Assessment of variations of mandibular canal using cone beam CT

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Assessment of variations of mandibular canal using cone beam CT

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하고 싶은 것을 마음대로 할 수 있도록 무한한 자신감을 심어준 영원한 반쪽 송종권과 바쁜 엄마를 둔 덕에 독립심이 갖게된 사랑스러운 두 딸 승현, 서현이에게도 사랑과 감사를 보냅니다. 아울러 친딸처럼 따뜻하게 대해 주시고 사랑을 베풀어 주신 시부모님과 살림과 육아를 도맡아 해주신 친정엄마와 동생들에게 이 글을 빌어 감사함을 전합니다.

마지막으로 삶의 목적이자 기쁨이신 주님께 이 모든 영광을 바칩니다.

2013 6

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Abstract

Assessment of variations of mandibular canal using cone beam CT

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Anatomical variations of mandibular canal such as bifid mandibular canal, retromolar canal, and accessory mental foramen may be vulnerable to damage during surgical procedures in the mandible. The variations of mandibular canal are of clinical importance as they include neurovascular bundle. However, low prevalence of the variations has been reported in studies with panoramic radiograph. Recently, as the use of cone beam CT has gained popularity, it is now possible to confirm more anatomical variations of the mandibular canal that cannot be assessed with conventional imaging. The objective of this study was to investigate the prevalence and features of bifid mandibular canal, retromolar canal and accessory mental foramen in Korean people using cone beam CT.

Cone beam CT images from total 446 patients were analyzed for the prevalence and configuration of the variations of mandibular canal on the reformatted images of panoramic, axial, cross-sectional, and sagittal sections

Bifid mandibular canals were found in 12.6% (56 patients), and retromolar canals were found in 8.5% (38 patients). Accessory mental foramina were found in 8.1% (36 patients), the prevalence of accessory mental foramen in male was higher than in female with statistical significance ($p<0.05$). According to classification of course, type I of bifid mandibular canal and type A of retromolar canal appeared more frequently. Accessory mental foramina mostly were located on anterior-superior region of the mental foramina.

In this study, the prevalence of bifid mandibular canal, retromolar canal, and accessory mental foramen was higher than that of previous reports using panoramic radiograph, and they are no longer considered as rare anatomic structures. Therefore special attention has to be paid for identification of the variations prior to surgical procedures involving the mandible. Cone beam CT with multiplanar reformatted images is considered as an effective modality for detailed evaluation of the presence and features of variations of mandibular canals.

Keywords : mandibular canal, bifid mandibular canal, retromolar canal, accessory mental foramen, cone beam computed tomography

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Ⅰ. INTRODUCTION

The mandibular canal transmits the inferior alveolar artery and nerve from the mandibular foramen to the mental incisive region. It was generally known to be a single structure, but branched variations such as bifid mandibular canal (BMC), retromolar canal (RMC), accessory mental foramen (AMF) have been reported. The RMC is often treated as a subtype of BMC by several researchers.[1-3]

The BMC, RMC and AMF include neurovascular bundles, which consist of arteries, numerous venules, and myelinated nerve fibers.[4-7] Therefore, the location and configuration of the variations are important prior to surgical procedures involving the mandible, such as anesthesia, flap surgery, the extraction of an impacted third molar, dental implant treatment, and sagittal split ramus osteotomy. If a nerve injury of BMC or RMC occurs during dental procedures, complications such as paraesthesia, excessive bleeding, and traumatic neuroma could arise.[2,4,5,8,10,30]

Also, a nerve injury of AMF in flap surgery can induce temporary sensory disturbance, such as pain and paresthesia.[9,31]

In previous studies using panoramic radiograph, the prevalence of BMC, RMC, and AMF was very low, so the variations were considered as rare anatomical variations.[11,12] Recently, because of high-resolution, low cost and low radiation dose, cone beam CT has been widely used in the field of dentistry.[13,14] Since cone beam CT provides reformatted panoramic, axial, cross-sectional, and sagittal images by 3 dimensional reconstruction, it is now possible to confirm more anatomical variations of the mandibular canal that cannot be assessed with conventional imaging. However, there have been few systematic studies that have evaluated the variations of mandibular canal using cone beam CT in Korean people. The objective of this study is to investigate the prevalence and features of BMC, RMC and AMF in Korean people using cone beam CT.

Ⅱ MATERIALS & METHODS

1. Materials

The study population comprises 446 patients who had undergone CBCT imaging for impacted third molar surgery, dental implant surgery or orthodontic treatment in Yonsei University Dental Hospital from December 2011 to February 2012 (male; 217, female; 229, age range; 15-70).

