PULP VITALITY PRESERVATION

Techniques for Preserving Pulp Vitality in an Asymptomatic Deep Carious Lesion: A Clinical Case Study

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Abstract: When complete caries removal will lead to pulp exposure, partial caries removal may be considered as an alternative treatment option. Various techniques can be used in such situations to preserve pulp vitality. Incomplete removal of carious dentin and subsequent carious dentin sealing has been found to result in the arrest of carious lesions in deciduous and permanent teeth. This case report documents the treatment a young patient who presented with a mandibular left first molar that exhibited active coronal caries that had reached the apical third of the dentin. With a high risk of pulp exposure, the case demonstrates the use of conservative procedures that produced effective results in preserving pulp vitality.

When a deep carious lesion is encountered in a vital, asymptomatic tooth, a decision must be made as to whether to remove the caries to the point of near pulpal exposure or completely remove all caries even if doing so results in pulpal exposure. If a pulp is exposed and infected during caries removal, this reduces the probability of a successful outcome.[1] Therefore, when a deep carious lesion is encountered, the goal should be to maintain pulp vitality to reduce the need for endodontic therapy or extraction.

Various techniques can be used in such situations to preserve pulp vitality. Incomplete removal of carious dentin and subsequent carious dentin sealing has been found to result in the arrest of carious lesions in deciduous and permanent teeth; moreover, complete caries removal is not essential to control carious lesions.[2,3] A study that examined atraumatic restorative treatments for which the deepest carious lesions were sealed with calcium hydroxide demonstrated that this treatment was effective in eliminating the need for deep lesion excavation.[3] Approximately 75% of cultivable bacteria are nonviable a month after the residual caries is treated with calcium hydroxide, with bacterial counts decreasing from 83,687 to 20,859 colony forming units per milligram of carious dentin.[4] As with any dental material, however, calcium hydroxide, while effective, has its drawbacks: its dissolution can create dead space that can result in tunnel defects, which can cause microleakage if the final restoration does not provide an adequate seal.[5]

Matrix Metalloproteinases

The bacteria (microbes) that produce caries release acids that cause enamel demineralization and also result in the release of host-cell-derived microbial proteolytic enzymes (matrix metalloproteinases [MMPs]) that cause degradation of the dentinal organic matrix.[6] Odontoblasts produce MMPs, which can be found in saliva and gingival crevicular fluid.[6,7] MMPs trapped in the dentin matrix during tooth development are calcium- and zinc-dependent endopeptidases that are known to contribute to the breakdown of collagen in areas that have been treated with acid or acidic adhesives.[6,8] MMPs are located throughout the dentin, with a high concentration along the dentinoenamel junction (DEJ), and this increased presence of MMPs along the DEJ may contribute to the spreading of caries along this junction.[6] When the oral environment's pH falls below 4.5, MMPs start the degradation of the matrix components of tooth structure.[7] MMPs are activated by lactic acid released by bacteria in a carious lesion and lead to collagen-matrix breakdown; however, when phosphoric acid (etching agent) contains benzalkonium chloride, the activation of MMPs is decreased.[7]

The impeding of collagen-matrix degradation is produced by benzalkonium chloride, which inhibits the activation of MMPs by reducing the degradation of collagen solubilization and enhances the bonding interface between resin and dentin.[8] Both dental phosphoric acid and dental adhesives contain benzalkonium chloride.[7,8] The use of benzalkonium chloride has been proposed for

disinfecting a cavity preparation prior to its restoration. After carious lesions were removed and the prepared cavities were treated with benzalkonium chloride–based disinfectant, bacteria were not detectable on the dentinal walls nor were pulpal reactions observed when restorations were placed using a light-cured bonding system consisting of a self-etching primer and bonding agent, and neither were the dentin bonding systems affected by the application of benzalkonium chloride and 2% chlorhexidine gluconate.[9,10]

