Review Article

Management of Deep Carious Lesions-a Review

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ABSTRACT

Caries prevalence is still high over the world, with the disease affecting more elderly and socially disadvantaged people. Caries will progress through dentine stimulating pulpitis, pulp infection, and necrosis if left untreated; nevertheless, pulpal healing can occur even in deep carious lesions if conservatively managed. Deep caries therapy has traditionally consisted of nonselective removal of all carious dentine; however, the promotion of minimally invasive biologically based treatment techniques for selective caries removal, and a lower risk of pulp exposure has been promoted. One-visit indirect pulp treatment or a two-visit stepwise technique is both options for selective caries removal. With the avoidance of pulpectomy and the re-emergence of essential pulp treatment techniques such as partial and complete pulpotomy, management tactics for the treatment of cariously exposed pulp are also evolving. Notably, the discovery of new pulp capping materials such as mineral trioxide aggregate which, while not ideal, has resulted in more predictable histology and clinical therapies. In operative dentistry and endodontology, there is a compelling need to promote minimally invasive treatment options; nonetheless, the development of reliable diagnostic tools, evidence-based management strategies, and education in exposed pulp management will be crucial in the future.

Keywords: Deep caries, Indirect pulp capping, Direct pulp capping, Pulpotomy.

Introduction

Caries is the most prevalent noncommunicable disease, and it affects individuals from underserved social groups more frequently.[1] Caries is a microbial biofilm-induced disease that is caused by fermentable carbohydrates in the diet.[2] With acidogenic by-products of bacterial metabolism starting enamel demineralization and encouraging defensive responses in the dentine and pulp, such as increased intratubular dentine and early inflammation, the carious potential of the biofilm increases in stagnant regions. Dentine will be exposed to bacterial invasion if enamel demineralization persists, which will result in additional demineralization and eventual cavitation.[3] Deep caries was recently described as radiographic evidence of caries reaching the inner third or inner quarter of dentine with a danger of pulp exposure, according to a consensus statement.[4] Deep caries has typically been treated with full (or nonselective) caries excision and root canal therapy if pulp exposure occurs.[5] Recent research on deep carious tissue management supports less invasive strategies, highlighting that complete removal of soft dentine to leave a thin barrier of residual dentine may not be necessary or desirable. The preservation of pulp vitality is at the crux of operative dentistry, which employs a biologically based approach that minimizes intervention while preserving the pulp's developmental, defensive, and proprioceptive capabilities.[6]

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Aetiology of Caries

As dental biofilm consists of commensal and noninvading microorganisms, the contemporary understanding, known as the "ecological plaque hypothesis," suggests caries is a result of an ecologic imbalance within the dental biofilm with acidogenic and aciduric species dominating within the biofilm under frequent intake of carbohydrates.[7] Numerous studies have shown a strong positive correlation between mutans streptococci, lactobacilli and bifidobacteria and the initiation of demineralization of the tooth surface. More advanced lesions tend to have a more diverse microflora with high levels of *Streptococcus mutans* and *Lactobacilli* spp.; however, other taxa such as a novel *Prevotella* spp.,

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Selenomonas spp., *Dialister* spp., *Eubacterium* spp. and *Fusobacterium* spp. have found to be abundant in such lesions. For bacteria to play a role in the carious process, they must possess certain characteristics that promote the disease. The ability to process sugars efficiently, to maintain sugar metabolism in an extreme environment (low pH) and produce intra/extracellular polysaccharides is important characteristics for cariogenic bacteria.

Diagnosis of dental caries

Diagnosis is an art and science, which results from the synthesis of scientific knowledge and clinical experiences in identifying the signs and symptoms of a disease process. Diagnosis is an art and science, which results from the synthesis of scientific knowledge and clinical experiences in identifying the signs and symptoms of a disease process. Radiography has been primarily used for the detection of lesions on the proximal surfaces of teeth, which are not clinically visible for inspection. Radiographs are also recommended as a supplement to the clinical examination of occlusal surfaces for the detection of pit and fissure caries. Over the years, it has been well established that more dental caries is detected by radiography than by clinical examination alone. The possibility of caries detector dyes was originally developed in the 1970s when basic fuchsin staining was used as a guide to the removal of the outer layer of infected unremineralizable dentine in carious lesions. There has always been concern about the safety of disclosing agents in terms of carcinogenicity. 1% acid red in propylene glycol was introduced as a safe and effective alternative.

