The Power of the Pulp
Part 1

by Dr Kishan Sheth

In the first of a two-part article, Dr Kishan Sheth discusses the importance of the pulpal tissues in regeneration and function of the living tooth.

Introduction

We once thought that the pulp was doomed for endodontic treatment if pulpal exposure had arisen. Our understanding has shifted and there are several smart materials in practice these days that can enrich the prognosis of an exposed pulp when it is appropriate to attempt to preserve pulpal vitality.

Dr. Pfaff performed the first pulp-capping procedure in 1756 whereby he took a piece of gold and covered a vital and exposed pulp to aid healing (Cohen & Combe, 1994).

This marked a leap forward in our understanding within dentistry—that the pulp had some degree of regenerative and self-healing abilities and properties. The dental industry has gone further to develop some very smart materials which can support this process, and these will be covered more extensively throughout this two-part article.
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This pulp in Fig. 1 is likely to be contaminated and infected with high amounts of bacteria. After caries removal it is likely that, should exposure occur, this might require endodontic therapy.

The goal of the first part of this article is to project the importance of the pulpal tissues in regeneration and function of the living tooth. In our next issue, I’ll present a balanced view of the different materials on the market that clinicians are using or have used as pulp-capping materials.

Astute clinicians will recognise the need for careful analysis of the particular situation before formulating a care plan. A major aspect of the endodontic treatment, which I feel personally is overlooked, is the appreciation of the inherent powers the pulpal tissues harbor, and the ability for pulpal tissues to self-regenerate, sometimes with the addition and aid of pulp-protective chemical applications.

Regenerative endodontic therapy, technically, is the branch of operative endodontics that aims to restore inflamed and necrotic vascular pulpal tissue with biologically similar tissues via the action of the odontoblastic cells and their mesenchymal progenitors, which line the pulpal–dentinal interface.

The pulp can be defined as the soft, mesenchymal connective tissue structure which is placed and located in the central portions of the tooth and is highly specialised because of its biological environment.

Learning from the literature

Cvek (1978) elegantly demonstrated this concept of pulpal regeneration in his high-profile, well-known study and clinical report on partial pulpotomy performance and calcium hydroxide pulp-protective application on 58 permanent incisor teeth, which had undergone complicated coronal tooth fractures, 32 of which had mature roots. Cvek reported a 96 percent success rate, whereby at recall appointments, which averaged 31 months after the pulp capping procedures had been performed, success was measured by the absence of clinical symptoms, the absence of detectable radiological pathological change, continuation of root formation and positive response to electric pulpal sensibility testing. This validated the level of understanding within the profession, regarding the powers of healing, which the pulp possessed.

Cvek and Mejare (1993) went further in their report on the performance of partial pulpotomy procedures and application of calcium hydroxide pulp-protective caps in 37 young permanent teeth with deep carious lesions and exposed pulps, to state that there was a good prognosis when some carious teeth had pulp-capping procedures performed.

The team divided the study participants into two separate groups. Group 1 consisted of 31 teeth with no clinical or radiographic symptoms, and Group 2 consisted of six teeth, which provoked pain and had detectable radiographic pathology, the most common being the widening of the periodontal ligament space.

Healing was observed in 29 teeth in Group 1 and four teeth in Group 2.
Ward (2002) stated elegantly that the fully living and functionally able pulp provides a major advantage to a tooth, in the form of defense mechanism capability against invading bacterial species.

In day-to-day practice, with permanent teeth we do not tend to consider minimally invasive options such as partial pulpotomy, whereby we would amputate the superficial diseased pulpal tissue and leave behind the more healthy tissue, which we consider able to repair and heal.

Caries in any tooth will inevitably make the assessment of pulpal repair capacity more challenging and difficult, and it is clear that traumatic fracture of teeth has a much better prognosis to pulp protective processes because it is highly unlikely for there to be an overwhelming bacterial presence in the pulp tissues. With carious teeth, the bacteria have had a long-standing opportunity to invade the pulp through the dentinal tubules, and bacterial acid has also been attacking the pulp for some period of time.

