Scientific Article

Pre-eruptive intracoronal resorption as an entity of occult caries

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Abstract

"Occult" or "hidden" caries refers to occlusal caries which is not diagnosed clinically because the occlusal surface appears ostensibly intact, and radiographs show radiolucencies in dentin. The prevalence of occult caries has been reported to range from 2.2% to over 50% of permanent molars. In spite of its relatively high prevalence, the etiology and pathogenesis of occult caries remain unclear. The author hypothesizes that occult lesions could have resulted from processes which are pre-eruptive or post-eruptive. Pre-eruptive processes include intracoronal resorption of unerupted teeth, and the post-eruptive process is occlusal fissure caries. Although the prevalence of intracoronal resorption has been shown to be around 3-6% by subject and 0.5-2% by teeth, the percentage contribution of this process to the overall prevalence of occult caries is unclear. When affected teeth are fully erupted, it is difficult to determine if pre-eruptive resorption had been present previously. The prevalence of occult lesions does not appear to be affected by fluoride exposure. Radiographs are useful adjuncts to aid in the diagnosis of occult lesions. Bitewing radiographs are useful for detecting early occlusal fissure caries while panorex radiographs of unerupted developing teeth aid in the diagnosis of pre-eruptive intracoronal lesions. It is suggested that all unerupted, developing teeth on radiographs be examined for pre-eruptive resorptive lesions. (Pediatr Dent 22:370-376, 2000)

The proportion of caries contributed by occlusal lesions has increased in fluoridated areas and is now thought to account for approximately 80% of all new lesions.[1] However, in spite of its relatively high prevalence rate, accurate diagnosis of occlusal caries remains difficult because of complex occlusal fissure morphology, and the pattern of spread and nature of the caries lesion.

For several decades, pediatric dentists have recognized that there exist some deep occlusal lesions in premolar and molar teeth, which have missed clinical detection because the occlusal surfaces remained ostensibly intact until large parts of the crowns have been destroyed. The terms "occult caries" [2,3] and "hidden caries"[4-8] are used to describe such lesions which are not clinically diagnosed but detected only on radiographs (Fig 1). However, the nature of these lesions, their etiologies, and reasons as to why they have eluded early clinical diagnosis are still unclear.

The aim of this paper is to critically examine the literature with regard to current understanding of the prevalence, and nature of occult lesions and to propose a novel hypothesis which suggests that a proportion of these occult lesions have their origins as pre-eruptive intracoronal resorptive lesions.

Prevalence of occult caries (Table 1)

In the few investigations studying occult caries, the prevalence was determined by correlating clinical examinations of occlusal surfaces with bitewing radiographic examinations of the same teeth, and those which showed intact occlusal surfaces and radiographic radiolucencies in dentin were considered to have occult caries.[7-12] Using these criteria, the prevalence of occult caries has been reported to range from 0.8 percent[10] in premolars in 14-15 year-olds to as high as 50 percent[7] in 20 year-olds (Table 1).

Table 1. Previous Studies on the Prevalence of Occult Caries

Authors/ Year	Mean age of subjects (N)	Teeth	Percent Occult caries
Sawle & Andlaw/ 1988[9]	14-16 yrs (740 subjects, 1974) (1319 subjects, 1982)	All 1st and 2nd molars	 3.6 (1974) 3.1 (1982)
Creanor et al/ 1990[10]	14-15 yrs (2623 subjects)	Mand 1st & 2nd molars Max 1st & 2nd molars, Premolars	11.8 3.1 0.8
Kidd et al/ 1992[11]	Adolescents (6110 teeth)	Mand 1st & 2nd molars Max 1st & 2nd molars	12.9 6.3
Weerheijm et al/ 1992[7]	14 yrs (131 subjects) 17 yrs (123 subjects) 20 yrs	All 1st and 2nd molars	26 38 50
Weerheijm et al/ 1992[6]	12.4 yrs (359 subjects)	All 1st and 2nd molars	15
Seow et al/ 1999[12]	6-12 yrs (2926 subjects)	All molars	2.2

