Depth and Activity of Carious Lesions as Indicators for the Regenerative Potential of Dental Pulp after Intervention

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Abstract

Studies on dental regeneration involving interventions for pulp therapy such as regeneration and revascularization procedures are promising for the injured tooth; however, a complete replication of the original pulp tissue does not seem to take place. In cases in which we wish to preserve or maintain parts of the pulp during treatment, it is apparent that the effectiveness of healing or biological regeneration is dependent on the degree of inflammation of the pulp tissue. Thus, the control or prevention of a pulp infection is still a major issue for the clinicians. Data indicate that the typical reason for performing endodontic treatment is deep caries. The biological concept of vital pulp therapy associated with deep caries takes the treatment and evaluation of the unexposed as well as the exposed pulp into account. Interestingly, the clinical diagnosis is typically the same. Deep caries with reversible pulpitis may receive differing treatments such as excavation procedures aiming to avoid pulp exposure or more pulp invasive treatments such as pulp capping or pulpotomy. This should not be the case. Consequently, huge treatment variation is noted among clinicians based on the same caries diagnosis. Which treatment should be selected? High-quality trials are needed, and it is important to obtain information on the actual lesion depth and an estimate of the lesion activity before treatment. These may be basic indicators for the regenerative potential of dental pulp. Recent clinical trials dealing with the treatment of deep caries lesion are discussed, including pulp invasive and noninvasive concepts, to attempt to solve the task of getting the best clinical outcome for adult patients. *(J Endod 2014;40:S76–S81)*

Key Words

Caries, direct pulp capping, endodontics, indirect pulp therapy, pulpotomy, stepwise excavation

Although oral health care in many parts of the Western world has been improving, with a marked decline in caries activity among children and adolescents (1), data indicate that caries is still the most frequent reason for performing endodontic treatment. In a questionnaire survey, 55% of previously performed root canal treatments were performed because of caries in a vital tooth by general dental practitioners (GDPs) (2). It is apparent that the effectiveness of healing or biological regeneration is dependent on the degree of inflammation in the pulp tissue (3) when preserving or maintaining parts of the pulp during caries treatment. This produces a dilemma not only in the clinic but also between the clinic and the laboratory because GDPs still lack a device for noninvasive measurements of pulp inflammation. How can pulp therapies be improved if the actual clinical condition of the pulp remains a diagnostic problem? A recent review dealing with the diagnosis of dental pulp has shown that the available diagnostic tools were insufficient to assess the proper status of the pulp (4). Is it possible to obtain information regarding the condition of the pulp if the diagnostic process was more focused on the characteristics of a specific carious lesion? Can patient age be related to the depth of the lesion? Similarly, when GDPs assess lesion activity by including established clinical variables on caries activity, is it possible to use this information as indicators for the regenerative potential of dental pulp after intervention?

Treatment Variation

The biological concept of vital pulp therapy associated with deep caries involves the treatment and evaluation of unexposed and exposed pulp, but, interestingly, the clinical diagnosis is typically the same (5, 6). In a dental practitioner environment, deep caries with reversible pulpitis may receive differing treatment modalities such as avoidance of pulp exposure, pulp capping, or pulpotomy. These treatment options have led to both pulp-invasive (7, 8) and non–pulp-invasive treatment strategies (9–13). From network-based studies, it has been documented that GDPs are prone to perform different treatment modalities for the same "deep caries lesion scenario" (14). The vast majority of GDPs suggest 1 complete excavation or a root canal treatment, and less than 20% prefer a less invasive excavation procedure aiming to avoid exposure of the pulp. In a large questionnaire survey, this trend was recently confirmed because 2 groups of GDPs were identified with opposite approaches to caries excavation (15). Apparently, it matters which GDP is treating the deep carious lesion. The patient may receive a root canal treatment, a pulp capping procedure, complete caries excavation, or a less invasive excavation procedure. From the viewpoint of the patient, this treatment variation is not an optimal scenario. Efforts have been made to solve this clinical dilemma, and the contemporary perspectives on vital pulp therapy have been discussed by both endodontists and pediatric dentists (16), but, of course, more profound educational initiatives are needed to reduce treatment variation. Consensus within the clinical

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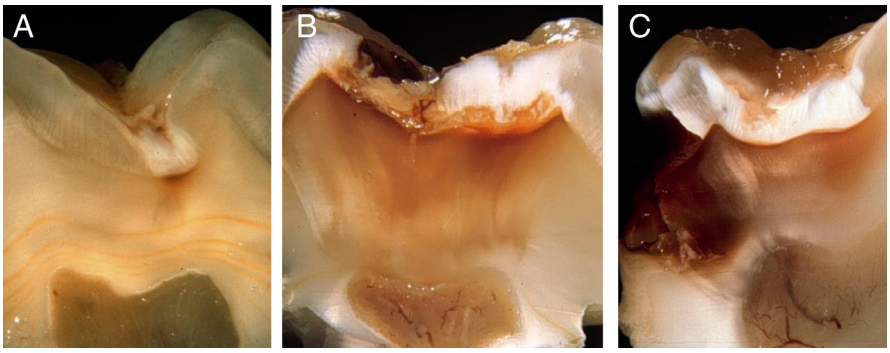

Figure 1. At the macroscopical level, it is possible to observe pulp reactions in relation to progressive stages of caries development.

community is an important prerequisite for developing improved treatment strategies for future collaboration within the scientific community.

