vital, because it must still complete its primary, formative function. Seltzer and Bender⁵⁰ state that, once the development of the root has been completed, the pulp has no reason to remain there. Since it represents only a threat because of the calcifications and internal resorption that may develop, it must be removed, and the tooth must be treated endodontically. After all, who can inform the pulp to stay vital and inert inside the root canal after the dentin bridge has been completed and the apical closure occurred?

On the other hand, pulp exposure in a tooth with a mature apex must be considered an indication for endodontic treatment, since, as Reibel⁴² stated as long ago as 1922, “an exposed pulp is a lost organ.”

**What we know today**

Recently, Dr. Mahmoud Torabinejad⁴⁰ of Loma Linda University in California has developed a new cement, Mineral Trioxide Aggregate (MTA; ProRoot MTA, Dentsply Tulsa Dental, Tulsa, Okla.) (Figs. 2, 3), which appears to have all of the characteristics requested of the ideal cement to seal pathways of communications between the pulp and the oral cavity (mechanical and carious pulp exposures), and between the root canal system and the periodontium (iatrogenic perforations, open apices, resorbed apices, root-end preparations).

MTA is an endodontic cement that is extremely biocompatible, capable of stimulating healing and osteogenesis, and is hydrophilic. MTA is a powder that consists of fine trioxides (tricalcium oxide, silicate oxide, bismute oxide) and other hydrophilic particles (tricalcium silicate, tricalcium aluminate, responsible for the chemical and physical properties of this aggregate), which set in the presence of moisture. Hydration of the powder results in formation of a colloidal gel with a pH of 12.5, that solidifies to a hard solid structure in approximately three to four hours.⁴³ This cement is different from other materials currently in use because of its biocompatibility, antibacterial properties, marginal adaptation and sealing properties, and its hydrophilic nature.⁴⁴ In terms of biocompatibility, Koh et al.⁴⁵ and Pitt Ford et al.⁴⁶ demonstrated the absence of cytotoxicity when MTA came in contact with fibroblasts and osteoblasts, and the formation of dentin bridges when the material was used for direct pulp capping.

Several in vitro and in vivo experiments⁴⁷⁴⁹ have shown that sealing ability and biocompatibility of MTA are superior to those of amalgam, Super-EBA and IRM, dye and bacterial leakage studies have confirmed the sealing ability of MTA; the cytotoxicity of MTA was found to be less than that of Super-EBA or IRM.

The characteristic that distinguishes MTA from other materials used to date in endodontics is its hydrophilic properties. Materials used to repair perforations, to seal the retro-preparation in surgical endodontics, to close open apices, or to protect the pulp in direct pulp capping, are inevitably in contact with blood and other tissue fluids. Moisture may be an important factor due to its potential effects on the physical properties and sealing ability of the restorative materials.⁴⁸ As shown by Torabinejad et al.⁴⁰ MTA is the only material that is not affected by moisture or blood contamination. The presence or absence of blood seems not to affect the sealing ability of the mineral trioxide aggregate. In fact, MTA sets only in the presence of water.⁴⁹ MTA has been used also as a pulp capping material in exposed pulps (Fig. 1) and today seems to be the material of choice.

Pulp capping is indicated for teeth with immature apices when the dental pulp is exposed, and there are no signs of irreversible pulpitis.⁵⁰ In such cases the exposures must be sealed to preserve vitality of the pulp tissue. Recent studies have shown that MTA stimulates dentin bridge formation adjacent to the dental pulp. Dentinogenesis of MTA can be due to its sealing ability, biocompatibility, and alkalinity.⁵¹ Faraco and Holland⁵² demonstrated that in teeth treated with MTA all bridges were tubular morphologically, and in some specimens the presence of a slight layer of necrotic pulp tissue was observed in the superficial portion of these bridges. This suggested that the material, similarly to calcium hydroxide, initially causes necrosis by coagulation in contact with pulp connective tissue. This reaction may occur because of the product’s high alkalinity, whose pH is 10.2 during manipulation and 12.5 after three hours.⁵³ In a previous arti-
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