Received February 11, 2000 Revision Accepted July 13, 2000

Table 2. Case Reports of Pre-eruptive Intracoronal Resorption

Author/Year	Maxillary teeth					Mandibular teeth					
	M1	M2	M3	PM1	PM2	M1	M2	M3	PM1	PM2	C
Skillen, 1941[40]								1			
Browne, 1954[41]								3			
Luten, 1958[42]						1					
Muhler, 1957[43]				1	1						
Blackwood, 1958[44]							1				
Wooden & Kuftinec,1974[45]										1	
Skaff & Dilzell, 1978[46]							2				
Baddour &Tilson, 1979[47]			3								
Mueller et al, 1980[48]									1		
Walton, 1980[49]						2					
Nickel & Wolske, 1980[50]								1			
Guinta & Kaplan, 1981[51]										1	
Coke & Belanger, 1981[52]										1	
Grundy et al, 1984[53]							3				
Baab et al, 1984[54]			1								
Wood & Crozier, 1986[55]	4					7	3			2	
Rankow et al, 1986[56]							1				1
Brooks, 1988[57]										1	
DeSchepper et al, 1988[58]							1				
Rubinstein et al, 1989[59]										1	
Ignelzi et al, 1990[60]							1				
Taylor et al, 1991[61]							1				
Holan et al, 1994[62]							1			1	1
Seow and Hackley, 1996[38]							1				
Rutar, 1997[63]										1	
Seow, 1998[39]							2	1		1	
Kupietzky, 1999[64]										1	

As shown in Table 1, using derived data from two fluoride-toothpaste clinical trials completed in 1974 and 1982, Sawle and Andlaw (1988) reported that the prevalence of caries diagnosed radiographically but not clinically, was 3.6% in the first and second permanent molars in 1974, compared to 3.1% in 1982.[9] In another investigation of 2,623, 14-15 year-old Scottish children, a prevalence of occult caries of 0.8% in all premolars, 11.8% in lower molars, and 3.1% in upper molars was found.[10]

A more recent study of over six thousand first and second permanent molars from adolescents on the Isle of Wight reported that 6.3% of clinically sound maxillary molars and 12.9% of mandibular molars showed occlusal dentin caries[11] (Table 1).

Furthermore, a Dutch study published in the same year found that the prevalence of occult caries increased with increasing ages, i.e, fourteen year-olds showed a prevalence figure of 26% compared to 37.5% in the 17 year-olds and 50% in the 20 year-olds[7](Table1). Another study by the same investigators reported the prevalence of occult caries in over three hundred, 12 year-old children to be around 15%[6] (Table1).

More recently, Seow et al (1999) reported that of 2,926 children examined in a school clinic, 66 (2.2%) showed on bitewing radiographs to have radiolucencies resembling caries in dentin of teeth which have been considered caries free during clinical inspection[12] (Table 1).

Diagnosis of occult caries

As occult caries is considered to be dentin caries, which is not diagnosed on visual examination of the occlusal surface but is present on a radiograph of the tooth, the accuracy of diagnosis of the occlusal fissures would clearly play an important role in determining its prevalence.

Diagnosis of caries in occlusal fissures would depend, in turn, on the clinical criteria which are followed for diagnosis of caries, as well as the techniques or instruments used. With regard to diagnostic criteria, the current WHO clinical system[13] has been most commonly employed by clinicians. This system, which considers caries to be present when there is frank cavitation detected by visual inspection or probing is likely to underdiagnose some occlusal lesions. For example in the study of Weerheijm et al (1992), it was found that 50% of occlusal surfaces thought to be clinically sound were shown to have dentin caries when the teeth were later examined histologically.[7]

On the other hand, the use of careful visual inspection, with or without tactile techniques, has been demonstrated by a few investigators to be of sufficient value in diagnosing occlusal caries. Ekstrand et al (1997) showed that a detailed five-point visual scoring system of occlusal fissures correctly predicted all dentin lesions visible on bitewing radiographs, and that no tooth scored visually as sound occlusally had histological evidence of dentin caries.[14] These results were substantiated by a recent study[15] which reported that the prevalence of occult caries was lowered from 5.2% to 1.7% when an expanded eleven-point clinical (non-radiographic) criteria was used to differentiate caries status of the occlusal surfaces. Thus, these studies show that careful, visual examination techniques employing enamel dehydration, can be highly sensitive for the diagnosis of occlusal caries.

