

A NOVEL APPROACH FOR TREATING FISSURE CARIES



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INTRODUCTION

Diagnosis and treatment of fissure caries is one of the most frequently-performed activities for most general dentists. Our objective is not only to prevent and control dental caries as an infectious disease, but also to treat the local effects of the disease process itself. We do this by early and accurate detection of dentin carious lesions, performing minimally-invasive treatment when necessary, and by providing effective restoration of diseased tooth structure. Two current clinical dilemmas impact our ability to provide optimum diagnosis and treatment of fissure caries at the level of the tooth: the phenomenon of hidden caries and the limits of current diagnostic methods. The purpose of this presentation is to explain the potential impact of hidden caries and currently-available diagnostic methods on treatment approaches for fissure caries, and to present a novel approach for treating fissure caries in light of these problems.

ABSTRACT

The impact of hidden caries and currently-available diagnostic methods on treatment approaches for fissure caries is significant, and provides an opportunity for a novel and conservative approach for treating these lesions. The problems of hidden caries and current diagnostic methods are considered in light of previous and proposed treatment solutions. A new system, the Fissurotomy™ System, is presented and the application of the system to treatment of fissure caries is explained.

The problem of hidden caries

Hidden caries can be defined as a dentin carious lesion that is not detectable clinically, but which is subsequently found to be present upon radiographic examination¹. This phenomenon is well-known to practicing dentists, often resulting in well-developed dentin lesions requiring substantial removal of tooth structure. Every dentist has encountered a localized dentin carious lesion within a fissure system in an area previously thought to be healthy, during preparation of the entire fissure system for placement of a traditional Class I amalgam restoration. When the entire fissure system is prepared using this traditional approach²,

a true diagnosis of the entire fissure system, millimeter by millimeter, is the usual result. A fissure system prepared because of a lesion diagnosed in one aspect often reveals additional disease, sometimes of significant size, in another aspect previously judged to be healthy. Although the non-selective approach of the traditional Class I cavity preparation for an amalgam restoration is being replaced somewhat by less invasive and more selective restorative approaches in general practice today, the problem of diagnosis of hidden caries persists. In fact, the problem as described actually understates the true incidence of hidden caries because radiographic imaging fails to identify all hidden caries.

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Fig. 1. In this undecalcified thin section of an occlusal fissure, both enamel and dentin lesions can be seen beneath an apparently intact enamel surface.

Current diagnostic methods

The traditional use of the dental explorer to assess the health of fissure systems is now considered inappropriate³. When a dental explorer "sticks" in a fissure, it is actually caught in the local anatomy of the tortuous fissure system, whether it is healthy or diseased. The correlation with the presence of a carious lesion or with healthy tooth structure is low, and of little diagnostic utility. In fact, the dental explorer can actually create a localized defect if used improperly. Except to carefully remove extraneous organic material in the orifice of the fissure or to guide the dentist's visual examination, the dental explorer is of little use in the diagnosis of fissure caries. Figures One and Two show the presence of dentin carious lesions beneath intact enamel surfaces.

Dental radiographs are helpful in diagnosing occlusal dentin carious lesions and have been recognized for the detection of hidden caries as explained above. However, radiographs often significantly underestimate the extent of occlusal dentin lesions, and miss many of them. A number of in vitro studies have demonstrated a poor correlation between radiographic, clinical and histo-



Fig. 2. This cut-away view of a carious occlusal fissure, slight discoloration of the overlying enamel can be seen although the enamel itself is non-cavitated.

logic findings^{4,5,6}. In one in vivo study involving third molars with suspected but non-cavitated occlusal lesions, radiographs missed 52% of dentin lesions, of which 12% were advanced within the inner half of the dentin⁷. There were even instances in which a carious lesion was diagnosed radiographically, but not confirmed histologically, 17% of all radiographically diagnosed dentin lesions in this study.

Electronic detection of occlusal lesions relies upon decreased electrical resistance within a specific carious fissure location compared to a healthy fissure system or location⁸. This is due to increase fluid in the carious area. Although this approach to diagnosis of fissure caries may have some clinical

utility, one study has discovered differences in electrical resistance readings between fissures of healthy, newly-erupted teeth and healthy, older teeth⁹. The impact of this finding and the potential of electronic caries detection combined with other means of diagnosis is yet to be determined.