2. Methods

A. Cone beam CT taking

Cone beam CT was performed with RayScan Symphony® (Ray Co., Seoul, Korea) which was being hold by the Department of Oral and Maxillofacial Radiology of Yonsei University Dental Hospital. The images were scanned under the condition that occlusal plane was parallel to the floor in order to reproduce the same location. All images were recorded at 90 kVp and 10 mA using a 14x10 cm field of view, and axial slice thickness of 0.38 mm and isotropic voxels.

B. Evaluation of images

All cone beam CT images were evaluated retrospectively by a single oral and maxillofacial radiologist with more than 3 years' experience. Reformatted panoramic images (parallel to the dental arch), cross-section (perpendicular to the dental arch) and sagittal images (longitudinal sections to mandibular canal) were reconstructed from volumetric cone beam CT data using imaging analysis software OnDemand 3D™ (Cybermed, Seoul, Korea). The various sections were rotated horizontally, and the center was moved buccolingually and anteroposteriorly by degrees to detect BMC, RMC and AMF (Figure 1). The actual presence of BMC or RMC was established only if it was found on all reformatted images such as panoramic, cross-sectional and sagittal section. AMF was established if it was found on all 3D reconstruction, axial, cross-sectional image.

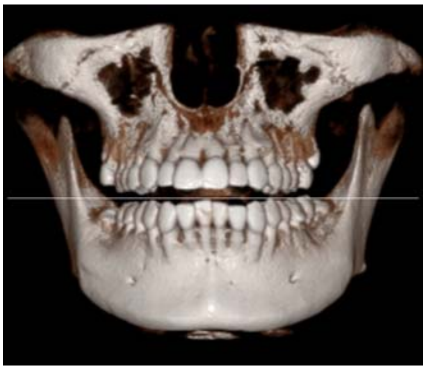


Figure 1A. 3D reconstruction image

Figure 1B. axial image

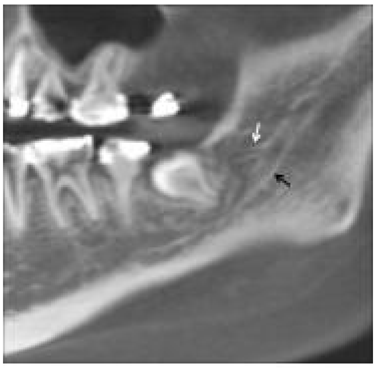


Figure 1C. sagittal image

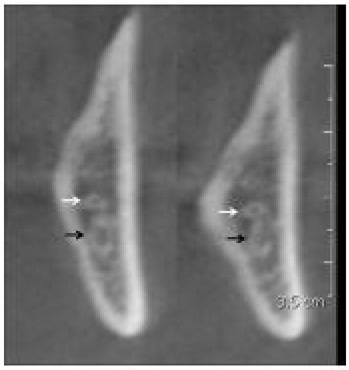


Figure 1D. cross sectional image

Figure 1. Cone beam CT images. To reconstruct useful images using OnDemand software, the center of rotation was set at the mandibular foramen in axial image (Figure 1B) (White arrow; BMC, Black arrow; main mandibular canal).

C. Definition of the variations

(A) Bifid mandibular canal (BMC)

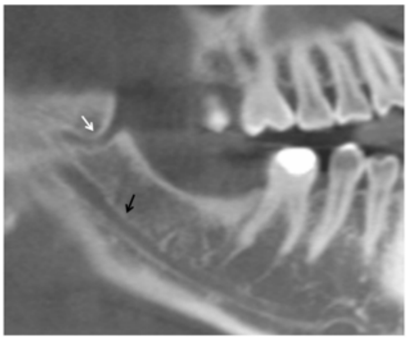
BMC branches off from the mandibular canal, which travels forward with main mandibular canal or toward the mandibular molars (Figure 2).

Figure 2A. Sagittal image   Figure 2B. Cross-sectional image

Figure 2. Cone beam CT images of BMC (white arrow; BMC, black arrow; mandibular canal).

(B) Retromolar canal (RMC)

RMC branches off from the mandibular canal and travels superior-posteriorly to the foramen in the retromolar fossa (Figure 3).



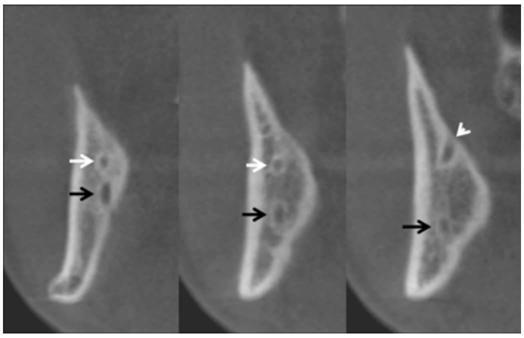


Figure 3A. sagittal image   Figure 3B. cross-sectional image

Figure 3. Cone beam CT images of RMC (white arrow; RMC, black arrow; mandibular canal, white arrow head; retromolar foramen).

