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Restorative Concepts in Pulp Protection

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Abstract

Introduction: The primary objective of any restorative procedure is the protection of pulp by maintaining its vitality. When the tooth structure is very compromised, the restoration that is placed should take into consideration the functioning, esthetics, and biological properties of the tooth. Failure of restorative materials in a deep cavity is not attributed to the acidic pH of the material but rather the poor sealing ability of the restorative material near the tooth restoration junction, which causes microleakage of the dental fluid present, which contains bacteria and toxins leading to failure of the restoration. More emphasis is being given to the kind of restorative material used and the restoration technique. The main aim of the newer techniques is to decrease the chances of bacterial penetration by providing a good marginal seal.

Aim of the Study: This review explains the various restorative concepts that have to be taken into consideration after pulp protection.

Methodology: The review is a comprehensive research of PUBMED and google scholar from the year 1970 to 2019.

Conclusion: Management of deep dental caries conservatively involves the complete excavation of caries while attempting to not expose the pulp during excavation. To remove caries completely or not has always been a controversial topic, and many researchers have varying schools of thought about it. Stepwise excavation has been accepted by many clinicians as the ideal treatment for deep caries management. Following the pulp protection, the permanent restoration that is placed determines the overall longevity of the procedure. The failure of deep caries management can also be attributed to microleakage, and hence a good adhesive restoration with high bond strength is important to increase the durability of pulp protection.

Keywords: *Deep Caries Management; Peripheral Seal Zone; Remaining Dentin Thickness; Stepwise Excavation; Caries Sealing Concept*

Introduction

The primary objective of any restorative procedure is the protection of pulp by maintaining its vitality. When the tooth structure is very compromised, the restoration that is placed should take into consideration the functioning, esthetics, and biological properties of the tooth. The available restorative options help us satisfy the functionality and esthetics of the patient, but the biological need of the tooth is not fulfilled by them. Regeneration of fractured teeth has still not been achieved, and restoring the fractured portion with a restorative material is the only feasible option. The restorative materials do not completely mimic the biological properties of the tooth but are expected to maintain the vitality of the pulp and the dentin pulp complex. Restorative materials, when placed directly on a cavitated tooth, produces severe pain because of the acidic pH that they inherently have, and hence whenever a deep cavity restoration has to be done, it is advised that a layer of cavity liner or base material should be applied followed by the restorative material [1].

The latest concept of pulpal protection is protecting the remaining dentin thickness (RDT) of the tooth. RDT is defined as the total thickness of the dentin, which is remaining after the carious dentin is removed between the pulp and the axial/pulpal wall of the cavity. RDT is proportional to the viable odontoblasts present; the thicker the RDT, the higher number of viable odontoblasts remaining, which ensures the vitality of the tooth. The protocol to be followed for pulp protection depends on the thickness of the dentin remaining. There are various materials present in the market for pulp protection [2].

The recent literature shows varying results stating that the failure of restorative materials in a deep cavity is not attributed to the acidic pH of the material but rather the poor sealing ability of the restorative material near the tooth restoration junction, which causes microleakage of the dental fluid present which contains bacteria and toxins leading to failure of the restoration [3]. Bacterial load in the patient's mouth has a huge role to play in pulpal pathologies as it has been established in recent literature [4]. In recent years it has been established that the role of restorative material placed is highly crucial in preventing any pulpal pathology, and hence more emphasis is being given to the kind of restorative material used and the restoration technique. The main aim of the newer techniques is to decrease the chances of bacterial penetration by providing a good marginal seal [5]. This review aims to focus on the various restorative techniques that can be used after pulp protection.

Concepts of caries excavation

Carious tooth consist of soft dentin and firm dentin, the soft leathery portion of dentin is completely demineralized and ought to be removed completely; the firm dentin can be remineralized. (Figure 1) The main aim of caries excavation is to stop the progression of caries and maintain the vitality of the pulp by preserving the remineralisable dentin. There are three main concepts for excavation that are being used in recent times.

