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Clinical Technique/Case Report

Histology of Irreversible Pulpitis Premolars Treated with Mineral Trioxide Aggregate Pulpotomy

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Clinical Relevance

When caries and bacterial contamination can be mostly eliminated from the dentin-pulp complex, the inflamed pulp of a human permanent tooth with irreversible pulpitis may have a chance to return to a healthy and functional status after mineral trioxide aggregate pulpotomy.

SUMMARY

Studies show that human permanent teeth with carious pulpal exposures can result in a high clinical success rate when treated with pulpotomy and direct pulp capping with mineral trioxide aggregate (MTA pulpotomy). In this case report, a 19-year-old female patient with a second premolar with irreversible pulpitis and symptomatic apical periodontitis was treated with MTA pulpotomy. Follow-up electric pulp tests showed viability of the tooth at three and 10 months. Ten months after the initial treatment, the tooth was extracted for orthodontic reasons and processed for histological examination. Microscopically, the pulpal wound treated with MTA was free from inflammation and covered with a thin layer of reparative dentin. The authors conclude that, when caries and bacterial contamination can be removed from the dentin-pulp complex, the inflamed but vital pulp of a permanent tooth may have a chance to return to a healthy, functional status after MTA pulpotomy.

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INTRODUCTION

Mineral trioxide aggregate (MTA) is currently the best material for use in primary molar pulpotomy[1-2] and immature permanent tooth vital pulp therapy.[3]

Compared with the traditional material of calcium hydroxide, MTA has better pulpal biocompatibility and sealing ability, stimulates higher quality and a greater amount of reparative dentin and has demonstrated a higher clinical success rate.[3]

In histological studies of healthy human third molars or premolars treated with pulpotomy and direct pulp capping with either MTA (MTA pulpotomy) or calcium hydroxide, pulps capped with MTA showed less pulpal inflammation and a more predictable hard tissue barrier formation than pulps capped with calcium hydroxide.[4-5] In a clinical study using either MTA or calcium hydroxide as a pulp dressing agent for partial pulpotomy of permanent first molars with carious pulpal exposures, MTA also demonstrated a slightly higher clinical success rate and frequency of induction of hard tissue barrier formation than when calcium hydroxide was used.[6] In addition, when MTA pulpotomy was used for treating human permanent teeth with pulp exposure caused by either caries or complicated enamel dentin fracture, a high clinical success rate was also obtained.[7-8] The findings from the above-mentioned studies suggest that MTA is the proper material of choice for direct pulp capping procedures.

This case report is a histologic evaluation of an MTA pulpotomy on an irreversible pulpitis premolar in a 19-year-old female patient.