Dentin caries dye has been shown to be useful for identification of the "inner carious dentin" in clinically accessible lesions¹⁰. This dye apparently stains the denatured collagen in the inner part of the lesion. Although this staining feature of the dentin lesion is closely associated with bacterial penetration within the dentin, the dye itself does not stain bacteria. Also, the dye does not penetrate carious dentin; it provides an indication of the status of the collagen on the exposed surface of the carious dentin. The dye can stain decalcified enamel, dental plaque, and organic debris. Normal dentin tissues can also be stained with the dye including interglobular and circumpulpal dentin. The authors of one in vitro study¹¹ of thirty mandibular molars of unknown history have concluded that "Caries detection dye is a reliable diagnostic tool for occlusal carious lesions". This study correlated the millimeters of fissures stained with dentin caries dye with the millimeters of actual dentin carious lesions seen in histologic sections, and found 100% correlation. The nature of the staining, i.e. decalcified enamel, cavitated lesion exposing carious dentin, organic debris or plaque within the fissure system, etc., was not reported. Although this study did report an excellent correlation between the histologic presence of caries and dentin caries dye-staining on the occlusal surface of the tooth, the lack of history of the teeth used in the study and the lack of knowledge about the actual histologic status of the external surfaces that stained make clinical application of this technique inappropriate at this time.

Visual indicators of occlusal carious lesions are well-known and can be useful. While external staining of the enamel surface within or adjacent to a fissure is not diagnostic of caries, sub-surface staining of dentin seen through translu-

cent enamel can indicate the presence of a dentin lesion¹². Decalcification of enamel within the walls of the fissure system indicates at least the presence of an enamel lesion. Frank enamel cavitation and smaller cavitations that can be seen with magnification are evidence of advanced enamel lesions, usually with dentin involvement as well.

In summary, we do not currently have a method or combination of methods to perfectly detect the presence of health or disease in occlusal fissures. Therefore, treatment approaches must recognize the impact of false-negative and false-positive decisions, and minimize their effects.

Previous and proposed solutions

In an environment of rampant caries in which about three-fourths of all teeth had occlusal dentin caries, diagnosis becomes less important and prevention and treatment the more effective approach. This was the case in 1923 when Hyatt proposed the concept of "prophylactic odontotomy" to the Academy of Stomatology of Philadelphia and subsequently in Dental Cosmos¹³. He proposed that the second premolars and first and second molars receive a preventive application of zinc phosphate cement as soon as the tooth erupted into the mouth, and then a Class I amalgam restoration soon afterward. Dr. Hyatt considered the health of these fissure systems to be the dentist's responsibility and proposed prevention via treatment, without the need for diagnosis. With today's decreased incidence of fissure caries and the modern goal of conserving healthy tooth structure, this approach does not make sense because many false positive treatments would occur.

Another, more modern approach, is to treat only those occlusal lesions that have actually cavitated, sealing questionable fissures including those that may likely be associated with established dentin carious lesions. This approach is based, in part, upon the apparent success of a long-term clinical

trial in which over 150 fissure lesions with confirmed dentin involvement were treated by removing only minimal amounts of enamel while leaving the dentin lesion in place, covered with a sealed composite resin restoration¹⁴. An advantage of restoring only cavitated lesions is that false-positive treatments will be virtually eliminated. Possible disadvantages are related to the need to "seal in" dentin lesions. This approach requires monitoring of these lesions radiographically, discussed earlier as being unreliable. The long-term retention and sealing ability of the sealant or sealed restoration becomes the key factor in non-progression of the dentin lesion. In addition, most dentists do not recognize the non-excavation of carious dentin as the current standard of care. Certainly, those motivated to support minimal treatment of patients would find merit in this approach, although outcomes in a range of actual general dental practices have not been determined.

A third approach has been to recognize that false-positive decisions will sometimes be made in diagnosis of fissure caries, and to utilize a treatment technique that will minimize the effects of these decisions. Air abrasion has been recognized for its ability to diagnose and treat fissure caries utilizing a minimally-invasive preparation¹⁵. This technology can, indeed, provide well-suited minimal preparations of occlusal fissures when indicated. Potential problems with air abrasion include the mess of the abrasive powder in the treatment room, a technical learning curve associated with significant errors, and cost. Small round burs used in the highspeed handpiece will also create very conservative exploratory cavity preparations, but their shape is not optimized for this procedure. Small round burs can create rough and irregular lateral cavity walls that are not ideal for restoration with adhesive materials, and they require multiple passes to reach the dentinoenamel junction. In addition, they are not well-suited to removing larger amounts of enamel when dentin lesions are discovered and access to them must be gained.

Conservative cavity preparation

The traditional Class I cavity preparation for amalgam restoration represents the least conservative approach for surgical treatment of suspected occlusal lesions. The design generally includes the preparation of the entire fissure system, establishment of a flat pulpal floor in dentin, and a bucco-lingual preparation width sufficiently large to permit restoration with dental amalgam. In 1928, Prime recognized the potentially destructive nature of this design, and called for minimal bucco-lingual preparation widths, careful cutting technique, and an abandonment of the concept of "extension for prevention" for Class I lesions¹⁶.

