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The New Modalities For Detecting Deep Carious Lesions: A Review of Literature

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ABSTRACT

The modern concept of minimal invasive dentistry aims to preserve tooth structure through removal of highly infected, irreversibly demineralized, and denatured dentin only with preservation of affected dentin in order to allow effective restoration and to maintain tooth vitality. However, the boundary between the superficial zone of dentin which require excavation and the deeper affected one is not always feasible. The inherent subjectivity during the excavation of this boundary can lead to clinical significant differences in the quality and quantity of dentin being removed and can increase the risk of pulp exposure. Therefore, new methods have been developed to aid to identify the amount of dentin that should be removed during deep caries excavation.

Keywords: *Deep caries, minimal invasive dentistry, tooth vitality, affected dentin, infected dentin.*

Introduction

The carious lesion can be defined as a localized destruction of dental hard tissues caused bacterial acids which are formed as a result of carbohydrates fermentation. Since the origin of the dental profession, management of carious lesions has been the main part of the dental clinical practice. As before restoration placement, dentists should decide when, how and to what extent to remove carious lesion considering the tooth restorability, pulp vitality and preservation of tooth structure.[4]

Dental caries starts in the enamel as a white spot lesion. If it is not treated, cavitation will be developed and will progress into the dentin.[25] According to Bjorndal et al.[1] deep carious lesions can be defined as carious lesions which can be seen radiographically spreading more than 70% –75% into dentin adjacent to the pulp. Deep carious lesions cause pulpal inflammation and if they are not managed, they may lead to pulp necrosis, involvement of the periradicular tissues and eventually tooth loss.[2]

Deep carious dentinal lesion consists of two layers that have different ultramicroscopic and chemical structures. The outer layer of caries infected dentin that is contaminated with bacteria and its organic matrix is degraded, as the degenerated collagen fibrils lose their cross linking. Therefore, this layer can not be remineralized. On the other hand, the inner layer of caries affected dentin can be remineralized because of limited collagen degradation and this layer is free of bacteria. Therefore, this layer should be preserved during operative procedure.[21]

It is not easy to clinically differentiate between caries affected and infected dentin. There are different methods to identify caries affected dentin from infected dentin aiming to avoid its removal during clinical procedure.[8]

Visual inspection and tactile sensation method

In this method dental explorers are used to detect infected carious dentin which is usually soft and wet and contain more bacteria than hard or dry affected dentin lesions. That's why clinicians are commonly advised to end caries excavation up to the level where dentin is firm and no longer leathery.[19] The tactile method, has an advantage of not requiring sophisticated equipment or use of any other products along with low cost and easy application.[18] However, this method is subjective and may lead to over excavation.[13]

Caries detector dyes

Another method to differentiate between caries affected and caries infected dentin is by using caries detector dyes. The first caries detector dye was developed in 1970, based on a solution of 0.5% basic fuchsin in propylene glycol. Due to its potential carcinogenicity, the basic fuchsin stain was subsequently replaced by another 1% acid red dye. Since then, various dyes have been released in dental market intended to improve complete removal of caries infected dentin without over reduction of sound dentin. The dyes were supposed to stain only infected dentinal tissue. Unfortunately, the caries disclosing dyes don't stain bacteria but instead they stain the organic matrix of less mineralized dentinal tissue.[15] The dye staining and bacterial penetration are independent phenomena, therefore it is not considered as reliable method to discriminate between affected and infected dentin.[16] Ganter et al.[9] revealed that the floor of the cavity of excavated dentin after dye staining was always deeper than the bacterial invasion.

A study conducted by Pugach et al.[22] assessed the efficiency of caries disclosing dyes in differentiation between different zones of dentin caries. The results of the study revealed that caries detector stains gave false positives results in sound dentin near the pulp chamber, as well as false negatives results in slightly demineralized dentin. The authors concluded that caries detector dyes may not be efficient to discriminate remineralizable demineralized dentin from that which should be removed. The results of this study agreed with a previous report performed by McComb et al.[15] who criticized the lack of specificity of caries disclosing dyes and recommended the use of other clinical evaluation methods instead.

A clinical trial conducted by Ntovas et al.[20] compared the effectiveness of caries detector dyes in selective caries removal to other excavation methods (diagnodent, visual inspection, and tactile method). It was reported that detector dyes showed 40% correct diagnosis, with 60% sensitivity and 80% specificity. As using caries detector dyes led to a high degree of overtreatment.

