



저작자표시-비영리-변경금지 2.0 대한민국

이용자는 아래의 조건을 따르는 경우에 한하여 자유롭게

- 이 저작물을 복제, 배포, 전송, 전시, 공연 및 방송할 수 있습니다.

다음과 같은 조건을 따라야 합니다:



저작자표시. 귀하는 원저작자를 표시하여야 합니다.



비영리. 귀하는 이 저작물을 영리 목적으로 이용할 수 없습니다.



변경금지. 귀하는 이 저작물을 개작, 변형 또는 가공할 수 없습니다.

- 귀하는, 이 저작물의 재이용이나 배포의 경우, 이 저작물에 적용된 이용허락조건을 명확하게 나타내어야 합니다.
- 저작권자로부터 별도의 허가를 받으면 이러한 조건들은 적용되지 않습니다.

저작권법에 따른 이용자의 권리는 위의 내용에 의하여 영향을 받지 않습니다.

이것은 [이용허락규약\(Legal Code\)](#)을 이해하기 쉽게 요약한 것입니다.

[Disclaimer](#)

2017년 2월

2017년 2월  
박사학위 논문

박사학위논문

CBCT Study on the mandibular first molars with distolingual root in Korean 김희호

CBCT study on the mandibular  
first molars with distolingual  
root in Korean

- CBCT study of mandibular first molars -

조선대학교 대학원

치의학과

김희호

# CBCT study on the mandibular first molars with distolingual root in Korean

- CBCT study of mandibular first molars -

2017년 2월 24일

조선대학교 대학원

치의학과

김 희 호

# CBCT study on the mandibular first molars with distolingual root in Korean

- CBCT study of mandibular first molars -

지도교수 황 호 길

이 논문을 치의학박사학위 신청 논문으로 제출함

2016년 10월

조선대학교 대학원

치의학과

김 희 호

## 김희호의 박사학위논문을 인준함

|     |       |    |                  |
|-----|-------|----|------------------|
| 위원장 | 서울대학교 | 교수 | <u>백 승 호 (인)</u> |
| 위 원 | 조선대학교 | 교수 | <u>김 흥 중 (인)</u> |
| 위 원 | 조선대학교 | 교수 | <u>김 진 수 (인)</u> |
| 위 원 | 조선대학교 | 교수 | <u>민 정 범 (인)</u> |
| 위 원 | 조선대학교 | 교수 | <u>황 호 길 (인)</u> |

2016년 12월

조선대학교 대학원

## CONTENTS

|                                  |    |
|----------------------------------|----|
| Abstract .....                   | iv |
| I . INTRODUCTION .....           | 1  |
| II . MATERIALS AND METHODS ..... | 3  |
| III . RESULTS .....              | 9  |
| IV . DISCUSSION .....            | 15 |
| V . CONCLUSION .....             | 19 |
| REFERENCES .....                 | 20 |

## TABLE LEGENDS

|  |    |
|--|----|
| Table 1. Incidence of 2R2C and 1R2C at the distal root in mandibular first molars .....                                  | 11 |
| Table 2. The mesial root canal type of mandibular first molars with 2R2C .....   | 12 |
| Table 3. Unilateral and bilateral status of 2R2C in mandibular first molars .....  | 12 |
| Table 4. The distance from root apex to outer surface of buccal cortical bone in mandibular first molars with 2R2C ..... | 13 |
| Table 5. The thickness of buccal cortical bone in mandibular first molars with 2R2C .....                                | 14 |

## FIGURE LEGENDS

- Fig. 1. Cone-beam computed tomography (CBCT) images .....6
- Fig. 2. On the coronal plane of CBCT image, three points that intersected with horizontal line at the mesial root apex in mandibular first molars with 2R2C .....7
- Fig. 3. On the coronal plane of CBCT image, four points that intersected with horizontal line at the distal root apex in mandibular first molars with 2R2C .....8



## ABSTRACT

### 한국인에서 원심설측 치근을 가진 하악 제1대구치의 CBCT 연구

- 하악 제1대구치의 CBCT 연구 -

Kim HeeHo

Advisor : Prof. Hwang HoKeel, Ph.D.

Department of Dentistry,

Graduate School of Chosun University

이 연구의 목적은 CBCT 영상을 이용하여 한국인에서 하악 제1대구치에서 원심설측 치근의 발현을 뿐만 아니라 형태를 조사하고 협측 피질골 두께를 측정하는 것이다.

이 연구를 위해 CBCT 데이터 중, 고해상도의 432개의 자료를 선택하였다. 먼저 하악 제1대구치의 원심설측 치근의 발현율을 조사하였다. 그리고 원심설측 치근을 가진 하악 제1대구치의 근심측 치근 근관의 형태와 근심측 치근단 부위로부터 협측 피질골 외면까지의 거리, 협측 피질골의 두께를 측정하였다. 그리고 원심설측 치근단 부위로부터 협측 피질골 외면까지의 거리와 원심협측 치근단 부위로부터 협측 피질골 외면까지의 거리를 측정하였다. 또한, 원심측 치근단 부위 협측 피질골의 두께도 측정하였다.