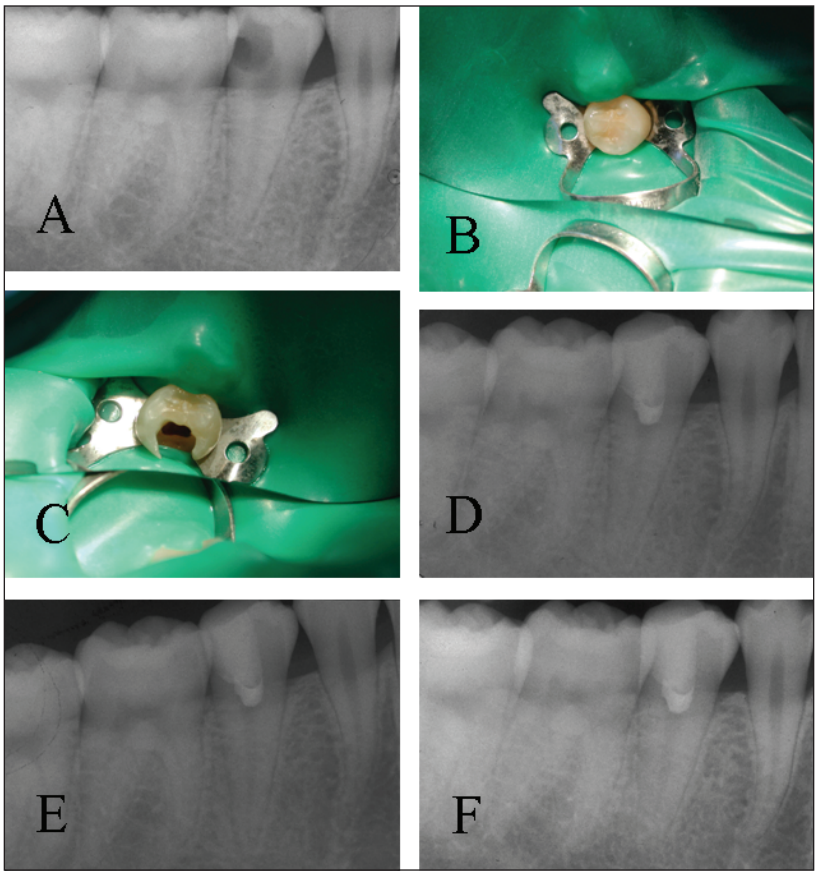

Figure 1. *Clinical photographs and periapical radiographs of tooth #29. Figure 1A: A radiograph showing a large distal proximal caries close to the coronal pulp of tooth #29. Figure 1B: Exhibits the intact occlusal surface of tooth #29. Figure 1C: Reveals fresh residual pulp tissue after removal of caries and 2-3 mm of the exposed superficial pulp tissue layers and control of pulpal bleeding. Figures 1D through 1F: Radiographs taken one month (Figure 1D), three months (Figure 1E) and 10 months (Figure 1F) after initial treatment showing a coronal filling of resin composite and MTA in tooth #29 and no apical pathosis at the periapical area of tooth #29.*

CASE REPORT

This 19-year-old female patient reported cold sensitivity and biting tenderness in her right lower posterior teeth for more than six months. She avoided chewing on the right side. The patient was referred to our clinic for consultation and management before orthodontic treatment. According to the patient's chief complaint, the pain was elicited by cold and lasted for several minutes. Visual oral examination did not show any decay of the teeth on the right side. However, periapical radiography revealed large distal proximal caries close to the coronal pulp of tooth #29 (Figure 1A). Upon ice testing, the patient reported lingering pain in the lower second premolar, lasting for two-to-three minutes. The biting test also induced slight tenderness but the discomfort subsided when the bite was relaxed. Using electric pulp testing (Analytic Endodontics, Redmond, WA, USA), the tooth responded with a reading of 37. Other clinical tests, including a percussion test, palpation test and periodontal probing, were all within normal limits.

The carious lower second premolar was diagnosed as having irreversible pulpitis with symptomatic apical periodontitis. Because the final orthodontic treatment plan had not yet been scheduled, a conservative approach was suggested and agreed upon by both the patient and her mother. The treatment plan included caries removal, pulpotomy in case of pulp exposure and direct pulp capping with MTA. A consent form was signed by the patient's mother before treatment commenced.

During the next appointment one week later, the rubber dam was applied after block anesthesia of lidocaine with 1:100,000 epinephrine (Figure 1B). The tooth was accessed and caries was removed with a sterilized diamond bur. A carious pulp exposure was immediate and the exposed superficial pulp tissue layers were removed with a sterilized new carbide fissure bur to a depth of 2-3 mm. Profound bleeding occurred from the residual pulp tissue. The pulp chamber was irrigated with 10 ml of 2.5% NaOCl. After dry cotton pellet com-

Figure 2. *Microphotographs of hematoxylin and eosin-stained tissue sections of tooth #29.*

