was reported that BMC was detected in 161 out of 242 individuals aged between 17 and 83 years (66.5%), with the most observed BMC variation being the forward canal (17.8%). It was determined that the non-merging type of the forward canal was more frequently encountered than the merging type. According to the findings of this study, the lingual canal was found to occur more regularly than the buccal canal. In contrast, the most common dental canal type was identified as the canal reaching the level of the third molar.

In another study examining 1933 individuals, BMC was detected in only 198 individuals (10.2%), with the most common type being Type 1 retromolar canal (52.5%). It was noted that the non-merging type of the forward canal was more prevalent (2).

Naitoh et al. (9) conducted a study involving the CBCT images of 9,122 individuals to determine the prevalence of BMC. They found it in 65% of the subjects, identifying the most common type as the type 3 forward canal. They emphasized that CBCT examinations have advantages over panoramic radiography.

In their 2017 study, Serindere et al. (10) reported a BMC prevalence of 3.05%, with the most frequently observed type being the Type 1 retromolar canal. Elnadoury et al. (11) examined CBCT images from 278 patients, revealing BMC in 181 canals (34%) and trifid canal in 46 canals (8.7%).

Rashsuren et al. (12) reported a prevalence of bifid canals at 22.6%, with the most observed subtype being retromolar canal (71.3%), followed by dental canal (18.8%), trifid canal (5.8%), and forward canal (4.1). They indicated that the merging type of the forward canal was more commonly found than the non-merging type, and they did not encounter any cases of the buccolingual canal type. In a recent study, Alali et al. (13) reported that the retromolar canal is the most observed type, and no significant differences were found based on gender and age. In their research, Dumanlı et al. (14) attempted to determine the prevalence of BMC in 300 patients using CBCT images, stating that they did not identify any trifid canals, while the most frequently observed subtype was the merging forward canal.

In this study focusing on the Central Anatolian population, the prevalence of BMC was calculated to be 35.9% (n=93), with the most common subtype being Type 3 forward canal (41.9%). This was followed by the retromolar canal (35.4%), the dental canal (31.1%), and the buccolingual canal (26.8%). The most prevalent subtype of dental canal was the one reaching the level of the second molar, while the most common type of forward canal was the subtype merging with the main mandibular canal. The most frequently observed subtype of the buccolingual canal was the buccal canal type. As noted above, while there are studies in the literature that are similar to the findings of our study, differences in sample sizes, variations in the radiographic techniques employed, and the diversity of the populations included can lead to differing results in other studies.

A meta-analysis conducted in 2023 indicated that geographic location, classification, gender, and the voxel size of the CBCT device all influence the prevalence of BMC. The study, which reviewed a total of 40 articles, reported a high level of heterogeneity and bias while also noting that most of the studies were conducted in Europe and that the prevalence of BMC was higher in males and on the right side (15). In another study that examined CBCT images of 558 patients from different ethnic backgrounds, it was reported that gender and ethnicity did not impact the prevalence of BMC (16). This study found that the prevalence of BMC did not differ significantly between genders; however, similar to findings in the literature (7,17), it was observed to be more common on the right side. Recent studies have categorized individuals into age groups to examine the variations in BMC prevalence according to age. This research divided individuals into three age groups: 15-34, 35-54, and 55-75. It was noted that the presence of BMC was significantly higher in the second group. The retromolar and forward canal frequencies were also considerably higher when examining subtypes in this group. While other subtypes were not statistically significant, they were still found in greater numbers in the second group. Dumanlı et al. (14) reported no significant differences in BMC prevalence based on age or gender. On the other hand, Okumuş and Dumlu (7), in a study conducted with 500 individuals aged 14-79 years, reported that BMC was significantly less common in individuals younger than 25 years. These findings may stem from the higher representation of middle-aged and older individuals in the studied group, suggesting that future research should analyze BMC prevalence in age subgroups with equal patient numbers.

This study has some limitations. First, it focused solely on the Central Anatolian population, limiting the generalizability of the results to other populations. Research conducted in different geographic regions and ethnic groups could contribute to a more comprehensive understanding of BMC prevalence and variations. Additionally, the retrospective nature of the study means that control over data collection methods and purposes was not possible, which could affect the homogeneity of the obtained images and data. Studies with more balanced distributions of different age groups could yield more substantial results regarding BMC prevalence.

The CBCT method used in the study is a reliable technique for detecting BMC and other mandibular canal variations; however, the resolution of the CBCT device may limit the detection of canal variations in low-quality images. Factors such as metallic artifacts or patient movements can negatively impact image quality, potentially leading to unclear identification of canal variations in some individuals.