In addition to clinical criteria, the instruments used may affect diagnostic accuracy as these have different sensitivities and specificities for occlusal caries. In addition to visual and tactile techniques, several non-invasive physical instruments may be used as adjuncts to aid diagnosis of occlusal caries. Radiography is commonly used by clinicians and has been shown to be of considerable value when visual findings are inconclusive.[16] Other instruments to aid occlusal caries diagnosis include fibre-optic transillumination (FOTI)[17,18], laser luminescence,[19,20] light scattering,[21] electrical resistance measurements (ERM),[22,23] and dye uptake.[24]

With regard to their relative effectiveness, meta-analysis comparing the performance of various techniques in the diagnosis of occlusal caries was reported recently.[25,26] In these analyses, which were based on their comparative specificities and sensitivities, electrical resistance measurements performed the best, whereas visual inspection was the least accurate, and radiography and FOTI were ranked in between.[25]

Apart from meta-analysis, another method of comparing the various techniques of occlusal caries diagnosis was correlation of the clinical test outcome with histological assessment of lesion depth or mineral loss. Correlation coefficients of these techniques had been reported in a few studies.[26-28] These analyses suggested that visual inspection of air-dried occlusal surfaces using a scoring system based on the translucency and breakdown of enamel showed the highest correlation with histology, followed by ERM and radiography.[16-28]

Pathogenesis of the occult lesion

The area of initiation of occult lesions may provide an explanation for the difficulty in their detection. In general, it is thought that occlusal lesions may begin in two locations. The first is an area superficially at, or near, the entrance to the fissure where dietary substrates are readily available.[4] The second is on the walls of the fissure near its base, and hidden from direct view.[29] Although it is most likely that cariogenic substrates reach the bacteria in these locations via penetration through the occlusal fissures, there is speculation that the cariogenic bacteria may be nourished by pulpal tissue fluids present in dentinal tubules.[30] This process would allow cariogenic bacteria to persist in deep, clinically obscured lesions enabling the caries process to continue.[7]

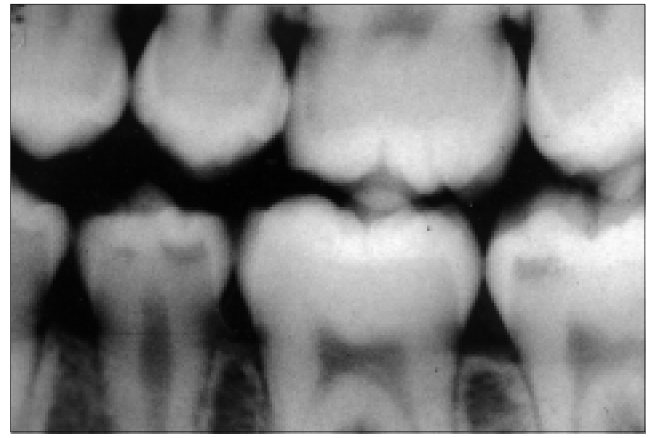

Fig 1. Occult lesions in the mandibular second premolar and second molar seen in left bitewing radiograph of a 14 yr-old girl. These lesions were thought to be occlusal fissure caries until examination of previous orthopantomograms revealed that these lesions were present even before the teeth erupted (see Figs 2 and 3).

Currently, the pathogenesis of the occult lesion is thought to be based on accepted concepts of cariogenic mechanisms. However, it is unclear if an occult lesion represents a discrete clinical entity different in some way from clinically-detectable occlusal caries. In this regard, it is possible that the microorganisms associated with occult caries are different or that the enamel may be altered so that the pattern and spread of caries is affected. However, a microbiological study reported that the bacteria profile within occult lesions was mainly limited to mutans streptococci and lactobacilli,[31] which suggests that these lesions are not associated with microorganisms different to those found in other carious lesions.