(C) Accessory mental foramen (AMF)

An accessory foramen located in the region surrounding the mental foramen and shown a connection with the mandibular canal was defined as AMF (Figure 4). Additional foramina shown no connection with the mandibular canal were excluded. The mental foramen was defined as the largest area of the foramen.

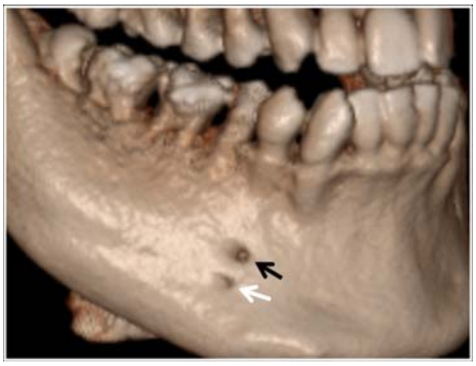


Figure 4A. 3D reconstruction image

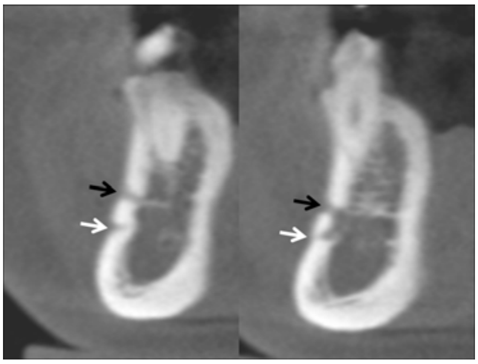


Figure 4B. cross-sectional image

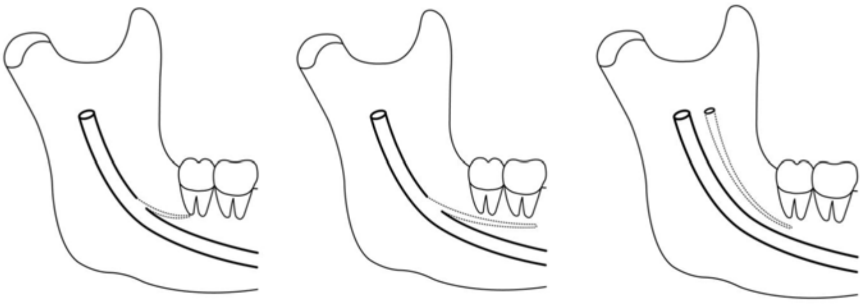
Figure 4. Cone beam CT images of AMF (white arrow; AMF, black arrow; mental foramen).

D. Analysis for prevalence and configuration according to the variations

(A) The prevalence of BMC, RMC and AMF assessed and gender difference in prevalence was analyzed.

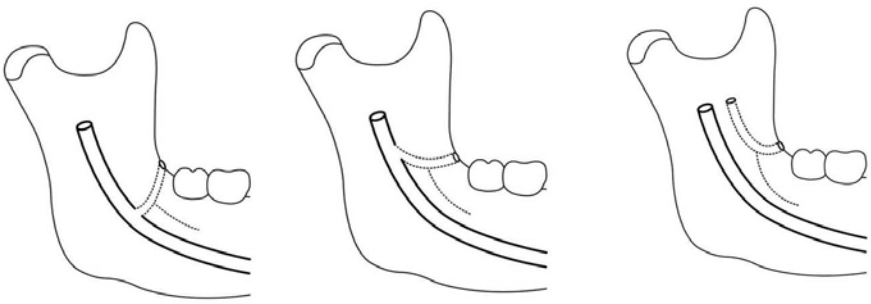
(B) The courses of BMCs were classified into I, II, III types (Figure 5). RMCs were classified into A, B, C types, respectively (Figure 6). And the gender difference in types according to classification was evaluated.

(C) The location of AMF in relation to the mental foramen was recorded. The reference point was defined as the centre of the mental foramen. The x-axis was parallel to the occlusal plane (Figure 7). The distance between the centre of AMF and the mental foramen was measured.



Type I　　　　Type II　　　　Type III

Figure 5. Classification of BMC. Type I; Two forward canals from single mandibular foramen. Type II; short canal toward the second molar or third molar teeth from single mandibular foramen. Type III; two canals from double mandibular foramina.



Type A　　　　Type B　　　　Type C

Figure 6. Classification of RMC. Type A; vertically curved RMC which branched off the mandibular canal around molars from single mandibular foramen. Type B; horizontally curved RMC which branched off the mandibular canal just beyond the single mandibular foramen. Type C; RMC from separate mandibular foramen.