Considering these limitations, future prospective and comparative studies on larger populations are recommended to validate the findings. Advanced imaging techniques, particularly high-resolution methods like micro-CT, may allow for the detection of more complex canal variations. Furthermore, studies investigating the clinical implications of BMC on surgical complications and local anesthesia failures could clarify the role of these variations on clinical outcomes. It is also essential to conduct studies with large participant groups encompassing various age ranges to examine the relationship between age and BMC prevalence in more detail.

CONCLUSION

In conclusion, regardless of the subtype, it is crucial to determine the presence of BMC in patients undergoing procedures in the mandible to prevent complications such as local anesthesia failures, postoperative paresthesia, or bleeding. This information should be included in the CBCT report to inform the treating physician adequately. In orthognathic surgery cases, the presence of a second neurovascular bundle complicates the surgical procedure and necessitates careful examination of the area to identify this variation, especially when harvesting bone grafts from the commonly used retromolar region. Additionally, in patients using complete dentures in the mandible who experience persistent pain or paresthesia, BMC variation should be considered, and treatment planning should be adjusted accordingly.

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REFERENCES

1. von Arx T, Bornstein MM. The bifid mandibular canal in three-dimensional radiography: morphologic and quantitative characteristics. J Swiss Dent. 2021;131:10-28.
2. Kang JH, Lee KS, Oh MG, et al. The incidence and configuration of the bifid mandibular canal in Koreans by using cone-beam computed tomography. Imaging Sci Dent. 2014;44:53-60.
3. Chávez-Lomeli M, Mansilla Lory J, Pompa J, et al. The human mandibular canal arises from three separate canals innervating different tooth groups. J Dent Res. 1996;75:1540-4.
4. Nortjé C, Farman A, Grotepass F. Variations in the normal anatomy of the inferior dental (mandibular) canal: a retrospective study of panoramic radiographs from 3612 routine dental patients. Brit J Oral Surg. 1977;15:55-63.
5. Rouas P, Delbos Y, Nancy J. Pseudo multiple and enlarged mandibular canals: the evidence-based response of cone beam computed tomography. Dentomaxillofac Radiol. 2006;35:217-8.
6. Orhan K., Aksoy S, Bilecenoglu B, et al. Evaluation of bifid mandibular canals with cone-beam computed tomography in a Turkish adult population: a retrospective study. Surg Radiol Anat. 2011;33:501-7.
7. Okumuş Ö, Dumlu A. Prevalence of bifid mandibular canal according to gender, type, and side. J Dent Sci. 2019;14:126-33.
8. Nithya J, Aswath N. Assessing the prevalence and morphological characteristics of bifid mandibular canal using cone-beam computed tomography - a retrospective cross-sectional study. J Clin Imaging Sci. 2020;10:30.
9. Naitoh M, Hiraiwa Y, Aimiya H, Ariji E. Observation of bifid mandibular canal using cone-beam computerized tomography. Int J Oral Maxillofac Implants. 2009;24:155-9.
10. Serindere G, Gündüz K, Bulut E. Investigation of bifid mandibular canal frequency with cone beam computed tomography in a Turkish population. Anatomy. 2017;11:30-6.
11. Elnadoury EA, Gaweesh YSE, Abu El Sadat SM, Anwar SK. Prevalence of bifid and trifid mandibular canals with unusual patterns of nerve branching using cone beam computed tomography. Odontology. 2022;110:203-11.
12. Rashsuren O, Choi JW, Han WJ, Kim EK. Assessment of bifid and trifid mandibular canals using cone-beam computed tomography. Imaging Sci Dent. 2014;44:229-36.
13. Alali Y, Mohammed WA, Alabulkarim M, et al. Assessment of bifid mandibular canals using cone beam computed tomography in general population: a retrospective evaluation. Eur Rev Med Pharmacol Sci. 2024;28:1741-50.
14. Dumanlı D, Geduk G, Şeker Ç. Retrospective evaluation of mandibular canal anatomy and variations by cone-beam computed tomography. J Int Dent Sci. 2023;9:40-5.
15. Aung NM, Myint KK. Bifid mandibular canal: a proportional meta-analysis of computed tomography studies. Int J Dent. 2023;2023:9939076.
16. Gartley S. Prevalence of Bifid Mandibular Canals in a United States Dental School Population. PhD Thesis, Temple University, USA, 2024.
17. Laçin N, Aytuğar E, Veli İ. Cone-beam computed tomography evaluation of bifid mandibular canal in a Turkish population. Int Den Res. 2018;8:78-83.