Chlorhexidine (CHX) digluconate is an amphiphilic molecule that binds to several proteins by a cation-chelating mechanism. Two-percent aqueous CHX prevents a decline in bond strength and inhibits MMPs' catalytic activities by chelation to Zn^{2+} and Ca^{2+} ions on MMPs' active sites; moreover, when MMPs are present, CHX digluconate reduces the percentage of collagen degradation in phosphoric-demineralized dentin.[11] In addition, hydroxyethyl methacrylate inhibits collagen degradation through adsorption of MMPs and facilitates a prolonged inhibitory effect of CHX on MMPs within the demineralized dentin.[11]

Caries Removal Considerations

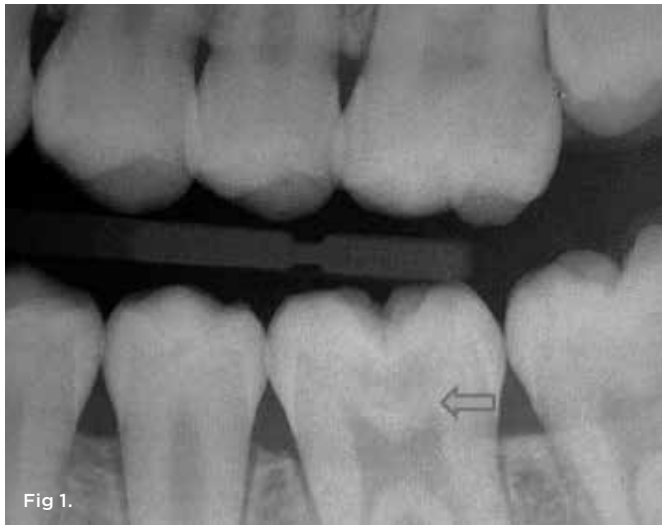
When treatment is required for an asymptomatic tooth that has a coronal carious lesion that has reached at least the middle third of the dentin, incomplete caries removal should be considered.[12] In the past, because it was thought that microorganisms beneath a restoration could cause restoration failure, dental schools often taught students to completely excavate the caries, and if this were to result in pulp exposure, the recommended treatment was direct pulp capping with calcium hydroxide or mineral trioxide acid. Recent studies, however, have indicated that after complete caries removal and direct pulp capping with calcium hydroxide, more bacteria are detected than with partial caries removal and carious dentin sealing with a bonding agent[12,13]; moreover, the in vivo determination found that complete removal of caries from dentin is not necessary when the caries is sealed with calcium hydroxide, with the sealed caries resulting in lower levels of bacterial infection than complete caries removal.[12]

Other studies have found that there were greater numbers of mutans streptococci and lactobacilli in the initial dentin after partial caries removal than complete caries removal; however, these numbers were decreased and the reduction of bacterial counts was confirmed when carious dentin was sealed with calcium hydroxide, with this procedure allowing the pulp to react and form tertiary dentin.[10,14] The above findings indicate that sealed dentin is less infected than is dentin after traditional complete caries removal.[12]

Case Presentation

An 11-year-old female patient (who had never been to a dentist) underwent a comprehensive oral examination, which included a panoramic and four bitewing radiographs. The patient's medical history was unremarkable. Her chief complaint was that she had "a hole on my tooth, but it's not hurting."

The intraoral examination found generalized incipient caries on the occlusal surfaces of the patient's posterior teeth. Although this finding was considered typical for a patient of this age, tooth No.19 (mandibular left first molar) exhibited active coronal caries, which had reached the apical third of the dentin (Figure 1). There was no indication of a periapical lesion on this tooth on the panoramic radiograph (Figure 2). The pulp vitality test indicated a normal vital pulp, and the intraoral examination indicated no sinus tract (Figure 3). The treatment options presented to the patient's parents were placement of either an amalgam or composite restoration; also presented to the parents (along with an informed consent form)