분리된 원심설측 치근의 발현율은 23.26 % 이었다. Weine의 분류법에 따르면 분리된 원심 치근을 가진 하악 제1대구치에서 근심측 치근의 근관의 형태는 Type II가 51.74 %, Type III가 48.26 % 이었다. 분리된 원심설측 치근을 가지는 하악 제1대구치에서 근심측 치근단 부위로부터 협측 피질골 외면까지의 거리는 5.98 mm, 원심협측 치근단 부위로부터 협측 피질골 외면까지의 거리는 5.51 mm, 원심설측 치근단 부위로부터 협측 피질골 외면까지의 거리는 12.09 mm 이었다 ( $P < .05$ ). 분리된 원심설측 치근을 가지는 하악 제1대구치에서, 원심설측 치근단 부위로부터 협측 피질골 외면까지의 거리는 우측이 12.48 mm, 좌측이 11.57 mm 이

었다 ( $P < .05$ ). 그러나 근심측 치근단 부위로부터 협측 피질골 외면까지의 거리는 우측이 6.20 mm, 좌측이 5.69 mm, 원심협측 치근단 부위로부터 협측 피질골 외면까지의 거리는 우측이 5.70 mm, 좌측이 5.27 mm 이었다.

분리된 원심설측 치근을 가지는 하악 제1대구치에서 원심측 치근단 부위의 협측 피질골 두께는 3.30 mm 로, 우측이 3.38 mm, 좌측이 3.09 mm 이었다 ( $P < .05$ ). 그러나 근심측 치근단 부위의 협측 피질골 두께는 3.26 mm 로, 우측이 3.24 mm, 좌측이 3.29 mm 이었다.

이 연구의 결과에 따르면, 분리된 원심설측 치근을 가진 우측 하악 제1대구치의 외과적 치근단 절제술시, 두꺼운 협측 피질골에 창을 형성하고 원심설측 치근에 접근하는 것은 더 많은 시간과 노력이 필요하다. 따라서 CBCT 방사선 사진은 통상적인 근관치료 뿐만 아니라 미세 치근단 수술 전 하악 제1대구치의 진단과 치료 계획을 위한 더 많은 정보가 필요할 때 고려되어야 한다.

## I . Introduction

Together with diagnosis and treatment planning, the knowledge of common root canal morphology is a basic requirement for endodontic success. And recognition of variations in root morphology is important for dental procedures such as root canal treatment and periradicular microsurgery.

Non-surgical endodontic treatment gives good results in most cases. But, a complex root morphology of the mandibular first molar makes it hard. The mandibular first molar usually has two roots, but occasionally it has three with two or three canals in the mesial root and one, two, or three canals in the distal root. Although the presence of two separate distal roots is rare, in Asian populations, literature reviews have shown the high prevalence of 3-rooted mandibular first molar from 5 % to more than 40 %.<sup>1-5</sup>

In such cases the distolingual (DL) root is smaller than the distobuccal (DB) root and usually more curved.<sup>6</sup> Also, the DL root often has a sharp apical hook toward the buccal that is not obvious on radiograph. The mesial root, the wider of the two roots, curves mesially from the cervical line to middle third of the root and then angles distally to the apex. The buccal and lingual surfaces are convex throughout their length, whereas the distal surface of the mesial root and the mesial surface of the distal root have a root concavity, which makes the dentin wall very thin. Care must be taken to minimize instrumentation against these walls, because overzealous cutting of the concavity can lead to a strip perforation of the root.

And roots of posterior teeth have the most isthmi which are often found connecting two canals in one root 3 mm from the apex.<sup>7</sup> An isthmus is a narrow connection between two root canals and usually contains

pulp tissue. The non-microsurgical traditional techniques can neither identify nor treat the isthmus.

The periradicular surgery, including apicoectomy and intentional replantation, may be indicated for teeth with persistent periradicular pathoses that have not responded to non-surgical approaches. Especially, surgical approaches to mandibular first molars are difficult because of complex root morphology, shallow vestibule and thick buccal alveolar bone.

In the routine diagnostic periapical radiograph, the central ray is placed perpendicular to the mandibular first molar and the film. Therefore, the image of the DL root is easily superimposed on the DB root, and it is unclear.<sup>8</sup> For non-invasive and three-dimensional reconstruction imaging, cone beam computed tomography (CBCT) can be used to evaluate morphologic analysis of the DL root of the mandibular first molar. And anatomic studies using CBCT can provide some guidance for an access to the surgical site.<sup>9-11</sup>

The aim of this study was to investigate morphology as well as the prevalence of separate DL root and to measure the thickness of buccal cortical bone of the mandibular first molars in Korean by using CBCT images.

## II. Materials and Methods

The research protocol of this study was approved by the Institutional Review Board of the Chosun University Dental Hospital of Korea (CUDHIRB-1606-030). For an analysis of the morphology of mandibular first molars, CBCT images that had been taken from July 2012 to June 2013 at Chosun University Dental Hospital (Gwangju, Korea) for third molar extraction were screened and examined.

