©Operative Dentistry, 2012, **37-6,** 571-575

Clinical Tech/Case Report

Periapical Healing After Direct Pulp Capping With Calcium-enriched Mixture Cement: A Case Report

S Asgary • A Nosrat • N Homayounfar

Clinical Relevance

This article shows the healing potential of pulp tissue in vital caries exposed mature permanent teeth; and also represents the "direct pulp capping" technique as a valuable treatment procedure to save pulp tissue.

SUMMARY

This article describes a successful direct pulp capping of a mature symptomatic mandibular second molar in a 14-year-old girl. The patient was referred with sensitivity to cold beverages and pain on chewing on the second left mandibular molar. Clinical examinations revealed extensive coronal caries and sensitivity to percussion. Radiographically, the tooth was mature and had a widened apical periodontal ligament (PDL) and a narrow periapical lesion. The concluding diagnosis was symptomatic irreversible pulpitis with symptomatic apical periodontitis. Treatment included caries removal under rubber dam isolation, capping of exposure sites with calcium-enriched mixture (CEM) cement, and permanent coronal restoration. At three-, 10-, and 15-month follow-up, the tooth was functional, had normal response to cold test, and did not have sensitivity to percussion. The PDL space regained its normal width, and the periapical lesion healed.

*Saeed Asgary, DDS, MS, professor, Iranian Center for Endodontic Research, Dental Research Center, School of Dentistry, Shahid Beheshti University of Medical Sciences, Tehran, Iran

Ali Nosrat, DDS, MS, assistant professor, Iranian Center for Endodontic Research, Shahid Beheshti University of Medical Sciences, Tehran, Iran

Negar Homayounfar, DDS, MS, graduate student, Department of Oral Biology, School of Dentistry, University of Washington, Seattle, WA, USA

*Corresponding author: Evin Blvd, Tehran, 1983963113, Iran; e-mail: ansrt2@yahoo.com

DOI: 10-2341/11-417-S

INTRODUCTION

Vital pulp therapies are biologically-based treatments in which the main objective is to save pulp health and vitality in carious or traumatic exposures.[1] These treatments include stepwise excavation and indirect pulp capping, direct pulp capping (DPC),[2] and pulpotomies.[3] Although vital pulp therapies are universally accepted in the treatment

of immature teeth, they are controversial in treating carious exposed mature teeth.[4]

DPC is defined as the treatment of an exposed vital pulp by sealing the pulpal wound with a pulp-capping material. The material is directly placed on a mechanical or traumatic exposure to promote pulp healing.[1] Several agents have been used for DPC; among them, calcium hydroxide (CH) and mineral trioxide aggregate (MTA) are the most studied ones. Histological studies on pulps capped with CH revealed that formation of dentinal bridges beneath CH is unpredictable. Besides, these bridges contain tunnel defects, and the underlying pulps are inflamed.[5,6] On the other hand, compared with CH, histological studies on DPC with MTA demonstrate favorable results, including continuous regular dentinal bridge formation along with less pulpal inflammation.[5,6] Dentinal bridges formed beneath MTA after DPC resemble tertiary dentin.[7] Properties such as biocompatibility, sealing ability,[8] and hard-tissue induction potential[5,7] make MTA an ideal biomaterial for vital pulp therapies.

Calcium-enriched mixture (CEM) cement is a water-based, tooth-colored cement containing lime (CaO), phosphorus oxide (P_2O_5), sulfur oxide (SO_3), and silica (SiO_2) as major elements.[9] Because of constant CH release during and after setting, CEM cement has antibacterial properties similar to CH and superior to MTA.[10] Several *in vitro* and *in vivo* studies reveal the similar sealing ability,[11] biocompatibility,[12] and hard-tissue induction potential[13] of CEM cement and MTA. Biological responses (the quality of dentinal bridges and the amount of pulp inflammation) after DPC with CEM cement and MTA were similar and better than CH in dogs' teeth.[13] CEM cement has been used successfully in pulpotomy of inflamed mature[14] and immature[15,16] human teeth. Two recent histological studies on DPC of healthy human teeth demonstrate similar biological responses to CEM cement and MTA.[17,18]

This article describes a successful direct pulp capping of a mature second mandibular molar with symptomatic pulpitis and symptomatic apical periodontitis using CEM cement.

