Successful regenerative approach with direct pulp capping using mineral trioxide aggregate after pulpal injury 2 years follow-up: Case report

Poppy Andriani[1]
Ade Prijanti Dwisaptarini[1*]
Eko Fibryanto[1]
Nur Zety Mohd Noh[2]

[1]Departement of Conservative Dentistry, Universitas Trisakti, Indonesia
[2]Departement of Restorative denstistry, Kulliyyah of Dentistry, International Islamic University Malaysia, Malaysia

***Korespondesi Email |** a.p.dwisaptarini@trisakti.ac.id

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ABSTRACT

Introduction: A complete excavation of dental caries can accidentally expose the pulp. Pulp exposure should be sealed immediately to maintain pulp vitality and heal after injury, called direct pulp capping. Direct pulp capping can stimulate the formation of dentinal bridgess to maintain pulp vitality after injury using biomaterial agents The objective of this case report is to demonstrate the efficacy of regenerative endodontic approach, specifically direct pulp-capping therapy using mineral trioxide aggregate, in treating the injury with a six-month follow up. **Case report**: A 19-year-old female complained of slight discomfort while drinking cold water on her right second incisor. Clinical examination revealed proximal dentin caries. Vitality and percussion tests were negative. Radiograph examination showed a radiolucent area on the mesial proximal part that affected both enamel and dentin. The tooth was diagnosed with reversible pulpitis. The area was isolated with a rubber dam. Dentin caries was removed using the rotary instrument. In the process, the pulp cavity was exposed iatrogenically at one site with minor bleeding, so direct pulp capping was applied to maintain pulp vitality. The cavity was disinfected with chlorhexidine 2%. Mineral Trioxide Aggregate (MTA) was selected as the material for direct pulp capping. Initially, it was administered to the exposed pulp, succeeded by the application of glass ionomer cement and temporary restoration. Two years follow-up, positive vitality and negative percussion test results were observed. X-rays showed the formation of hard tissue, and there were no pathological findings in the apical on tooth #12. **Conclusion:** When pulp is exposed due to deep caries, endodontic regenerative methods involving biomaterial agents can be employed. MTA has the capacity to encourage the formation of dentinal bridges and promote pulpal regeneration following an injury.

Keywords

dental caries, direct pulp capping, mineral trioxide aggregate, pulpal injury, pulp regeneration

Keberhasilan kaping pulpa direk menggunakan mineral trioxide aggregate paska injuri 2 tahun follow-up: laporan kasus

ABSTRAK

Pendahuluan: Ekskavasi lesi karies dentin yang dalam secara tidak sengaja dapat menyebabkan eksposur pada pulpa. Jika eksposur pulpa terjadi, pulpa perlu dilapisi dengan segera untuk menjaga vitalitas pulpa dan regenerasi kembali setelah terjadi injuri yang disebut dengan kaping pulpa direk. Kaping pulpa direk dapat menstimulasi formasi jembatan dentin untuk menjaga vitalitas pulpa pasca injuri dengan suatu bahan biomaterial. Tujuan laporan kasus ini menunjukkan keberhasilan pendekatan regeneratif endodontik dengan perawatan kaping pulpa direk menggunakan *mineral trioxide aggregate* pasca injuri dengan 6 bulan follow-up. **Laporan kasus**: Pasien perempuan berusia 19 tahun mempunyai keluhan ada rasa ngilu yang ringan saat minum air dingin pada gigi depan kedua sebelah kanannya. Pemeriksaan klinis terdapat karies dentin pada bagian proximal. Tes vitalitas dan perkusi negatif. Pemeriksaan radiografi menunjukkan daerah radiolusen pada proksimal bagian mesial yang mengenai enamel dan dentin. Gigi tersebut didiagnosa dengan pulpitis reversibel. Daerah kerja diisolasi dengan *rubber dam.* Saat melakukan ekskavasi karies secara iatrogenik pulpa terbuka dengan titik perdarahan kecil dalam kavitas, perawatan kaping pulpa direk dipilih dalam mengatasi masalah tersebut. Kavitas di desinfeksi dengan larutan *chlorhexidine* 2%. *Mineral Trioxide Aggregate* (MTA) dipilih sebagai bahan biomaterial kaping pulpa direk. Setelah dua minggu pasca perawatan, restorasi akhir dilanjutkan dengan restorasi resin komposit. Pemeriksaan berkala 2 tahun paska perawatan, tes vitalitas dan perkusi negatif. Pemeriksaan radiografi terlihat formasi jaringan keras dan tidak terlihat adanya kelainan periapikal pada gigi #12. **Simpulan:** Pendekatan regeneratif endodontik dengan kaping pulpa direk, dapat diterapkan dalam perawatan pulpa yang terkena injuri saat ekskavasi karies dentin yang dalam. Penggunaan MTA dapat menstimulasi formasi jembatan dentin dan regenerasi pulpa setelah injuri.