Fully erupted and completely root formed mandibular first molars without root canal treatment were selected. Among those CBCT data, 432 subjects (209 females and 223 males) which had high quality of radiographic data were selected for this study. The patients were 11 to 62 years, mean age was 24. Finally, total of 864 mandibular first molars were examined retrospectively.

The CBCT images were taken by using CB Mercuray (Hitachi medical corp, Tokyo, Japan) and the scan setting were  $\varnothing$  10 cm scan field of view, 0.2 mm voxel size, 120 kVp, 15 mA, with a 10 second exposure time. Tomography sections were displayed by Ondemand3D software (Cybermed, Seoul, Korea) in the axial, coronal, and sagittal planes. Contrast and brightness of the image could be adjusted using the image processing tool of the software to ensure an optimal visualization. The long axis of each mandibular first molar was determined and cross-sectional images at the apical third of the root were examined by rolling the tool bar from pulp chamber to the apex of the tooth. The type of mesial root canal morphology and the prevalence of separate DL root of mandibular first molar was investigated through these procedures (Figure 1).

For an exacting investigation of the distance from root apex to outer surface of buccal cortical bone of mandibular first molar with 2R2C (2 separate distal roots with 1 canal each root), fine adjustment

was done on CBCT image using Ondemand3D software.

To investigate the mesial root anatomy, in axial view, an intersecting point was moved to mesial root of mandibular first molar with 2R2C. Then, in axial and sagittal view, the coronal plane was set as parallel to mesial root of mandibular first molar with 2R2C. In coronal view, the horizontal line passing a mesial root apex perpendicularly was drawn. And the line was extended to the buccal cortical bone. On the coronal plane of CBCT image, three points that intersected with horizontal line were set up as A, B, and C, which were mesial root apex (A), inner surface of buccal cortical bone (B) and outer surface of buccal cortical bone (C) (Figure 2).

The distance from mesial root apex to outer surface of buccal cortical bone was measured, which is the distance between A and C. And the thickness of buccal cortical bone was measured, which is the distance between B and C.

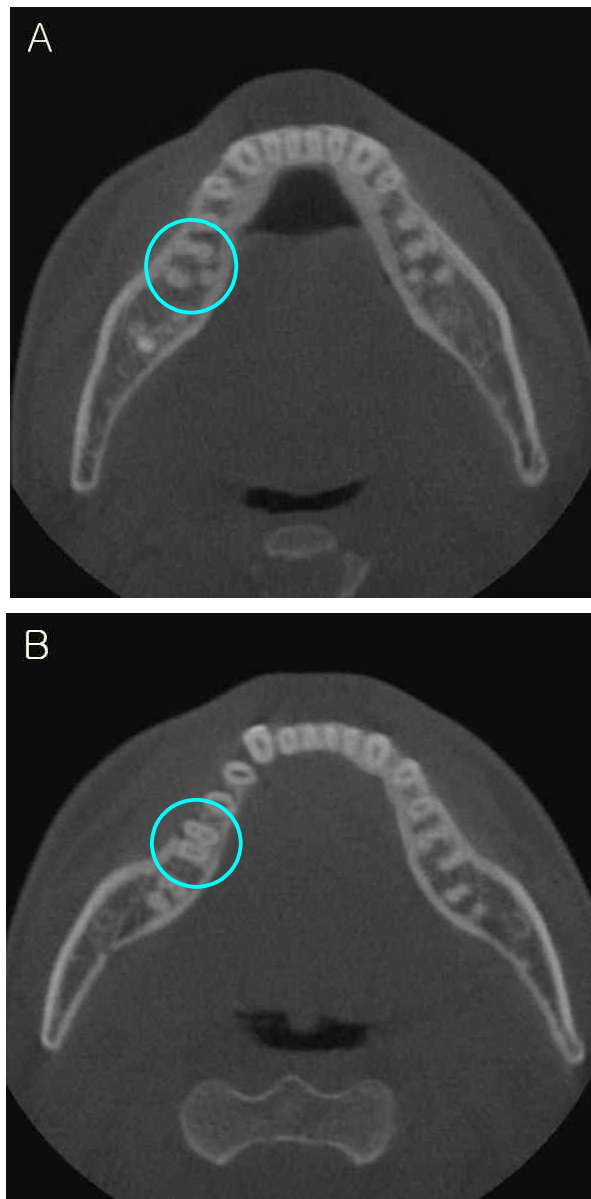
To investigate the distal root anatomy, in an axial view, the intersecting point was moved to DL root of mandibular first molar with 2R2C. Then, in an axial and sagittal view, the coronal plane was set as parallel to two long axis of DL and DB root of mandibular first molar with 2R2C. In a coronal view, the horizontal line passing two points, DL and DB root apex, was drawn. And the line was extended to the buccal cortical bone. On the coronal plane of CBCT image, four points that intersected with horizontal line were set up as A, B, C and D, which were DL root apex (A), DB root apex (B), inner surface of buccal cortical bone (C) and outer surface of buccal cortical bone (D) (Figure 3).