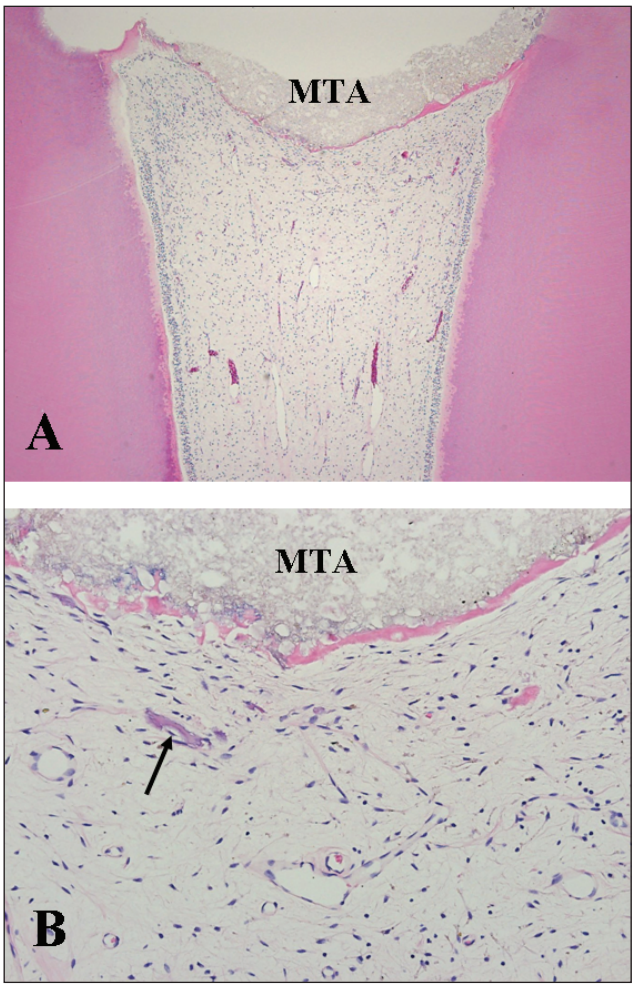

Figure 2A: Low-power (original magnification 10×) microphotograph showing a thin reparative dentin bridge below MTA and no inflammation in the underlying residual pulp tissue. A short segment of superficial odontoblastic layer just below the dentin bridge was destroyed. However, the deeper odontoblastic layer was intact. Figure 2B: High-power (original magnification 50×) microphotograph revealing no inflammation and a small focus of dystrophic calcification (arrow) in the underlying residual pulp tissue.

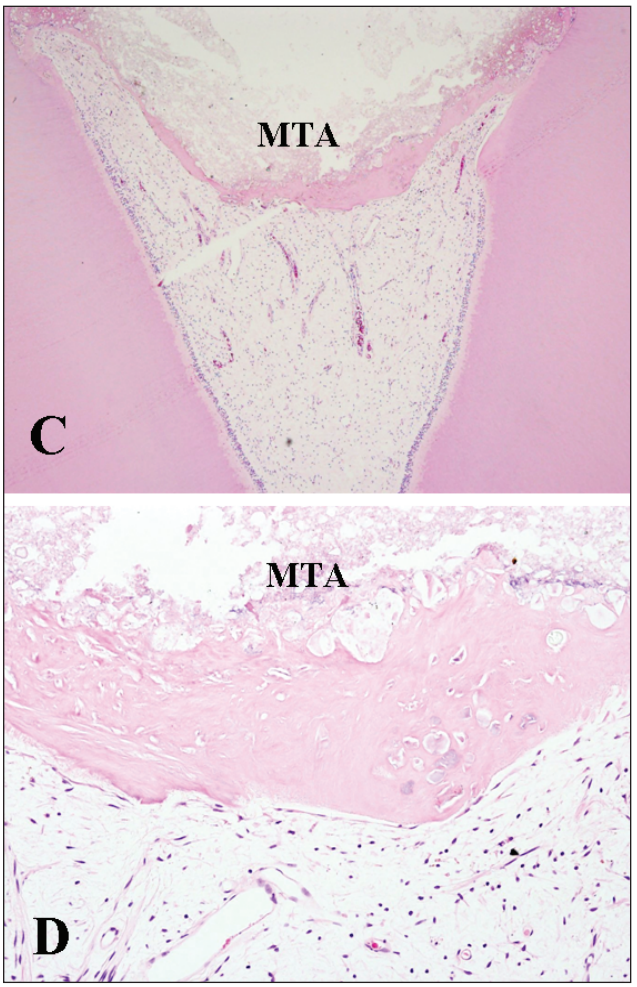

Figure 2C: Low-power (original magnification 10×) microphotograph of a deeper tissue section showing a thicker reparative dentin bridge below MTA and the nearly normal underlying residual pulp tissue. Figure 2D: High-power (original magnification 50×) microphotograph exhibiting the reparative dentin bridge that is made up of osteodentin and no inflammation in the underlying residual pulp tissue.

pression, the bleeding continued. Therefore, the Racelet cotton pellet (Pascal International, Inc, Bellevue, WA, USA) was used for compression. After the bleeding was controlled (Figure 1C), an approximate 2 mm-thick MTA paste was applied onto the exposed pulp tissue. A moist cotton pellet was placed onto the MTA paste and the cavity was sealed with Caviton (GC, Aichi, Japan). Because the MTA paste required moisture and took four-to-six hours to set, the tooth was restored with resin composite by a prosthodontist the next day. The patient claimed that the tooth was slightly sensitive after treatment but no analgesics were needed.