Kata kunci

injuri pulpa, kaping pulpa direk, karies dentin, mineral trioxide aggregate, regenerasi pulpa

INTRODUCTION

Preserving pulp vitality is a minimally invasive biological concept to maintain the normal function of the pulp.[1,2] The primary objectives of modern clinical endodontics are to preserve the pulp in vigorous condition with continuous vitality, prevent apical periodontitis, and develop minimally invasive biological-based approach.[2] The vital condition of the pulp serves an important role in maintaining the tooth structure and its physiological function.[3] Pulp treatment aims to preserve the vitality of the pulp, which functions for the life-sustaining qualities of the dental pulp, and preserve the body's immune system.[3–5] Pulp injuries may be caused by mechanical factors during caries excavation (*iatrogenic*) and dental trauma due to the individual's activity.[2,3,5,6] The therapy for the vitality of the pulp, which has been evaluated in regenerative dentistry, includes direct pulp capping.[4] Direct capping pulp therapy, in a root canal treatment, is used as an alternative to invasive therapy.[6] The vitality state of the dental pulp is an important indication of successful post-trauma pulp therapy.[3,7] The state of periodontal tissue and adequate blood supply in the area of injury may determine the effectiveness of pulp vitality treatment.[7] In addition, the successful treatment of vital teeth following injury can be observed in a case of teeth with irreversible pulpitis and periapical lesion.[4,7]

A therapy of traditionally excavated dental caries involves the complete removal of the dentin, including both the infected and unaffected areas.[1,8] Currently, the excavation of deep caries lesions involves a minimally invasive strategy that selectively removes caries or employs stepwise excavation techniques. The goal is to prevent pulp exposure during the process.[1,2,8–10] An ultra-conservative approach has also been applied in the partial removal of deep dental caries. The partial excavation is employed by removing the most affected dentin and covering the cavity before a permanent restoration is conducted.[2] Regenerative endodontic procedures are defined as biological techniques designed for replacing the damaged structure including dentin and root structures, as well as dentin-pulp complex cells. Pulp-capping treatment is a regenerative endodontic concept in regenerating pulp tissues that aims to sustain pulp vitality and promote restorative formation in the injured area using biomaterials.[2,11]

Biomaterial application in the injured areas after excavation aims to form dentinal bridges.[3,12] Calcium hydroxide and mineral trioxide aggregate (MTA) can be used in pulp-capping therapy, which is applied after the dental injury.[3,12,13] Calcium hydroxide, a gold standard material, was commonly used decades ago for direct pulp-capping therapy.[13–15] However, the use of calcium hydroxide has limitations due to tunnel defect formation as a result of the production of dentinal bridgess.[5,13] Mineral trioxide aggregate (MTA) is biomaterial that induces tissue regeneration and promotes the recovery process.[5] Direct application of MTA onto the exposed pulp generates calcium ions, which increase adhesion and cell proliferation.[5] MTA has the ability of inducing dentinogenic and osteogenic potential cell formations.[16] The objective of this case report is to demonstrate the efficacy of regenerative endodontic approach, specifically direct pulp-capping therapy using mineral trioxide aggregate, in treating the injury with a six-month follow up.