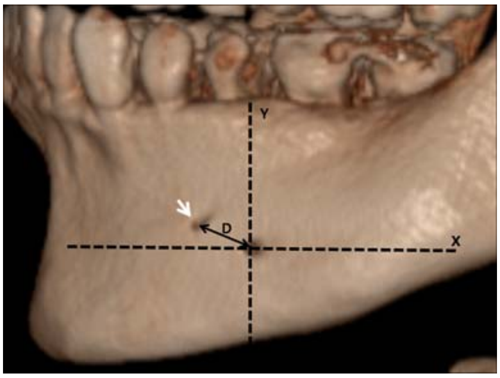


Figure 7. The location of AMF and the distances between AMF and mental foramen. 3D reconstruction shows the location of AMF and the distance between the center of AMF and the mental foramen (D) (white arrow; AMF).

(D) The width of BMC was measured at the point below 3 mm from main mandibular canal. The width of RMC at the point of 3 mm below the retromolar foramen (RMF) was measured.

(E) The vertical distance from midpoint of retormolar foramen to the superior border of main mandibular canal was measured. And the horizontal distance from midpoint of retromolar foramen to distal aspect of the second molar was measured (Figure 8). The differences of gender in vertical and horizontal distances of RMC were analyzed.

(F) The differences of vertical and horizontal distances of RMC according to the last tooth of arch were analyzed.

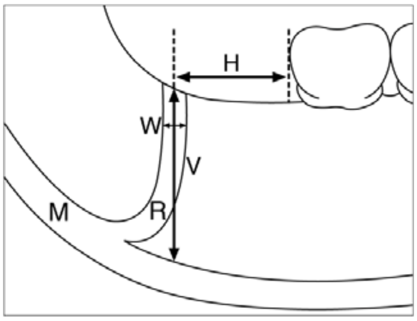


Figure 8. Vertical distance and horizontal distance of RMC (V; the vertical distance from midpoint of retormolar foramen to lower point of RMC, H; the horizontal distance from midpoint of retromolar foramen to distal aspect of the second molar, W; width of RMC, M; mandibular canal, R; RMC).

E. Statistical analysis

The data set was analyzed using the Statistical Package for Social Science ver. 19.0 (SPSS, Chicago, IL) and a prevalence analysis, t-test, and χ^2 qualification were used for statistical analysis. The results were considered significant at $p<0.05$.

II. RESULTS

1. Prevalence of BMC, RMC and AMF

In the 446 subjects under cone beam CT images, 56 patients (12.6%) presented with 62 BMCs. Among the 56 patients with BMCs, 6 had bilateral presentation, while 24 unilateral presentation in the right mandible and 26 had presentation in the left mandible (Table 1). Significant difference in gender was not noted (male: 25, female: 31) (Table 2). RMCs were presented in 38 patients (8.5%). Among the 38 patients with 45 RMCs, 7 had bilateral presentation, while 22 unilateral presentation in the right mandible and 9 had presentation in the left mandible (Table 1). Significant difference in gender was not noted (male: 22, female:16) (Table 2). 39 AMFs were observed in 36 patients (8.1%). 3 were observed bilaterally while 20 had presentation in the right mandible and 13 had presentation in the left mandible (Table 1). We found higher prevalence of AMF for males ($p<0.05$) (Table 2).

2. Distribution of types of BMC and RMC according to the course.

The results regarding the types of course are shown in table 3. In 62 BMCs, type I was observed in 69.4%, type II was observed in 27.4%. Type III was observed in 3.2%. In 45 RMCs, type A was observed most frequently in 66.7%, then type B was observed in 20% and type C was observed in 13.3%. Types of BMC and RMC do not show statistical difference between genders ($p>0.05$) (Table 3).

Table 1. Prevalence of BMC, RMC and AMF in examined patients

	Patients (n=446) (%)	**Hemi-mandibles (n=892) %**
BMC		
Absence	390 (87.4)	780 (87.4)
Presence	56 (12.6)	62 (7.0)
Unilaterally BMCs	50 (11.2)	50 (5.6)
in right	24 (5.4)	24 (2.7)
in left	26 (5.8)	26 (2.9)
Bilaterally BMCs	6 (1.3)	12 (1.3)
RMC		
Absence	408 (91.5)	816 (91.5)
Presence	38 (8.5)	45 (5.0)
Unilaterally RMCs	31 (7.0)	31 (3.5)
in right	22 (4.9)	22 (2.5)
in left	9 (2.0)	9 (1.0)
Bilaterally RMCs	7 (1.6)	14 (1.6)
AMF		
Absence	410 (91.9)	820 (91.9)
Presence	36 (8.1)	39 (4.4)
Unilaterally AMF	33 (7.4)	33 (3.7)
in right	20 (4.5)	20 (2.2)
in left	13 (2.9)	13 (1.5)
Bilaterally AMF	3 (0.7)	6 (0.7)