The distance from DL root apex to outer surface of buccal cortical bone was measured, which is the distance between A and D. And the distance from DB root apex to outer surface of buccal cortical bone was

measured, which is the distance between B and D. The thickness of buccal cortical bone was also measured, which is the distance between C and D.

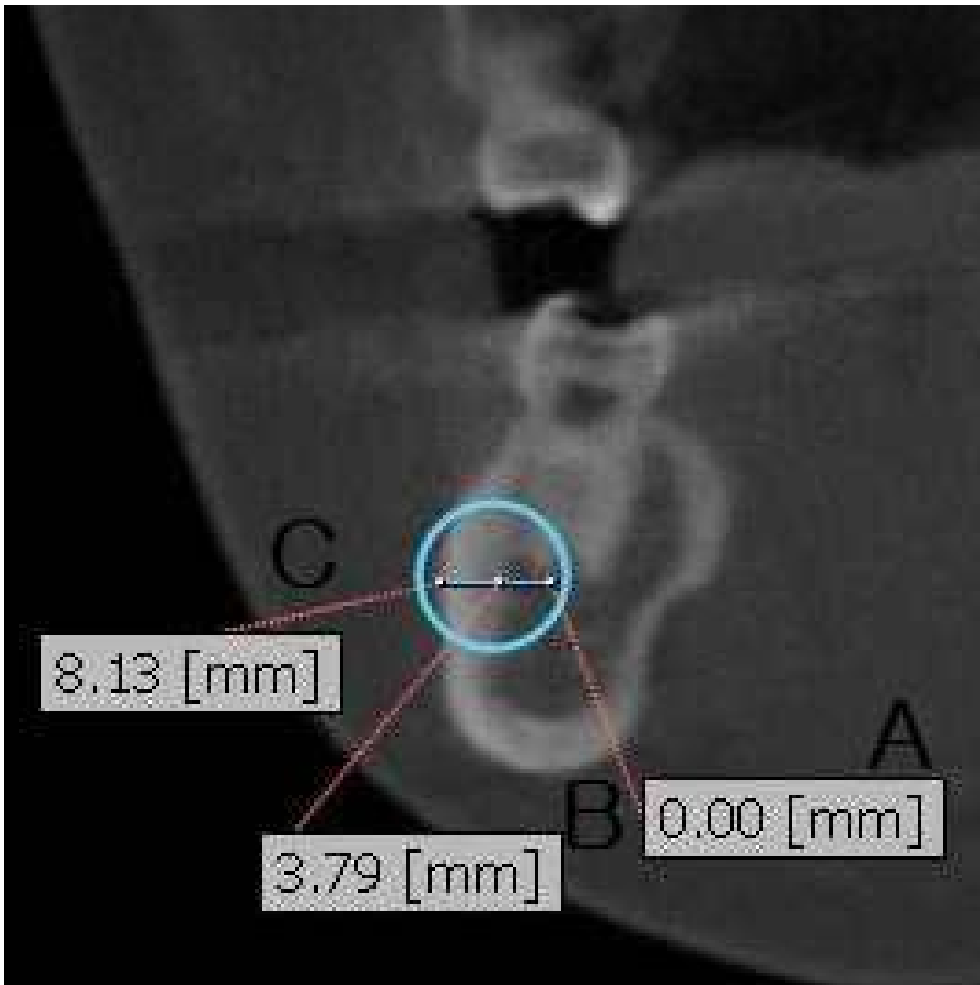
This study using CBCT that adjusted coronal plane to mandibular first molar shows precise measurement. Gender ratio, bilateral and unilateral occurrence, and the difference distance between right and left mandibular first molars were also analyzed.

Statistically significant differences were evaluated by *t* test using SPSS software (Version 12.0; SPSS Inc, Chicago, IL, USA). All statistical inferences were made within a 95 % confidence interval ( $P < .05$ ).

