

Radiographic, histologic, and electronic comparison of occlusal caries: an in vitro study

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Abstract

The purpose of this in vitro study was to compare visual-tactile diagnoses, radiographic findings, and electronic data with the histological appearances of pit and fissure caries in occlusal surfaces. Forty-eight permanent molars were placed into 4 groups according to clinical diagnoses. The extent of caries involvement of the occlusal surfaces was evaluated using radiographs, electrical conductivity readings, and polarized light microscopy. The findings indicated that electrical conductivity readings may assist in occlusal caries detection and treatment. These readings may provide an indirect measure of lesion depth.

Caries prevalence among children has been declining in the United States, and with this decline there has been a change in the nature of this disease process. Epidemiologic studies of dental caries over the past decade have shown occlusal caries to represent the major portion of the total caries experience in children.

During the early 1970s, the National Center for Health Statistics¹ conducted a nationwide survey of dental caries. At that time, occlusal caries in the 5- to 17-year-old age group represented 49% of the total caries experience. More recently, the National Dental Caries Prevalence Survey,² conducted in 1979-80, demonstrated that occlusal caries accounted for 54% of the caries experience in this age group. The prevalence for this type of disease pattern was observed to be the same for fluoridated vs. fluoride-deficient communities.

Detection of pit and fissure lesions has been based primarily on the clinical appearance of the occlusal surfaces, the use of an explorer for tactile feedback,

and less frequently radiographic evidence of caries. The accuracy of these methods for diagnosing pit and fissure caries depends on the clinical experience of the operator and the thoroughness of the examination.

A diagnostic aid which has been developed to provide additional information about the occlusal surfaces of teeth is the electronic caries detector.^a This instrument uses electrical conductivity to evaluate the integrity of occlusal surfaces. The portable, battery-operated device measures the electrical resistance of the tooth from the probe tip through the dental pulp to a hand-held ground. Upon completion of the circuit, a numerical reading is obtained from the instrument which evaluates the electrical conductivity of the probed tooth surface.

In principle, sound enamel surfaces should demonstrate limited or no electrical conductivity, while carious or demineralized enamel should have a measurable conductivity which varies according to the amount of mineral loss. Measurement is possible because microscopic porosities formed during demineralization fill with saliva, providing highly conductive pathways for electrical transmission through the porous enamel. In general, the greater the amount of demineralization, the higher the electrical conductivity through the affected enamel.³ Several studies,⁴⁻⁶ using low-voltage electrical current, have demonstrated that a direct relationship exists between the electrical conductivity of a tooth and its susceptibility to carious attack.

The purpose of this in vitro study was to compare the visual-tactile diagnoses, radiographic findings, and

^a Vanguard — Massachusetts Mfg Corp: Cambridge, MA.

electronic data with the histological appearances of pit and fissure caries in the occlusal surfaces of molars.

Methods and Materials

Extracted permanent molars were divided into 4 groups based on the clinical appearances of the occlusal surfaces and tactile examination with a #23 dental explorer, using the visual-tactile diagnostic criteria for dental caries established by Radike.⁷ Each of the 4 groups contained 12 molars for caries evaluation. The clinical classifications of these groups included: Group 1 — caries free; Group 2 — enamel caries; Group 3 — dentinal caries; Group 4 — dentinal caries (deep).

Radiographs of these molars were taken at 70 kVp and 10 mA, with the central beam passing perpendicular to the long axes of the teeth. After examination of the individual radiographs, the molars were assigned either a value of 0 for no evidence of pit and fissure caries or a value of 1 for evidence.