Simonsen's "preventive resin restoration"¹⁷ utilizes the advantages of adhesive restorative materials, and calls for smaller preparations limited in size by the actual extent and location of carious tooth structure, in addition to the use of sealants for adjacent non-suspicious fissures. Both preparation depth as well as the extension of the outline form are controlled in this approach. Paterson¹⁸ has introduced a modification of this approach utilizing small round burs, and Mount¹⁹ has described a combined diagnostic and treatment classification for these lesions, labelling these as "1.1" lesions: "Small defect in one section of a pit or fissure; it is often combined with placement of a fissure seal on the remainder of the fissure system".

Two goals are accomplished in treating fissure caries by minimally invasive means: sound tooth structure is preserved when diseased teeth are restored, and sound tooth structure is preserved in teeth that are minimally and progressively explored for the suspected presence of a lesion.

To optimize the restorative approach to the localized treatment of fissure caries, a system was developed through the efforts of Temple University School of Dentistry, SS White Burs, Inc., and Ivoclar/Vivadent. The Fissurotomy™ System includes a specially designed

carbide bur for exploration and treatment of carious fissures, a dentin caries dye, and the flowable composite resin Heliomolar Flow™ designed for restoration of Fissurotomy™ cavity preparations. The design goals in the creation of the Fissurotomy™ bur included the following:

- 1- Conservative cutting tip that removes less tooth structure than a 1/4 round bur.
- 2- Bur head of sufficient length to extend to the DEJ during a one-pass cut, but short enough to permit the neck/head interface to remain within the visual operating field thus permitting depth gauge function.
- 3- Cavity profile consisting of smooth, divergent lateral walls with no sharp internal line angles, appropriate for adhesive restoration.
- 4- Minimal cavity profile dimensions that will provide for explorer access to dentin when required, with minimal additional loss of tooth structure.
- 5- Smooth, yet efficient cutting operation characterized by well controlled cut, efficient clearing of cutting debris, minimal vibration, and minimal heat production during cutting.
- 6- Differential cutting action along the bur head providing very conservative cutting action at the bur tip with progressively efficient cutting toward the head/neck interface to permit efficient enamel removal at full cutting depth when required for gaining access to established dentin lesions.

Establishing bur parameters

Two major factors determined the minimal preparation width created by the Fissurotomy™ bur. The first factor is the lateral opening required for explorer access to dentin, necessary for diagnosis of dentin caries. By measuring the width of thirty dental explorers of various designs in actual clinical use (tip diameter 2.5mm from the end of the tine), it was determined that a preparation width of approximately 0.8mm was necessary. The second factor is the width required for placement of flowable composite resin. Again, studies on extracted teeth showed that approxi-



Fig. 3. Features of the Fissurotomy™ Bur can be seen in this diagram. These include the small head tip diameter, width at head/neck interface, head length, and depth gauge feature at the head/neck interface.

sure was measured. From this data, a bur head length of 2.5mm was chosen. Actual depth of cut is determined on a case-by-case basis by the dentist from clinical and radiographic evidence.

To obtain the desired cavity preparation geometry and the various cutting characteristics, bur parameters such as blade number, blade profiles, and helix angle were varied. The result is a carbide bur that meets the design specifications listed above. Figure Three is a diagram of the Fissurotomy™ Bur. Figure Four is a graph comparing the cross-sectional area of a cut created by various burs including the Fissurotomy™ Bur at various depths.

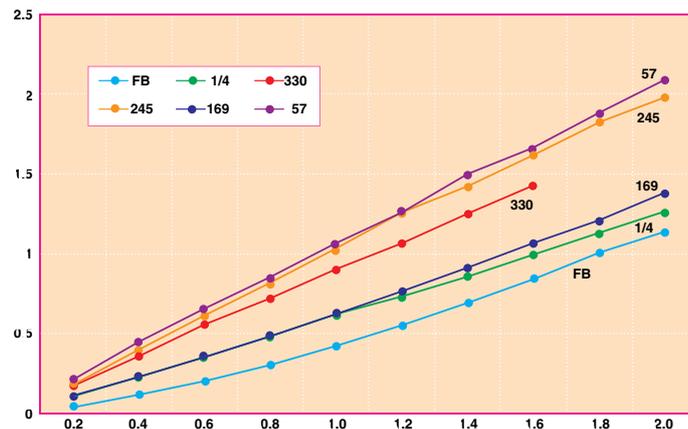


Fig. 4. Preparation cross-sectional area vs. preparation depth for several burs. Notice that the Fissurotomy™ Bur™ resulted in the lowest cross-sectional area of all burs tested.

mately 0.8mm width is necessary when the preparation is extended to the DEJ.

