Prevalence of cervical enamel projection and its impact on furcation involvement in mandibular molars: a cone-beam computed tomography study in Korean

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Prevalence of cervical enamel projection and its impact on furcation involvement in mandibular molars: a cone-beam computed tomography study in Korean

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This certifies that the dissertation of *Seok-Kyun Jeon* is approved.

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감사의 글

석사 과정을 마치며 지금까지 도와주신 모든 분들께 깊은 감사를 드립니다. 학교 공부는 그저 과정이라 여겼던 저는 사회라는 큰 벽을 만난 후 큰 좌절을 맛보았습니다. 요령과 팁을 익히는데 주력했던 저의 임상과 치의학적 지식은 많은 환자를 대하면 대할수록 좁아지고 어려워 지는 것을 느끼게 되었습니다. '나는 정말로 부족하구나 정말 많은 노력이 필요하다'는 사실을 깨닫기 까지 너무나 많은 시간이 걸렸습니다. 그래서 조금 더 나은 나를 위해 결정하게 된 학위과정은 생각보다 만만치 않았습니다. 개인 병원과 학교를 왔다 갔다 정신 없는 가운데 학위 과정 중간 둘째 아이가 큰 병을 얻게 되어 생사의 기로에 있을 때 지금 내가 하고 있는 많은 것들을 내려놓고 싶었습니다. 이때 기다려주시고 격려해 주신 정의원 교수님과 사랑하는 가족들이 아니었다면 학위과정을 온전히 마치지 못했을 것입니다.

큰 기대를 가져주시고 많은 배려를 해주신 정의원 교수님께 감사 드립니다. 교수님의 정성 어린 지도에도 불구하고 여러 가지 이유로 원하는 결과를 내지 못할 때에도 이해해 주시고 기회를 주신데 대해 깊은 감사를 드립니다. 지구 반대 편에서도 늘 관심 가져 주시고 배려해 주심으로 이러한 결과물이 나올 수 있었습니다. 논문 쓰는 과정 내내 지원해 주시고 큰 도움을 주신 임현창 선생님께 감사 드립니다. 꿈을 향해 전진하시는 모습이 부럽고 어려운 과정을 선생님을 통해 무사히 진행할 수 있게 되어 진심으로 감사 드립니다.

마지막으로 세상 무엇과도 바꿀 수 없는 사랑하는 우리 가족에게 고마움을 전합니다. 세 아이를 키우는 와중에도 항상 웃는 얼굴로 저를 격려해준 아내 지혜에게 무한한 감사를 올립니다. 항상 나 하고 싶은 대로 인생을 계획하지만 언제나 나를 존중해 주고 인정해주는 당신에게 늘 고맙고 미안합니다. 항상 우리가족을 사랑으로 품어주고 기도해 주는 당신이 있어 제가 세상으로 나아갈 수 있습니다. 힘든 상황에서도 서로 의지할 수 있었기에 지금의 내가 있음을 고백합니다. 어려운 가운데서도 교육의 중요성을 잊지 않으시고 아들에게 항상 격려와 지원을 아끼지 않으셨던 어머님께 큰 감사를 올려 드립니다.

사랑하는 우리 첫째 딸 사랑이 둘째 아들 하랑이 막내 소망이가 있음으로 아빠는 누구보다 강한 사람이 될 수 있습니다. 공부 잘하는 아이들이 아닌 주어진 환경에서 최선을 다하는 아이들로 키우고 싶습니다. 아이들에게 조금이라도 도전이 되는 아빠의 모습으로 남고 싶습니다. 아빠에게 살아갈 용기를 주는 사랑하는 우리 자녀들에게 감사의 인사를 전합니다.

“너의 행사를 여호와께 맡기라 그리하면 네가 경영하는 것이 이루어 지리라”. 내려 놓는 삶, 하나님께 맡기는 삶, 조금 더 낮아지는 용기 있는 삶을 위해 하루하루 열심히 살아가겠습니다. 감사합니다.

2016 년 2 월

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Abstract

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Aim: The aim of this study was to evaluate the prevalence of cervical enamel projections (CEP) in mandibular molars, and to analyze the correlation between CEP and furcation involvement (FI) based on cone beam computed tomography (CBCT) data in Korean population.

