Vital pulp therapy is practiced daily in dentistry. We routinely arrest or remove carious lesions in our offices using a variety of treatments. There is some debate, though, in the fields of pediatric dentistry and endodontics about therapy for vital permanent teeth with deep carious lesions.¹,²

There are several clinical techniques for treating vital carious permanent teeth in children and adolescents. Maintaining pulp vitality is important in an effort to avoid root canal therapy or extraction. If necrosis develops it can be problematic—specifically in immature permanent teeth, which can be difficult to treat because of:

- thin dentinal walls that are susceptible to fracture.
- the amount of necrotic debris.
- ability to disinfect the root.
- the lack of an apical stop.

Pulpal vitality is key to obtaining apexogenesis, or ensuring continued root development.³⁻⁵ Aside from the clinical and anatomical difficulties, management of a young patient’s behavior can also present issues for clinicians.⁶

Developments in the use of calcium silicates led by ProRoot MTA proved beneficial in the management of vital immature permanent teeth affected by deep carious lesions.⁷ Mineral trioxide aggregate, or MTA, is a biocompatible material made of tricalcium and dicalcium silicates. It has been used successfully for indirect pulp caps, direct pulp caps, partial pulpotomies and complete pulpotomies in permanent teeth.⁸

When MTA contacts tissue fluid, it releases calcium, which in turn results in the formation of hydroxyapatite.⁹ This appears to form a chemical bond to dentin and will entomb bacteria in dentinal tubules.¹⁰ MTA has a basic pH, which creates an unfavorable environment for bacteria and can create adequate seal against leakage.¹¹⁻¹²

The setting time of MTA is two to four hours, which can impose difficulty when attempting to restore teeth at the same time of treatment. It has been associated with a high cost and difficult handling.⁷

MTA can create a dark discoloration when in contact with sodium hypochlorite, a commonly used endodontic irrigant. Staining has been attributed to bismuth oxide, which is added to the material as a radiopaque agent. Other compositions often have less discoloration.¹³
Indirect pulp cap

Indirect pulp therapy can be utilized in cases of reversible pulpitis. Teeth should be free of signs of irreversible pulpitis (spontaneous pain, lingering pain to cold, pain that is not controlled by over-the-counter analgesics), respond to sensibility testing (cold, electric pulp test) and show no signs of periapical pathology.

While remaining dentin thickness cannot be evaluated clinically or radiographically, teeth should have greater than 0.5 millimeter of sound dentin between pulp and lesion. If there’s less than 0.5mm, pathologic pulpal changes may exist.14

The goals of indirect pulp therapy are aimed at limiting the progression of a carious lesion by removing access of substrate to the bacteria in the lesion, thus stopping the progression. Studies have shown high success rates.15 When bacterial cultures are taken after initial caries removal, a reduction in colony-forming units is obtained regardless of the material.16 The bacterial entombment discussed earlier is one of MTA’s advantages because it can help provide an additional seal and aid in the arrestment of a lesion.10

Indirect pulp caps can be used when performing partial or complete caries removal. While one goal of partial caries removal (stepwise excavation) is to avoid a pulpal exposure, practitioners should be able to successfully manage an exposure should it occur.

Case 1: Partial caries removal

A 6-year-old female presented with four deep carious lesions on permanent first molars. The patient was symptomatic to cold the past few weeks. No history of spontaneous pain was reported at the time of examination.

Periapical radiographs showed open apices, and no apical pathology was evident. The patient was treated in two appointments. The patient was anesthetized and
the teeth isolated with rubber dam isolation. Caries removal was completed to the dentin, enamel junction and towards the pulp. Remaining caries was left adjacent to the pulp to avoid pulpal exposure.

A composite restoration was placed using Filtek A2B. There is no plan for re-entry to the teeth unless restorations begin to leak or symptoms arise. The teeth remain asymptomatic at recall visits, and no apical pathology is evident on periapical films. Note that radiolucencies may be evident if decay is left, and clinicians should combine subjective and objective findings when evaluating teeth with deep restorations. It may be advisable to place a colored glass ionomer, such as Fuji Triage, as a base to alert practitioners that caries was not completely excavated.

**Case 2: Complete caries removal**

A 17-year-old male presented with a history of pain in the maxillary right region. The patient localized the pain to tooth #14. The tooth had a large carious lesion on the occlusal surface and tested positive to sensibility testing without lingering pain. The patient complained of pain when biting. He was anesthetized and the tooth isolated with rubber dam isolation. Caries removal was completed without pulpal exposure, and NeoMTA from NuSmile was placed as an indirect pulp cap using an amalgam carrier and cotton pellet. The tooth was restored with a composite resin.

**Direct pulp cap**

Direct pulp caps have historically been carried out with calcium hydroxide. Calcium hydroxide works by inducing coagulative necrosis in the superficial pulp and stimulates the formation of dentin. Calcium hydroxide has dissolution over time, and dentin formed by it is porous; 89 percent of caps with calcium hydroxide have tubular defects after two years. This makes the material more prone to failure from coronal leakage.