Obviously, case assessment and selection is important and any traumatic pulp exposure will have prognosis of pulp-capping procedure dependent on several factors, including the size of the exposure, the time the exposure has been present (long-standing exposures can lead to bacterial contamination), and the age of the patient (younger patients have more vascularized pulps, immature teeth may have better vascular entry through the apex as the apex has not yet fully formed).

In teeth that have had carious activity present, such minimally invasive pulp-protective measures like pulpotomy are likely to be less predictable and less successful than conventional endodontic gutta percha therapy; therefore, it may be advisable to remove the pulpal contents, clean the canals and create gutta percha fillings in the root canal system to definitively restore the pulpal regions within the tooth.

In 1894, Miller first discussed the concept of bacteria having an important role in the inflammation of pulpal tissue. Kakehashi et al. (1965) recognised the unpredictability of minimally invasive pulp-protective measures, and the fact that this is a great concern for clinicians who would like to employ these procedures, when appropriate.

It has been well considered that successful management of pulpal exposures depends not only on the degree of intrinsic pulpal tissue resistance, but also more importantly on the presence of bacterial microorganisms in acute and chronically inflamed pulp tissue.

Kakehashi et al. (1965) brought this concept to the forefront of operative dentistry by assessing the effects of surgical pulp exposure in gnotobiotic (germ-free) and conventional (germ-rich) laboratory rats. Both groups of laboratory rats had their pulps exposed and packed with food.

Conventional rat teeth were later associated with pulp inflammation, pulpal necrosis and periapical periodontitis, granulomas or abscesses, whereas the pulps of the gnotobiotic rats experienced dentinal bridge formation (starting at just 14 days and completing by 28 days), and no evidence of inflammation was detected. It can therefore be assumed that the presence of bacteria is the most important factor in a clinician’s attempt to preserve pulpal vitality in exposed rodent pulps. Sundquist (1976) demonstrated that the necrosis of the pulp is mostly associated with obligative anaerobic bacterial species. Obligative anaerobic species are poisoned by the presence of oxygen.

Moller et al. (1981) recognised that the development of periapical periodontitis was only possible if bacteria were present. There were two separate groups of monkeys created. In one group, the teeth of the monkeys were aseptically exposed and the pulpal tissue traumatised by the introduction of a hand file using a balanced force technique, thus disrupting the pulpal tissue.

In the second group of monkeys, the pulps were exposed and the pulp tissue contaminated by plaque from the monkey teeth.

The teeth that had their pulps aseptically exposed showed no signs of periapical periodontitis, whereas those that were
contaminated by plaque and infected by bacteria showed long term signs of periapical periodontitis.

It is clear from the above pieces of writing that when considering endodontic therapy, be it minimally invasive options or conventional root canal therapy, the presence of bacteria may well constitute the ‘be-all or end-all’.

Small traumatic exposures have good prognosis if treated fast and it helps considerably when the pulpal tissue is uninflammed and noninfected.

The challenge, many clinicians will point out, is what to do if you cannot get a rubber dam over the individual tooth and isolate it from the internal oral environment.

A good example is a newly erupting #6, whereby there is not enough tooth clearance above the gingival region to allow for a rubber dam clamp to grip. It is clear that thorough cleaning and disinfection of the wound is necessary, but cotton wool isolation is the next best alternative with regular cleaning via a sodium hypochlorite-soaked cotton wool pellet. Should the operative procedure be carried out fast in a compliant patient, you are likely to get a similar result to a situation where you did use a rubber dam. After all, is dentistry not about adapting to situations and environments?

Preservation of pulpal vitality

The foundation of minimally invasive dentistry lies on the ability of dental operators to retain as much tooth structure as possible and preserve pulpal vitality.

Deep carious lesions present particular issues and challenges. Iatrogenic exposure of the pulp can have severe consequences, the resulting morbidity is likely, and bacterial penetration into the pulpal space may demand the need for pulpotomy or pulpectomy in primary teeth or conventional root canal procedures or even extractions in permanent teeth. However, the placing of a pulp cap over dentine components or exposed pulpal tissues is a serious and important consideration.