Materials and Methods: CBCT images taken from March 2012 to August 2012 were analyzed. In 3D reformatted images and cross-sectional views, CEP and FI on the buccal and lingual surface were classified and the correlation was analyzed.

Results: A total of 982 teeth in 425 patients were analyzed. The total prevalence of CEPs was 76% (71% and 27% on the buccal and the lingual surface, respectively). Grade I CEP was observed most widely, followed by grade II and III. The correlation of the grade of CEPs and the degree of FI on the buccal and lingual surface was statistically significant, but showed negligible correlation.

Conclusion: Within the limitation of this cross-sectional study, high prevalence of CEPs were found in Korean population, but the role of CEP in provoking FI appeared not to be decisive.

Key words: Cone-Beam Computed Tomography; Furcation Defects; Dental Enamel; Tooth Cervix; Prevalence

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I. Introduction

Predicting the prognosis of multirooted teeth is one of the main concerns for clinicians. Previous studies have commonly pointed out that furcation involvement (FI) is one of the main factors determining the prognosis of multirooted teeth (Hirschfeld and Wasserman, 1978, McFall, 1982, McGuire and Nunn, 1996). It has been demonstrated that it is difficult to manage teeth with FI by nonsurgical treatment, even for experienced specialists (Fleischer et al., 1989, Nordland et al., 1987). Cases in which periodontal destruction progressed in teeth with FI in spite

of professional therapy and maintenance program have been reported (Pretzl et al., 2008).

.Several factors for provoking FI have been investigated, which has been found to be mostly related to the resistance against the challenge of bacterial plaque, whether this is associated with oral hygiene practices or certain innate characteristics—given an equivalent level of oral hygiene, a fixed level of bacterial challenge can result in more deterioration when certain innate characteristics are present. A cervical enamel projection (CEP) is one such anatomic structure. As a product of continuing activity of ameloblasts after enamel formation on the crown(Chan et al., 2010), CEP is defined as a continuous structure of enamel that extends from the cementoenamel junction to the furcation area (Bissada and Abdelmalek, 1973). The enamel surface of a CEP favors epithelial attachment, which is more susceptible to bacterial challenge than is connective-tissue attachment (Machtei et al., 1997). Accordingly, a CEP can represent a shortcut for bacterial plaque to the furcation. Correlations between CEPs and FI of degrees II and III have been demonstrated (Hou and Tsai, 1987, Hou and Tsai, 1997).

Previous studies on CEPs have been performed by observations in extracted teeth or cadavers, using macroscopy during periodontal surgery, or by probing in the region of the cementoenamel junction (Bhusari et al., 2013, Hou and Tsai, 1987, Leib et al., 1967, Swan and Hurt, 1976, Zee and Bratthall, 2003). However, these

methods can be subject to limitations such as the inconvenience of performing cadaver examinations, the limited number of samples, the need for invasive surgery, and the possibility of inaccurate assessments.

Cone-beam computed tomography (CBCT) is now widely used in dentistry, and detailed assessments can be made with less radiation compared to conventional computed tomography (Laky et al., 2013). CBCT is widely used in implant therapy (Braun et al., 2014, Walter et al., 2009, Walter et al., 2010)., and its benefits in periodontal treatment have also been reported 18-20. In addition, three-dimensional reconstruction of CBCT images enables clinicians to visualize the actual morphology of a defect and the overall tooth structure prior to performing surgery. Accordingly, CBCT can be used to determine the presence and extent of a CEP, and aid the treatment planning.

The aim of this study was to determine the prevalence of CEP in mandibular molars and the correlation between CEP and FI based on CBCT data in a Korean population.

II. Materials and Methods

All CBCT images that were obtained between March 2012 and August 2012 at the Dental Hospital of Yonsei University were enrolled in the present study. This

study was approved by the institutional review board of the Dental Hospital of Yonsei University (IRB no. 2-2014-0021).

1. Study subjects

In total, 1027 CBCT images were collected during the study period. Image selection and abandonment were performed based on the following inclusion and exclusion criteria:

Inclusion criteria

1. Korean adults aged 20 years or older.
2. At least one mandibular molar present.

Exclusion criteria

1. Loss of both mandibular first and second molars or/and their replacement by a dental implant
2. The mandibular first and second molars not providing clear visualization of the intact cervical area, such as due to the presence of a cervical defect or a restoration covering the cervix.
3. The presence of apical pathoses in the mandibular first and second molars.