CASE REPORT

A 14-year-old healthy girl was referred with a history of lingering pain on the left posterior mandible. The patient's chief complaint was severe lingering pain with cold beverages and pain on chewing. Clinical examinations showed extensive caries and a cavity in the left mandibular second molar. The tooth was sensitive to percussion but not to palpation. Cold test, using Endo-Frost cold spray (Roeko, Coltene Whaledent, Langenau, Germany), elicited a lingering, long-lasting pain. Radiographic examination demonstrated a mature tooth with an obvious widening of the apical periodontal ligament (PDL) space and a narrow apical radiolucent lesion (Figure 1a). Considering the clinical and radiographic findings, our concluding diagnosis was symptomatic irreversible pulpitis with symptomatic apical periodontitis. After explanation of possible risks of treatment, a written informed consent from the patient's legal guardians was obtained.

After local anesthesia with one vial (1.8 mL) of 2% lidocaine (36 mg) and 1:80,000 epinephrine (Darou Pakhsh, Tehran, Iran) and rubber dam isolation, caries were removed with a diamond fissure bur (Diatech, Heerbrugg, Switzerland) and high-speed hand piece with copious water spray. Two exposure spots were detected on mesiolingual and mesiobuccal pulp horns. Using the same bur and high-speed hand piece, the clinician gently extended the diameter of the exposures to 1–2 mm without entering the pulp. Hemostasis was achieved using NaOCl 5.25% for five minutes. CEM cement powder and liquid (Bionique-Dent, Tehran, Iran) were mixed according to the manufacturer's instructions. CEM cement was placed over the pulp wounds using an amalgam carrier and gently adapted to the pulp wounds and surrounding dentin. An ≈2-mm-thick layer of glass ionomer (Fuji II, Fuji Corporation, Japan) base was placed over the CEM cement, and the tooth was restored permanently with amalgam (SDI gs80, SDI limited, Australia; Figure 1b). The patient was recalled 2 days after treatment. Clinical examinations at this time showed that the tooth was not sensitive to either percussion or palpation, and the patient did not have any complaint about chewing with the tooth.

At three, 10-, and 15-month follow-up, the tooth was functional without any signs/symptoms. A cold test using Endo-Frost cold spray elicited normal response, and the tooth was not sensitive to percussion or palpation. The PDL space regained its normal width, and the apical radiolucent lesion healed (Figure 1c, d).

DISCUSSION

The success rate of DPC in carious pulp exposures in mature and immature human teeth is evaluated in some clinical studies using CH or MTA as pulp-capping agents. A retrospective study on 122 carious exposed teeth capped with either CH or MTA and