The specimens then were prepared for testing with the electronic caries detector. The roots of each tooth were removed and a saline-saturated cotton pellet was placed into the pulp chamber with an insulated wire connected to the instrument ground. This method provided a means to obtain conductance through the extracted teeth. The teeth then were evaluated by probing the deepest clinically detectable pit in the occlusal surface with the probe of the detector. Each selected tooth surface was measured 3 times for electrical conductivity and the mean score was recorded. The scores measured by the detector ranged from 0 for no electrical conductivity to 9 for maximal electrical conductivity. The tested teeth were supplied with an intermittent stream of water to avoid desiccation. As recommended by the manufacturer, compressed air (30 psi) was passed through the tip of the detector probe which was in contact with the extracted teeth.

Multiple, longitudinal sections were prepared from the pits and fissures of the teeth evaluated with the detector. These sections were imbibed with water for histological evaluation with polarized light microscopy. Lesion depths then were measured with an eyepiece graticule. This part of the study was performed without reference to data from the various clinical examinations.

Results

The results of this study have been summarized according to the clinical classifications of the groups and the methods of evaluation (Table 1). In the caries-free group, no evidence of occlusal caries was identified radiographically. A mean electronic caries reading of 1 was obtained with a standard deviation of \pm

0.6. When longitudinal sections of these molars were imbibed with water and viewed with polarized light, a mean lesion depth of $208 \pm 62 \mu\text{m}$ was measured (Fig 1).

In the enamel caries group, occlusal caries could not be detected in the radiographs of these molars. However, a mean caries detector reading of 2 was obtained with a standard deviation of ± 0.4 . Mean lesion depth in this group of molars was found to be $578 \pm 143 \mu\text{m}$ when examined with polarized light (Fig 2).

The dentinal caries group demonstrated radiographic evidence of caries in 33% of the specimens studied. A mean electronic caries detector reading of 6 was obtained for this group of molars with a standard deviation of ± 0.5 . Mean lesion depth was found to be $2253 \pm 308 \mu\text{m}$ when examined with polarized light (Fig 3).

The final group of molars included deep dentinal involvement and demonstrated radiographic evidence of occlusal caries in all specimens. A mean electronic caries detector reading of 9 was obtained for these extensive lesions with a standard deviation of ± 0 . Mean lesion depth in this group of molars measured $3649 \pm 420 \mu\text{m}$ when examined with polarized light (Fig 4).

Discussion

Pit and fissure caries is the primary disease process that the dental practitioner encounters today in the pediatric population. The National Dental Caries Prevalence Study of 1979-80² revealed that only 16% of the caries experience of 5- to 17-year-old children occurred on interproximal surfaces, while 84% involved occlusal surfaces and the pits and fissures of buccal and lingual surfaces. Recent studies have shown that in 12-year-old children, 65% of all first permanent molars have occlusal caries.⁸ Furthermore, in elementary school children, 90% of all lesions in first permanent molars were pit and fissure caries.⁹ These reports led the ADA Council on Research¹⁰ to suggest that pit and fissure caries represents the predominant dental disease in children.

These statistics are important because of the treatment alternatives which are available to the dental practitioner in preventing or restoring pit and fissure caries. These treatment alternatives include:

1. No treatment, or observation only
2. Sealant placement
3. Preventive resin restoration
4. Amalgam or posterior composite restoration.

The electronic caries detector may be a valuable diagnostic aid for the dentist when attempting to evaluate which treatment approach is most appro-

TABLE 1. Comparison of Electronic, Radiographic and Histologic Evaluation of Occlusal Caries

	<i>Caries Free</i> (N = 12)	<i>Enamel Caries</i> (N = 12)	<i>Dentinal Caries</i> (N = 12)	<i>Dentinal Caries Deep</i> (N = 12)
Electronic caries detector ($\bar{x} \pm SD$)	1 \pm 0.6	2 \pm 0.4	6 \pm 0.5	9 \pm 0
Radiographic detection (\bar{x})	0%	0%	33%	100%
Lesion depth	208 \pm 62 μ m	578 \pm 143 μ m	2253 \pm 308 μ m	3469 \pm 420 μ m

