

Evaluation of Enamel and Dentinal Cracks using Methylene Blue Dye (MBD) and the Operating Microscope



Dr. Glenn A. van As

Introduction

The operating microscope has become a staple of the endodontic discipline with the introduction of the microscope by Apotheker in 1981.¹ Since the late 1980s and early 1990s when Carr, Ruddle, Arens, Buchanan and others integrated it into both standard and surgical endodontic therapy, it has become the standard of care in that discipline. The tremendous improvement in visual acuity through enhanced levels of magnification (2-20X) and coaxial shadow free illumination has allowed for improvements of treatment outcomes in the field of endodontics.²⁻¹⁹

During the rest of the 1990s and into the early years of the next millennium, the microscope gained a new foothold in general practice, particularly with those dentists interested in doing molar endodontics, prosthodontics, and cosmetic procedures.²⁰⁻³⁷ These clinicians from microscope centered practices, almost always noted two things when first beginning to use the operating microscope (Figs. 1 and 2) routinely for restorative procedures. The two most noticeable things noted were an alarming amount of new and recurrent decay, and an overwhelming number of crack lines- mostly around existing restorations, most notably amalgams.³⁸

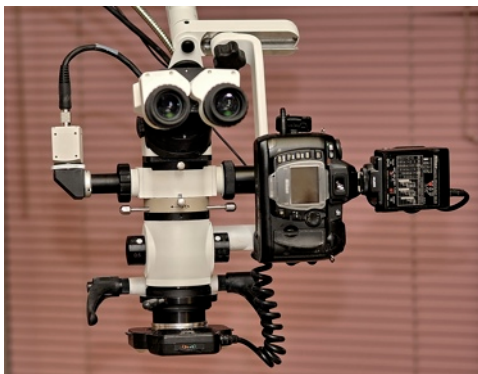


Fig. 1 Dental Operating Microscope. Fig.2 Author at work with the scope.

Studies by Guertzen et al ³⁹ looking at the prevalence of cracked teeth found that these teeth were the third most common cause of tooth loss in industrialized countries, primarily affecting maxillary molars and premolars as well as mandibular molars. The visualization of these cracks has been deemed as difficult with the naked eye or low levels of telescopic loupes, unless the crack is fairly well advanced resulting in a large or darkly stained fracture line. Early cracks are often called incomplete fractures, whereas late stage fractures are called complete (cuspal fracture has occurred or tooth has split vertically). In many instances treatment of these incomplete but “end-stage” symptomatic cracks involves cuspal coverage on those teeth with short term chewing sensitivity and endodontics combined with full coverage restorations in those with thermal sensitivity. Unfortunately, due to the difficulty in the past in visualizing the early, and asymptomatic fracture lines which often are lightly stained enamel and dentin cracks they can be missed until they become fairly advanced, symptomatic or complete in nature.

In general there are two basic varieties of dentinal fractures: the Oblique and the Vertical fractures. The most commonly seen fractures in dentin, often which occur under existing amalgam restorations, are the Oblique fractures. These fractures run in the floor of the preparation undermining cusps, they run in a more horizontal direction, and are often the precursors to a fractured cusp. When they become symptomatic, many patients will complain of sharp and intense, but generally a short term sensation to chewing foods, particularly when they apply lateral pressure to the cusp or cusps that are involved. In the literature, Fennis et al found that oblique complete fractures are more common on molars than premolars (79% to 21%) and occur on the maxillary buccal cusps (66% to 34%) and the mandibular lingual cusps (75% to 25%).⁴⁰ Vertical fractures which run mesial to distal on the tooth and may be the precursors to a split tooth. These more dangerous vertically oriented cracks may result in devastating fractures, with pulpal and or periodontal breakdown. The vertical fractures may progress into a split tooth that is completely fractured and unrestorable. (Figs. 3a, b and Figs.4a and b).



Fig 3a and b End-stage Fractures are symptomatic and once complete they will split teeth, cause irreversible pulpitis or cuspal fractures. (Note DL cusp fractured subgingivally on lower first molar).

(Fig. 3a courtesy of Dr. David Clark)



Fig 4a and b Early stage cracks may be asymptomatic but visible with scope and Methylene blue dye (Note MB oblique crack line on asymptomatic upper 1st molar).