A popular belief has been that occult caries have resulted from the widespread use of fluoride. Many occult lesions were termed "fluoride bombs" or "fluoride syndrome."[2,3] According to this theory, fluoride encourages remineralization and slows down progress of the caries in the pit and fissure enamel, while the cavitation continues in dentin, and the lesion becomes masked by a relatively intact enamel surface.[32-34]

This hypothesis was held for many years because the putative roles of fluoride in the development of occult caries are in line with current understanding of the actions of fluoride in promoting remineralization in enamel.[35,36] There is also suggestion that occult caries increases with increasing age[6] which appears to reflect the putatively delayed progression of caries by fluoride.[4] Furthermore, Weerheijm et al (1992) reported that occult caries is usually associated with very low caries scores, which is suggestive of increased fluoride exposure.[7] In accordance with this theory, in the study of Sawle and Andlaw (1988), the authors speculated that the increase in the prevalence of occult caries observed in the trial of 1982, compared to that of 1974, may be associated with increased fluoride exposure by the subjects in 1982 trial.

However, the hypothesis that occult caries is associated with fluoride has been challenged recently in a study which compared the prevalence of occult caries in two cities in the Nederlands, one which was optimally fluoridated (Tiel) and the other non-fluoridated (Culemborg).[34] The results showed that in Tiel, 16.9% of occlusal surfaces judged clinically sound

Table 3. Studies on the Prevalence of Pre-eruptive Resorptive Defects

Authors/ Year	Seow, Wan, McAllan/ 1999	Seow, Lu, McAllan/ 1999
Radiographs	Bitewings	Orthopantomographs
Number of subjects (%)	126 out of 1959 (6%)	42 out of 1281 (3%)
Number of teeth (%)	163 out of 9919 (2%)	57 out of 11,767 (0.5%)
Max 1st molar	1%	4%
Max 2nd molar	NA	0.4%
Max 3rd molar	NA	0.2%
Max 1st premolar	1%	0.1%
Max 2nd premolar	0.2%	0%
Mand 1st molar	4%	3%
Mand 2nd molar	1%	0.9%
Mand 3rd molar	NA	0.4%
Mand 1st premolar	2%	0.8%
Mand 2nd premolar	1%	0.5%

showed radiolucencies in dentin, compared to a figure of 24.6% in Culemborg. There was thus a 31% decrease in the prevalence of occult lesions in the fluoridated town. This finding was directly opposed to the "fluoride bomb" hypothesis, and suggests that fluoride has minimal role in the pathogenesis of occult lesions.

In summary, current opinion regarding the pathogenesis of occult lesions is centered on traditional mechanisms of caries development. In this regard, it is possible that a proportion of these lesions began their course as fissure caries which, because of misdiagnosis in the early stages, progressed to occult caries. In the following sections, the author proposes that there may be another pathogenetic mechanism for occult caries, namely pre-eruptive intracoronal resorptive defects.

Pre-eruptive intracoronal resorptive lesions

It was reported in a few studies of occult caries, that when previous radiographs of the affected teeth during their unerupted stages were examined, these showed that the radiolucencies had been already present in the same locations within the teeth even prior to tooth eruption[37-39] (Figs 1-3). These findings suggest that a percentage of occult caries may have their origins as pre-eruptive defects which are detectable only with the use of radiographs (Fig 4).

These defects which are present on unerupted teeth, are referred to as intracoronal resorptive defects, and are usually detected incidentally on routine dental radiographs. They are often found within the dentin, adjacent to the amelodentinal junction in the occlusal aspects of the crown.[12,37] Nearly half of the lesions are located on the central aspects of the crown, with smaller percentages in mesial or distal aspects of the occlusal.[12,37] In prevalence studies, at the time of discovery, the majority of defects were found to be less than one-third the thickness of dentin.[12,37]

As the lesions resemble caries, they are often referred to as "pre-eruptive caries."[40] There is little scientific basis for this nomenclature as a pre-eruptive, developing tooth which is completely encased in its crypt is not likely to be infected with cariogenic microorganisms.