The dentin barrier formed by calcium hydroxide also takes a longer period of time to form compared to that formed by MTA. A recent study on direct pulp caps found MTA to be superior to calcium hydroxide. A key finding of the study was that placing a final restoration at the time of pulp cap resulted in high success rates regardless of the material used.
Case 3: Treatment instead of extraction

An 8-year-old female presented with a history of pain associated with the maxillary left permanent first molar. She was evaluated and extraction of the permanent first molars was recommended because of the depth of carious lesions and evident space loss from premature loss of primary molars. The family denied extraction and elected for treatment. Tooth #19 was diagnosed with reversible pulpitis. The tooth was anesthetized and rubber dam isolation was performed. Caries removal was completed and a pulp exposure was evident. The tooth was disinfected with sodium hypochlorite; ProRoot MTA was placed with an amalgam carrier and adapted to cover the entire pulpal floor with a cotton pellet. A wet cotton pellet was placed over the MTA, and the tooth was temporized with IRM. The tooth was later restored with a composite resin restoration. The tooth remains asymptomatic and shows no signs of pathology after two years.

Cvek (partial) pulpotomy

The Cvek pulpotomy is named after Dr. Miomir Cvek, who initially popularized the partial pulpotomy procedure. The procedure removes the inflamed or exposed portion of pulpal tissue and leaves healthy pulp tissue apical the exposure site with the goal of maintaining as much healthy tissue as possible. A medicament is then placed to allow for pulpal healing to occur.21

Traditionally, the material that has been utilized is calcium hydroxide, but calcium silicates such as mineral trioxide aggregate have been shown to have equivocal results.22 The procedure is backed by the histological progression of dental caries and the pulpal response. As caries progression occurs, the pulp responds to the bacterial invasion; studies have shown that even when coronal inflammation and necrosis exists, healthy pulp tissue may exist below the site.23
Case 4: Pulp exposure and restoration

An 11-year-old male presented with history of pain originating from the mandibular left quadrant. He had previously been evaluated by a general practitioner, placed on an antibiotic, and was referred to an endodontist for root canal therapy but was unable to be seen by the specialist. The patient reported moderate intermittent pain originating from the tooth but no history of spontaneous pain.

Clinically, tooth #19 had a large carious lesion on the occlusal surface. It responded to sensibility testing and did not exhibit lingering pain to cold. Radiographically, the lesion appeared to be more than two-thirds into dentin and apical formation appeared to be incomplete. The diagnosis: reversible pulpitis with normal apical tissues.

The patient was anesthetized and the tooth isolated with a rubber dam. After caries removal was completed, a pulp exposure was evident. A partial pulpotomy was completed using a diamond bur from Komet USA, and the pulp was treated with 6 percent sodium hypochlorite from Vista Dental. ProRoot MTA from Dentsply was adapted to the exposure site using an amalgam carrier and a cotton pellet. A Fuji IX glass ionomer base from GC America was placed and the tooth was restored with Filtek Supreme A2B composite resin from 3M.

At the recall appointment, the patient remained asymptomatic and no apical pathology was evident. The tooth will be re-evaluated to determine if apexogenesis occurs.

Pulpotomy

Pulpotomies are very common practice in primary teeth and are increasing in frequency in permanent teeth. A systematic review reported the success rates for MTA pulpotomies in primary teeth to be 89.6 percent. The properties of MTA make it a suitable material for pulpotomies in the permanent dentition. Recently it has been advocated for teeth with signs of irreversible pulpitis and has been shown to have success.

Case 5: Irreversible pulpitis

A mandibular right permanent first molar presented with a diagnosis of irreversible pulpitis. Radiographically, the apices appeared to be immature. After anesthesia, rubber dam isolation was utilized and caries removal was completed. Vital tissue was evident in the orifi and hemostasis was controlled. Sodium hypochlorite was utilized as a pulpal medicament, and ProRoot MTA was adapted over the vital tissue.

A wet cotton pellet was placed over the MTA, and the tooth was temporized with IRM. Later the tooth was restored with a stainless steel crown. Radiographically, at follow-up visits the tooth remained asymptomatic and showed signs of increased root development.

Conclusion

The goal of all treatment modalities presented is to maintain pulpal vitality to avoid extraction or root canal therapy. These modalities have an advantage of being more cost effective in maintaining teeth than root canal therapy given the proper diagnosis is reached. The practitioner is charged with making the proper clinical diagnosis based off the subjective and objective findings that are gathered during examination to help guide the correct treatment of the disease.

If done properly, clinicians can obtain a high level of success when treating deep carious lesions on vital permanent teeth. Every attempt should be made to maintain a viable and healthy pulp when treating children and adolescents.
References