Caries Progression and the Pulp-Dentin Organ

The belief that there is no correlation between pulp inflammation and the presence or absence of a toothache including an abnormal response to thermal testing has led to the opinion among clinicians that it is justified to excavate deep caries to pulp exposure (7) because the pulp may be severely inflamed even though it remains "silent" in terms of subjective symptoms. If caries remains untreated, a frank exposure may occur, and classic articles have shown that the pulp reacts with an infiltration of acute inflammatory cells and perhaps also the development of a small abscess (17, 18). Therefore, it seems logical that the removal of infected pulp tissue in such cases is the treatment of choice. The pulp becomes increasingly inflamed as caries progresses (Fig. 1). But, when is the point of no return? What happens if the speed of caries progression is reduced?

Since the article by Brännström and Lind (19), a missing link has been made between the early signs of caries and the inflammatory reactions of the pulp. Because of histologic difficulties, this link could not be shown directly but rather by comparing tooth halves in the laboratory. Changes along the odontoblastic and subodontoblastic layers were noted subjacent to enamel lesions. Later, the use of thin undemineralized tooth sections made it possible to simultaneously examine the enamel lesion and the pulp-dentin organ, confirming not only early odontoblast cell reactions (20) but also a difference in tertiary dentin formation as a response to slow and active lesion activity (21).

Extracted third molars show findings regarding the influence of caries lesion activity on dentin and pulp (Fig. 2). A partially erupted mandibular third molar (Fig. 2*A*) shows evidence of an undisturbed cariogenic plaque, and a typical light yellow or yellow demineralized dentin is noted, reflecting an actively progressing lesion (Fig. 2*A, inset*). In a fully erupted maxillary third molar without the presence of cariogenic surface plaque, the occlusal surface displays a chronic/inactive discolored surface lesion and the appearance of a dark brown/black discolored demineralized dentin (Fig. 2*B, inset*). Alterations in the odontoblast cell layer can be noted both in arrested and active lesion sites, whereas a different appearance of the subodontoblastic region is apparent in subjacent active sites (Fig. 2*C*) as compared with the unaffected control (Fig. 2*D*). This may indicate that the pulp is able to react dynamically to caries without necessarily reaching stages of irreversible pulpitis, necrosis, or infection. In short, using classic qualitative histologic parameters, a different pulp response can be noted toward rapidly and slowly progressing caries (20–22). It is also well-known that dentin is a bioactive extracellular matrix (23–26), and during demineralization there is a release of bioactive molecules (27–29). Our knowledge of the odontoblast is steadily increasing (30) as well as our knowledge regarding the role of inflammation (31). Taken together, it might be possible to further investigate the relative influence of carious activity with respect to the use of both indirect pulp therapy (IPT) and pulp therapy. In particular, more information is needed during the dynamic nature of human caries progression and the clinical importance of the reservoir of bioactive molecules in the dentin during various concepts of caries excavation.

Several studies on the proteomics of human dentin have been performed that have shed light on the protein composition of the dentinal matrix (32, 33). Interestingly, the dentinal matrix appears, among a myriad of other proteins, to contain sequestered growth factors, and it has been shown that the dentinal matrix plays an active role because the sequestered bioactive substances can be released because of acidic and enzymatic dissolution of the dentinal matrix within the caries lesion (27–29). To our knowledge, no studies have

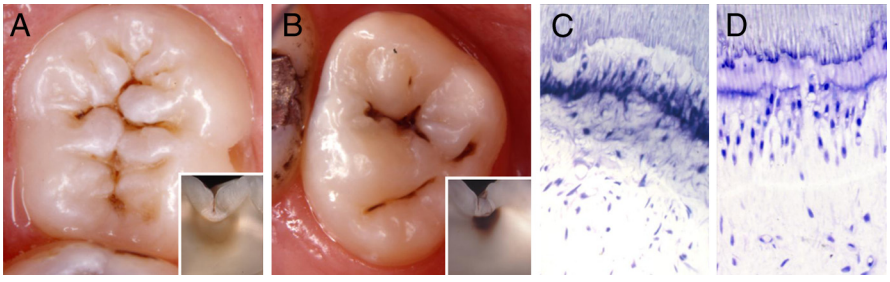

Figure 2. (*A*) A mandibular third molar (partly erupted) presents a cariogenic local environment in which the surface plaque can remain undisturbed. (*A, inset*) A macroscopical cutting profile of the tooth shows a light yellow/yellow appearance of the discolored demineralized dentin. (*B*) A maxillary third molar is observed with an arrested occlusal enamel lesion. (*B, inset*) A macroscopical cutting profile of the tooth shows a dark brown/black appearance of the discolored demineralized dentin. Along an active site, (*C*) a specific qualitative subodontoblastic reaction is apparent compared with (*D*) an unaffected control.