Table 2. The gender differences in prevalence rates of BMC, RMC and AMF

	Patients		
	Male (n=217) (%)	Female (n=229) (%)	p-value
BMC			
Absence	192 (88.5)	198 (86.5)	
Presence	25 (11.5)	31 (13.5)	0.521 (Fisher's p=1.000)[a]
RMC			
Absence	195 (89.9)	213 (93.0)	
Presence	22 (10.1)	16 (7.0)	0.233 (Fisher's p=1.000)[a]
AMF			
Absence	189 (87.1)	221 (96.5)	
Presence	28 (12.9)	8 (3.5)	0.000*** (Fisher's p=0.002*)

*p<0.05 **p<0.01 ***p<0.001 a. p-value of Fisher's Exact test

Table 3. Distribution of BMC and RMC according to course and gender difference

Classification	Gender			
	Male	Female	Total	p-value
BMC				
I	23 (53.5)	20 (46.5)	43 (69.4)	0.161
II	7 (41.2)	10 (58.8)	17 (27.4)	
III	0 (0.0)	2 (100.0)	2 (3.2)	
Total	30 (48.4)	32 (51.6)	62 (100)	
RMC				
A	18 (60.0)	12 (40.0)	30 (66.7)	0.086
B	4 (44.4)	5 (55.6)	9 (20.0)	
C	6 (100.0)	0 (0.0)	6 (13.3)	
Total	28 (62.2)	17 (37.8)	45 (100.0)	

*p<0.05 **p<0.01 ***p<0.001

3. Location of AMF related to mental foramen and the distance between AMF and mental foramen

Figure 9, 10 show positional distribution of AMFs, mostly located antero-superior of the mental foramen. The mean distance between AMF and mental foramen was 5.80 mm (SD±2.90, 1.40-13.0) (Table 4).

Table 4. The mean distance between AMF and mental foramen

Distance between AMF and mental foramen	Mean value (mm)
The shortest distance	5.80±2.90 (39, 1.40-13.00)
The horizontal distance	4.09±3.37 (39, 0.00-13.90)
The vertical distance	3.11±2.11 (39, 0.00-6.70)

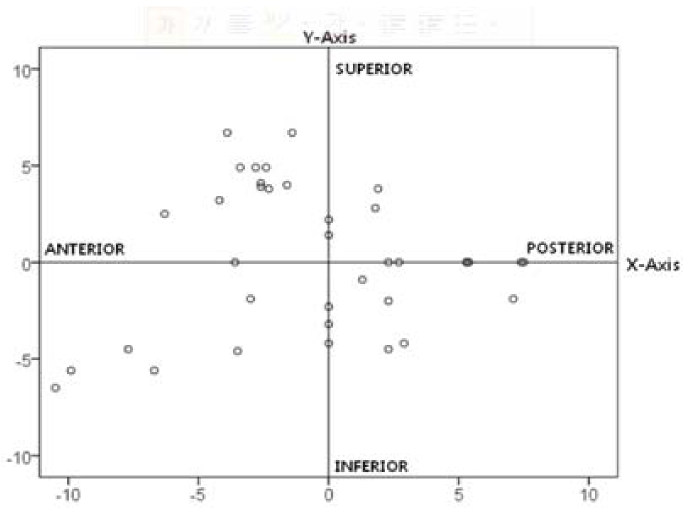


Figure 9. Location of AMF related to mental foramen. The center of the figure is defined as the center of the mental foramen, and the x-axis is parallel to the occlusal plane.

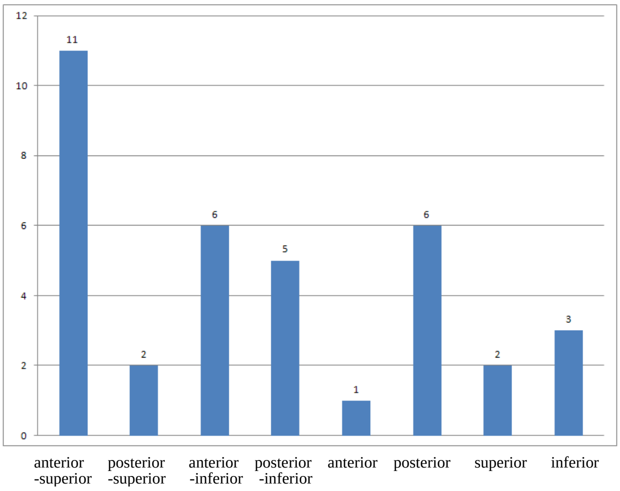


Figure. 10. Distribution of AMF related to mental foramen.