(Fig. 4a courtesy of Dr. David Clark)

In 2003, Dr. David Clark in his landmark article ⁴¹ on the detection and evaluation of early enamel and dentinal cracks with the operating microscope, provided guidelines for the “recognition, visualization, classification and treatment of cracked teeth based on the routine use of x16 magnification.” This fantastic article was the first time that someone tried to provide order to the often bewildering of fractures that are encountered in posterior teeth viewed under the microscope, particularly under existing amalgam restorations. Many of these fracture lines are present on teeth that were not symptomatic but the fractures are still detectable with the operating microscope at magnifications of 12-14X and above. The exciting possibility became of actually trying to for the first time treat these cracked teeth prior to symptoms being present with cuspal coverage restorations that would hopefully prevent further progress of the crack to a symptomatic stage.⁴²⁻⁴⁴

Historically, dentistry has been driven by a “symptoms based approach” to the treatment of cracks, where the microscopic details pertaining to the size and location of the crack were not visible to the naked eye. The patient presents with complaints of chewing or thermal sensitivity and the clinician sets about trying to determine which tooth is the culprit. The crack was localized by having patients bite on cotton roles or hard plastic instruments (ie Tooth Sleuth) to isolate individual cusps which may be cracked. Traditionally, cracks have been detected by transillumination, using caries detector dyes, alternating between hydrated and dry views and using methylene blue dye (MBD). (See Figs.5-7). Although transillumination is the most popular method used, its intensity of light illuminates all cracks and makes subtle cracks invisible. Methylene blue dye is superior to caries indicator dyes because it pools much better. This dye is very dark and is very useful for both extra and intra-coronal cracks As Clark mentioned in his article, there are some negatives to using methylene blue in that plaque will stain profusely, as it does with dentin that has been treated with sodium hypochlorite. The MBD stains all cracks and does not differentiate between early cracks which may not be stained well either before or after MBD, and the stain can alter the dentists ability to differentiate the cracks. The MBD is extremely effective though for educating patients about the cracks and vital for documentation as many of the cracks in dentin are

extremely difficult to photograph. The ability to photograph these extensive cracks is especially important in gaining approval from insurance dental plans for cuspal coverage restorations for these teeth.⁴⁵⁻⁴⁷



Fig.5 Transilluminating MB crack on upper right first molar.

Fig.6 Methylene Blue unidose package from Vista Dental (Vista Blue).

Fig.7 Methylene blue being brushed on upper left first molar to view enamel fractures.

Protocol for using MBD and the Microscope

Dr. David Clark has suggested that in order to inspect cracks with the microscope that all posterior teeth should be polished with a coarse pumice slurry, then completely dried and the MBD is applied with a disposable applicator tip. The MBD will stain clothing and countertops so extreme care must be taken to prevent the dye coming into contact with these items. The author has found that the unidose packaging of Vista Blue (Vista Dental Products) to be a nice way of limiting the risk of staining to clothing, as well as being a nice sized brush tip that can be used for a single patient and disposed of without the fear of sterilization issues.

Early detection of these enamel and dentinal cracks became possible with the operating microscope because of the incredible magnification and illumination possible, but the documentation of these fractures was still difficult. The ability to capture these early cracks digitally with photographic images was necessary for at least two reasons. Firstly, when dealing with cracks on asymptomatic teeth, patients need to be educated as to why extracoronary restorations may be required when the existing restoration seemed to be fairing well in their minds. The ability to demonstrate visually from a digital photograph that is magnified at 2-20X and displayed on a large monitor or TV helps incredibly in educating the patients to the need for cuspal coverage on these teeth. Secondly, insurance plans required proof that full coverage restorations on teeth which at times had minimally sized existing restorations, but had a devastating array of

severe fracture lines. Radiographically, the teeth in question seem to be restored often in a conservative fashion without evidence of decay or fractures. It is only at the end stage of development that these fracture lines become evident radiographically. It became obvious that a system on enhancing and documenting these “sleeping giant “ fractures was essential in both educating patients and insurance plans to the problems that are present in these teeth.

The author has developed a system of documenting these fracture lines that starts with photographs preoperatively prior to placing a rubber dam. Upon placement of the rubber dam, the tooth is pumiced with a slurry of prophylaxis paste and then evaluated both visually and photographically. It is then that the enamel cracks are dyed (prior to removing the restoration). The placement of the MBD is left to sit for 10-15 seconds and then rinsed off. The cracks in the enamel are very evident after MBD placement and give the clinician an idea of the underlying pathological cracks. Often the actual extent and final direction of the cracks is not conclusive until the restoration has been removed and the floor of the preparation has been evaluated after MBD. Photographs at low and high power of cracked portions of tooth are taken. The existing restorations, if they are present (often these are amalgam) are now removed and the dentinal surface is now evaluated dry and moist to see the final extent and direction of the fractures is present. It is at times obvious from the initial MBD placement on the enamel cracks where the final fractures will exist but at times the direction and extent of the dentin cracks can be surprisingly different from what was postulated prior to the removal of the restorations.