2. CBCT analysis

The CBCT images were acquired using two types of systems; Alphard 3030 (be Asahi Roentgen Ind. Co., Ltd., Kyoto, Japan) and Raycan Symphony (Ray Co., Ltd., Suwon, Korea). The settings for the former were a tube voltage of 80 kV, a tube current of 5 mA,a shooting time of 17 s, a field of view (FOV) of 102 × 102 mm2, and a voxel size of 0.2 mm; the corresponding settings for the latter were 90 kV, 10 mA, 19.5 s, 147 × 97 mm2, and 0.38mm, respectively. The acquired images were saved in the DICOM (Digital Imaging and Communications in Medicine) file format.

The presence of CEPs and FI was analyzed in the cross-sectional and the three dimensionally reconstructed images (OnDemand3D, CyberMed, Seoul. Korea) by two investigators (H-C.L and S-K. J). The CEPs and FI were classified according to the grading system of Masters and Hoskins (Masters and Hoskins, 1964) (Fig. 1) and of Hamp et al. (Hamp et al., 1975). The analysis was performed on both buccal and lingual surfaces.

3. Statistical analysis

SPSS software (SPSS 20.0, IBM Corporation, Armonk, NY, USA) was used for the statistical analysis. The interexaminer agreement for determining the CEP

grade and the degree of FI was analyzed using Cohen's κ (Cohen, 1960). The prevalence of CEPs depending on sex and site was analyzed using chi square tests. The correlations between the grade of CEPs and the degree of FI were analyzed using Spearman`s correlation tests. The strength of correlation coefficient R was categorized as follow; 0.9-1.0: very strong, 0.7-0.9: strong or high, 0.4-0.7: moderate, 0.2-0.4: weak or low, 0.0-0.2: very weak. Statistical significance was set at $P<0.05$.

III. Results

In total, 982 teeth from 425 patients (224 male and 201 female) were analyzed. The age of the patients ranged from 20 to 77 years (20-29 years old: 141 patients, 30-39 years old: 80 patients, 40-49 years old: 69 patients, 50-59 years old: 88 patients, 60-69 years old: 36 patients, over 70 years old: 11 patients). (Table 1). Of the 982 teeth, 174 were right mandibular second molars, 327 were right mandibular first molars, 323 were left mandibular first molars, and 158 were left mandibular second molars.

Table 1. Age and sex distribution of the included patients.

	Male (n=224)	Female (n=201)	Total (n=425)
20-29	68	73	141
30-39	42	38	80
40-49	45	24	69

50-59	51	37	88
60-69	14	22	36
70-	4	7	11

Cohen`s κ between two investigators was 0.912 for CEPs (P<0.001) and 0.916 for FI (P<0.001), which According to Landis & Koch (Landis and Koch, 1977), 25 indicates almost perfect agreement.

1. Prevalence of CEP

Most of the patients had at least one CEP (87.5% in males and 91.5% in females). The percentage of teeth having CEP on either the buccal or lingual surface was 76.0% (746/982). Buccal CEPs were more common (70.9%, 697/982) than lingual CEPs (27.0%, 265/982). CEPs were present on both surfaces in 22.0% of teeth (216/982). The prevalence of buccal CEPs was significant correlated with sex (P=0.001), while the prevalence of lingual CEPs was significant correlated with both sex (P=0.009) and tooth number (P<0.001) (Table 2).

Table 2. Chi square test for the prevalence of cervical enamel projections disaggregated by sex, quadrant and tooth number.

Variables		Chi-square	DF	*P* value
Male vs.	Buccal	10.838	1	**0.001**

Female	Lingual	6.762	1	**0.009**
Rt. molar vs. Lt. molar	Buccal	0.517	1	0.472
	Lingual	0.162	1	0.687
1st molar vs. 2nd molar	Buccal	0.041	1	0.840
	Lingual	23.051	1	**<0.001**

DF, degree of freedom.

Bold face indicates $P < 0.05$.

The distribution of CEPs according to classification on each tooth is shown in Figure 2. Grade I CEPs were the most common on the buccal surface (54.8%), followed by grade II CEPs (34.8%) and grade III CEPs (10.3%). Most CEPs on the lingual surface were grade I(90.5%), followed by grade II (9.0%) and grade III (0.006%).