4. Measurements of BMC width and RMC width, and correlations by gender

The mean width of BMC was measured as 1.17 mm (SD±0.33, 0.50-1.90), and that in male patients were thicker than in females with statistical significance ($p<0.05$). The mean width of RMC was 1.13 mm (SD±0.38, 0.60-2.00), it was higher in males with no statistical significance ($p>0.05$) (Table 5).

Table 5. Measurements of BMC width and RMC width, and differences in gender

	Male	**Female**	**Total**	**p-value**
BMC width (mm)	1.30±0.32 (0.70-1.90)	1.06±0.30 (0.50-1.70)	1.17±0.33 (0.50-1.90)	0.003**
RMC width (mm)	1.17±0.40 (0.60-2.15)	1.07±0.35 (0.60-2.00)	1.13±0.38 (0.60-2.00)	0.398

*$p<0.05$ **$p<0.01$ ***$p<0.001$

5. Vertical distance and horizontal distance of RMC, difference in gender

The mean vertical distance was 11.04 mm (SD±2.02, 7.80-17.90) and was higher in males with statistical significance (P<0.01)(Table 6). The mean horizontal distance of RMC was 14.08 mm (SD±3.85, 8.50-24.00) without any difference between the genders (p>0.05). The horizontal distance of RMC with third molar had higher values than the other groups with second molar (p<0.05) (Table 7).

Table 6. Vertical distance and horizontal distance of RMC

	Male (n=28)	**Female** (n=17)	**Total** (n=45)	**p-value**
Vertical distance (mm)	11.70±2.05 (7.80-17.90)	9.96±1.44 (7.90-13.00)	11.04±2.02 (7.80-17.90)	0.004**
Horizontal distance (mm)	14.50±3.76 (9.10-24.00)	13.40±4.03 (8.50-21.80)	14.08±3.85 (8.50-24.00)	0.374

*p<0.05 **p<0.01 ***p<0.001

Table 7. Difference according to last tooth in vertical and horizontal distance of RMC

	Last tooth of arch in RMC		
	Second molar (n=12)	**Third molar (n=29)**	**p-value**
Vertical distance (mm)	11.09±2.88 (7.90-17.90)	11.00±1.75 (7.80-14.60)	0.897
Horizontal distance (mm)	12.08±3.05 (9.10-18.90)	15.04±3.86 (8.50-24.00)	0.023*

*p<0.05 **p<0.01 ***p<0.001

IV. DISCUSSION

In our study, the prevalence of BMC was 12.6% (56 patients). This value was similar to that of Kuribayashi et al[1] (13.6%), but lower than that of Naitoh et al[2] (40%), and that of Orhan et al[3] (43.3%). The prevalence of RMC was observed in 8.5% (38 patients). The result was lower than prevalence by von Arx et al[15] (25.6%) and Lizio et al[18] (16%).

The minor prevalence of BMC and RMC in our study with respect to the previous studies may be explained with the restriction of detection criteria to the presence of the variations, which was prescribed on the method. Structures observed on all reformatted panoramic, cross-sectional, sagittal images were only confirmed as BMC or RMC. Other reason might considered to be due to racial difference. Ossenberg[19] reported variability in RMC might appear to be largely due to genetic differences.

Similar to the report by von Arx et al,[15] we found a higher prevalence rate of the RMC in male (10.1%) than in female (7.0%), but without statistical significance. Previous studies on the prevalence of RMC have been mostly conducted by using cadaver mandibles, and those studies generally assessed the retromolar foramen rather than RMC.[6,19] Because of differences in methodology, cadaver studies have reported a wide range of prevalence of retromolar foramen (7.7-72%).[6,8,20] Some authors suggested that the small retromolar foramina do not connect to canals, and hence prevalence of RMC does not exceed 25%.[8,15,21]

AMF, known as double or plural mental foramina, showed prevalence range of 3-10.7% using cone beam CT.[16,22-24,25] In our study, the prevalence of AMF was 8.1% (36 patients). Reason for the wide range of prevalence is thought to be due to different definitions. And prevalence of AMF varies between ethnic groups.[26] We found higher prevalence of AMF for males ($p<0.05$). Some studies reported that there was no statistically significant difference between the genders.[28] However, Sawyer et al[26] suggested that the prevalence were higher in male in certain populations, as shown in this study.