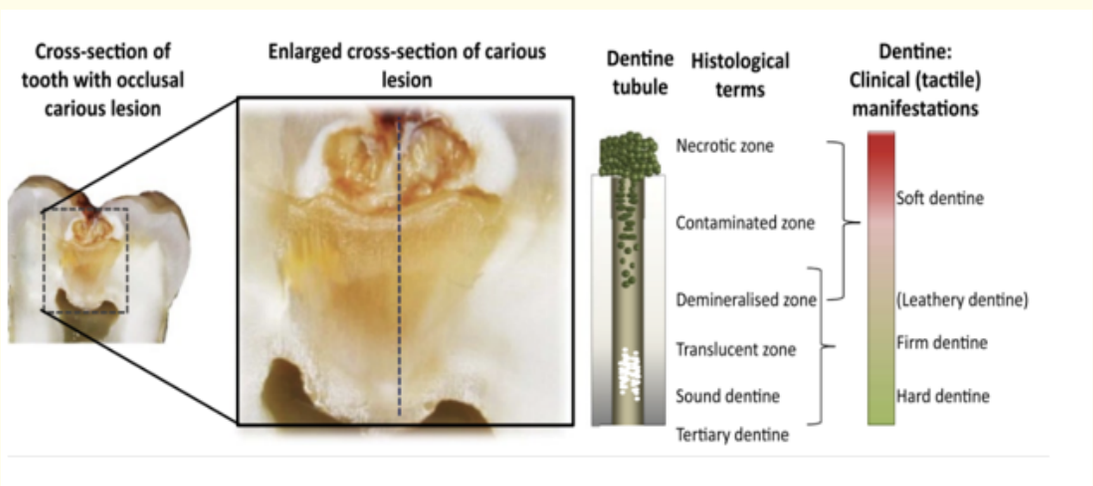

Figure 1: *Histological representation of carious dentin and extent of excavation [12].*

Caries sealing concept

In this method, the main concept is to seal caries where it is so that the microorganisms don't get enough nutrients, and eventually, all activity is seized, stopping the caries progression. In a study conducted by Handelman., *et al.* [6] in 1976, they studied that after the caries sealing was done, they could see the following changes, 1- the clinical and radiographical depth of caries became less; 2- the microorganism load decreased in a period of 2 - 5 weeks. In another study conducted by Mertz., *et al.* [7] in 1998, where they removed only enamel caries leaving dentinal caries intact, revealed that composite restored caries sealing gave better results than amalgam restoration. In the long turn, when all the caries were completely excavated, the amalgam group showed better results. One of the main problems with this technique is that when the clinician is changed, a restoration done by the previous dentist may be felt as insufficient by the new dentist, and the new clinician may remove the remaining active caries [8].

Partial caries removal

John Tomes stated that leaving a layer of carious dentin very close to the pulp was better than exposing the pulp while attempting to remove caries completely, which would then lead to a root canal procedure. Peripheral caries on the walls of the cavity was to be completely removed, thereby ensuring a tight marginal seal. This technique was thought to stop the progression of caries without actually removing all the bacteria from the carious tooth. In 1956 Swoden described Step Wise excavation for permanent teeth, where he treated four thousand teeth which had no symptoms for a period of seven years and excavated the lesions, partially covering it with a 1 mm layer thick calcium hydroxide layer and restoring it with amalgam. After a span of 2-3 weeks, the remaining caries were excavated, and remineralization was seen in a few cases [9]. Leaving behind a layer of carious dentin has not been accepted completely, and a lot of researchers are against it, claiming that the radiological and clinical extent of the carious dentin is not visible, thereby making the excavation extent not reliable [10].

Now the question that arises in stepwise excavation is whether a two-step process is required or not that is opening the cavity again after 2 - 3 weeks is a must or if caries progression can be arrested at the first step only. Because of the lack of studies answering this particular question, there is a lack of agreement between researchers. Advantages of stepwise excavation include the opportunity to evaluate the carious lesion again on reopening and excavating it completely as dry dentin would be easier to remove as the thickness of dentin also increases due to deposition of tertiary dentin. Pulpal stimulus can also be assessed better during the reopening of the cavity as the pulp is out of the state of shock and responds better. The main disadvantage of stepwise excavation as stated by the supporters of the immediate final restoration is that a lot of patients tend to miss the second appointment because of cessation of pain and presence of temporary restoration; this causes the failure of restoration because of a dislodged temporary of marginal leakage present in temporary restoration [11].