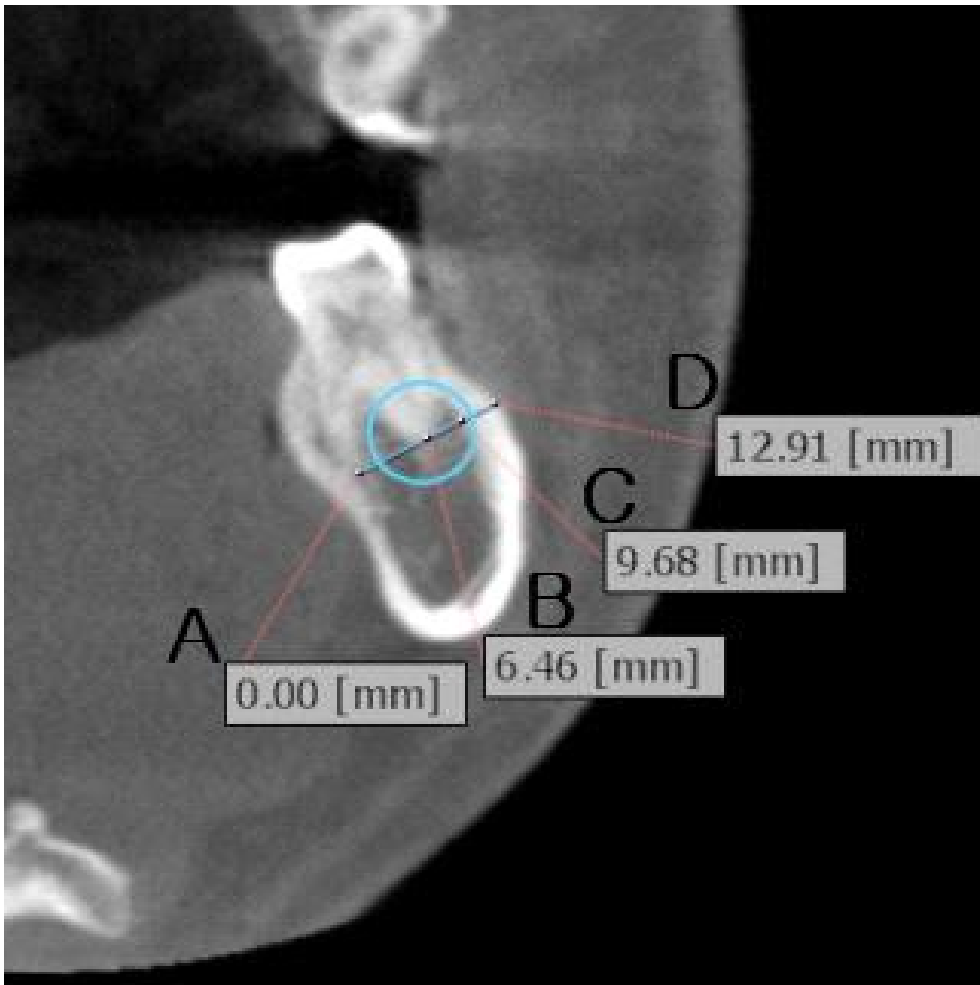


**Figure 1.** Cone-beam computed tomography (CBCT) images. (A) Mandibular first molars with 2R2C (2 separate distal roots with 1 canal each root). (B) Mandibular first molars with 1R2C (1 distal root with 2 separate canals).





**Figure 2.** On the coronal plane of CBCT image, three points that intersected with horizontal line at the mesial root apex in mandibular first molars with 2R2C were set up as A, B and C, which were mesial root apex (A), inner surface of buccal cortical bone (B) and outer surface of buccal cortical bone (C). CBCT, cone-beam computed tomography.



**Figure 3.** On the coronal plane of CBCT image, four points that intersected with horizontal line at the distal root apex in mandibular first molars with 2R2C were set up as A, B, C and D, which were DL root apex (A), DB root apex (B), inner surface of buccal cortical bone (C) and outer surface of buccal cortical bone (D). CBCT, cone-beam computed tomography; DL, distolingual; DB, distobuccal.

### III. Results

864 CBCT images (432 people) of mandibular first molars were evaluated. The total incidence of separate DL root was 23.26 % (201 / 864). The incidence of 2R2C was 19.90 % (86 / 432) on the left side and 26.62 % (115 / 432) on the right side. And total incidence of mandibular first molars with 1R2C (1 distal root with 2 separate canals) was 25.69 % (222 / 864). The incidence of 1R2C was 26.85 % (116 / 432) on the left side and 24.53 % (106 / 432) on the right side (Table 1). The mesial root canal anatomy of mandibular first molars with 2R2C has Type II (104 / 201, 51.74 %) and Type III (97 / 201, 48.26 %) configuration by Weine classification (Table 2).<sup>12</sup>

The patients who had concurrent bilateral 2R2C were observed in 18.75 % (81 / 432). Among 432 patients, 5 patients (5 females and 0 male) who had unilateral 2R2C on the left side were observed and 34 patients (14 females and 20 males) who had unilateral 2R2C on the right side were observed (Table 3).

In mandibular first molars with 2R2C, the distance from mesial root apex to outer surface of buccal cortical bone was 5.98 mm. The distance from DB root apex to outer surface of buccal cortical bone was 5.51 mm. And the distance from DL root apex to outer surface of buccal cortical bone was 12.09 mm. The results showed a significant statistical difference between the groups ( $P < .05$ ).

In mandibular first molars with 2R2C, right mandibular first molar showed a significantly longer distance from DL root apex to outer surface of buccal cortical bone (12.48 mm) than that of left mandibular first molar (11.57 mm) ( $P < .05$ ). But there was no significant statistical difference between right side (6.20 mm) and left side (5.69 mm) of the distance from mesial root apex to outer surface of buccal

cortical bone. And there was no significant statistical difference between right side (5.70 mm) and left side (5.27 mm) of the distance from DB root apex to outer surface of buccal cortical bone (Table 4).

In mandibular first molars with 2R2C, the thickness of buccal cortical bone at the mesial root apex of mandibular first molar was 3.26 mm. And the thickness of buccal cortical bone at the distal root apex of mandibular first molar was 3.30 mm. There was no significant statistical difference between the groups. In mandibular first molars with 2R2C, right mandibular first molar had a significantly longer distance from inner to outer surface of buccal cortical bone at the distal root apex (3.38 mm) than that of left mandibular first molar (3.09 mm) ( $P < .05$ ). But there was no significant statistical difference between right side (3.24 mm) and left side (3.29 mm) of the distance from inner to outer surface of buccal cortical bone at the mesial root apex (Table 5).