A CASE REPORT

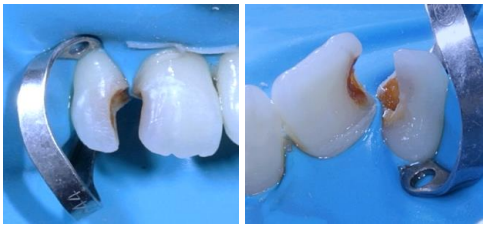
A 19-year-old female patient presented with dental caries in her anterior teeth. The patient reported experiencing minor discomfort in her right maxillary incisor when consuming cold beverages. She desired to have a treatment for her anterior tooth to alleviate her discomfort. The patient had no history of systemic disease and allergy.

Clinical examination revealed caries lesions on the first incisor (#11) and right second incisor (#12) (Figures 1A and 1B). The vitality test on teeth #11 and #12 was positive, and percussion was negative. An x-ray of tooth #11 showed a radiolucent area on the distal proximal part made up of enamel and dentin. Another x-ray of tooth #12 showed a radiolucent area on the mesial proximal part made up of enamel and dentin that was almost touching the pulp (Figure 1C). No abnormality was seen in the apical part of teeth #11 and #12. Teeth #11 and #12 were diagnosed with reversible pulpitis.

A **B** **C**

Figure 1. A. The clinical view of teeth #11 and #12 labial view. B. The clinical view of teeth #11 and #12 palatal view. C. Radiographs of teeth #11 and #12 before treatment.

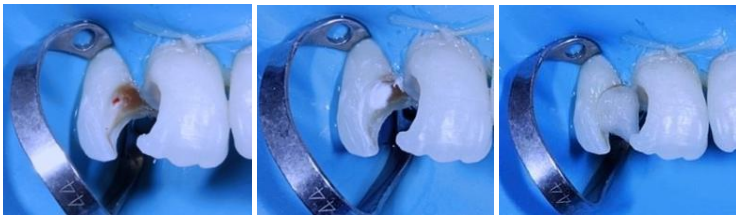
On the first visit, the primary objective of the therapy was to specifically target the patient's main problem, which was reducing her discomfort associated with her right anterior tooth. Clinical examination, anamnesis, intra oral photographs, radiographic examination, diagnosis, treatment plan, and informed consent were performed prior to the initiation of treatment. The patient was asked to use povidone-iodine gargling liquid for one minute to disinfect her oral cavity, followed by caries risk assessment, dental health education (DHE) and scaling in order to remove plaque and calculus on the surface of the patient's teeth. A rubber dam was applied to isolate the working area (Figure 2A and 2B). The caries excavation was employed by carefully using excavator on teeth #11 and #12, followed by the use of carbide bur and high-speed handpiece with water coolant to complete the process.



A B

Figure 2. A. The clinical feature of teeth #11 and #12 after rubber dam placement in the labial view. B. The clinical view of teeth #11 and #12 after placement of rubber dam in palatal view.

During the preparation on tooth #12, a minor bleeding was observed on the base of the cavity (Figure 3A). It was rinsed with sterile distilled water and dried with sterile cotton pellets. A hemostatic agent was used to stop the bleeding for two to three minutes. The bleeding could be stopped in less than two minutes by disinfecting the infected areas using sterile cotton pellets that had been soaked in a 2% chlorhexidine solution for five minutes. The white mineral trioxide aggregate (MTA) was selected for the reconstructed direct pulp-capping material for tooth #12. The MTA powder and distilled water solution in the ratio of 3:1 was mixed using a glass plate and spatula until a paste consistency was achieved. This paste was applied onto the injured area using gun carrier, the MTA applicator, and compressed with sterile cotton pellets that had been soaked in distilled water solution for five minutes (Figures 3B and 3C)



A B C

Figure 3. A. Pulp exposure of tooth #12. B. Application of MTA on tooth #12. C. Placement of moist sterile cotton pellets in the cavities.

The process continued by monitoring the MTA until it became visibly hardened, followed by the application of the glass ionomer cement on the coronal area of the MTA, and the temporary restoration was used to close the cavity. The tooth #11 was restored by making lining on the cavity base, which had been priorly disinfected with a 2% chlorhexidine, using glass ionomer cement and followed by a composite resin restoration (Figure 4A). Next visit was scheduled two weeks post-treatment.

Figure 4. A. A temporary clinical restoration view on tooth #12 and a composite resin restoration on tooth #11.

