

# CERVICAL ENAMEL PROJECTIONS AND ENAMEL PEARLS IN A COLLECTION OF AUSTRALIAN EXTRACTED MOLARS

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**ABSTRACT** Cervical enamel projections (CEPs) and enamel pearls (EPs) are generally located on permanent molars. They are detected less frequently in Caucasian than in Mongoloid teeth. No data are available documenting these features in teeth collected in Australia. The aim of this study was to determine the frequency and degree of expression of CEPs and EPs in a large sample of Caucasian deciduous and permanent extracted dried molars. The molars were examined under a stereomicroscope, and only those with intact CEJ (cemento-enamel junction) and bifurcation were scored for CEPs and EPs. Scoring of CEPs was based on the classification system of Zee et al. (1991).

Genuine CEPs were observed in 19.1% of the 282 deciduous molars and 44.0% of the 2827 permanent molars examined. In deciduous molars, CEPs were regularly seen on the lingual surface of mandibular second molars, with the Grade I type being most common. In permanent molars, CEPs were generally seen on the buccal surface of mandibular second molars, with the Grade III type being the most frequent. External composite EPs were observed in 1.1% of deciduous molars and 3.3% of permanent molars examined. EPs in permanent molars were frequently detected in maxillary third molars on the distal or mesial surfaces. The results obtained in this study are in broad agreement with previous investigations of Caucasian extracted molars. However, we noted a higher frequency of CEPs in permanent molars than did other studies and found that the Grade III type of CEP occurred most frequently. A modification is proposed to the Zee et al. (1991) scoring system: inclusion of Grade IIIc being a CEP consisting of droplets of enamel streaming toward the furcation. CEPs and EPs are of clinical importance, as they have been implicated as contributing factors in localized periodontal lesions.

## INTRODUCTION

Extensions of enamel from the cemento-enamel junction onto the root surface have been termed cervical enamel projections (CEPs). CEPs are divided into two basic types depending on their location in relation to the root topography (Carlsen, 1967). Genuine CEPs are found in a definite and direct topographical relationship to either a bifurcation or a root groove leading to root separation. False CEPs have no direct topographical relationship to either a bifurcation or a root groove. Genuine CEPs are the most commonly observed type, whereas false CEPs occur rarely.

Masters and Hoskins (1964) classified CEPs as follows: incipient CEP — a slight deviation of the cemento-enamel junction towards the furcation, Grade I — a distinct change in the cemento-enamel junction with enamel projecting toward the bifurcation, Grade II — enamel projection approaching the furcation but not making contact with it, Grade III — enamel projection extending into the furcation proper, Grade IIIa — a long, slender enamel projection extending into the furcation proper, Grade IIIb — an enamel projection which is interrupted or displays a discontinuous extension into the furcation proper. Figure 1 shows the different types.

CEPs are very rarely seen in deciduous teeth or in permanent incisors, canines, or premolars. Studies of extracted molars have concluded that CEPs are most commonly found in permanent molars with a greater frequency in Asian groups compared with Caucasians (Kawasaki et al., 1976; Zee et al., 1991). The majority of CEPs are of the Grade I type and often occur on the buccal surface of mandibular second molars (Masters and Hoskins, 1964; Grewe et al., 1965; Leib et al., 1967; Tsatas et al., 1973; Risnes, 1974a). However, in Asian groups the Grade III type is the most common (Kawasaki et al., 1976; Zee et al., 1991). One CEP per root surface is usually observed, but up to three genuine CEPs can occur on one tooth.

Enamel pearls (EPs) are discrete masses of enamel found on the root surface. They have been classified into two main groups: external (true and composite) and internal. External (extradental) enamel pearls are found external to



Fig. 1. Classification of cervical enamel projections adapted from Masters and Hoskins (1963) and Zee et al. (1991).