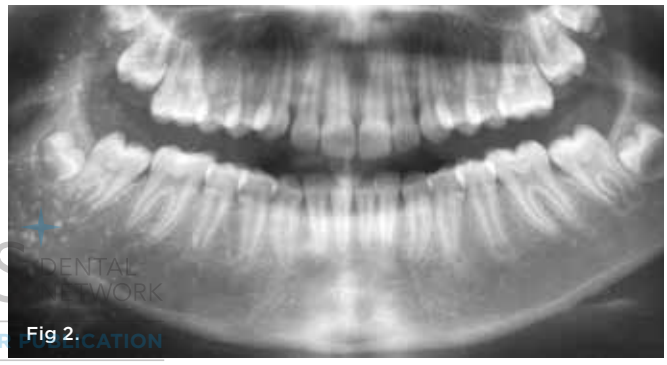


Fig 1. Preoperative bitewing radiograph obtained in December 2016. The caries on tooth No. 19 extended into the apical third of the dentin (arrow). Pulp vitality testing consisted of percussion, palpation, sensibility testing, and periodontal probing. All test results were within normal limits. **Fig 2.** Preoperative panoramic radiograph obtained in December 2016. **Fig 3.** Preoperative clinical photograph that indicated no inflammation or sinus tract in the area on tooth No. 19.

were the advantages and disadvantages of direct pulp capping and indirect pulp capping with partial caries removal.

The parents signed the informed consent form, and in July 2017 the patient presented for partial caries removal. An automatic, vital-sign monitoring system was used to record vital signs preoperatively and every 30 minutes. The patient rinsed with 0.12% chlorhexidine for 60 seconds and expectorated the rinse. Nitrous oxide inhalation and local anesthesia were used for the procedures. A dental dam was placed to isolate tooth No. 19. Sterile carbide burs (330 and round bur sizes 4 and 6) and a spoon excavator were used for preparation and partial caries removal. The depth of the caries-infected dentin was measured radiographically using bitewing x-rays from the central occlusal pit to the lower border of the caries. These measurements were applied clinically using a periodontal probe during excavation to the point of selective caries removal in preventing pulp exposure. The removal of caries peripherally to ensure a border of clean enamel and dentin (Figure 4) was verified using an explorer and confirmed visually using 4.5 magnification prism loupes.

The cavity preparation was etched with phosphoric acid (37%) placed on the enamel for an initial 10 seconds and then on the dentin

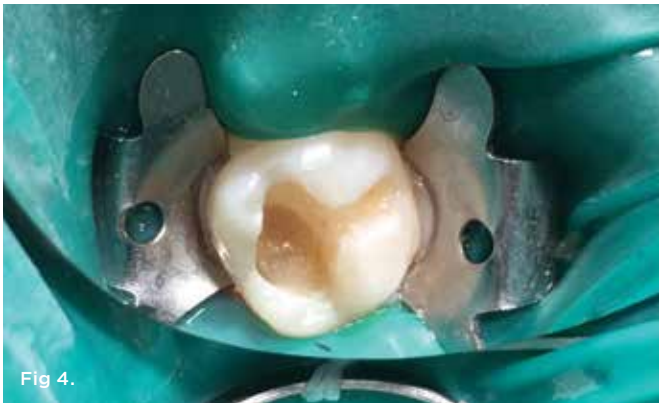


Fig 4.


Fig 5.

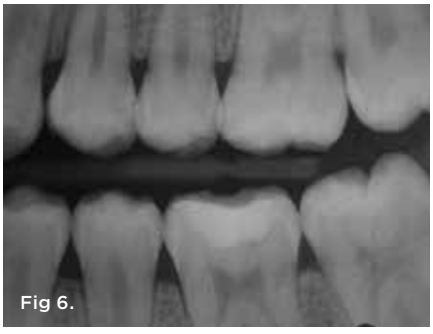


Fig 6.


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Fig 10.