2. Prevalence of FI

FI was present in 663 of the 982 teeth (67.5%). FI of degrees I, II, and III accounted for 61.5% (356/579), 34.5% (200/579), and 4.0% (23/579), respectively, of the FI on the buccal surface of the teeth; the corresponding proportions on the lingual surface were 75.4% (364/483), 19.9% (96/483), and 4.8% (23/483). FI was seen in 69.2% and 58.9% of first molars on the buccal and

lingual surfaces, respectively, and in 48.2% and 40.4% of second molars. Among teeth with FI, 70.1% had buccal CEPs (379/569) and 30.5% had lingual CEPs (147/482).

3. Correlation of CEP with FI

The total distributions of FIs and CEPs are shown in Fig. 3 and 4. The CEP grade and the degree of FI were significantly but weakly correlated for both buccal and lingual surfaces (P=0.027 and 0.003, respectively, and Spearman's R=0.07 and 0.094).

When CEPs and FI were disaggregated into categories of male vs female, first molar vs second molar, and right molar vs left molars, the correlation in each category was either statistically insignificant or very weak (Table 3).

Table 3. Spearman correlation between the grade of cervical enamel projections and the degree of furcation involvement.

Variables			Spearman`s R	*P* value
Total		Buccal	0.07	**0.027**
		Lingual	0.094	**0.003**
Sex	Male	Buccal	0.040	0.360
		Lingual	0.098	**0.026**
	Female	Buccal	0.115	**0.014**
		Lingual	0.091	0.051

Quadrant	Right-handed	Buccal	0.111	**0.013**
		Lingual	0.043	0.332
	Left-handed	Buccal	0.029	0.518
		Lingual	-0.005	0.907
Tooth number	Mand. 1st molar	Buccal	0.078	0.086
		Lingual	0.070	0.122
	Mand. 2nd molar	Buccal	0.066	0.142
		Lingual	0.096	**0.035**

Bold face indicates $P < 0.05$.

When the teeth from patients older than 40 years were pooled separately, there was no significant correlation for the buccal surface (P=0.980) and a negligible correlation for the lingual surface (P=0.002, Spearman's R=0.142). The correlations in the categories of male vs female, first molar vs second molar, and right molar vs left molar were either statistically insignificant or very weak (Table 4).

Table 4. Spearman correlation between the grade of cervical enamel projections and the degree of furcation involvement in the teeth from patients over 40-year old.

Variables			Spearman`s R	*P* value
Total		Buccal	0.001	0.980
		Lingual	0.142	**0.002**
Sex	Male	Buccal	-0.035	0.586
		Lingual	0.135	**0.033**

	Female	Buccal	0.044	0.530
		Lingual	0.157	**0.025**
Quadrant	Right-handed	Buccal	-0.028	0.669
		Lingual	0.073	0.262
	Left-handed	Buccal	0.032	0.632
		Lingual	0.211	**0.002**
Tooth number	Mand. 1st molar	Buccal	-0.030	0.609
		Lingual	0.125	**0.031**
	Mand. 2nd molar	Buccal	0.053	0.509
		Lingual	0.080	0.319

Bold face indicates $P < 0.05$.

IV. Discussion

FI is one of the main factors predictive of the prognosis of multirooted teeth. It has been suggested that the susceptibility of FI can be modified by certain anatomical factors, including CEPs. The present study evaluated the prevalence rate of CEPs in mandibular molars using CBCT data. CBCT images can be reconstructed in three dimensions as well as cross-sectionally using computer software; this makes it relatively easy to identify the presence of CEPs noninvasively.