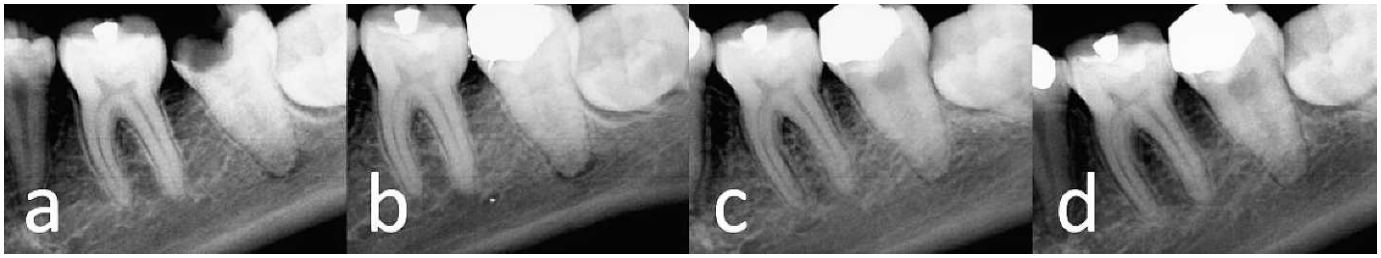

Figure 1. *(a) Preoperative periapical radiograph of a second mandibular left molar in a 14-year-old female patient. The tooth was sensitive to cold and percussion. Note the mesio-occlusal extensive caries and related coronal cavity, apical periodontal ligament (PDL) widening, and narrow radiolucent lesion. (b) Immediately after direct pulp capping with calcium-enriched mixture cement, placement of a glass ionomer base, and permanent coronal restoration. (c) Ten-month follow-up. (d) Fifteen-month follow-up. The tooth was functional without sensitivity to percussion. The PDL space regained its normal width, and the radiolucent lesion healed.*

follow-ups up to 80 months, excluding cases with symptoms of irreversible pulpitis, demonstrated significantly higher clinical and radiographic success rates for the MTA group.[19] A two-year clinical study on DPC with MTA in 30 young carious exposed asymptomatic permanent molars showed 93% vitality.[20] Moreover, a long-term (≈four-year) prospective study on DPC with MTA in 49 immature and mature carious exposed teeth with symptoms of reversible pulpitis demonstrated a 100% and 98% success rate, respectively.[21] The outcomes of these studies concur with histological evidences of favorable pulp responses to capping with MTA and unpredictable responses to capping with CH.[5,6,13]

The biological properties of MTA, including sealing ability, biocompatibility, and hard-tissue induction potential, are attributed to bioactive reactions between calcium ion released from MTA and phosphorus ion in the surrounding tissue fluids. These reactions cause formation of hydroxyapatite crystals.[22] In addition, the sealing ability of MTA increases during storage in phosphate-buffered saline solution, a phenomenon that does not happen in normal saline.[23] However, CEM cement releases calcium and phosphorus ions from indigenous sources and, unlike white MTA, has the ability of inducing hydroxyapatite crystal formation in the absence of environmental phosphorus.[24] Therefore, the comparable features of CEM cement and MTA, such as biocompatibility,[12] sealing ability,[11] and hard-tissue induction potential,[13] and the superior bioactive properties of CEM cement (which is associated with its indigenous phosphorus reservoirs),[24] make CEM cement a potentially suitable biomaterial for DPC. These properties can partly explain the favorable results in the presented case.

Based on histological and clinical evidences, some recent studies show that carious exposed pulps with established irreversible pulpitis in mature and immature teeth maintain their healing potential.[3,14,16,25,26] However, the treatment technique in these studies is full pulpotomy, which often causes negative response to pulp vitality tests in follow-up sessions. By saving coronal pulp in the DPC technique, the clinician has the opportunity to perform pulp vitality tests in addition to periapical and radiographic examinations and to compare them with the baseline data and draw a distinct conclusion about pulp status. Besides, compared with pulpotomy and root canal therapy, DPC is a simpler, less expensive, and more conservative treatment.[27]

Although there are several reports of successful partial pulpotomy of carious/traumatic exposed pulps,[28,29] successful DPC in symptomatic carious exposed mature teeth is a rare finding. The authors believe that to reach this goal, some technical modifications are necessary. Gentle extension of exposure site to ≈1–2 mm diameter may eliminate infected dentinal chips from the pulp surface, increase the contact area between the pulp-capping agent and pulpal wound, and facilitate bioactive reactions in the pulp-pulp capping agent interface.[30] The antibacterial properties of CEM cement[10] and its sustained CH release[24,31] are also other important factors that can keep the pulpal wound bacteria free over time.

As demonstrated in long-term studies, an immediate permanent coronal seal plays an important role in the success rate of DPC treatment.[19,32] Therefore, performing immediate coronal restoration in this case can be another reason for favorable results.

Although studies have shown that the success rate of DPC with CH decreases with the passage of time,[19,32] the success rate of DPC with MTA remains almost constant over time.[19,21] Regarding the similar biological properties of CEM cement and MTA, it is

anticipated that the successful results in the presented case remain constant over time. However, yearly follow-up of the presented case is recommended.