Optical Caries Detection

Optical caries detection methods are based on observation of the interaction of energy which is applied to the tooth, or the observation of energy which is emitted from the tooth. Such energy is in the form of a wave in the electromagnetic spectrum. The resultant area of demineralised tooth substance is filled mainly by bacteria and water. The porosity of this area is greater than that of the surrounding structure. Increased scattering of incident light due to this structural change appears to the human eye as a so-called white spot. Hence, the caries process leads to distinct optical changes that can be measured and quantified with advanced detection methods based on light that shines on and interacts with the tooth.

Fiber-Optic Transillumination (FOTI)

FOTI has been used for detection of a proximal caries. The basis for FOTI as a technique for the detection of caries is that decayed tooth material has a lower index of light transmission than sound tooth structure, and the area of decay is seen as a dark spot in the surrounding sound structure. The FOTI examination is performed with a fiber optic illuminator.

Posterior proximal caries can be diagnosed with the light probe positioned on the gingiva below the cervical margin of the tooth, whereby the light passes through the tooth structures and proximal decay produces a dark shadow on the occlusal surface.[8] Enamel lesions appear as gray shadows, and dentinal lesions appear as orange-brown or bluish shadows.

Laser-induced Fluorescence

The DIAGNOdent (KaVo, Biberach, Germany) is a portable commercially available device for detection and quantification of caries. The method generates a simple numerical index of de- and remineralisation in enamel and dentin that can be recorded in the patient's file and monitored over time. Red laser light ($\lambda = 655$ nm) is emitted by the device via an optical fibre and a probe to the caries lesion. When the light interacts with certain organic molecules that have been absorbed into the porous structure, the light is reemitted as invisible fluorescence in the NIR region. The NIR fluorescence is believed to originate from protoporphyrin IX and related metabolic products of oral bacteria: These products are chiefly responsible for the absorption of red light. The emitted light is channelled through the hand piece to the detector and digitally displayed on a screen (0–99). A higher number indicates greater fluorescence and by inference a more extensive subsurface lesion.

Terahertz Imaging

This method of imaging uses waves with terahertz frequency (=1012 Hz or a wavelength of approximately 30 μm). This wave-form is short enough to provide reasonable resolution but long enough to prevent serious loss of signal due to scattering.[9] To detect terahertz irradiation photoconductive detectors can be used in addition to a technique called "free-space electro-optical sampling." The advantages of terahertz imaging include: The relative transparency of human tissue to terahertz rays, low powers used for imaging (~1_W), the use of non-ionizing radiation and no alteration of electrical charge of the tissues examined.

Treatment to Avoid Pulp Exposure

Both complete caries removal and the classic indirect pulp capping concept, advocated in the 1960s, were invasive strategies, leaving either no or only residual carious dentine behind, resulting in a higher risk of pulpal exposure. Indeed, recent consensus reports have stated that the complete or nonselective carious removal is now overtreatment.[4] Based on a 5-year follow-up of a randomized clinical trial, a stepwise excavation approach for the management of deep carious lesions was superior to a complete carious removal procedure carried out in one visit, with less pulpal exposure, less pain and more teeth with vital pulps in the stepwise group.[1] Studies in the primary dentition have also shown that a one-stage selective carious removal procedure performs successfully. Including the concept of sealing the entire carious lesion with a stainless-steel crown in the Hall Technique.[10]

Notably from an endodontic viewpoint, a clear definition of lesion depth is lacking in many studies and the available evidence on well-defined deep carious lesions in adult teeth

remains limited. The treatment of permanently leaving carious dentine in a one-stage selective approach for caries in the pulpal third has shown comparable results with stepwise excavation. It is accepted that an inadequate temporary restoration and lack of a permanent coronal seal during the less invasive carious removal strategies will lead to failure including pulpal and apical pathosis. Although a one-stage selective caries removal technique saves on both clinical and patient time, another potential limitation is that if the patient moves to a new dentist it may appear that caries remains and further intervention may be suggested.

Stepwise Excavation in Detail

This is a selective caries removal technique carried out in two visits. The aim of the first stage is to change the cariogenic environment. Selective carious dentine removal to soft dentine is performed to the extent that a temporary restoration can be properly placed. The clinical result of leaving behind carious dentine is that over time the appearance changes to that of arrested carious dentine. The initial active carious environment can be identified clinically as soft discolored and wet tissue, which turns into a darker, harder and drier appearance after the first stage. The second-stage excavation several months later is carried out to firm dentine following the recommendation of carious tissue removal.[11] It is easier to perform, as the consistency of the retained dentine has changed. A calcium hydroxide $Ca(OH)_2$ base material is used between visits, or a hydraulic calcium silicate cement and the tooth are restored with a glass-ionomer restorative material.