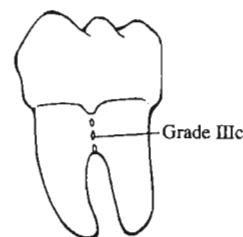


Fig. 2. Grade IIIc.

dentine on the root surface. True (simple) enamel pearls are composed of enamel only. They are less than 0.3 mm in diameter, and difficult to diagnose macroscopically. Composite enamel pearls are composed of a core of dentine covered by a layer of enamel. Pulpal tissue may or may not be found within the pearl. These are variable in size (usually greater than 0.3 mm in diameter) and are seen macroscopically. Composite enamel pearls are the most commonly described type of EP in the literature. Internal (intradental) enamel pearls are found within dentine. They occur on three surfaces: coronal, cervical and, radicular; and are not seen macroscopically.

In general EPs are rarer than CEPs. External composite EPs are very rarely seen in the deciduous dentition or in permanent incisor, canine or premolar teeth. They are usually found on permanent molars with a low prevalence in both Caucasian and Asian populations (Cavanha, 1965; Risnes, 1974b; Loh, 1980). Enamel pearls are more frequently observed in permanent third molars than on the other teeth: on the mesial and distal surfaces of maxillary molars and on the buccal and lingual surfaces of mandibular molars (Cavanha, 1965; Risnes, 1974b; Loh, 1980).

A CEP and an EP can occur together on the same surface of a tooth. A CEP may join and touch an EP or stop short of it. A CEP can also be found on one surface (e.g. buccal) and an EP on another surface (e.g. lingual) (Risnes, 1974a,b). Pedersen (1949) and Risnes (1974b) thought that EPs were closely related to a tendency toward CEPs. Most recent studies, however, show no statistically significant association between the CEP and the EP (Loh, 1980; Chan et al., 1988).

## MATERIALS AND METHODS

The teeth used in this study were obtained from a large collection (The Ramsey Smith Collection) of Caucasian dried extracted teeth. They were collected predominantly from 1900 to the 1930's in South Australia. A total of 1702 deciduous and 5106 permanent teeth were examined. Only those teeth with an intact cemento-enamel junction and root furcation were examined for CEPs and EPs.

The teeth were gently cleaned with hand scalers in regions where calculus obscured the cemento-enamel junction or the furcation area. They were then classified as maxillary or mandibular molars and separated into first, second, and third molar teeth. The criteria of Jordan, Abrams, and Kraus (1992) for number and size of cusps, occlusal and proximal surface, and number and morphology of roots were used to classify maxillary and mandibular teeth as first, second, or third molars. If any molar could not be positively identified, it was classified as an "unidentified tooth," but still examined for CEPs and EPs.

The teeth were initially examined with the naked eye. The Zee et al. (1991) classification system for CEPs was a more appropriate system than that of Masters and Hoskins (1964) because the it is more descriptive than the older system. In addition, another form of Grade III CEP that did not appear in either classification was apparent in the sample. This was a series of enamel nodules directed toward the root furcation region. This type of CEP was classified as Grade IIIc (Fig. 2).

The teeth were then viewed under a stereomicroscope (Olympus) with 1.5x magnification and scored for the presence/absence of CEPs and EPs, the surface(s) on which the CEPs and EPs appeared, the number of CEPs and EPs per tooth, and the grade of CEP. A note about whether or not a CEP and EP were joined together was also made.

A randomly selected sample of 100 molars was selected and re-examined on a separate occasion. Concordance for scoring presence/absence on both occasions was 99.0%. Frequencies of both traits were similar in both the sub-sample and the main sample.

## RESULTS

### Genuine CEPs in Deciduous Molars

A total of 282 deciduous molars were suitable for examination. Genuine CEPs were observed in 54 teeth (19.1%), which contained a total of 68 CEPs (Tables 1a and 1b). CEPs were more commonly found in mandibular second molars (55.9%) than in first and third molars.

Table 1c shows that for all molars, most CEPs were seen on the lingual surface (47.1%). The most common type of CEP was the Grade I (98.5%). The only other type of CEP observed was one example of Grade IIIa. Table 1d shows that most molars exhibiting CEPs had one CEP per tooth (75.9%). In those teeth with two or more CEPs per tooth, most had identical types on opposite root surfaces. Two false CEPs were detected.