On the second visit, two weeks after the first treatment, a clinical examination with percussion and palpation tests on tooth #12 was negative. The patient confirmed of not having any complaints on teeth #12 and #11. Povidone-iodine gargling liquid was administered for one minute to disinfect her oral cavity, followed by the application of a rubber dam to isolate the working area. The temporary restoration of tooth #12 was thoroughly cleaned. The next stages of the treatment were continued by giving a 35% phosphoric acid to the enamel for 15 seconds, disinfecting the cavity with a 2% chlorhexidine, applying adhesive material to the tooth cavity, which was then dried using mild three-way syringe and polymerized for 20 seconds. Composite resin fillings were performed using the incremental technique of polymerizing for 20 seconds (Figure 5A). This was followed by the polishing of tooth #12 until it looked good (Figure 5B). Follow-up was scheduled six months post-treatment.

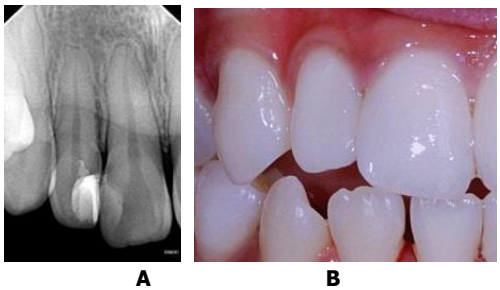
A B

Figure 5. A. The clinical view of tooth #12 before polishing the composite resin filling. B. The post-treatment clinical view of tooth #12.

The third visit after six months post-treatment: a clinical examination was conducted by percussion test and tooth palpation on teeth #12 and #11 with a negative result. Radiographic examination showed a radiopaque area on the mesial pulp horn of tooth #12, indicating good hard tissue formation in the injured area, and no abnormalities were seen in the apical part of tooth #12. Regular follow-ups were scheduled in this case (Figure 6).

Figure 6. Radiographic image 6 months post-treatment. Hard tissue formation can be seen in the injured area (yellow arrow).

Two years recall, the patient returned for a follow-up. Clinical and radiographic assessments were conducted. Tooth #12 exhibited an asymptomatic condition, with the pulp remaining vital. No radiographic changes were observed in tooth #12 (Figure 7A and B). Tooth #11 showed no clinical symptom and normal periapex (Figure 7).



A B

Figure 7. A. Radiograph of tooth #12 at two years post-treatment showing normal periapex. B. Clinical view of tooth #12 in two years.

DISCUSSION

Minimally invasive approaches have been widely studied in modern dentistry to research and develop the technique of excavating deep dental caries. The objective is to perform caries excavation with controlled and selective or partial approach.[9,17,18] Dentin caries partial excavation is conducted in two stages: (1) the excavation of infected soft dentin, leaving the hard part, by covering the cavity with temporary fillings that last for six months; and (2) the excavation of hard dentin selectively and proceeding with final restoration.[1,10]

Dental caries can lead to ongoing demineralization of the dentin, which can later develop into pulp. This process may produce dentin matrix components (DMCs). Matrix metalloproteinases (MMPs) with DMCs will break down the dentin matrix and produce bioactive molecules that move into the dentin tubules to create tertiary dentin formation and regenerate the pulp (reparative dentinogenesis). DMCs contain bioactive components such as growth factors, chemokines, cytokines, MMPs, and bioactive proteins. They have an important part in several processes involving tissue repair, including chemotaxis, angiogenesis, mineralization, stem cell, and neurogenesis.[1]