Researchers have used different classifications in describing BMCs.[2,11,27] We classified BMCs into three types according to configuration. According to our classification, type I was observed the most common (69.4%, 43/62). Naitoh et al[2] and Orhan et al[3] also reported that forward type BMC such as type I in this study was the most common. It has been reported that RMC was specifically called ‘retromolar type’ as a subtype of BMC,[1-3] but the recent studies focused on the radiological detection and configuration of RMC by cone beam CT independently.[15,18]

With regard to course of RMC, most RMCs were type A, which was a vertically curved RMC branched off the mandibular canal around molars (66.7%, 30/45), then was type B, which was a horizontally curved RMC branched off the mandibular canal just beyond the mandibular foramen (20.0%, 9/45), type C RMC with double mandibular foramina (13.3%, 6/45). This results were close to those of Ossenberg.[19]

Naitoh et al[22] and Katakami et al[23] reported that most AMFs are distributed on posterior region of mental foramina. Also Katakami et al[23] suggested that since most AMFs are located inferior to mental foramina, chances of AMF injury during dental procedure are fairly low. However, the superior-to-inferior ratio (superior 15, inferior 14) in the present study was close. In case of another neurovascular bundle superior to mental foramen, alveolar bone resorbs to the proximity of mental foramen, patients with mandibular prostheses may experience discomfort because of the pressure placed on the neurovascular bundle. According to the comparison of the anterior and posterior regions, the majority of AMFs were located in the anterior region in our study. The shortest distance between AMF and mental foramen was 5.80 mm (SD±2.90, 1.40-13.00), similar to result by Naito et al.[28] Katakami et al[23] suggested that the horizontal variance is greater due to the fact that location of AMF is depends on the branched site and the length of accessory branch, but the difference of horizontal and vertical distance in this study was very little.

The mean width of BMC was measured as 1.17 mm (SD±0.33, 0.50-1.90), this was slightly less than 1.5 mm by de Oliveira-Santos et al,[24] 1.68 mm by Kuribayashi et al.[1] The reason for difference was thought to be due to discrepancy of measuring points. In this study, width of BMC in male were thicker than in females with statistical significance ($p<0.05$).

The mean width of RMC was 1.13 mm (SD±0.38, 0.60-2.00), with no statistical difference in gender. The mean horizontal distance between the midpoint of retromolar foramen and the distal aspect of 2nd molar was 14.08 mm (SD±3.85, 8.50-24.00), which was shorter than that of von Arx et al[15] by 1 mm, and longer than that of Bilecenoglu and Tuncer[8] by 2 mm. The horizontal distance by von Arx et al was measured between the midpoint of retromolar foramen and distal cementoenamel junction of the 2nd molar, whereas that by Bilecenoglu and Tuncer was measured between mesial border of retromolar foramen and distal edge of 2nd molar socket.

The mean vertical distance between the midpoint of retromolar foramen and the superior border of the main mandibular canal was 11.04 mm (SD±2.02, 7.80-17.90), which agrees with the measurements reported by von Arx et al.[15] The mean vertical distance of RMC in male was significantly longer than in female ($p<0.05$). This is explained by the fact that men have an overall greater height of the mandible in the retromolar area. Such measurements are rare, since most studies were based on retromolar foramen. Moreover, the standard points of measurement were different in some studies,[8,15] which made it difficult for various comparisons. The horizontal distance of RMC with 3rd molar is longer ($p<0.05$).

Fukami et al,[4] in his study on BMC using cadaver, suggested that the canal contains artery and nerve bundle, and claimed to have confirmed artery in similar size of the largest canal. The RMC also contains neurovascular system. RMC might conduct accessory innervation to the mandibular molars.[6] The bone dissections in the report by Bilenenoglu and Tuner[8] showed that a branch of the RMC goes to the 3rd molar. However some authors suggested RMC contains an anomaly of buccal nerve.[29] Though its neural contents are not clear yet, clinical significance of RMC is important such as BMC. When RMC or BMC exists, local anesthetic insufficiency can be raised, and if a nerve injury of BMC or RMC occurs during dental procedures, complications such as paraesthesia, excessive bleeding, and traumatic neuroma could arise.[4,30] Furthermore RMC may be at risk of damage when harvesting bone blocks, since this region is commonly used as a donor site.[31]

In patients with AMF, an accessory mental nerve may be present as well, considered a branch of the inferior alveolar nerve, which presence can cause anesthesia and surgery failure.[25] Toh et al[5] described the distributions of accessory mental nerve emerging from the AMF to the mucous membrane and skin of the corner of mouth to the labial region and reported that pain could arise when an injury occurs in the AMF. A nerve injury of AMF in flap surgery can induce temporary sensory disturbance, such as pain and paraesthesia.[5,9,32] Some authors defined AMF as an accessory foramen on the buccal side of the mental foramen that connects to mandibular canal. And other fine foramina on the bone surface are called nutrient foramina, which are entry sites of arteries distributed to the bone marrow and matrix.[22,23] However, Fuakimi et al[9] suggested the difficulty in defining AMF only with radiological methods.