Prevalence of pre-eruptive intracoronal defects (Table 3)

While over 60 teeth with pre-eruptive intracoronal lesions have been reported in over 25 case reports,[38-64] beginning as early as 1941 (Table 2), the prevalence of this entity was unknown until recently. In a study using bitewing radiographs, a recent investigation reported a subject prevalence of 6% and a tooth prevalence of 2%[37] (Table 3). Another study by the same authors, but using employing orthopantomograms instead of showed a subject prevalence of 2% and a tooth prevalence of 0.9%[12] (Table 3).

From bitewing radiographs, the permanent teeth which showed the highest percentage of defects were mandibular first molars (4%), and mandibular first premolars (2%)[37] (Table 3). In contrast, from panorex radiographs, the highest prevalence was reported in the maxillary first molars and the mandibular first molars at 4% and 3%, respectively[12] (Table 3). In the primary dentition, the prevalence is unknown, as few radiographs of unerupted primary teeth are exposed. To date, only one case has been reported in the primary dentition.[38]

In controlled studies, there was no gender or racial predilection, nor were there any associations with medical conditions.[12,37] Of significance is the fact that the lesions were

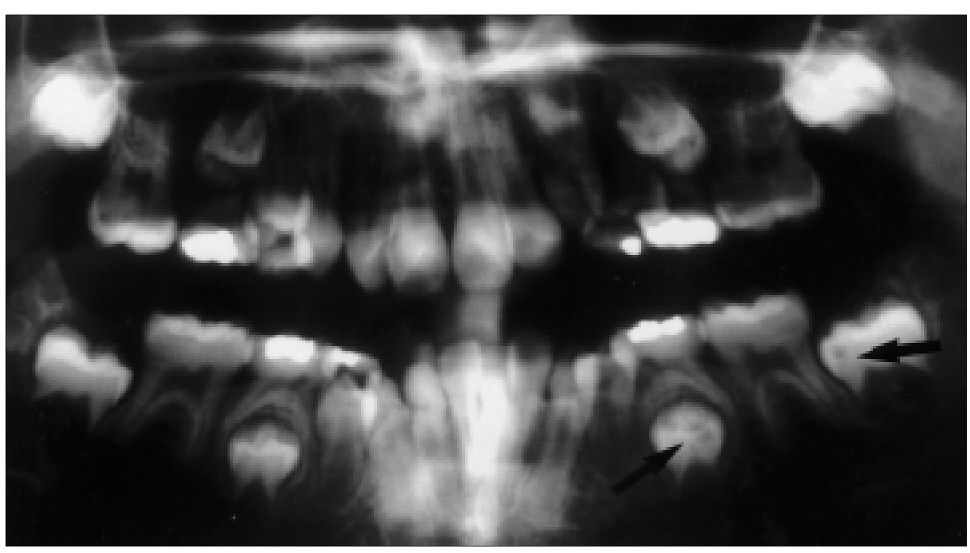

Fig 2. Orthopantomogram of the subject in Fig 1 at age 9 yrs, showing that radiolucencies (arrowed) were already present within the crowns of the mandibular left second premolar and second molar. These are likely to be pre-eruptive intracoronal resorptive defects.