Fig 4. Tooth No. 19 after partial caries removal. **Fig 5.** Tooth No. 19 with cotton pellet (wetted with 2% chlorhexidine) that was placed in the pulp chamber for 60 seconds. Pulp chamber was then dried with sterile cotton pellets. **Fig 6.** Post-treatment bitewing radiograph (March 2020). A pulp vitality test indicated that the pulp in tooth No. 19 was vital. **Fig 7.** Final assessment post-treatment bitewing radiograph (December 2020). A pulp vitality test indicated that the pulp of tooth No. 19 was vital. **Fig 8.** Final assessment post-treatment periapical radiograph (December 2020) indicated no periapical radiolucency on tooth No. 19. Pulp vitality testing indicated that the pulp was vital. **Fig 9.** Final assessment post-treatment clinical buccal view photograph (December 2020) indicated no inflammation or sinus tract. **Fig 10.** Final assessment post-treatment clinical occlusal view photograph (December 2020) showed no indication for dental concern.

for a final 10 seconds, after which the cavity preparation was thoroughly rinsed with water and air-dried without desiccation. A sterile cotton pellet soaked with 2% chlorhexidine was placed in the pulp chamber for 60 seconds, removed, and the pulp chamber was dried with sterile cotton pellets (Figure 5). Calcium hydroxide was used for sealing the remaining caries; it was placed with a carrier instrument. A primer and dental adhesive were placed and light-cured according to the manufacturer's instructions. Flowable composite was placed on top of the calcium hydroxide. Subsequent to this, 2 mm increments of a packable composite resin were placed and light-cured until the cavity preparation was filled. Proper occlusal contacts were verified in the centric position and in excursive movements.

Two weeks later, the patient started comprehensive, 3-year orthodontic treatment. Pulp vitality tests were performed every 6 months and, indeed, confirmed pulp vitality. At the time of orthodontic band and bracket removal, a bitewing radiograph (Figure 6) and pulp vitality test were assessed with positive results. In December 2020, 3 years and 4 months after the start of orthodontic treatment, a final assessment was completed with a bitewing radiograph (Figure 7), periapical radiograph (Figure 8), and intraoral photographs (Figure 9 and Figure 10). Pulp vitality tests (percussion, palpation, and sensibility) and periodontal probing measurements were all within normal limits. All assessments indicated an absence of apical pathology.

Discussion

When complete caries removal leads to pulp exposure, partial caries removal may be considered as an alternative treatment option. The use of benzalkonium chloride (which is available in 37% phosphoric acid), 2% chlorhexidine, and dental adhesives reduces the degradation (solubilization) of collagen, which is caused by MMPs. The application of these dental materials combined with calcium hydroxide eradicates the remaining caries, and with an adequately sealed restoration, pulpal vitality can be maintained.

When clinicians are faced with the challenge of excavating deep caries in permanent teeth with the risk of pulp exposure if caries are completely excavated, alternative treatment options should be evaluated to preserve pulp vitality. A study on pulp-capped teeth found success rates of 37% and 13% at 5 and 10 years, respectively.[15] A literature search by the authors did not identify a longitudinal study on partial caries removal when the risk of pulp exposure was high and could subsequently result in endodontic therapy or extraction. When the risk of pulp exposure is high, the following procedures have been demonstrated to produce promising results: partial caries removal followed by disinfecting the cavity preparation with solutions containing benzalkonium chloride to deactivate MMPs, and then isolating the remaining caries with calcium hydroxide, which is highly effective for pulp capping,[5] prior to placement of the permanent restoration. With these procedures, pulp vitality testing and a healthy and asymptomatic tooth need to be confirmed prior to partially removing caries.

Conclusion

When a patient presents with a vital, asymptomatic tooth with a deep carious lesion that leads to pulp exposure with complete excavation, partial caries removal may be an alternative treatment option. This case study demonstrates that the preservation of pulp vitality can be achieved with dental dam isolation, the application of dental materials with 37% phosphoric acid, 2% chlorhexidine, and dental bonding agents that contain benzalkonium chloride.

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