Clark has mentioned in his article that dentin cracks fall into two basic categories. Oblique fracture lines run along the floor of the preparation, undermining cups of enamel and are often found on symptomatic teeth that are sensitive to chewing for short periods of time. Clinical experience has shown that these cracks are less likely to create pulpal problems than the precursor to vertical root fractures which are vertical cracks. Oblique fractures are often best treated with cuspal coverage restorations, and can be found often in asymptomatic teeth when the existing restorations are present. These fractures are precursors to cuspal fractures and the patient should be advised of their presence. The author will often suggest cuspal coverage in the form of extracoronal restorations as the preferred treatment, although some literature suggests that a bonded intracoronal restoration may provide a solution as well.⁴²

Clark mentioned that the more ominous type of fractures were described as vertical in direction. Vertical fractures run in a mesial to distal direction and are more commonly associated with thermal sensitivity in addition to chewing sensitivity. These fractures are more commonly associated with teeth that either have or will develop irreversible pulpitis and should be treated expeditiously with full coverage restorations. Often on these teeth, the author will provisionally cement the final restoration for a period of a 2-3 months to evaluate if the tooth requires endodontics when symptoms initially are not present or of a mild nature. These vertical fractures can be found in teeth which are not symptomatic and still vital. They are a precursor to a complete vertical fracture and

should be treated comprehensively and quickly to avoid devastating fractures resulting in the need for extraction.

Occasionally, these fractures are visible running mesially to distally through the floor of the pulp chamber during endodontic access and if this is the case then the prognosis for the tooth is severely jeopardized. Should interproximal probings be increased on either side of the tooth in conjunction with the discovery of a vertical fracture running along a pulpal floor then current thought is that an extraction of the tooth and replacement with an implant is the best alternative.

Protocol for the Evaluation and Documentation of Enamel and Dentin Fractures.

| Step # | Procedure | Magnification | Reason |
|--------|----------------------------|---------------|---|
| 1 | Preop photo low mag | 2-3X | Photograph posterior quadrant. |
| 2 | Preop photo med mag | 5-8X | Photograph individual tooth. |
| 3 | Preop photo high mag | 12-20X | Photograph cracks on enamel of tooth. |
| 4 | Place rubber dam | 2-3X | Isolate tooth. |
| 5 | Propy with pumice, dry. | 2-3X | Remove plaque (stains with MBD). |
| 6 | Evaluate and photograph | 2-20X | Evaluate enamel cracks dry/wet and photograph them prior to MBD. |
| 7 | Use Vista Blue (MBD) | 2-3X | Stains enamel cracks. |
| 8 | Evaluate and photograph | 2-20X | Photos of enamel cracks at low, medium and high power with MBD. |
| 9 | Remove restoration. | 2-8X | Gain access to dentin cracks |
| 10 | Evaluate and photograph | 2-20X | Evaluate dentin cracks dry/wet and photograph them prior to MBD. |
| 11 | Use Vista Blue (MBD) | 2-3X | Stains dentin cracks. |
| 12 | Evaluate and photograph | 2-20X | Photos of dentin cracks at low, medium and high power. |
| 13 | Restore (Buildup or resin) | 2-8X | Determine final treatment for tooth. |

Clinical Cases

Case 1:

In this case, an asymptomatic maxillary left first molar with a conservative existing OL amalgam restoration that radiographically showed no signs of recurrent decay, but clinically at high magnification demonstrated a gray shadow around the periphery of the amalgam which is a sign of marginal leakage and recurrent decay. Several fractures were seen as well at higher magnifications on the occlusal surface. The tooth was photographed at low, medium and high magnifications (Figs 8a-c) and then the rubber dam was placed.



Fig. 8a Preop 2.1X power. Fig. 8b Preop 8X power Fig. 8c Preop 19X power.

Initial application of methylene blue to the enamel cracks demonstrated substantial cracks on the occlusal surface and a pair of cracks on the mesial marginal ridge, one of which was large enough to house debris.(Fig. 9a-c) There was a substantial crack on the midbuccal of the tooth in an anatomic groove which according to Clark is a low risk area for large fractures. Additional fractures ran across the transverse ridge connecting the mesial and distal pits and in addition ran up the ML cusp from the mesial pit.



Fig. 9a MBD brushed on enamel cracks prior to removal of amalgams.

Fig. 9b Enamel cracks at 5x magnification.

Fig. 9c Enamel cracks at 12X magnification.