Once invasion and treatment of the pulp begins, the tooth begins to embark on a long restoration process whereby a root canal treatment may necessitate the placement of a crown, and replacement restorations or even extractions further down the tooth’s lifespan.

Dentists must attempt to avoid pulpal exposure and, where pulp exposure occurs, must ensure that hemorrhage is controlled by saline or sodium hypochlorite. Saline has been demonstrated to be the most benign to the pulp; however, sodium hypochlorite has an additional disinfection and haemostasis achievement function (DeSouza et al., 2001).
Calcium hydroxide-based materials have a long history of being used as pulp-capping materials and are considered by the dental literature to be the best way to preserve pulp vitality after exposure has occurred. The operator must additionally ensure the provision of a permanent, well-sealed and adapted restoration to prevent leakage of material and ensure no bacterial ingress occurs to the pulpal space (Besic, 1943).

The histological status of the pulp may be determined only through the use of histological samples, because often the signs, symptoms or radiographic appearance do not correlate with the changes at the microscopic tissue level (Accorinte et al., 2005). The gold standard for pulp status assessment is histological analysis. Countless studies have demonstrated that chronically inflamed pulpal tissue has been present in patients with no clinical signs and symptoms. Clinicians have only a few tools at their disposal such as the application of cold ethyl chloride spray, TTP tests and electric pulp testers, and it may be sometime before laser Doppler flowmetry is rolled out into clinical practice (DeSouza et al., 2001).

Special investigations

The best way to gather information about dental aberrant function is to use a multitude of tests to supplement the initial examination and conversation with the patient. No test should be interpreted alone and astute clinicians will remember well that all tests are prone to false negative and false positive results.

Radiographs are a useful adjunct to assess mineral density in the hard and soft tissues of the oral environment. However, it must be emphasised that the radiographical appearance of any carious lesion is actually around 6–10 months behind the physical spread in the tissues. It is often too challenging to detect pulpal tissue changes on a radiograph in any case.

A useful test for clinicians to employ is the sensibility test. Often described as a ‘vitality’ test, this test does not in fact measure blood flow through the pulp but rather the ability of the nerve endings in the pulp to become excited upon thermal or electrical stimulation.

Warm gutta percha points can be applied to the tooth, cold ethyl chloride spray or dichlorofluoromethane can be placed on cotton wool and then onto the tooth, and the use of polar-electric pulp testing machines that will use a circuit completing electrolytic coupling agent to allow for current application and direction onto the hard tissues can be employed. Vital teeth will tend to respond fast (DeSouza et al., 2001).

Other useful tools include: noting grey colouring or general darkening of the tooth as a result of the haemoglobin breaking down, a useful sign of necrosis; or the presence of any abscess or sinus tract whereby the pus at the apical portion of a tooth attempts to escape. Sinus tracts often allow relieving of the patient’s tenderness, whereas an abscess where a sinus tract cannot form will lead to excruciating pain and tenderness.

Percussion tests, via gently tapping the tooth with the back of a mirror handle to assess the periapical tissues and periodontal membrane’s condition, will provide information on the degree of inflammation of the periapical tissues.

The use of pulp caps may be further divided into either indirect or direct pulp caps. Indirect pulp caps are medicaments, usually nonsetting calcium hydroxide-based chemicals, which are placed over residual cavities or thin sections of remaining tooth structure to upregulate the mesenchymal preodontoblastic stem cells to upregulate into odontoblasts and lay down a dentinal bridge—that is, tertiary dentine laid down in response to chemical stimuliants.

The use of indirect pulp caps are outside the remit of this article, and we shall concentrate on direct pulp caps, medicaments placed over a small exposure of pulpal tissue, no greater than the tip of a William’s probe, to ensure the base of the restoration is walled off from the exposure and also to ensure the odontoblasts get upregulated and lay down tertiary dentine, (Pashley et al. 1984; Yamamura et al. 1985; Nie et al. 2006; Jontell et al. 1998).

References

A full bibliography for this paper (Parts 1 and 2) can be found via this link.

In our next issue:

Part 2: The idea properties of direct pulp-capping materials. Dr. Kishan Sheth presents a balanced view of the different materials on the market that clinicians are using or have used as pulp-capping materials.
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