Polymer burs

Polymer burs were first introduced by Boston in 2003.[3] They are made of a special polymeric material and have slightly lower mechanical properties than sound dentin. Their blade was designed to remove dentin by locally depressing the carious tissue and pushing it forward along the surface until it ruptures and carried out of the cavity. According to the manufacturer, self-limiting polymer burs are made of material which is harder than infected dentin (15-20 KHN) but softer than affected and sound dentin (68 KHN), thus allowing a very selective caries removal.[7] As when burs touch sound or caries affected dentin, they become dull and produce vibrations, rendering further cutting impossible. Unlike conventional burs, polymer burs have straight cutting edges not spiraled.[6] Moreover, the excavation using polymer burs is not carried out from the periphery to the center of the lesion, instead, it is performed from the center to the periphery to avoid contact with the harder enamel.[5]

- **The first generation**

The first generation of polymer burs was launched under the brand name SmartPrep (SSWhite, Lakewood, NJ, USA). These burs have a unique flute design and they are made from a medical-grade polyether-ketone-ketone (PEKK). According to manufacturer, these polymer burs has a hardness of 50 KHN while conventional carbide burs have hardness of 1,600 KHN.[14] Polymer burs are used in a slow running hand-piece at a speed of 500 to 800 rpm.[5]

- **The second generation**

Later, a new and improved polymer burs with reinforced blades were launched on the market (SmartBur; SSWhite, Lakewood, NJ, USA). The hardness of these burs was only 26.6 (± 1.2) KHN.[14]

- **The third generation**

During the last decade, the third generation of polymeric burs was released in 2010 (SmartBur II; SSWhiteBurs, Lakewood, NJ, USA) and in 2011 (PolyBur P1; Komet, Gebr. Brasseler, Lemgo, Germany). The SmartBur II polymer instrument has a cutting edge similar to its predecessor, but with a higher hardness. According to the manufacturer's information, PolyBur P1 has cutting edge similar to that of a conventional bur. In addition, the shank is more delicate, therefore, it is suitable for small cavities. Over excavation should be avoided while using the PolyBur P1 due to the material hardness. During caries excavation, the contact pressure must be observed where the elasticity of the shaft is a control function. If the contact pressure is too high, it will bend. The application range of this bur is from 2,000-8,000 rpm.[14]

A clinical trial was conducted by Prabhakar et al.[21] who compared carious dentin removal efficacy of polymer burs to conventional burs in 40 patients. The study results showed that polymer burs appeared to offer a straightforward and efficient mean for removing caries-infected dentin and conserving healthy tooth structure. Also conventional carbon steel burs led to cavity over preparation.

Meller et al.[17] assessed the effectiveness of polymer burs in removing dentin caries of thirty extracted permanent molars. The study result showed that in the group treated by carbide burs, 84.5% of samples were caries free while for polymer burs group, 93.0% of samples were caries-free. However, the study outcomes revealed that there were no statistical significant differences between the two groups. Regarding the mean working time, the two groups showed similar results with no statistical significant differences. The study concluded that polymer burs were as effective as tungsten carbide burs in caries excavation.

A laboratory study performed by Somani et al.[23] evaluated the effectiveness of polymer burs in removing infected carious dentin in terms of bacteriology. The study results revealed that there was no statistical significant difference in terms of presence or absence of microorganisms after caries removal by either polymer or conventional burs. The authors stated that caries removal by polymer burs in cavitated teeth was comparable to that of the conventional burs regarding microbial count in remaining dentin after caries excavation.

Toledano et al.[24] performed a laboratory study to assess the performance of carbide and polymer burs regarding the effectiveness of caries excavation and minimal invasiveness potential by using digital image analysis. The study outcomes revealed that polymer burs showed higher preservation of affected dentin after caries excavation than carbide burs. In addition, regarding minimal invasiveness potential, the carbide burs had the worst results. The authors concluded that polymer burs achieved the concept of minimal invasive dentistry, showing their self-limiting ability.

Recent methods

The conventional methods of caries excavation, such as manual and mechanical rotating instruments (dentin spoon, turbine, or drill), are often painful for patients. In spite of pain elimination by local anesthesia, discomfort can be related to noise, vibration, or fear of the needle. Also, there is a risk of removing healthy tissue. Mechanical techniques may also damage the pulp by increasing the temperature due to thermal stimulation. Different alternative treatment modalities have been introduced, such as chemomechanical methods, ozone therapy, and laser technology, aiming to preserve the tooth structure by removing only the softened carious tissue and being as conservative as possible.[26]