### External Composite EPs in Deciduous Molars

Only three of the 282 deciduous molars exhibited EPs (1.1%). Each had only one EP. Two of the EP's were observed on the buccal surface of mandibular second molars, while the third EP was seen on the mesial surface of a maxillary first molar. All molars with EPs also had a CEP on the same surface. One tooth had an EP and a Grade I CEP on the buccal surface. The second tooth had an EP and a Grade I CEP on the mesial surface. The third tooth had a Grade IIIa CEP and an EP (which were actually touching) on the mesial surface.

TABLE 1a. Number of deciduous molars with CEPs.

Molars with CEPs		Molars without CEPs		Total	
N	%	N	%	T	%
54	19.1	228	80.9	282	100.0

N is number. T is total number, % is N/T or T/T.

TABLE 1b. Distribution of CEPs according to deciduous molar tooth type.

Maxilla				Mandible				Total	
First molar		Second molar		First molar		Second molar		T	%
N	%	N	%	N	%	N	%	T	%
7	10.3	18	26.5	5	7.3	38	55.9	68	100.0

TABLE 1c. Distribution of CEPs in all deciduous molars.

Grade	Surface								Total	
	Mesial		Distal		Buccal		Lingual		N	%
	N	%	N	%	N	%	N	%	N	%
I	11	16.2	5	7.3	19	27.9	32	47.1	67	98.5
II	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
III	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
IIIa	0	0.0	0	0.0	1	1.5	1	0.0	1	1.5
IIIb	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
IIIc	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Total	11	16.2	5	7.3	20	29.4	32	47.1	68	100.0

TABLE 1d. Number of deciduous molars with 1, 2, or 3 CEPs.

1 CEP		2 CEPs		3 CEPs		Total CEPs	
N	%	N	%	N	%	T	%
41	75.9	12	22.2	1	1.9	54	100.0

### Genuine CEPs on Permanent Molars

A total of 2,827 permanent molars was suitable for examination for genuine CEPs and external composite EPs. Of this total, 2,597 molars (1,033 maxillary and 1,564 mandibular) were positively identified and 230 molars (87 maxillary and 143 mandibular) were unidentified.

Genuine CEPs were observed in 1,245 of the total number of molars (44.0%). Some teeth had more than one CEP, making the total number of CEPs 1,649. The majority of the CEPs (69.6%) were in mandibular molars (Tables 2a and 2b). Most of the CEPs appeared on mandibular second molars (29.4%), with the maxillary third molars (7.5%) exhibiting the least number of CEPs (Table 2b).

Table 2c shows that for all molars, most of the CEPs was detected on the buccal surface (67.3%), with the least on the mesial surface (5.8%). The most frequently occurring type of CEP was Grade III (57.9% for Grades III, IIIa, IIIb, and IIIc), followed by Grade I (38.4%), with the least common being Grade II (3.6%). Examination of the different subtypes of Grade III further showed that Grade III (22.3%) was the most frequently observed, followed by Grade IIIb (21.9%), Grade IIIa (11.1%), and Grade IIIc (2.6%).

Table 2d shows that those molars with CEPs usually had one CEP per tooth (70.0%). A maximum of three genuine CEPs per tooth was seen. Those with two or three CEPs per tooth usually had identical types of CEPs on opposite root surfaces. False CEPs were also identified.

### External Composite EPs in Permanent Molars

Enamel pearls were observed in 94 (3.3%) of the total number of permanent molars, with a total of 108 EPs observed (Some teeth had more than one EP). More EPs were detected in maxillary molars (88.9%) than in mandibular molars (Tables 3a and 3b). The maxillary third molar exhibited the greatest number of EPs (54.6%), with the mandibular first molar exhibiting the least number of EPs (2.8%) (Table 3b). Most of the EPs were found on the distal (45.4%) and mesial surfaces (41.7%) as shown in Table 3c. One EP was usually observed per tooth (87.3%), although up to three EPs per tooth were detected (Table 3d). If two or more EPs were seen, they were usually on opposing root surfaces.

### Association between EPs and CEPs in Permanent Molars

Of the 108 EPs identified, 53 had no associated CEP on the same surface. Thirty-five EPs had no associated CEP on the same surface, but a CEP occurred elsewhere on the tooth. Twenty EPs had a CEP occurring on the same surface, but none were found to be touching. Ten of these CEPs were Grade I; five were Grade II; and five were Grade III. Thus, a CEP occurred on the same surface as an EP in 18.5% of the cases. A chi-square test showed a statistically significant association ( $p < 0.05$ ) for expression on the same tooth, irrespective of surface.