Indirect Pulp Capping

Indirect pulp capping is a procedure in which carious dentin closest to the pulp is preserved to avoid pulp exposure and is covered with a biocompatible material. This technique is used when most of the decay has been removed from a deep cavity, but some softened dentin and decay remains over the pulp chamber that if removed would expose the pulp and trigger irreversible pulpitis. Instead, the dentist intentionally leaves the softened dentin/decay in place, and uses a layer of protective temporary material which promotes remineralization of the softened dentin over the pulp and the laying down of new layers of tertiary dentin in the pulp chamber. The color of the carious lesion changes from light brown to dark brown, the consistency goes from soft and wet to hard and dry.

Direct Pulp Treatment

Direct pulp treatment is defined as the treatment of a mechanical or traumatic vital pulp exposure by sealing the pulpal wound with a biomaterial placed directly on exposed pulp to facilitate formation of reparative dentin and maintenance of the vital pulp. A prerequisite for a successful outcome following pulp capping is control of bleeding and the avoidance of blood clot formation between the capping material and the pulp tissue. Practically, it is challenging to place a capping material on a wet surface such as a blood clot, whilst the presence of a blood clot has been linked to higher risk of post-operative infection. A clinical trial investigated different methods of attaining haemostasis using either saline, NaOCl or chlorhexidine digluconate, before pulp capping. Furthermore improved outcomes can be seen, if a disinfection agent such as NaOCl is applied the haemostatic protocol prior the application of a capping material. The two key points to the success of $Ca(OH)_2$ DPC have been emphasized; pulp-capping should only be performed in asymptomatic teeth and a well-sealed restoration should be placed immediately after DPT. A variety of materials have been recommended for use in DPT: Antibiotics, calcitonin, collagen, corticosteroids, cyanoacrylate, resorbable tricalcium phosphate ceramic, resin-based adhesive composite systems, bioceramic, biodentine, CEM cement, tricalcium phosphate cement, ZOE, $Ca(OH)_2$ and MTA. The three last ones have been used more frequently.

The Physiological Response of the Pulp to Capping

Formation of reparative dentine by odontoblast-like cells is possible after pulp exposure, where hard tissue (mineralized bridge) formation should replace the lost dentine if successful. The quality of the mineralized bridge formation after pulp capping procedure has been evaluated histologically and reveals many nonmineralized defects, so-called 'tunnel defects', that can easily be invaded by microorganisms.[12]

Pulpotomy

The American Academy of Pediatric Dentistry (1998) defined pulpotomy as the amputation of affected, infected coronal portion of the dental pulp preserving the vitality and function of the remaining part of radicular pulp. Objectives of pulpotomy are to removal of inflamed and infected coronal pulp from the site of exposure thus preserving the vitality of the radicular pulp and allowing it to heal. The next main objective is to maintain the tooth in the dental arch.

Partial or Cvek Pulpotomy

It is defined as "the surgical removal of a small portion of the coronal pulp tissue to preserve the remaining coronal and radicular pulp." (American Association of Endodontists Guideline, 2003). The inflamed tissue is removed to the level of healthy coronal pulp tissue. There are several different treatment options for vital pulp therapy in extensively decayed or traumatized teeth. Pulpotomy procedures rely upon an accurate assessment of the pulp status, and careful management of the remaining pulp tissue.

Full Pulpotomy

Full pulpotomy is defined as "the removal of the entire coronal pulp to the level of the root canal orifice or as much as 2–3 mm apical to the orifice. Tooth is anaesthetized and isolated with

rubber dam. The coronal pulp is removed to the level of root canal orifices. If there is bleeding, homeostasis is done by placing cotton pellet moisture with 3-6% sodium hypochlorite for 10–20 s. If bleeding cannot be controlled, then decision for pulpectomy should be taken. Any blood clot should be removed. If homeostasis is achieved, hard setting calcium hydroxide or MTA and coronal restoration are carried out as with partial pulpotomy.

Conclusion

The maintenance of pulp vitality and the promotion of biologically based management strategies are at the core of deep caries management. Pulp exposure can be avoided in radiographically deep caries and asymptomatic or mildly symptomatic teeth by selective removal of caries and restoration in one or two visits. Alternatively, strategies to nonselectively remove the caries will result in more frequent pulp exposure; however, it seems from the limited evidence available that careful management of the damaged pulp and VPT may also have favorable success rates. Decision-making in this area is currently hampered by the crude diagnostic techniques available to assess accurately the state of the pulp as well as a paucity of adequately powered, well-controlled randomized studies addressing key questions. From a scientific perspective, further understanding of the processes of inflammation, repair and material interaction is important to deepen understanding and develop novel diagnostic and therapeutic solutions. Clinically, a focus on high-quality primary research investigating the efficacy of management strategies for the treatment of deep caries is a priority.

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