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Topical drug treatment for the dental pulp: An idea whose time has come

Teeth are extensively innervated, and a spectrum of pain symptoms can be experienced originating in these structures. Severe, spontaneous pain generally indicates an irreversible inflammatory process where the pulp has to be removed and either replaced with an inert material in conventional endodontics, or with a regenerated tissue. In contrast, milder pulpal conditions are potentially reversible. These conditions are marked by brief pain episodes where sensitivity only occurs when thermal, osmotic (in sensitivity to sweets), or tactile stimuli are applied to the teeth. Often these sensitivity symptoms arise in teeth with exposed dentin and can be relieved by the restoration of the tooth, or other treatments that occlude the dentinal tubules. In these instances, pain is caused by the physiologic activation of nerve fibers by dentin stimulation, and reflects little inflammatory facilitation. Inflammation can, in a number of conditions, facilitate tooth sensitivity in a manner similar to the enhancement of pain in other body areas. Both caries and the restorative procedures that are used to remove and replace carious tissue induce inflammation in the dental pulp.

By removing bacterially contaminated tissue and sealing the dentinal tubules, restorative procedures should create an environment where the resolution of inflammation and pulpal healing occur. Materials such as calcium hydroxide, glass-ionomer cements, or the more recently introduced calcium silicate-based materials are intended for use on circumpulpal dentin. Successful use of these materials as indirect and direct pulp-capping agents indicates that they possess a degree of bioactivity in encouraging healing of the dentin-pulp complex. What these materials lack is an ability to curb the pulp's inflammatory response.

Bad feelings from good fillings

Tooth sensitivity following restorative procedures continues to be a problem that is frequently perceived by patients, but not always reported to the treating dentist. The duration of these pain symptoms is usually limited to the first few weeks following the procedure. The time course of post-restoration sensitivity appears to mirror the sequence of reversible peripheral and central neuroplastic changes observed following experimental dentin injury in animals.[1] Being a self-limited phenomenon, clinicians may overlook the impact this pain has on patient satisfaction with their dental treatment.

Unfortunately, despite great progress in developing endodontic and regenerative technologies to treating teeth with "very sick" pulps, little progress has been made applying the existing vast arsenal of pharmacologic tools to the treatment of reversible pulp pathologies. Some examples of pulpal pharmacotherapy do, however, exist in current practice. Potassium nitrate, a commonly used dentin-desensitizing agent, is regulated as an over-the-counter drug in the United States. Potassium salts are believed to exert their desensitizing effect by reducing the excitability of the intradental nerves.

In the past, eugenol was so widely used as a pulp medicament to treat pain in carious teeth

that most dental offices smelled like clove oil. Although eugenol liquid is toxic to tissue, zinc oxide-eugenol (ZOE) temporary restorations release small quantities of eugenol owing to the gradual hydrolysis of the cement. The resulting low concentrations of eugenol in the dentinal fluid exert local anesthetic, anti-microbial, and anti-inflammatory effects.[2] David Pashley, the noted dentin authority, said that zinc oxide-eugenol was (I paraphrase) "more than a temporary filling material, but a wondrous and mysterious medicine". Recent pharmacologic examination of eugenol's action on sensory nerves has removed some of the mystery but none of the wonder. Like capsaicin, another plant-derived substance, eugenol activates a certain ion channel, and like a local anesthetic inhibits pain by inactivating excitatory membrane channels.[3]

Owing to eugenol's incompatibility with many dental materials and lack of evidence supporting the multi-visit practice of stepwise excavation of deep caries, use of ZOE has declined (personal observation). ZOE does, however, provide a point of comparison against which other therapeutics can be measured.

The profession's past reliance on ZOE as a sedative dressing and the continued problem of post-restoration sensitivity indicate that although "the seal is the deal" in terms of the success of modern restorative practices, a need exists for materials that can be used in restorative procedures possessing analgesic and anti-inflammatory properties. In the dental practice that we forsee, pharmacologically active materials would not be applied as a temporary restoration, but used to extend the dentist's ability to treat deep caries in a single restorative visit, with fewer occurrences of postoperative sensitivity and pain.

In medicine, mild to moderate pain complaints are typically treated pharmacologically. Patients too instinctively reach for various analgesics, especially nonsteroidal anti-inflammatory drugs (NSAIDs) following dental procedures. Though effective, these drugs have side effects that are avoidable when the same drugs are used topically. Targeted, local drug delivery makes sense when the therapy is directed towards small accessible areas of the body, and is commonly used to deliver agents to the ear, eye, skin, periodontium, and mucosa. NSAID eye drops enhance patient comfort and facilitate healing when used following cataract surgery and other procedures.[4] Topical delivery is now being used to administer a variety of drugs to intraoral sites for treating neuropathic pain; these preparations can include NSAIDs as well as agents such as seizure medications and antidepressants, drugs once thought to act only in the central nervous system. These observations broaden the scope of possible therapeutic targets amenable to manipulation with topical drug therapies.[5]

A system to deliver NSAIDs to the dental pulp would be a useful pharmacologic adjunct to restorative procedures, preventing postoperative sensitivity, and by restraining the inflammatory process, encouraging pulp healing. Although dentin appears to be a solid, impermeable tissue, the dentinal tubules provide a diffusion pathway connecting the base of a prepared dentin cavity with sites of the drug's action in the pulp. A drug delivery system targeting the dental pulp can deliver a variety of therapeutic agents that would relieve pain, have antimicrobial action, and promote healing.

Considered a mere nuisance, post-restoration sensitivity has not attracted much attention. Recent surveys indicate that post-restoration sensitivity is a common problem that negatively affects patient satisfaction.[6] The profession's experience with pain management has taught us that new therapies get adopted rapidly and soon become the standard of practice. As is the case in other areas of health care, we foresee the application of pharmacology, drug delivery technology, and materials science; combined with the dentist's drive for excellence, these will lead to more predictable and comfortable restorative dental practice.

Conflict of interest

The authors have founded a company to develop an anti-inflammatory drug delivery system for use in conjunction with restorative dental procedures.

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