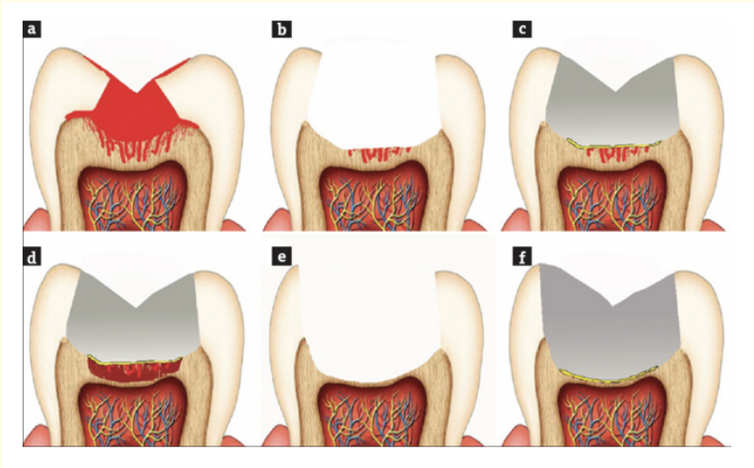

Figure 2: *Stepwise excavation procedure. A: Carious lesion; B, C: Excavation followed by placement of calcium hydroxide; D, E: During the interval between two appointments, the thickness of remaining dentin increases; F: Placement of final restoration [13].*

Complete caries removal

This concept ensures complete removal of the soft and demineralized dentin, which may or may not cause pulp exposure, and if the pulp is exposed, the vitality of the pulp is maintained either fully or partially. The methods used are Direct pulp capping, partial pulpotomy, or complete pulpotomy (advised in primary dentition)-the chances of pulpal exposure increase in cases of complete caries removal. In a study done by Bjorndal et al. in 2010, he discovered that 28.9% of cases resulted in pulpal exposure while removing caries in one sitting compared to only 17% in the case of stepwise excavation [14].

Peripheral seal zone concept

Dental caries has become the most common pathology that is treated by clinicians; this treatment involves a good diagnosis which is followed by management of the existing lesion by removing the biofilm and remineralization of the decayed portion. The amount of caries that has to be removed is a dilemma for many clinicians; for shallow cavities with small carious lesions, complete removal of caries through tactile and visual sense is enough. Minimally invasive techniques like air abrasion, Glass ionomer restoration, ART are sufficient for such caries. When the lesion size of caries increases, going through the visual and tactile sense is not possible as it may cause pulpal exposure while removing caries completely. The ideal depth of caries removal has to be stopped at the point where the vitality of the pulp can be maintained, and enough strength and durability is provided to the overlying restoration. The general objectives for caries removal criteria as described in a study by Alleman et al. are described in table 1. Apart from the general objectives, the main specific objective of caries removal, according to Alleman., *et al.* is creating a Peripheral seal zone and avoidance of pulpal exposure at any cost while maintaining the longevity of the restoration provided [15].

General Objectives of caries removal:	
1.	The vitality of the pulp should be maintained.
2.	Dentinal infections that are present should be eliminated
3.	The bacterial activity should be deactivated or sealed
4.	The maximum amount of intact tooth structure should be maintained with good durability.