Determining the appropriate length for the Fissurotomy™ bur required further study, however. To reach the DEJ when cutting through occlusal enamel in the region of a fissure, it is necessary to consider not only the nominal thickness of the enamel, but also the angulation of the inner cusp inclines as well as the adjacent anatomic structures such as triangular ridges and fossae. A set of extracted teeth with normal bucco-lingual dimensions, sectioned in bucco-lingual and mesio-distal planes, were digitally imaged to display enamel thickness, DEJ, and surface form. A digitally-constructed bur, 0.8mm in width, was placed into this image and the depth from the highest lateral wall cavosurface margin to a perpendicular pulpal floor touching the DEJ directly below the fis-

Fissurotomy™ Bur Modes of Operation

The Fissurotomy™ Bur can be used in five distinct modes:

- 1- The bur can be used to progressively explore suspect fissure systems or portions of fissure systems. This is done by using the bur tip in repeated, shallow sweeping motions progressively entering the depths of a suspect fissure. Exploration continues until the suspicion of caries is confirmed by the presence of a lesion, or until the fissure is confirmed to be healthy. Within the fissure system of one tooth, this exploration may extend to varying depths, depending upon the presence of diagnostic information.
- 2- The bur can be used to create one-pass cutting to the DEJ, when it is

determined that access to dentin is required to diagnose the presence of a dentin carious lesion. In this mode,

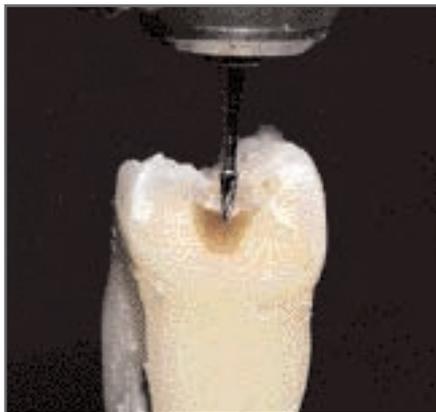


Fig. 5. The Fissurotomy Bur™ has been placed over an established occlusal lesion for comparison of bur dimensions to occlusal anatomy and pathology. Note the conservative profile of the bur.

depth is accurately judged by knowing the bur head length (2.5mm) and gauging depth by relating the bur head/neck junction to the cavosurface cavity preparation margin. Figure Five shows the Fissurotomy™ Bur in place over a cross-section of an established fissure carious lesion.

- 3- The bur can be used to remove very small amounts of carious dentin. When larger amounts of carious dentin are encountered, appropriate round burs (#2 to #6) or hand excavators should be used.
- 4- The bur can be used to gain access to larger dentin carious lesions by efficiently removing overlying enamel. When positioned in the developing cavity preparation at full depth, the portion of the bur head closer to the head/neck interface will quickly and smoothly remove enamel as the bur is directed laterally. The greater head diameter in this region as well as the design of the bur blades provides efficient, yet controlled cutting.
- 5- Finally, the bur can be used for enameloplasty procedures to remove irregular surface and fissure-related defects, and to prepare an area for restoration or sealing.

Use of caries dye and Heliomolar Flow™
Although dentin caries dyes have ques-

tionable utility in the diagnosis of fissure caries prior to gaining access to the dentin, their use in diagnosing dentin caries is well established. Once access to dentin has been gained, dentin caries dye can be applied to the exposed dentin surface, and after excess is rinsed away, the surface can be examined for residual staining, which is an indication of the presence of dentin caries. The presence of a lesion can be confirmed by the introduction of an explorer into the Fissurotomy™ bur cavity preparation, feeling for softened dentin. At the level of the dentin, both the dental explorer and caries dye ARE useful for diagnosis, especially if one is used to confirm the findings of the other.

Flowable composite resins have the advantage of easily conforming to the geometry of cavity preparations, and of moving into position with little direction from a hand instrument. Heliomolar Flow™ has been specifically designed to flow into and to fill the preparations created by the Fissurotomy™ Bur. For preparations or portions of preparations where larger amounts of tooth structure must be restored, a non-flowable composite resin such as Heliomolar™ can be used. In areas of occlusal contact, this is preferred. To seal the dentin surface and to provide the best bond of composite resin to tooth structure, an enamel/dentin bonding agent should be used routinely. Care should be taken to prevent puddling of bonding agent within the preparation prior to polymerization.

Conclusions

In the current clinical environment of hidden occlusal carious lesions and sub-optimal diagnostic techniques for identifying healthy and diseased fissure systems, conservative treatment approaches are especially important. Unless one is willing to delay treatment until occlusal cavitation has occurred, localized treatment will at times be performed in an environment of varying uncertainty. The Fissurotomy™ System provides a novel approach to this problem by bringing selective, conservative solutions to the varying clinical presen-

tations of occlusal caries. Properly applied, and coupled with treatment and prevention of dental caries as an infectious disease, this approach can result in appropriate conservative dental care for our patients.

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«Dr. Boston and Temple University have a financial interest in the Fissurotomy™ Bur»