### DISCUSSION

In general, the results obtained for EPs in this study are in agreement with those obtained in previous investigations for Caucasian molars (Cavanha, 1965; Risnes, 1974b). An interesting finding from this study was that the frequency of CEPs in permanent molars is 10 to 20% greater than that reported previously for Caucasian molars (Masters and Hoskins, 1964; Grewe et al., 1965; Leib et al., 1967; Tsatas et al., 1973; Risnes, 1974a). Our sample size was larger than previous studies and may, therefore, provide a more accurate estimate of the frequency of CEPs in Caucasians than do previous reports. However, difference in scoring methodology may exist between investigators. Another area of contrast was that the most frequent grade of CEP observed in this study is the Grade III.

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Some similarity in the results was obtained for CEPs in both deciduous and permanent dentitions: that is, most CEPs occur on mandibular second molars. If a CEP exists, it is the only one on the tooth. However, some CEP results differ. Deciduous molars have a lower frequency of CEPs than do permanent molars. CEPs were more frequently seen on the lingual than on the buccal surface in deciduous molars. Grade I is the most frequent type of CEP seen in deciduous molars, whereas Grade III predominates in permanent molars.

Use of a stereomicroscope assisted in determining whether or not a CEP had reached the furcation entrance, as well as in providing a clearer image of CEPs and EPs than did macroscopic examination. The point at which the furcation entrance began was difficult to establish especially where roots were fused.

Differences in the distribution of CEPs and EPs in the different molar groups in this and previous studies may be attributed to the way in which the molars were identified. Many investigators do not state how teeth were identified and whether any problems were encountered. Risnes (1974a,b) is an exception. This study showed that correct tooth identification can be a difficult task, especially for a novice. Molars can be wrongly identified given variation in crown and root morphology and the condition of the teeth in the sample. Use of identification criteria (e.g. Jordan, Abrams, and Kraus, 1992) can be of great value in reducing misclassification. Incorrect identification of the different molars could lead to over- or under-estimation of the distribution of CEPs and EPs.

The Zee et al. (1991) modification to the grading of CEPs provides a more descriptive classification system than the Masters and Hoskins (1964) system alone. However, some CEPs cannot be adequately described by this classification. These are the CEPs which have an unusual shape.

Turner et al. (1991) have provided a metrically-based scoring system following Pedersen's (1949) classification. Their scores 1, 2, and 3 correspond to grades 1, 2, and 3 of the Zee et al. (1991) classification system. Although a metric system may help to reduce inter-observer variability, some problems of interpretation remain. Examples are placement of calliper beaks on curved root surfaces and determination of the precise location from which

TABLE 2a. Number of permanent molars with CEPs.

Molars with CEPs		Molars without CEPs		Total	
N	%	N	%	T	%
1,245	44.0	1,582	56.0	2827	100.0

TABLE 2b. Distribution of CEPs according to permanent molar tooth type.

	First molar		Second molar		Third Molar		Unidentified		Total	
	N	%	N	%	N	%	N	%	T	%
Maxilla	150	9.1	188	11.4	123	7.5	41	2.3	502	30.4
Mandible	277	17.0	484	29.4	259	15.7	127	7.7	1147	69.6

TABLE 2c. Distribution of CEPs on permanent molar tooth surfaces.

Grade	Mesial		Distal		Buccal		Lingual		Total	
	N	%	N	%	N	%	N	%	N	%
I	66	4.0	92	5.6	268	16.3	209	12.7	635	38.5
II	2	0.1	7	0.4	43	2.6	8	0.5	60	3.6
III	6	0.4	10	0.6	344	20.9	7	0.4	367	22.3
IIIa	6	0.4	10	0.6	159	9.6	8	0.5	183	11.1
IIIb	9	0.6	26	1.6	289	17.5	37	2.2	361	21.9
IIIc	7	0.4	13	0.8	7	0.4	16	1.0	43	2.6
Total	96	5.8	158	9.6	1110	67.3	285	17.3	1649	100.0

TABLE 2d. Number of permanent molars with 1, 2, or 3 CEPs.