**Table 1.** Incidence of 2R2C and 1R2C at the distal root in mandibular first molars

|      | Left       |          |                    | Right      |          |                    | Total, n (%)       |
|------|------------|----------|--------------------|------------|----------|--------------------|--------------------|
|      | Female (n) | Male (n) | Total, n (%)       | Female (n) | Male (n) | Total, n (%)       |                    |
| 2R2C | 37         | 49       | 86 / 432, (19.90)  | 55         | 60       | 115 / 432, (26.62) | 201 / 864, (23.26) |
| 1R2C | 51         | 65       | 116 / 432, (26.85) | 49         | 57       | 106 / 432, (24.53) | 222 / 864, (25.69) |

2R2C, 2 separate distal roots with 1 canal each root.

1R2C, 1 distal root with 2 separate canals.

**Table 2.** The mesial root canal type of mandibular first molars with 2R2C

|      | Type II, n (%)     | Type III, n (%)   |
|------|--------------------|-------------------|
| 2R2C | 104 / 201, (51.74) | 97 / 201, (48.26) |

2R2C, 2 separate distal roots with 1 canal each root.

Type II, two separate canals leaving the chamber but merging short of the apex to form only one canal.

Type III, two separate canals leaving the chamber and exiting the root in separate apical foramina.

Root canal type was classified by Weine.<sup>12</sup>

**Table 3.** Unilateral and bilateral status of 2R2C in mandibular first molars

|      | Unilateral left |          | Unilateral right |          | Bilateral  |          | Total, n (%)      |
|------|-----------------|----------|------------------|----------|------------|----------|-------------------|
|      | Female (n)      | Male (n) | Female (n)       | Male (n) | Female (n) | Male (n) |                   |
| 2R2C | 5               | 0        | 14               | 20       | 32         | 49       | 81 / 432, (18.75) |

2R2C, 2 separate distal roots with 1 canal each root.

**Table 4.** The distance from root apex to outer surface of buccal cortical bone in mandibular first molars with 2R2C

|      | A, mean (mm) |       |                   | B, mean (mm) |       |                   | C, mean (mm)       |                    |                    |
|------|--------------|-------|-------------------|--------------|-------|-------------------|--------------------|--------------------|--------------------|
|      | Left         | Right | Total             | Left         | Right | Total             | Left               | Right              | Total              |
| 2R2C | 5.69         | 6.20  | 5.98 <sup>A</sup> | 5.27         | 5.70  | 5.51 <sup>B</sup> | 11.57 <sup>a</sup> | 12.48 <sup>b</sup> | 12.09 <sup>C</sup> |

2R2C, 2 separate distal roots with 1 canal each root.

A, The distance from mesial root apex to outer surface of buccal cortical bone.

B, The distance from DB root apex to outer surface of buccal cortical bone.

C, The distance from DL root apex to outer surface of buccal cortical bone.

DB, distobuccal; DL, distolingual.

The superscript letter indicates significant difference between the groups ( $p < .05$ ).

**Table 5.** The thickness of buccal cortical bone in mandibular first molars with 2R2C

|      | At the mesial root<br>apex, mean (mm) |       |       | At the distal root<br>apex, mean (mm) |                   |       |
|------|---------------------------------------|-------|-------|---------------------------------------|-------------------|-------|
|      | Left                                  | Right | Total | Left                                  | Right             | Total |
| 2R2C | 3.29                                  | 3.24  | 3.26  | 3.09 <sup>a</sup>                     | 3.38 <sup>b</sup> | 3.30  |

2R2C, 2 separate distal roots with 1 canal each root.

The superscript letter indicates significant difference between the groups ( $p < .05$ ).



## IV. Discussion

The earliest permanent posterior tooth to erupt, the mandibular first molar most often requires dental therapy such as caries control, root canal treatment and periradicular surgery.<sup>6</sup> It often is extensively restored, and it is subjected to heavy occlusal stress. Therefore the pulp chamber frequently has receded or is calcified. And roots of posterior teeth have the most isthmi which are often found connecting two canals in one root 3 mm from the apex. These root anatomic complexes of mandibular first molar make it difficult to perform root canal treatment. Therefore, it is essential to know the anatomic complex of mandibular first molar for dental clinicians.

An isthmus is formed when an individual root projection is unable to close itself off.<sup>7</sup> Partial fusion results in the formation of two root canals with an isthmus between them, which occurs in the mesial root of the mandibular first molar. The mesial canal morphology including canal type is essential knowledge for conventional root canal treatment. No fusion cause the formation of a large, ribbon-shaped canal that forms an isthmus throughout the entire root, which is a common finding in the distal root of the mandibular first molar. More isthmi are found in the mesial roots than in the distal roots of mandibular molars. In the mesial root of the mandibular first molar, approximately 80 % of the sections from the 3 mm level contain isthmi. By contrast only 15 % of the distal roots have isthmi at the 3 mm level.