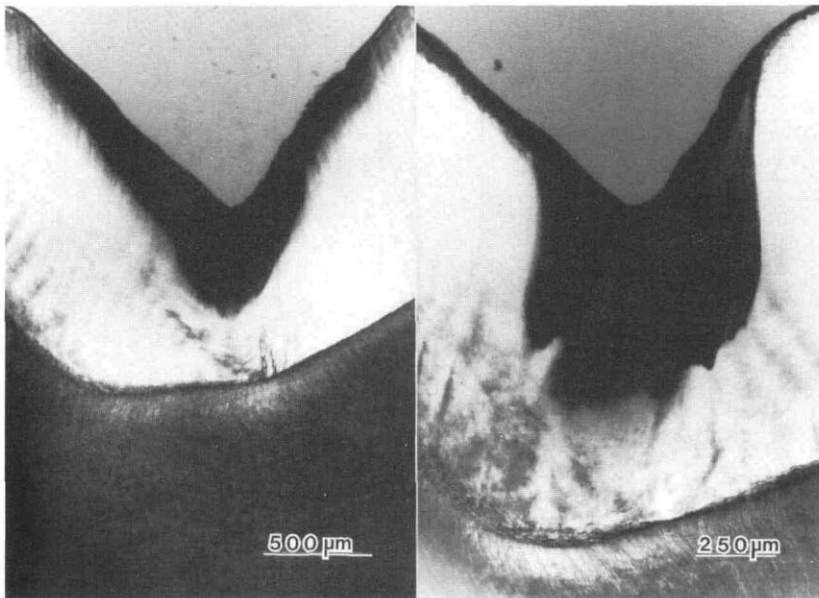


FIG 1. A naturally occurring lesion confined to enamel is present in the fissure of a molar from the caries-free group. The lesion has an intact surface overlying the body of the lesion (water imbibition, polarized light microscopy).

FIG 2. An intact surface is present over the body of the lesion in this fissure of a molar in the enamel caries group. This lesion involves greater than one-half the total depth of enamel on the occlusal surface (water imbibition, polarized light microscopy).

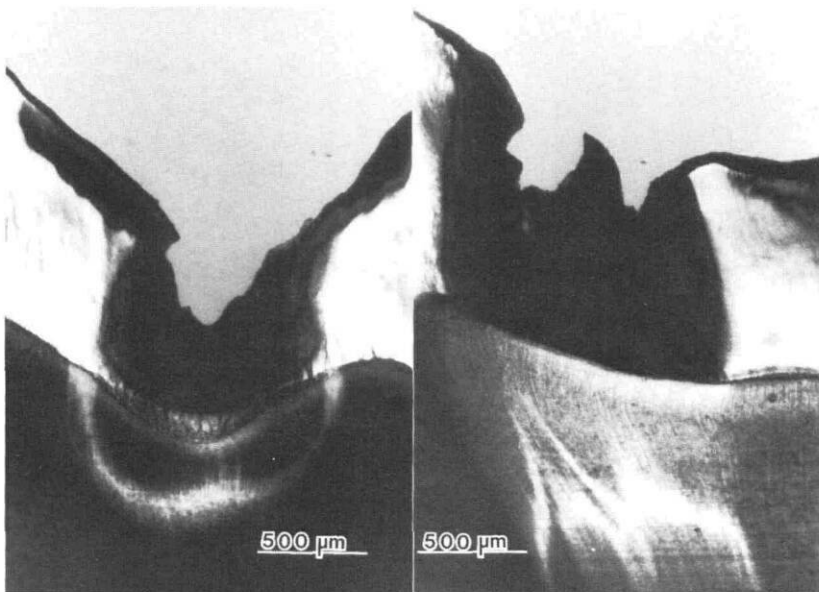


FIG 3. A significant degree of dentinal involvement has occurred with this lesion in a fissure of a molar in the dentinal caries group. Cavitation of the surface enamel of the fissure has occurred and the lesion extends toward the cuspal tips along the cuspal inclines (water imbibition, polarized light microscopy).