CONCLUSION

Based on biological properties of CEM cement, especially its bioactive and antibacterial properties, this cement might be a suitable biomaterial in direct pulp capping of symptomatic carious exposed mature teeth. However, further clinical studies with longer follow-up periods and larger samples are recommended. While clinical studies are important, histological confirmation using human teeth will provide the ultimate proof of the success of calcium-enriched mixture cement.

Conflict of Interest

The authors of this article certify that they have no proprietary, financial, or other personal interest of any nature or kind in any product, service, and/or company that is presented in this article.

(Accepted 6 February 2012)

REFERENCES

1. Bogen G, & Chandler N. (2008) Vital Pulp Therapy. In: Ingle J, Bakland L, Baumgartner J (eds) *Ingle's Endodontics* 6th ed. BC Decker Inc, Hamilton, Canada 1310-1329.
2. Bjørndal L, Reit C, Bruun G, Markvart M, Kjaeldgaard M, Nasman P, Thordrup M, Dige I, Nyvad B, Fransson H, Lager A, Ericson D, Petersson K, Olsson J, Santimano E, Wennstrom A, Winkel P, Gluud C (2010) Treatment of deep caries lesions in adults: randomized clinical trials comparing stepwise vs. direct complete excavation, and direct pulp capping vs. partial pulpotomy *European Journal of Oral Science* **118(3)** 290-297.
3. Witherspoon D, Small J, & Harris H (2006) Mineral trioxide aggregate pulpotomies: a case series outcomes assessment *Journal of American Dental Association* **137(5)** 610-618.
4. Miyashita H, Worthington H, Qualtrogh A, & Plasschaert A (2007) Pulp management for caries in adults: maintaining pulp vitality *Cochrane Database of Systematic Reviews* **18** CD004484.
5. Nair P, Duncan H, Pitt Ford T, & Luder H (2008) Histological, ultrastructural and quantitative investigations on the response of healthy human pulps to experimental capping with mineral trioxide aggregate: a randomized controlled trial *International Endodontic Journal* **41(2)** 128-150.
6. Pitt Ford T, Torabinejad M, Abedi H, Bakland L, & Kariyawasam S (1996) Using mineral trioxide aggregate as a pulp-capping material. *Journal of American Dental Association* **127(10)** 1491-1494.
7. Andelin W, Shabahang S, Wright K, & Torabinejad M (2003) Identification of hard tissue after experimental pulp capping using Dentin Sialoprotein (DSP) as a marker *Journal of Endodontics* **29(10)** 646-650.
8. Torabinejad M, & Parirokh M (2010) Mineral trioxide aggregate: a comprehensive literature review—part II: leakage and biocompatibility investigations *Journal of Endodontics* **36(2)** 190-202.
9. Asgary S, Shahabi S, Jafarzadeh T, Amini S, & Kheirieh S (2008) The properties of a new endodontic material *Journal of Endodontics* **34(8)** 990-993.
10. Asgary S, & Kamrani F (2008) Antibacterial effects of five different root canal sealing materials *Journal of Oral Science* **50(4)** 469-474.
11. Asgary S, Eghbal M, & Parirokh M (2008) Sealing ability of a novel endodontic cement as a root-end filling material *Journal of Biomedical Materials Research* **87(3)** 706-709.
12. Parirokh M, Mirsoltani B, Raoof M, Tabrizchi H, & Haghdoost A (2011) Comparative study of subcutaneous tissue responses to a novel root-end filling material and white and grey mineral trioxide aggregate *International Endodontic Journal* **44(4)** 283-289.
13. Asgary S, Eghbal M, Parirokh M, Ghanavati F, & Rahimi H (2008) A comparative study of histologic response to different pulp capping materials and a novel endodontic cement. *Oral Surgery Oral Medicine Oral Pathology Oral Radiology Endodontology* **106(4)** 609-614.
14. Asgary S, & Ehsani S (2009) Permanent molar pulpotomy with a new endodontic cement: a case series *Journal of Conservative Dentistry* **12(1)** 31-36.
15. Nosrat A, & Asgary S (2010) Apexogenesis treatment with a new endodontic cement: a case report *Journal of Endodontics* **36(5)** 912-914.
16. Nosrat A, & Asgary S (2010) Apexogenesis of a symptomatic permanent molar with calcium enriched mixture. *International Endodontic Journal* **43(10)** 940-944.
17. Zarrabi M, Javidi M, Jafarian A, & Joushan B (2010) Histologic assessment of human pulp response to capping with mineral trioxide aggregate and a novel endodontic cement *Journal of Endodontics* **36(11)** 1778-1781.
18. Zarrabi MH, Javidi M, Jafarian AH, & Joushan B (2011) Immunohistochemical expression of fibronectin and tenascin in human tooth pulp capped with mineral trioxide aggregate and a novel endodontic cement *Journal of Endodontics* **37(12)** 1613-1618.
19. Mente J, Geletneky B, Ohle M, Koch M, Friedrich Ding P, Wolff D, Dreyhaupt J, Martin N, Staehle H, Pfefferle T (2010) Mineral trioxide aggregate or calcium hydroxide direct pulp capping: an analysis of the clinical treatment outcome *Journal of Endodontics* **36(5)** 806-813.
20. Farsi N, Alamoudi N, Balto K, & Al Mushayt A (2006) Clinical assessment of mineral trioxide aggregate (MTA) as direct pulp capping in young permanent teeth *Journal of Clinical Pediatric Dentistry* **31(2)** 72-76.
21. Bogen G, Kim J, & Bakland L (2008) Direct pulp capping with mineral trioxide aggregate: an observational study *Journal of American Dental Association* **139(3)** 305-315.
22. Sarkar N, Caicedo R, Ritwik P, Moiseyeva R, & Kawashima I (2005) Physicochemical basis of the biologic