Mandibular first molars usually have 2 roots located mesially and distally. But DL root is considered as a normal morphologic variant at mandibular first molar in an Asian population. Many studies show similar results about that.<sup>1-3,13</sup> We found 23.26 % (201 / 864) of the mandibular first molars had 2R2C. Also, we found 25.69 % (222 / 864) of

the mandibular first molars had 1R2C. These results of this study supported previous studies.

Topological predilection for the presence of DL root in the mandibular first molar is a controversial issue. Many studies found right side predominance.<sup>1,3,14-16</sup> To the contrary, some investigators reported predilection for the left side.<sup>17,18</sup> The results of this study supported the predilection for the right side.

The incidence of bilateral appearance of DL root was 18.75 % (81 / 432) in this study, similar to the result of previous study (18.38 %, 17.64 %).<sup>19,20</sup> If the incidence was calculated by using 3-rooted molars as the common denominator, the bilateral distribution increased to 80.59 % (162 / 201). This was higher than that of Taiwanese individuals (68.60 %), that of the population of Hong Kong (61.00 %) and that of the population of Korea (77.31 %).<sup>3,16,20</sup> The diversity in the outcomes of the previously mentioned studies might result from their different methods, sample size, and subject inclusion criteria.

After an conventional root canal treatment, periapical lesion may occur on DL root of mandibular first molar. Then, clinicians consider three kinds of treatment plans such as re-treatment, apicoectomy and intentional replantation. It is an ideal situation if re-treatment is successful. But when re-treatment is failed or unable, surgical treatment as apicoectomy and intentional replantation will be an option. When surgical treatment is planed, clinicians must deliberate on an anatomic consideration and variation. Evaluating the access to the surgical site is the most important step in case selection for periradicular surgery.

Whereas the mesial root of the mandibular first molar is apparently close to the buccal cortical plate, the distal root of it is centrally located in the bone, and the roots of the second molar are

significantly close to the lingual cortical plate.<sup>20,21</sup> For this reason, an access to distal root is more difficult than mesial root in surgical approaches to mandibular first molar. In mandibular first molars with 2R2C of this study, the distance from mesial root apex to outer surface of buccal cortical bone was 5.98 mm. The distance from DB root apex to outer surface of buccal cortical bone was 5.51 mm. And the distance from DL root apex to outer surface of buccal cortical bone was 12.09 mm. According to the results of this study, the presence of DL root makes it more difficult to access. Therefore, clinicians take CBCT image for a better diagnosis and surgery before surgical endodontic treatment. The results of this study will be helpful to estimate the anatomical distance of mandibular first molars in Korean.

According to previous study using CBCT image with voxel size (0.4 mm), the distance from DL canal to buccal cortical bone was significantly different between 2R2C and 1R2C.<sup>20</sup> In 2R2C, the distance was longer than that of 1R2C. On the contrary, the distance from DB canal to buccal cortical bone of 2R2C was shorter than that of 1R2C. It means that an access to DL canal in 2R2C is more difficult than 1R2C during apicoectomy, and an access to DB canal in 2R2C is easier than 1R2C.

This study is performed at the base of CBCT data, which has a better resolution by the smaller voxel size (0.2 mm). The better resolution than that of previous study has a great influence on an accuracy of radiographic investigation. And fine adjustment of CBCT image using Ondemand3D software enabled us to measure the anatomical distance more precisely.

In this study, tooth anatomy between right and left mandibular first molar with 2R2C was evaluated. The distance from DL root apex to outer surface of buccal cortical bone and the buccal cortical bone thickness

at the distal root apex showed a significant statistical difference between right and left side. It will be necessary that further study of relationship between the anatomy of mandibular first molar and the mastication involved unilateral chewing.

In a periradicular surgery of mandibular first molar which has DL root, the distance between outer surface of buccal cortical bone and DL root apex is important. The long distance makes it hard to visualize and access the operating site of DL root apex. In this study, the distance from outer surface of buccal cortical bone to DL root apex showed a significant statistical difference between left (11.57 mm) and right (12.48 mm) side. And the thickness of buccal cortical bone at the distal root apex in mandibular first molars with 2R2C, which has to be removed for periradicular surgery, showed a significant statistical difference between left (3.09 mm) and right (3.38 mm) side.

According to these results of this study, when the apicoectomy of DL root of mandibular first molar with 2R2C on right side is done by the clinicians, more time and concentration is required to make a bony window on thick buccal cortical bone. During the process, heat generation must be minimized to preserve healthy hard tissue.<sup>22,23</sup> And the long distance from outer surface of buccal cortical bone to DL root apex makes it hard to see the DL root apex. Therefore, the clinicians may need a larger bony window at the mandibular first molar with 2R2C for a good visualization than they do for the other teeth.

With proper case selection, morphologic knowledge and operator's skill, periradicular surgery for mandibular first molar, which has a persistent periradicular disease on separate DL root after nonsurgical re-treatment, can be considered a predictable, cost-effective alternative to an extraction and tooth replacement.