- **Chemomechanical caries removal**

Chemomechanical caries removal principle rely on using a solution to chemically change carious lesion and to further soften it, thus facilitating its easy removal. The softened dentin is then mechanically removed using a hand instrument. Early attempts were introduced in the 1970s using various agents such as ethylene diamine tetra-acetic acid (EDTA), collagenase and sodium dodecyl sulfate. Most of these systems were time consuming to be used clinically. Therefore, recently, other agents have been developed such as Carisolv (Mediteam, Göteborg, Sweden).[11]

- **Er:YAG Laser**

Lasers have a double effect (mechanical and thermal) and potentially able to disorganize the microbial biofilm. This is important, because carious lesion can increase and evolve, attacking the pulp, if pathogenic microorganisms are not well eliminated from the cavity. The residual microorganisms can also represent a possible cause of recurrent caries in conservative dental treatments.

The introduction of laser therapy not only has an effect on the microbial load reduction, but also on bacterial adhesion to dental surface. Er:YAG laser therapy is a the commonly used system for hard dental tissue ablation, as its wavelength coincides with the absorption peak of water and hydroxyapatite, causing the removal of mineralized dental substance through micro-explosions. In addition, carious tissue contains more water than healthy one, so the Er:YAG laser has higher chromophores absorption on infected tissues, and it well represents a selective and conservative device for caries removal, allowing for the creation of a therapeutic cavity preparation without excessive extension to healthy dental tissues below the lesion. Er:YAG laser combines photoablation and decontamination properties with minimal invasive characteristics.

The advantages of treating a carious lesion with Er:YAG laser, compared to conventional treatment is not only include less vibrations and noises for the patient, but also the bactericidal and bacteriostatic properties. The photothermal effect developed during the ablation can be responsible for the disinfection of residual bacteria in the cavities, without causing thermal damage to the dental pulp. In addition, laser irradiation melts inorganic components of dentin and can cause remineralization. In this way, the Er:YAG laser allows a seal of treated dentinal surfaces and increases the resistance to recurrent caries.[26]

- **Laser fluorescence device (LF)**

This method is recently introduced as an option for caries detection. DIAGNOdent is a LF-based device, capable of discriminating caries lesions from sound tissues depending on the difference of fluorescence displayed by the two different structures when subjected to a red and infrared spectrum. The fluorescence is transformed into a numerical scale. This system has a range of 0 to 99 where value 0 indicates a sound tooth structure and the number increases with the increase of degree of destruction.

Gurbuz et al.[10] compared the performance of a visual-tactile examination and a laser fluorescence device for detecting residual dentinal caries after removal of carious dentin with bur excavation, hand excavation and chemomechanical excavation (Carisolv™].The study concluded that laser fluorescence system could be an effective method for checking dentin removal and to avoid excessive removal of the sound dentin.

- **Air abrasion**

Air abrasion has been evolved over a period of time as an alternative concept of caries excavation, providing a conservative preparation for preservation of a maximal sound tooth structure. It can be described as a pseudo-mechanical, non-rotary method of cutting and removing dental hard tissue. It has the advantage of decreased noise and vibration when compared to conventional rotary instruments.

Air abrasion removes tooth structure using a stream of aluminium oxide particles generated from compressed air or bottled carbon dioxide or nitrogen gas. The abrasive particles strike the tooth with high velocity and remove small amounts of tooth structure. The efficacy of tooth removal depends on the hardness of the tissue or material being removed and the operating parameters of the air abrasion device.

A number of parameters such as the amount of air pressure, particle size, quantity of particles passing through the nozzle, nozzle diameter of the hand-piece, angulation of nozzle of the hand-piece, distance from object, and time of exposure to the object vary the quantity of tooth removal and depth of penetration. Generally, air pressures range from 40 to 160 psi. The recommended levels are at 100 psi for cutting and 80 psi for surface etching.

Care must be taken when working near soft tissues due to risk of laceration, air dissection, and emboli. Air abrasive systems also cannot be used with magnification devices such as loupes and dental operating microscopes. Moreover, air abrasion produces a rounded cavosurface margin and thus it is not suitable for restorative preparations requiring definitive walls and sharp, well-defined cavosurface margins.[12]

Conclusion

The carious dentin excavation rationale and the criteria used by dentists for tissue removal are not clear cut. Determining amount of caries removal from tooth structure is essential for preservation of tooth vitality. The recent diagnostic modalities used in case of deep caries excavation, has given a new dimension to "minimally invasive dentistry." Further clinical investigations are required to confirm the reliability of these methods and to provide a consensus of best suitable approach for deep carious lesion excavation.

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Not Applicable

Disclosure

The author reports no conflicts of interest in this work.

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