properties of mineral trioxide aggregate. *Journal of Endodontics* **3192** 97-100.

23. Parirokh M, Askarifard S, Mansouri S, Haghdoost A, Raoof M, & Torabinejad M (2009) Effect of phosphate buffer saline on coronal leakage of mineral trioxide aggregate. *Journal of Oral Science* **51(2)** 187-191.
24. Asgary S, Eghbal M, Parirokh M, & Ghoddusi J (2009) Effect of two storage solutions on surface topography of two root-end fillings *Australian Endodontic Journal* **35(3)** 147-152.
25. Eghbal M, Asgary S, Baghlue R, Parirokh M, & Ghoddusi J (2009) MTA pulpotomy of human permanent molars with irreversible pulpitis. *Australian Endodontic Journal* **35(1)** 4-8.
26. Chueh L, & Chiang C (2010) Histology of Irreversible pulpitis premolars treated with mineral trioxide aggregate pulpotomy *Operative Dentistry* **35(3)** 370-374.
27. Komabayashi T, & Zhu Q (2010) Innovative endodontic therapy for anti-inflammatory direct pulp capping of permanent teeth with a mature apex. *Oral Surgery Oral Medicine Oral Pathology Oral Radiology Endodontology* **109(5)** e75-e81.
28. Cvek M (1978) A clinical report on partial pulpotomy and capping with calcium hydroxide in permanent incisors with complicated crown fracture *Journal of Endodontics* **4(8)** 232-237.
29. Mejare I, & Cvek M (1993) Partial pulpotomy in young permanent teeth with deep carious lesions *Endodontics and Dental Traumatology* **9(6)** 238-242.
30. Asgary S, & Ahmadyar M (2012) Can miniature pulpotomy procedure improve treatment outcomes of direct pulp capping? *Medical Hypotheses* **78(2)** 283-285.
31. Asgary S, Nosrat A, & Seifi A (2011) Management of inflammatory external root resorption by using calcium-enriched mixture cement: a case report. *Journal of Endodontics* **37(3)** 411-413.
32. Barthel C, Rozenkranz B, Leuenberg A, & Roulet J (2000) Pulp capping of carious exposures: treatment outcome after 5 and 10 years: a retrospective study *Journal of Endodontics* **26(9)** 525-528.