The amalgam restoration was removed and the tooth was again stained with MBD to show a dramatic and large vertical crack that runs from the Mesial interproximal area to the mid buccal groove.(See Fig 10a-10c) Given the location, type and the degree of fracture combined with dentinal fractures in the rest of the tooth, a resin core buildup was completed, and the occlusion adjusted. (Fig 11a-11c). The patient was shown the photos, which were sent away for insurance pre-authorization for a full coverage restoration, and the patient was advised of the definitive treatment plan for this tooth.



Fig. 10a MBD application to dentin after removing amalgam restoration at 5x mag.

Fig. 10b Enamel and dentin cracks at 8X mag.

Fig. 10c Note large fracture from Mesial to buccal in a vertical direction in dentin.



Fig. 11a low mag (2.1X) view of large fracture.

Fig. 11b 19X mag view of fracture nearing pulp.

Fig. 11c Core buildup provisional with articulation marks completed prior to definitive treatment.

Case 2:

In case 2, the asymptomatic upper right first molar had a conservative occlusal amalgam present in the tooth again with evidence of a shadow representing recurrent decay.(Figs. 12a-c) Higher magnifications on the microscope revealed fractures at the mesial marginal ridge (housing debris) and on the distal marginal ridge. Upon placing

MBD on the occlusal surface the fractures on the mesial and distal marginal ridges became much more obvious. (Figs. 13a-c)

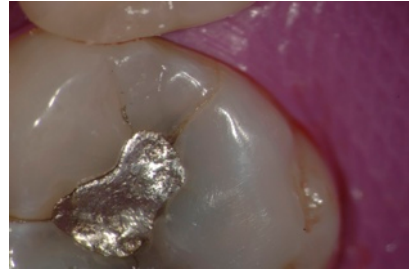
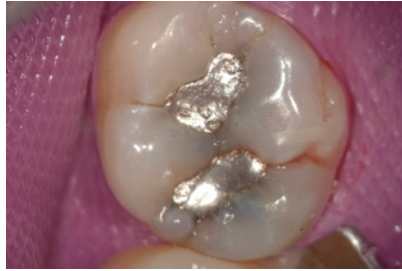


Fig.12a low mag preop.

Fig.12b 8X mag preop

Fig.12c 12x mag preop.

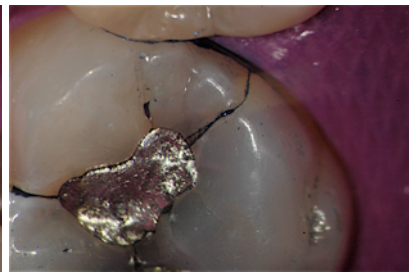


Fig.13a. MBD for enamel.

Fig.13b. Distal crack.

Fig.13c. Mesial, Facial cracks.

After removal of the amalgam in the first molar the tooth was again stained with Methylene Blue Dye and the fractures were found to be similar in the dentin to what was observed in the enamel. Patient decision was to restore the tooth with resin and wait and see on sensitivity. The final restoration chosen for this tooth was a conservative MOD resin restoration bonded into place. The patient had some reversible pulpitis with this tooth post-operatively, which quickly settled down after a week or so.

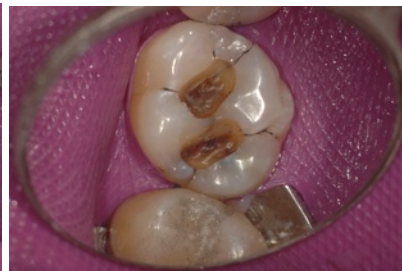


Fig.14a 2.1x mag after amalgams removed

Fig.14b. 5X mag of the amalgam removed.

Fig.14c MBD brushed onto dentin.



Fig.15a 12X mag of large Mesial Facial fracture.

Fig.15b 2.1X mag of cracks.

Fig.15c 12X mag of preparation nearing end.



Fig.16a 3X mag of restorations done on molars in composite resin.

Fig.16b 5X mag of resin completed on first molar.

Fig.16c 3 x mag of resins done without rubber dam in place.

Conclusion

As more clinicians recognize the value of high levels of magnification present with the operating microscope, they will encounter the propensity of enamel and dentin cracks that are present. Many of these fractures are asymptomatic harbingers of the future and if detected with MBD and documented with the microscope earlier, the opportunity to treat these “sleeping giants” earlier may become more prevalent. If this occurs then the treatment of fractures in our profession will change from a “symptoms based approach” to a “signs based approach” and perhaps the devastating effects of vertical and oblique fractures will become a thing of the past.

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