Prevalence of the variations of mandibular canal is quite low in the previous reports using panoramic radiograph.[11,12,30] Since BMC, RMC, and AMF are generally very narrow or small, it is difficult to detect them on panoramic radiograph. In addition, because the images in the mandible overlap the shadow of the opposite mandible, the detailed status of the variations may be difficult to depict on panoramic radiograph.[33] However, cone beam CT is able to detect narrow variations of mandibular canals through reformatted panoramic, axial, cross-sectional, and sagittal images by 3 dimensional reconstruction. Then, this enables further study on the anatomical features of BMC, RMC, and AMF.

In this study, since the prevalence of BMC, RMC, and AMF were higher than those of previous reports using panoramic radiograph, they are no longer considered as rare anatomic structures. Therefore special attention has to be paid for identification of the variations prior to surgical procedures involving the mandible. Cone beam CT with multiplanar reformatted images is considered as an effective modality for detailed evaluation of the presence and features of variations of mandibular canals.

However, a radiographic study is insufficient in confirming the precise contents of the neurovasculature. More studies using cadaver are needed in order to identify the neurovascular bundle contained in the canals, and compared them with results obtained from cone beam CT. Moreover, additional studies of the reasons for the varying prevalence of mandibular canal variations according to racial difference are needed.

Ⅴ CONCLUSION

The conclusions of this study are as follows.

1. BMC, RMC and AMF were observed 12.6%, 8.5%, 8.1% among 446 patients on cone beam CT images. The prevalence of AMF was higher in males than in females with statistical significance ($p<0.05$).
2. According to the course of BMC, type I was the most frequent (69.4%), then type II was observed in 27.4% and type III was observed in 3.2%.
3. According to the course of RMC, the prevalence of type A, B and C was 66.7%, 20%, and 13.3%.
4. Most AMFs were located on antero-superior region of the mental foramina
5. The mean width of the BMCs was 1.17 mm (SD±0.33, 0.50-1.90). And the mean width of RMCs was 1.13 mm (SD±0.38, 0.60-2.00).

In this study, since the prevalence of BMC, RMC, and AMF was higher than that of previous reports using panoramic radiograph, they are no longer considered as rare anatomic structures. Therefore special attention has to be paid for identification of the variations prior to surgical procedures involving the mandible. Cone beam CT with multiplanar reformatted images is considered as an effective modality for detailed evaluation of the presence and features of variations of mandibular canals.

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Abstract (Korean)

콘빔시티를 이용한 하악관 변이에 관한 연구

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이열하악관 (bifid mandibular canal), 구후관 (retromolar canal) 및 부이공 (accessory mental foramen)과 같은 하악관의 해부학적 변이는 하악에서 행해지는 수술과정 중에 손상받기 쉬운 구조물이다. 이들의 내부에 신경혈관계를 포함하고 있으므로 임상적으로 중요한 의미를 갖는다. 그러나 기존의 파노라마 영상을 이용한 연구에서는 하악관의 변이의 빈도가 매우 낮게 나타났다. 최근 고해상도와 낮은 방사선조사량의 장점을 가진 콘빔시티가 하악관의 연구에 많이 이용됨으로써 기존의 방사선검사에서는 평가할 수 없었던 하악관의 변이에 관해 확인하는 것이 가능해졌다.

본 연구의 목적은 콘빔시티를 이용하여 한국인에서 나타나는 이열하악관과 구후관 및 부이공의 빈도와 해부학적 특징을 조사하는 것이다.

총 446명의 한국인의 콘빔시티 영상을 대상으로 하여 3차원 재구성을 통해 파노라마, 축상, 절단면, 시상 단면을 얻어 이열하악관과 구후관 및 부이공의 빈도와 해부학적 특징을 분석하였다.

그 결과 이열하악관은 12.6% (56명)에서 관찰되었고, 구후관은 8.5% (38명), 부이공은 8.1% (36명)에서 관찰되었다. 이열하악관과 구후관은 성별에 따른 빈도의 차이가 없었으나 부이공은 남성에서 빈도가 높게 나타났다 ($p<0.05$). 주행방향에 따른 분류 결과, 이열하악관은 I형이 가장 많았으며

구후관은 A형이 가장 많이 관찰되었다. 부이공은 위치분포 조사에서 이공의 전상방에 위치하는 경우가 가장 많았다.

본 연구에서의 이열하악관, 구후관 및 부이공의 빈도가 파노라마 영상을 이용한 기존의 연구에서 보다 매우 높게 조사됨으로써, 이러한 하악관의 변이들은 더 이상 희귀한 구조물로 생각되지 않는다. 따라서 하악에서의 수술과정 전에 하악관의 변이를 확인하는 데에 특별한 주의가 요구된다. 또한 3차원 재구성을 통한 다면 영상을 제공하는 콘빔시티는 하악관 변이의 존재와 특징을 자세히 평가하는데 있어서 효과적인 도구라고 생각된다.

핵심되는 말 : 하악관, 이열하악관, 구후관, 부이공, 콘빔시티