1 CEP		2 CEPs		3 CEPs		Total CEPs	
N	%	N	%	N	%	T	%
872	70.0	342	27.5	31	2.5	1245	100.0

TABLE 3a. Number of permanent molars with EPs.

Molars with EPs		Molars without EPs		Total	
N	%	N	%	T	%
94	3.3	2,733	96.7	2827	100.0

TABLE 3b. Distribution of CEPs according to permanent molar tooth type.

	First molar		Second molar		Third Molar		Unidentified		Total	
	N	%	N	%	N	%	N	%	T	%
Maxilla	4	3.7	26	24.1	59	54.6	7	6.5	96	88.9
Mandible	3	2.8	4	3.7	5	4.6	0	0.0	12	11.1
Total	7	6.5	30	27.8	64	59.3	7	6.5	108	100.0

TABLE 3c. Distribution of EPs in permanent molars.

Surface	First		Second		Third		Unidentified		Teeth	
	N	%	N	%	N	%	N	%	N	%
Mesial	2	1.8	14	13.0	27	25.0	2	1.8	45	41.7
Distal	4	3.7	12	11.1	28	25.9	5	4.6	49	45.4
Buccal	1	0.9	2	1.8	1	0.9	0	0.0	4	3.7
Lingua	0	0.0	2	1.8	7	6.5	1	0.9	10	9.2
Total	7	6.5	30	27.8	63	58.3	8	7.4	108	100.0

TABLE 3d. Number of permanent molars with 1, 2, or 3 EPs.

1 EP		2 EPs		3 EPs		Total Teeth	
N	%	N	%	N	%	T	%
82	87.3	10	10.6	2	2.1	94	100.0

to measure CEP form. Furthermore, the Turner et al. (1991) classification records any extensions that are not attached to the tooth crown as being absent.

In this study the incipient form of CEP was not scored. No other previous study with which we are familiar has scored them either. The incipient form is envisioned as a slight dip in the cemento-enamel junction toward the root surface, and not a true CEP. In this study, accurately distinguishing between a Grade I CEP and an incipient form could be difficult. This problem in grade assessment could result in incorrectly scoring Grade I CEPs.

Distinguishing between Grade II and Grade III CEPs was difficult in a few cases in which the exact point at which the furcation entrance could not be established. This type of difficulty can result in an underestimation of Grade II/III or and overestimation of Grade II/III CEPs.

Use of extracted teeth did not allow determination of possible gender differences in the frequency and distribution of CEP and EP. Previous studies using skeletal material have lacked reports about sex differences. Therefore, assessment of a large sample of skeletal material would be worthwhile.

CEPs and EPs are more than just an anatomical curiosity. They have definite clinical implications in some patients. In a clinical study, Hou and Tsai (1986) found a statistically significant association between molars with Grade II and III CEPs and respective furcation lesions. Other studies report a junctional epithelial attachment to enamel on the root surface, which is seen as less favorable than a connective tissue attachment (Masters and Hoskins, 1964; Grewe et al., 1965; Hou and Tsai, 1987). Hence these anatomical features may be one of many other factors that can contribute to periodontal lesions in some individuals. Further clinical studies are required to investigate this issue.

### CONCLUSIONS

First, the frequency of genuine CEPs in the sample of extracted deciduous molars was 19.1% and the frequency of EPs was 1.1%. CEPs were commonly found on the lingual surface of mandibular second molars, with Grade I the most common grade. Second, the frequency of genuine CEPs in the sample of extracted permanent molars was 44.0% and the frequency of EPs was 3.3%. CEPs were commonly found on the buccal surface of mandibular second molars, with Grade III the most common grade. EPs were commonly found on the distal/mesial surfaces of maxillary third molars. Third, a modification to the Zee et al. (1991) classification system, involving addition of a Grade IIIc, is proposed (Fig 2). Fourth, use of a stereomicroscope and well-defined identification criteria (e.g. Jordan, Abrams, and Kraus, 1992) are important for distinguishing between different molar types when recording CEPs.

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