## V. Conclusion

Separate DL root is not rare in the mandibular first molars in Korean. According to the results of this study, when the apicoectomy of DL root of mandibular first molar on right side is done by the clinicians, more time and concentration is required to make a bony window on thick buccal cortical bone and approach DL root. Anatomic and morphologic knowledge about mandibular first molar such as the mesial root canal morphology, the occurrence of DL root, buccal cortical bone thickness, and the distance from DL root apex to outer surface of buccal cortical bone can improve the success rate of an endodontic microsurgery. Therefore the CBCT image must be considered when more information for diagnosis and treatment planning of mandibular first molar is needed before not only conventional root canal treatment but also endodontic microsurgery.

## References

1. Song JS, Choi HJ, Jung IY, Jung HS, Kim SO. The prevalence and morphologic classification of distolingual roots in the mandibular molars in a Korean population. *J Endod* 2010;36:653-657.
2. Wang Y, Zheng QH, Zhou XD, Tang L, Wang Q, Zheng GN, Huang DM. Evaluation of the root and canal morphology of mandibular first permanent molars in a western Chinese population by cone-beam computed tomography. *J Endod* 2010;36:1786-1789.
3. Tu MG, Tsai CC, Jou MJ, Chen WL, Chang YF, Chen SY, Cheng HW. Prevalence of three-rooted mandibular first molars among Taiwanese individuals. *J Endod* 2007;33:1163-1166.
4. Chen YC, Lee YY, Pai SF, Yang SF. The morphologic characteristics of the distolingual roots of mandibular first molars in a Taiwanese population. *J Endod* 2009;35:643-645.
5. De Moor RJ, Deroose CA, Calberson FL. The radix entomolaris in mandibular first molars: an endodontic challenge. *Int Endod J* 2004;37:789-799.
6. Stephen C, Kenneth MH. *Pathways of the pulp*. 9th ed. Philadelphia: Mosby; 2005. Chapter 7, 20.
7. Kim SC, Gabriele P, Richard AR. *Color atlas of microsurgery in endodontics*. 1st ed. Philadelphia: Saunders; 2000. Chapter 10.
8. Cotton TP, Geisler TM, Holden DT, Schwartz SA, Schindler WG. Endodontic applications of cone-beam volumetric tomography. *J Endod* 2007;33:1121-1132.
9. Tu MG, Huang HL, Hsue SS, Hsu JT, Chen SY, Jou MJ, Tsai CC. Detection of permanent three-rooted mandibular first molars by cone-beam computed tomography imaging in Taiwanese individuals. *J Endod* 2009;35:503-507.
10. Patel S, Dawood A, Ford TP, Whaites E. The potential applications

of cone beam computed tomography in the management of endodontic problems. *Int Endod J* 2007;40:818-830.

11. Nair MK, Nair UP. Digital and advanced imaging in endodontics: a review. *J Endod* 2007;33:1-6.

12. Weine FS. *Endodontic therapy*. 5th ed. St Louis: Mosby; 1996. p243.

13. Choi MR, Moon YM, Seo MS. Prevalence and features of distolingual roots in mandibular molars analyzed by cone-beam computed tomography. *Imaging Sci Dent* 2015;45:221-226.

14. Gulabivala K, Opananon A, Ng YL, Alavi A. Root and canal morphology of Thai mandibular molars. *Int Endod J* 2002;35:56-62.

15. Song JS, Kim SO, Choi BJ, Choi HJ, Son HK, Lee JH. Incidence and relationship of an additional root in the mandibular first permanent molar and primary molars. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2009;107:e56-60.

16. Walker RT, Quackenbush LE. Three-rooted lower first permanent molars in Hong Kong Chinese. *Br Dent J* 1985;159:298-299.

17. Loh HS. Incidence and features of three-rooted permanent mandibular molars. *Aust Dent J* 1990;35:434-437.

18. Curzon ME. Three-rooted mandibular permanent molars in English Caucasians. *J Dent Res* 1973;52:181.

19. Huang RY, Cheng WC, Chen CJ, Lin CD, Lai TM, Shen EC, Chiang CY, Chiu HC, Fu E. Three-dimensional analysis of the root morphology of mandibular first molars with distolingual roots. *Int Endod J* 2010;43:478-484.

20. Kim SY, Yang SE. Cone-beam computed tomography study of incidence of distolingual root and distance from distolingual canal to buccal cortical bone of mandibular first molars in a Korean population. *J Endod* 2012;38:301-304.

21. Gutmann JL, Harrison JW. *Posterior endodontic surgery: anatomical*

considerations and clinical techniques. *Int Endod J* 1985;18:8-34.

22. Matthews LS, Hirsch C. Temperatures measured in human cortical bone when drilling. *J Bone Joint Surg Am* 1972;54:297-308.

23. Eriksson RA, Albrektsson T, Magnusson B. Assessment of bone viability after heat trauma. A histological, histochemical and vital microscopic study in the rabbit. *Scand J Plast Reconstr Surg* 1984;18:261-268.