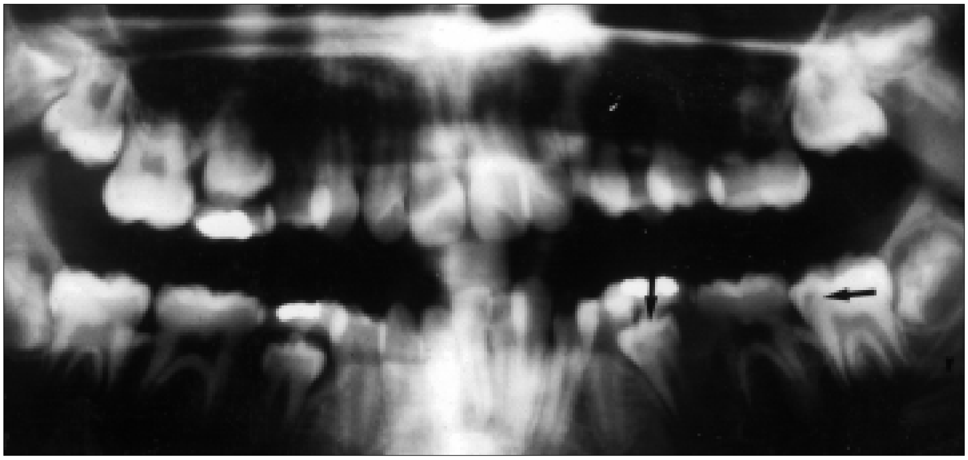

Fig 3. Orthopantomogram of the subject in Fig 1 at age 11 yrs, confirming the presence of radiolucencies (arrowed) within the crowns of the unerupted mandibular left second premolar and second molar. These are likely to be pre-eruptive intracoronal resorptive defects.

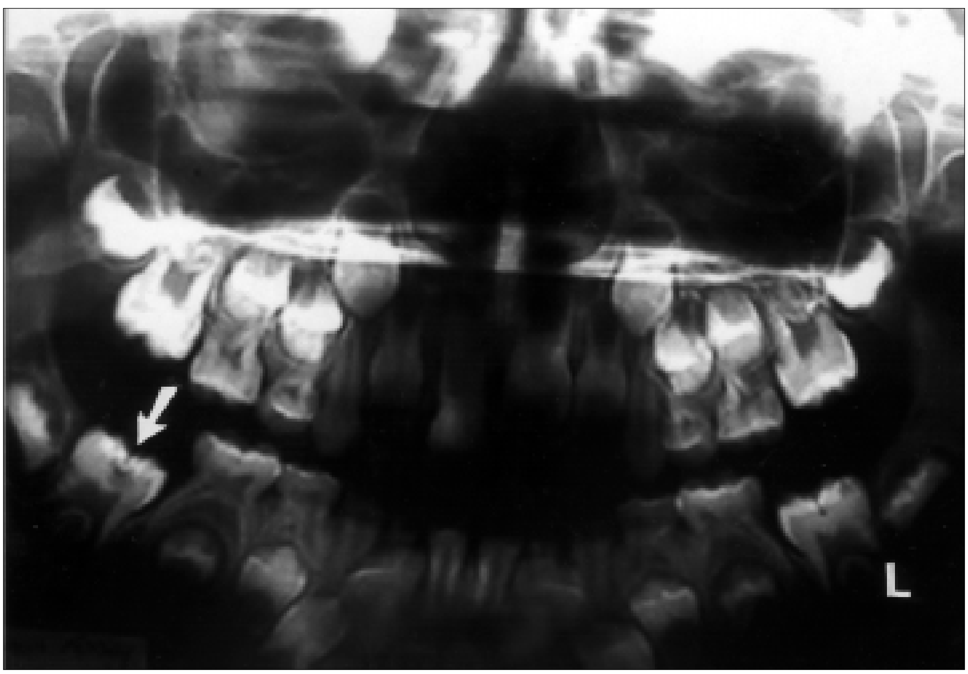

Fig 4. An intracoronal resorptive defect within the crown of an unerupted mandibular right first permanent molar (arrowed), discovered incidentally on the orthopantomogram.

not associated with fluoride supplementation, or the drinking of fluoridated water.[12,37]

Pathogenesis of pre-eruptive intracoronal resorptive defects

To date, clinical and histological evidence substantiate the hypothesis that these defects are acquired, as a result of coronal resorption.[38,39,53,56,57] In the pre-eruptive state, these lesions were reported to contain soft tissue when examined during surgical exposure.[38] Histological examination often reveals signs of resorption such as scalloping of the lesion margins, as well as resorptive cells such as osteoclasts and macrophages.[38,39,53] The resorptive cells are thought to enter the dentin through poorly coalesced enamel fissures or the cemento-enamel junction.[39] Although trigger factors for the resorption are unknown, a high association of ectopic positioning of affected teeth or in the adjacent abutting teeth was reported in controlled studies,[12,37] which suggests that abnormal local pressure may be an inciting factor for the resorption.