Previous studies have found various prevalence rates of CEP in mandibular molars. Grewe et al. (1965), Leib et al. (1967), and Bissada and Abdelmalek (1973) reported rather low prevalence rates of 25.2%, 25.4%, and 10.37%, respectively, while higher rates of 48%, 85%, 78%, and 79% were reported by Hou & Tsai (1987), Hou & Tsai (1997), Zee & Brattall (2003), Zee et al (1991) respectively. The overall prevalence rate of CEPs in the Korean population included in the present study was 76% (70.8% on the buccal side and 26.6% on the lingual side). These markedly different rates have been attributed to the involvement of different study subjects, including in terms of their ethnicity. The studies of Grewe et al. (1965) and Leib et al. (1967) involved Americans with possibly mixed ethnicities, while Bissada and Abdelmalek (1973) investigated Egyptians (Bissada and Abdelmalek, 1973). On the other hand, the prevalence rates in Far East populations, such as Taiwanese (Hou and Tsai, 1987, Hou and Tsai, 1997), Chinese (Zee et al., 1991), and Koreans, and among Eskimos (Zee and Bratthall, 2003) have been much higher (over 70%). Anthropologically these populations can be categorized as Mongoloids, which suggests a strong genetic effect on the prevalence of CEPs. Managing CEPs may have greater clinical relevance in such populations. Interestingly, the prevalence of CEPs in mandibular molars appears to vary geographically among Asians. A recent study involving Indians found very low prevalence rates of 10% and 14% in the first and second mandibular molars, respectively (Bhusari et al., 2013). The

prevalence in Asia increases when moving to East Asia, as demonstrated for Chinese (Zee et al., 1991), Taiwanese (Hou and Tsai, 1987, Hou and Tsai, 1997), and the Koreans in the present study. Some authors demonstrated that Indians can be classified into two groups on a basis of genotypes: (1) "Ancestral North Indian," who are genetically close to Middle Eastern, Central Asian, and European populations (39–71% of people of Indian substructural populations), and (2) "Ancestral South Indian." (Reich et al., 2009). Such findings may explain the difference in the prevalence of CEPs among Asian countries. Studies investigating the prevalence of CEPs in Egyptians (a Middle Eastern population) found a similar prevalence rate to that in Indians (Bhusari et al., 2013, Bissada and Abdelmalek, 1973).

Among the 425 patients and the 982 teeth that were included in the present study, CEPs were observed in 87.5% of the males, 91.5% of the females, and 76% in all of the teeth. Despite its high prevalence, the CEP grade was only very weakly correlated with the degree of FI in total, but this result should be interpreted cautiously. The detection of CEPs requires clear visualization of the cervix. Initially collected CBCT images that indicated a defective cervix, restorations covering the cervix, loss of teeth, or replacement by dental implants were all excluded, which might have reduced the number of molars included from older patients and molars with FI. Moreover, relatively few teeth had grade III CEP and/or FI of degree III.

These factors might also have affected the correlation analysis in the teeth from patients older than 40 year, despite age being positively correlated with the prevalence of periodontitis 29. The present study had a cross-sectional design, which meant that teeth with various periodontal conditions were included. Previous studies that examined teeth with periodontitis found a significant relationship between CEP and FI (Hou and Tsai, 1997, Machtei et al., 1997). However, the influence of CEP in the subjects without information about their periodontal conditions is unclear. Most studieshave found CEP to be associated with FI (Bhusari et al., 2013, Bissada and Abdelmalek, 1973, Grewe et al., 1965, Hou and Tsai, 1987, Zee and Bratthall, 2003), but other studies—including the present one—found no such relation (Leib et al., 1967, Zee et al., 2003).

CEPs on the buccal surface were clinically easy to detect due to the good visibility in this area, while those on the lingual surface as well as their severity were difficult to determine due to lower visibility and accessibility for the lingual surface. Moreover, clinicians generally recognize that CEPs mostly exist on the buccal side. These factors increase the likelihood that the presence of lingual CEPs will be underestimated. The prevalence rate of CEPs on the lingual surface was 26.6% in the present study, which is similar to or much greater than the prevalence rates reported for Americans, Indians, and Egyptians (Grewe et al., 1965, Leib et al., 1967, Bhusari et al., 2013, Bissada and Abdelmalek, 1973). Mandibular molars

anatomically have a lingual inclination, which leads to a more-apical position of the furcal entrance compared to the buccal entrance. Such anatomical features can interfere with the correct contact of oral hygiene devices, and the presence of lingual CEPs may modify the susceptibility of FI.

Walter et al (2009) assessed the validity of using CBCT for maxillary molars, and reported that the interpretation of CBCT images can result in both over- and underestimations (Walter et al., 2009). When identifying FI, demineralization at an early stage of disease progression can be seen as regions with bone defects in radiographic images. FI of degree I was frequently underestimated in maxillary molars in CBCT compared to intrasurgical findings (Walter et al., 2010). Such over-/underestimating errors might also occur when determining the CEP grade. The presence of a calculus lining on CEPs may affect the determination of the grade. Although the abovementioned errors were not confirmed macroscopically in the present study, our approach did have the significant advantages of being based on the noninvasive interpretation of CBCT images and being able to deal with a large number of samples.

