UTILIZING BIOACTIVE LINERS

Stimulating Post-Traumatic Dentin Formation

INTRODUCTION

Bioactive refers to a material that causes an effect, or response, from living tissue. There are several new materials that are bioactive in that they stimulate dentin bridging and apatite formation by using calcium silicates or calcium alumimates.

TheraCal LC (BISCO Dental Products) is a liner, ProRoot MTA (DENTSPLY Tulsa Dental Specialties) is an endodontic reparative material, Biodentine (Septodont) is a base, and Ceramir (Doxa) is a cement; all of these materials have the potential to seal dentin, stop microleakage, almost eliminate sensitivity, and even promote pulp healing.1 Today, instead of merely replacing tooth, we hope to stimulate the formation of tooth.

TheraCal, the focus of this article, is a material that creates a new category of resin-modified calcium silicates (RMCS). It is a light-cured, resin-based, and highly radiopaque liner designed to release calcium to promote hard-tissue formation, and is indicated for use under direct restorative materials as a replacement to calcium hydroxide (CaOH), glass ionomers, eugenol-based sedative materials, and pulp capping restoratives.

Liners and Pulp Capping Materials

Calcium silicates as found in mineral trioxide aggregate (MTA) have been used for many years as a bioactive material in various endodontic procedures as well as effective pulp capping and pulp replacement therapies.2,3 TheraCal LC consists of a single paste containing CaO, calcium silicate particles (type III Portland cement), Sr glass, fumed silica, barium sulphate, barium zirconate, and resin containing Bis-GMA and poly dimethacrylate. ProRoot MTA is composed of white Portland cement and bismuth oxide.4 While MTA has been shown to be a reliable pulp capping, dentin sealing material, and is biocompatible; its formulation and chemical curing make it a less efficient material to use routinely for restorative lining or pulp capping material.5

The rapid release of calcium in these materials makes it an excellent material to cause repairing and healing of dentin, and studies have shown it to be more effective at stimulating pulp healing than traditional liners (such as light-cured resin-modified CaO-Hs) with less pulpal necrosis.6

The significant calcium release, provides reparative ions, creates a sustaining alkaline environment required to promote wound healing, provides immediate bond and sealing properties, and stimulates hydroxyl-apatite and secondary dentin formation within affected tissues.

TheraCal LC has been approved as “apatite stimulating” by the US Food and Drug Administration and is an interactive flowable resin that provides the early high alkalinity, pH 10 to 11, required for pulpal healing but reverts back to a neutral pH after several days.7 It is self-sealing, which aids in antimicrobial activity with initial bonds to dentin to resist accidental air-drying removal. This high calcium release has been shown to be critical for the stimulation of apatite formation and secondary dentin bridge formation while providing a mechanical seal of the pulp without adhesive.8

Dentists have been placing liners under restorations for many years as a pulp protectant to reduce pulpal necrosis and sensitivity.9 When pulpal tissue is exposed during tooth preparation, certain liners have been shown to reduce pulpal infection and necrosis than direct bonding onto the pulp alone.10

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Direct pulp capping with some self-etching adhesive systems have shown dramatic histologic failure indicating the need for a bioactive liner to stimulate reparative dentin formation.  

CaOH has been used for decades in hopes of stimulating reparative dentin formation by its high alkalinity. This liner may weaken the restoration, cause negative effects with restoration longevity, and may cause a decrease in bonding strengths of the restoration to the tooth. As a pulp capping material, CaOH has had mixed results that have diminished with time after placement. Newer resin-based materials based on the MTA and other high calcium releasing materials have superior long-term sealing ability and they have the potential for greater stimulation of reparative dentin.  

A major drawback of traditional self-cured CaOH materials is high solubility and dissolution over time (within one to 2 years after application) in tissue fluids. Fluids from restoration leakage, dentinal tubules, or the pulp may cause the disappearance of this type of lining material and the formation of voids/defects in reparative dentine underneath the capping. This can lead to a failure of the definitive seal against bacterial invasion and restoration failure. By contrast, the RMCS liner, TheraCal LC, has a very low solubility leaving a secure lining despite contact with dentinal or pulpal fluids; at the same time it releases substantial amounts of calcium for apatite stimulation.  

Clinical uses for this new RMCS include: as a general liner under restorations before etching or dentinal bonding, as a liner for pulp protection in restorations placed close to the pulp, as a liner over remaining pulp in deciduous pulpotomies or pulpectomies, and as a pulp capping material in permanent or deciduous teeth. 

Light-curing of the liner is a large clinical benefit. Clinically, it must be remembered that TheraCal LC is a liner only, and the manufacturer recommended depth-of-cure of about one mm means it must be placed in thinner increments than a more “base-like” material. Light-curing as opposed to chemical curing makes this material an excellent choice for office efficiency as definitive restorations can be placed immediately and the setting of the material is pre-
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dictable even in the moist environment of the pulp. Because this material is opaque and "whitish" in color, it should be kept thin so as to not show through composite materials that are very translucent or very shallow affecting final restoration shading.