Table 1: *Objectives of caries removal in deep caries management [15].*

Peripheral seal zone is an area which is 1-3mm wide and consists of normal superficial dentin, enamel, and dentin enamel junction; this seal zone helps to increase the bond strength of the restoration to 45-55 MPa. (Figure 3) [15] The peripheral seal zone must be free of any caries activity and should be confirmed with caries detecting agents like dyes or Diagnodent. In the insides of the peripheral seal zone, infected demineralized dentin is present, which although demineralized, has a good bondability and increases the bond strength to 30MPa. This zone is confirmed by light pink staining and a reading of 20 - 24 in the Diagnodent for intermediate and 36 for deep dentin. For better understanding, the intermediate dentin is 4mm from the occlusal surface of the tooth, and deep is 4 - 5 mm. When the risk of pulpal exposure is present, the outer infected area of the dentin should be left behind, this area will be identified by an increased reading of Diagnodent and a depth of 5mm from the occlusal surface. (Figure 4) This concept increases the bonding ability of the restoration, thereby increasing the longevity of the restoration, especially in cases of deep and wide cavities [16].

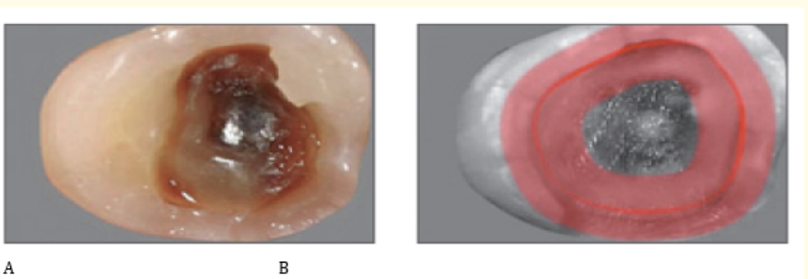

Figure 3: *Peripheral Seal zone Concept. A: Deep carious lesion which cannot be excavated completely without pulpal exposure by only visual and tactile sense. B: Peripheral seal zone consists of caries-free enamel, DEJ, and dentin. C: [15].*

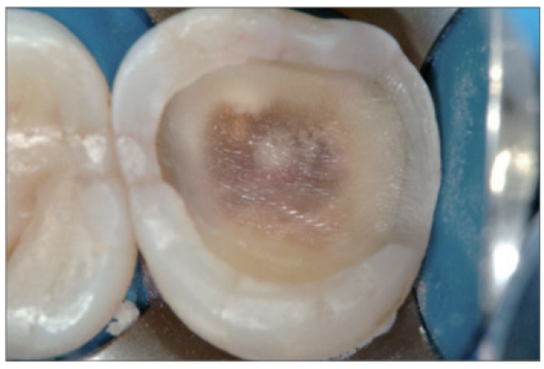

Figure 4: *Peripheral Seal zone with the ideal endpoint for caries removal in a deep carious premolar [15].*

Total adhesion concept for pulp protection

Pulp protection can be achieved only by maintaining a bacteria-free region with a maximum amount of vital tooth being intact. Adhesive restoration enables clinicians to achieve a higher bond strength with good retention without compromising the tooth structure to a great extent. The main advantages of using an adhesive restoration are most of the retention that is achieved is done by adhesion and micromechanical tags that provide retention, resistance form is not an issue when using an adhesive restoration, the unsupported enamel, which is generally removed in conventional cavities, is retained and helps in limiting the caries extent, which improves the marginal seal. A lot of studies have validated the high performance of adhesive restoration [17-19]. The main restriction of adhesive restoration is the sensitivity towards the procedure; adhesive restorations are very technique sensitive, and long term *In vitro* studies have shown degradation of bonding over time. The current adhesive system limits microleakage to a greater extent than any other conventional amalgam restoration. The bonding is better in enamel than dentin, and hence caries limited to enamel have better resistance to microleakage than dentinal caries. Dental adhesives are more compatible with composite restoration and hence are widely used after pulp protection in deep caries, adhesives can also be used under amalgam restorations and ceramic caps, but the best results are seen with composite resin restoration [20].

Conclusion

Management of deep dental caries conservatively involves the complete excavation of caries while attempting to not expose the pulp during excavation. To remove caries completely or not has always been a controversial topic, and many researchers have varying schools of thought about it. Stepwise excavation has been accepted by many clinicians as the ideal treatment for deep caries management. Following the pulp protection, the permanent restoration that is placed determines the overall longevity of the procedure. The failure of deep caries management can also be attributed to microleakage, and hence a good adhesive restoration with high bond strength is important to increase the durability of pulp protection.

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