Within the limitations of the present study, the high prevalence of CEPs detected in the mandibular molars of the Korean subjects showed an insignificant or only a very weak correlation with the degree of FI. These findings may be due to the specific characteristics of the study population, but more importantly they

indicate that FI is a product of multiple factors. A long-term follow-up for monitoring the progression of periodontal disease in molars with CEPs is required in future studies.

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국문요약

한국인에서 CBCT 를 이용한 치경부 법랑돌기의 유병률과 치근 이개부 병변과의 상관 관계 연구

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진행된 치주질환이라고 할지라도 치주치료를 받고 적절한 유지 치료를 받았을 때 많은 수의 치아가 유지될 수 있음이 장기적인 연구 결과에서 밝혀진 바 있다. 하지만, 다근치의 상실률은 단근치에 비해 보다 높은 것으로 보고되어 왔으며, 특히 이개부 병변에 이환된 다근치는 부착 상실에 더욱 취약하다고 알려져 있다. 법랑돌기는 백악법랑경계로부터 치근이개부 쪽으로 형성된 법랑질의 연속되는 구조로 다근치의 부착 소실에 영향을 준다고 알려져 있다. 따라서 법랑돌기의 존재를 술전에 파악하고 치료계획에 포함시키는 것은 치아의 예후를 판단, 치료 방법 결정, 유지 치료 등 에 큰 도움을 줄 수 있을 것이다. 이번 연구는 콘빔 전산화 단층 촬영법으로 통해 얻은 영상 자료를 토대로 하악 대구치에서 법랑 돌기의 유병율을 조사하고 법랑돌기와 치근이개부 병변과의 연관성을 분석하고자 하였다.

2012년 3월부터 2012년 8월까지 연세대학교 치과대학병원에서 촬영한 콘빔 전산화 단층 촬영 영상을 전수 조사하여 분석하였다. 총 425 개의 콘빔

전산화 단층 촬영 영상이 선택되었으며 총 982 개의 하악 대구치가 분석의 대상이 되었다.

각 치아에서의 법랑돌기의 분포는 협측에서는 70.9%, 설측에서는 27%의 치아에서 법랑돌기가 관찰되었으며, 협설면을 총괄하여 한 개 이상의 법랑돌기가 관찰되는 치아는 76% 였다. 협측에서는 제 1 대구치과 제 2 대구치 사이에 법랑돌기의 발현율에 있어서 통계적인 차이가 없었지만, 설측에서는 제 1 대구치에서 통계적으로 유의하게 발현율이 더 높았다. 협측과 설측, 양측 모두에서 남자보다 여자에서 통계적으로 유의하게 법랑돌기의 발현이 더 높은 것으로 나타났다.

982 개의 치아 중 치근이개부 병변을 가지고 있는 치아는 67.5%였다. 협설측으로 나누어 법랑돌기와 치은이개부 병변의 관계를 분석하여 보았을 때, 협측에서는 통계적 유의성이 없었지만, 설측에서는 통계적으로 유의한 관련성을 보였다. 이번 연구에서 설측의 법랑돌기는 이개부 병변과 유의한 관계가 있는 것으로 나타났다.

본 연구를 통해 CBCT 를 이용한 본 연구를 통해 한국인에서의 법랑돌기의 높은 유병률을 확인할 수 있었다. 그러나 법랑돌기가 치근 이개부 병변의 발생에 절대적인 요소라 할 수 없다. 앞으로 CBCT 를 이용하여 비침습적이고 객관적인 방법으로 법랑돌기 이외의 치주질환에 영향을 주는 여러 요인들에 대해 더 많은 연구와 진단에 응용할 수 있을 것으로 기대한다.