Although an intracoronal resorptive lesion is unlikely to contain microorganisms in the pre-eruptive stages, once it has emerged into the oral cavity, it rapidly becomes colonized by the oral flora. The retentive nature of the cavitated lesion favors the development of caries, and the lesion becomes indistinguishable from a carious lesion once it is exposed in the oral cavity.

Pre-eruptive intracoronal resorptive defects as an entity of occult caries

The author hypothesizes that many lesions diagnosed as occult caries in erupted molars and premolars began as pre-eruptive intracoronal lesions. This hypothesis is based on reports which demonstrated that many occult lesions showed the presence of radiolucent defects in previous radiographs of the affected teeth during the pre-eruptive stages.[12,38,39] After the teeth are erupted, both occult carious lesions and pre-resorptive intracoronal resorptive defects show similar clinical presentations, namely an apparently intact enamel with loss of mineral in dentin detectable only through radiographs. Furthermore, both occult caries and pre-eruptive intracoronal dentin resorption do not appear to be influenced by exposure to fluoride, which suggests that classical mechanisms of caries pathogenesis and their inhibition by fluoride are unlikely to be operating.

The actual contribution of pre-eruptive resorptive defects to the overall prevalence of occult caries is unknown, but is likely to be significant. As shown in one of our earlier studies, two percent of children examined in one year at a school clinic had occult caries.[37] Of these children, nearly half had radiographic evidence that the affected teeth showed intracoronal radiolucencies during the pre-eruptive stages. Based on these data, it is suggested that intracoronal resorptive lesions constitute at least half of all occult caries. The percentage is likely to be higher if greater numbers of children had radiographs exposed during the pre-eruptive stages of teeth development, so that more pre-eruptive lesions may be diagnosed.

Clinical significance of occult lesions

Bitewing radiographs are currently one of the most useful aids in the diagnosis of early fissure caries, and their use in conjunction with careful clinical examination techniques are likely to detect occlusal caries efficiently. On the other hand, panoramic radiographs are useful in the detection of intracoronal resorptive lesions in unerupted teeth. It is recommended that the crowns of all unerupted teeth be examined on panoramic radiographs for these lesions.

An erupted tooth showing an occult lesion should be examined to determine if the defect was present pre-eruptively, on radiographs exposed when the teeth were in the developing stages. Occasionally, comparison of the size of the occult lesion relative to the patient's dental age, and the estimated rate of progress of caries may provide clues as to whether the defect had originated pre-eruptively. Differentiation of the two types of lesions may be useful in determining the caries risk of the patient.

Occult lesions which are undiagnosed may progress rapidly, with severe destruction of the dentin crown[39], and endodontic involvement. In the case of pre-eruptive intracoronal resorption lesion, surgical exposure of the developing crown may be necessary if there is a rapid rate of progress of the lesion.[38] However, many lesions may enlarge only minimally while in the pre-eruptive stages, so that it may be possible to wait for tooth emergence before restoration.

In conclusion, occult caries refer to lesions which result from inadequate clinical diagnosis, and could have resulted from processes which were pre-eruptive or post-eruptive. The pre-existence of a pre-eruptive intracoronal resorptive defect may occur in many occult lesions. Upon eruption of the teeth, pre-eruptive lesions become indistinguishable from those resulting from true fissure caries. The prevalence of occult lesions in a community will depend on differences in operator ability to diagnose caries and the criteria applied for caries diagnosis, as well as the examination techniques used. Early diagnosis of occult lesions is the best management. As radiographs are probably the most effective method of diagnosing all occult lesions, they should be recommended at appropriate ages to aid early detection of these lesions. Also, examination of the crowns of unerupted teeth for intracoronal defects is suggested on all routine radiographs.

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