FIG 4. A large area of dentin is involved with this lesion in a fissure of a molar in the deep dentinal caries group. Surface cavitation also has occurred with this lesion (water imbibition, polarized light microscopy).

appropriate for pits and fissures, particularly with the pediatric patient. In a previous study using a prototype of this caries detector, electrical conductivity measurement of occlusal surfaces was shown to be 6 times more sensitive than the dental explorer in detecting caries, when compared with results from teeth sectioned for histologic examination and stained with murexide for determination of lesion depth.⁵

In the present *in vitro* study, the electronic caries detector was able to discriminate among the 4 clinical groups with respect to the lesion depths in the pits and fissures of the occlusal surfaces. Because the electronic caries detector readings correlated well with the histologic findings, this instrument may provide an indirect measure of microscopic lesion depth. The caries detector was more sensitive in assessing incipient enamel lesions from dentinal lesions than the traditional radiographic survey. Only when there was frank dentinal involvement did the radiographs demonstrate a consistent diagnostic value. These *in vitro* findings suggest that radiographs are not indicated for diagnosis of occlusal caries in the clinical setting.

Although obvious dentinal and deep dentinal caries were included in this study, the value of electronic caries detection would be most valuable in evaluating questionable occlusal surfaces. With a questionable surface, the decision regarding observation, sealant placement, or restoration of pits and fissures with a preventive resin or amalgam restoration is difficult. Additional information that would not be provided by radiographs may be obtained by evaluating the electrical conductivity of the tooth surface. In this way, the extent of carious involvement can be determined and a decision regarding the treatment alternative to be employed may be made more confidently by the dental practitioner. With obvious clinical caries involving dentin, there would be no need to use any additional information regarding restoration of the occlusal surface with the exception of a radiograph to determine if the interproximal surface is involved or if the dentinal caries is approaching the pulp.

There may be several advantages for using the electronic caries detector when diagnosing pit and fissure caries.

1. It may allow for the monitoring of occlusal surfaces if a decision is made to observe the occlusal surface only.
2. It may aid in making a decision regarding sealant placement vs. a more aggressive restorative treatment.
3. It may provide an additional source of information when a lesion is suspected but the explorer and radiograph fail to demonstrate a carious surface.
4. It may provide the patient and/or parent with immediate information about the integrity of the oc-

clusal surface which reinforces the clinical diagnoses of the dentist.

The disadvantages of the electronic caries detector include obtaining false positives. Inaccurate high readings are most often observed in newly erupted molars due to lack of posteruptive maturation. However, because posteruptive maturation of occlusal surfaces occurs within a short time, this would apply only to molars that have been in the oral environment for fewer than 2-3 months.¹¹⁻¹³ False positives also may be observed when the tooth is not properly isolated, resulting in either excessive saliva saturation or excessive air, whereas false negatives may occur with drying of the tooth surface. In the present *in vitro* study, no false positive readings were obtained. The electronic caries detector cannot be used to monitor caries progression once an amalgam restoration is placed. With sealant placement, readings may be taken on enamel surfaces that have not been sealed in order to monitor the occlusal surface.

Conclusions

The conclusions from this *in vitro* study suggest that:

1. Radiographic evidence of pit and fissure caries in occlusal surfaces is not demonstrated until significant dentinal involvement has occurred histologically. Radiographs are of limited value in diagnosing occlusal caries and would not be indicated for clinical diagnosis.
2. Electrical conductivity may provide an indirect measure of histologic lesion depth.
3. Electronic caries detection may be of assistance in the diagnosis of pit and fissure caries, especially when attempting to decide between restoration or sealant placement on an occlusal surface. This instrument may be of particular value in distinguishing lesions that are confined to enamel from lesions involving both enamel and dentin. However, a certain degree of caution must be exercised when applying *in vitro* results to the clinical situation.

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