핵심되는 말 : 콘빔 전산화 단층촬영, 치근 이개부 병변, 법랑돌기, 치경부, 유병률

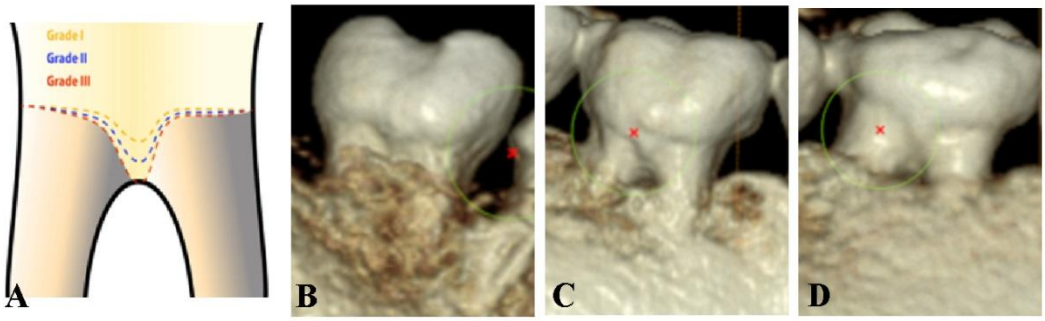

Figure 1. . Classification of the cervical enamel projection and the corresponding three-dimensionally reconstructed images. (A)Schematic drawing of CEPs, Grade I = yellow dashed line; Grade II = blue dashed line; Grade III = red dashed line. (B) Grade I CEP on a reconstructed image. (C) Grade II CEP on a reconstructed image. (D) Grade III CEP on the reconstructed image..

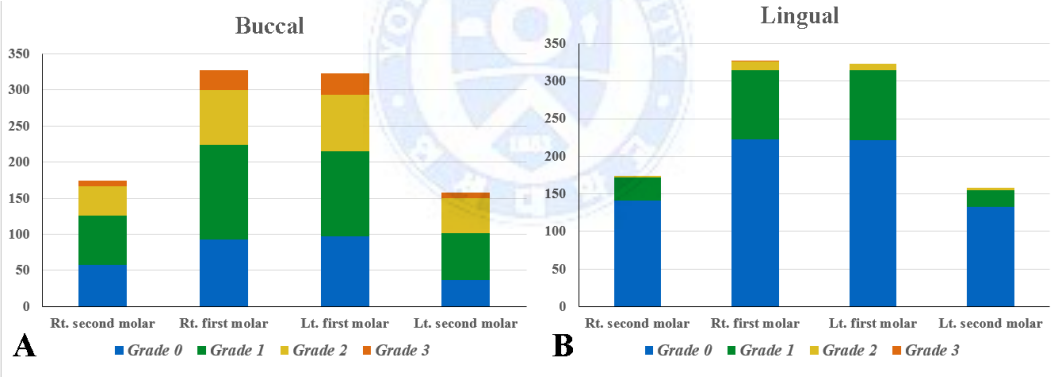

Figure 2. Distribution of CEPs on molar (A) buccal surfaces and (B) lingual surfaces.

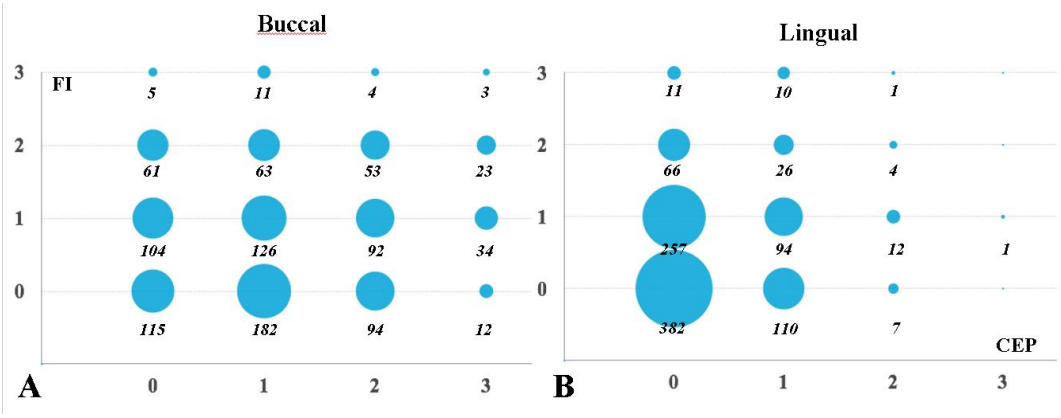

Figure 3.Association between CEPs and furcation involvement (FI) (A) on the buccal surface and (B) on the lingual surface. X and Y axes indicate the CEP grade and the degree of FI, respectively.