In the early stages of injury, the dentin pulp can initiate the recovery process by stimulating the activity of the odontoblast around the injured area and generating reactive dentin within the dentin-pulp complex. Reactive dentin formation due to injury will create new tissues resembling real odontoblasts or odontoblast-like cells. If the pulp injury becomes more severe, the real odontoblasts will be destroyed, and the pulp inflammation will increase. Consequently, the response from the injured pulp will produce new odontoblasts to recover and regenerate pulp tissues. The odontoblast-like cell formation will produce reparative cells generated from the injured area, called reparative dentinogenesis.[1] Post-injury pulp repair requires multiple growth factors, including BMP-2, BMP-4, BMP-7/OP-1, FGF-2, IGF-1, and -2, and TGF-b1, to induce the formation of tertiary dentinogenesis.[19] Direct pulp-capping is a treatment procedure to maintain pulp vitality and form reparative dentin after exposure, either traumatically or mechanically, without inducing inflammation using biomaterials.[3–5] The objective of direct pulp-capping treatment is to produce regeneration at the injured area of dental pulp by creating dentinal bridges.[4] This dentin bridge formation aims to preserve the pulp in its vital condition after the injury.[4,11–13] Dentinal bridges lead to the formation of a calcified barrier, which is advantageous in pulp-capping procedures for dentin formation.[12] The biomaterials used for direct pulp-capping treatments include calcium hydroxide, resin-modified glass ionomer cements (RMGICs), mineral trioxide aggregate (MTA) and calcium silicate–based cements (CSCs).[3]

In the last few years, mineral trioxide aggregate (MTA) has become a commonly used material for pulp-capping treatment.[20] According to a systematic review conducted by Nie et al.[4], MTA and MTA-based biomaterials have shown a high-level of efficacy in dentin regeneration. MTA was initially introduced by Mohammed Torabinejad.[16] The main compositions of MTA are tricalcium silicate and dicalcium silicate.[3,20] Additional bismuth oxide in the composition increases its radiopacity.[3,20] MTA displays good coating ability in preserving the pulp vitality, biocompatibility, bioactivity, and creating even and thicker dentinal bridges compared to calcium hydroxide.[6,13] MTA has a high pH level that can serve as an antibacterial agent.[21] MTA can be used as biomaterials for pulp capping, apexogenesis, root-end filling, apical plug, and perforation repair.[16] The toxicity level produced after the MTA application is known to be the lowest.[5]

According to Moussa et al.[20], dentinal bridge formation for direct pulp-capping therapy with MTA application produces thicker dentinal bridges than that with calcium hydroxide. The result can be seen after one to three weeks after therapy.[16] When directly applied to the exposed area, the MTA will create calcium hydroxide to release calcium ions, which function in adhesion and cell proliferation.[5] MTA does not react to restorative materials, such as glass ionomers and composite resins.[16] It has antibacterial properties with a pH level of 10.2 - 12.5. The MTA's compressive strength is 40 MPa within 24 hours and rises to 67,8 MPa within 21 days.[16] MTA has a long setting time of 2 hours and 45 minutes, so it requires a second visit for its application. The first visit is the MTA application, and the second visit is the permanent restoration on the hardened MTA surface.[20] During the setting process of MTA, it has a high tolerance for the presence of blood fluid.[16]

Grey MTA and white MTA are commonly found in the marketplace. The gray MTA contains tetracalcium aluminoferrite, which accounts for the gray discoloration that is not used for anterior teeth, a large particle size, longer setting time and better compressive strength. White MTA contains ferrous oxide replaced by magnesium oxide causing no teeth discoloration, a small particle size, and less compressive strength.[16] The drawbacks of MTA include the complexity of application, extended curing time, potential discoloration, and its comparatively high cost. Nevertheless, MTA remains a highly popular biomaterial option because of its exceptional attributes.[16]

A successful direct pulp-capping treatment is highly associated with the ability to manage the bleeding after immediate exposure. Prolonged bleeding causes increased inflammation in the pulp, affecting the pulp's ability to recover.[3,14] Bleeding should be managed to stop within one to ten minutes after the exposure, depending on the type of exposure after injury.[3] The application of permanent restoration directly after pulp-capping treatment can be a determining factor in successful treatment.[19]

CONCLUSION

A conservative and minimally invasive approach to partially excavating caries lesions aims to prevent pulp exposure. In the event of pulp injury, regenerative endodontic approaches may be considered, treating the pulp chamber to maintain its vitality. Mineral Trioxide Aggregate (MTA) is a biomaterial capable of stimulating pulp

tissue regeneration, forming hard tissue in injured areas, and exhibiting superior characteristics compared to calcium hydroxide. Controlling the bleeding time after pulp exposure plays an essential role in the successful direct pulp-capping treatment.

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