Direct Pulp Capping

Direct pulp capping is the treatment of the exposed vital pulp by sealing the pulpal wound with a dental material to induce a reparative dentinogenic response, and is one of the most important endodontic modalities for maintaining dental pulp vitality. The material must act as a barrier protecting the pulp while inducing the formation of new dentine bridge between the pulp and restorative material.

The bioavailability of calcium (Ca) ions plays a key role in this process by stimulating cells involved in the new formation of mineralized hard tissues. Ca ions stimulate the expression of bone-associated proteins mediated by calcium channels and large quantities of Ca ions could activate adenosine triphosphate, which plays a significant role in the mineralization process. Ca ions are also necessary for the differentiation and mineralization of pulp cells and formation of odontoblastic cells which are needed to formulate the apatite of the dentin bridge. This release of Ca at the pulp also enhances the activity of pyrophosphatase, which helps to maintain dentin mineralization and the formation of new dentine bridging.

CASE REPORT

Diagnosis and Treatment Planning

A 16-year-old male broke tooth No. 9 off at the incisal portion of the pulp while lifting weights at school (Figures 1 and 2). The broken piece of tooth was placed in milk (2%) and was brought to the office about 45 minutes after the accident. The break was at a level where about two thirds of the tooth was missing and the denitification was intact with good oral hygiene (Figure 3). The pulp was clean with very little bleeding (Figure 4). Because of the relatively short time of exposure, the controlled bleeding, and the overall general health of the patient, a successful result was expected. However, the patient was informed of the possibility of darkening, sensitivity, periapical radiolucency, spontaneous pain, swelling, and other symptoms that may indicate the need for subsequent endodontic treatment.

Radiographic examination showed no obvious subgingival fractures or PA problems (Figure 5).

After warning the patient about signs of infection or necrosis, vital pulp capping with a RMCS liner (TheraCal LC) was agreed upon (Figure 6).

Clinical Protocol

The moist tooth fragment was inspected, rinsed, and placed on the tooth to verify the fit (Figure 7). Only a small amount of incisal edge was missing.

The surface of the broken tooth and pulp was cleaned with sodium hypochlorite on a microbrush and allowed to set for about 30 seconds (Figure 8). A one-mm layer of TheraCal LC was then placed and light-cured 10 seconds from the occlusal, 10 seconds from the facial, and 10 seconds from the lingual to insure adequate polymerization (Figure 9). Care was taken to place the liner 0.5 mm to 1.0 mm onto sound dentin away from the defect while keeping the material away from the enamel so that excellent sealing of the restoration could occur (Figure 10).

The moist tooth fragment was hollowed out with a 330 bur to provide relief where the liner was placed (Figure 11). After verification of fit it was then etched with phosphoric acid (Etch 37 with BAC [BISCO Dental Products]) for 20 seconds and rinsed thoroughly (Figure 12). The benzylkynonium chloride, BAC, is a microbial agent that aids in the killing of bacteria and may help with the disinfection of the preparation. After rinsing, several coats of a universal dentin bonding agent was applied (All Bond Universal [BISCO Dental Products]) and air-thinned (Figure 13).

Inside the mouth the tooth was isolated with retractor (See-More [Phillips]), a Mylar strip placed, and phosphoric acid with the BAC etchant placed, rinsed thoroughly, and suctioned moist (Figure 14). Several coats of universal bonding agent (All Bond Universal) were applied, air thinned, and light-cured for 20 seconds (Figure 15). A giomer flowable composite (Beautiful Flow Plus [Shofu Dental]) was placed inside the broken piece and repositioned onto the tooth (Figure 16). This material has a great combination of strength, flow, and fluoride release and rechargeability, making it ideal for proper fragment positioning and inhibition of microleakage.

Light-curing was then done for 20 seconds from both the lingual and facial (Figure 17). The flowable composite was allowed to flow out from the restored piece and cured with flash intact so that the fragment would not be “bumped,” disturbing the bonding of the material (Figure 18).

To increase the overall strength of the restoration and decrease the chances of microleakage, the facial was veneered with a microhybrid composite. After thorough curing, the flowable flash that remained from fragment placement was removed with a diamond bur and the enamel was roughened removing around one mm of tooth structure. The facial was then etched and dentin bonding agent applied. Tints and layers of composite were added to mimic the aesthetic characteristics of the tooth and restoration of the incisal chip (Figure 19). Shaping was done with a finish diamond, bur, and polishing disks (Figure 20). The tooth was adjusted out of occlusion slightly. The opacity of the RMCS liner is readily evident in the radiograph (Figure 21).

CLOSING COMMENTS

The result was an aesthetically pleasing and minimally invasive restoration (Figures 22 and 23). The preoperative condition of the tooth (fractured and involving the pulp) presented a wide range of therapeutic options to the dentist. The mantra of conservative dentistry is carried on as long as the therapy provided has a reasonable degree of expected success and the patient is warned of signs of failing treatment; and in this case, this included the possibility of darkening, pain, swelling, and radiographic signs of necrosis. At 10 months, the restoration is asymptomatic and the restoration is functioning well (Figure 24). The patient is also fully aware of the need for further restorative work in the future.
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References


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