During the one-month follow-up period, tooth #29 was asymptomatic, having normal chewing function. A periapical radiograph showed normal periapex (Figure 1D). Electric pulp testing was performed, resulting in a reading of 67; whereas the reading was 41 for the two control teeth—#28 and #20. At the three- and 10-month follow-up, the electric pulp testing showed readings of 59 and 61 for tooth #29, respectively. In addition, the cold and percussion tests performed at one-, three- and 10-month follow-up visits were all within normal limits. The periapical radiographs taken at the three- and 10-month time periods revealed no apical pathosis (Figure 1E and 1F). Ten months after the initial treatment, due to orthodontic reasons, tooth #29 was extracted. It was then processed for histological examination.

To facilitate the penetration of fixing solution into the pulp tissue, 2 mm of the apex of the extracted premolar was cut off and the remaining tooth was fixed in

10% neutral formalin for seven days. The tooth was then decalcified in 14% EDTA solution for four weeks, subdivided axially into two halves in the bucco-lingual plane, embedded in paraffin and cut into 4 µm serial sections. The tissue sections were stained with hematoxylin and eosin (H&E) and examined by light microscopy.

Microscopically, the pulpal wound treated with MTA was free from inflammation and was covered with a thin reparative dentin bridge (Figures 2A and 2B). A short segment of the superficial odontoblastic layer just below the dentin bridge was destroyed. However, the deeper odontoblastic layer was intact (Figure 2A). When a deeper tissue section was observed, a thicker reparative dentin bridge was found. A high-power view showed that the reparative dentin bridge was made of osteodentin and there was also no inflammation in the underlying residual pulp tissue (Figures 2C and 2D).

DISCUSSION

In both animal and human studies, MTA has been shown to have excellent potential as a pulp-capping and pulpotomy medicament but studies with long-term follow-up are limited.[9] For healthy human third molars treated with pulpotomy and direct pulp capping with MTA, iatrogenic pulpal wounds were predominantly free from inflammation after one week and became covered with a dentin bridge of steadily increasing length and thickness within three months following capping procedures.[4] For healthy human premolars undergoing iatrogenic pulpotomy, the radicular pulps capped with MTA showed minimal inflammation and a homogeneous and continuous dentin bridge formation at the end of four and eight weeks.[5] The results of these two investigations indicate that MTA is a very biocompatible capping medicament for healthy human teeth.

Previous studies also showed that MTA can be used as a direct pulp capping agent for young permanent teeth with irreversible pulpitis.[6-8] When restorable human permanent first molars with carious pulp exposures were treated with partial pulpotomy, then capped with MTA, a clinical success rate of 93% was obtained after a follow-up period of 25-46 months. Furthermore, radiographic evidence of the presence of a hard tissue barrier under MTA was noticed in 64% of the treated teeth.[6] In a prospective clinical study using MTA as a direct pulp capping material for cariously-exposed young human permanent first molars undergoing partial pulpotomy, 22 of the 28 treated teeth did not show any clinical or radiographic signs of failure during the follow-up period for up to 24 months. The remaining six teeth did not respond to vitality testing at 24 months; however, no radiographic signs of failure or clinical symptoms were detected.[7] Another study assessed the clinical and radiographic outcomes of 23 caries or complicated enamel dentin fracture-induced pulp-exposed human teeth treated with MTA pulpotomy procedures. Of the 19 treated teeth that were available for recall after a mean follow-up time of 19.7 months, 15 were healed, three were healing and only one had persistent disease. In the current case report, a premolar with irreversible pulpitis receiving MTA pulpotomy also showed nearly normal residual pulp tissue 10 months after the initial treatment. The findings from the above studies also indicate that teeth with irreversible pulpitis can have a good clinical outcome after MTA pulpotomy.

Endodontists strive to maintain pulp viability of teeth with different severities of pulpal diseases. Previous studies have proven that a human immature open-apex permanent tooth with pulp necrosis and apical pathosis can still achieve continued root development after regenerative endodontic-treatment procedures with MTA.[3,10-12] In this case report, the authors demonstrate histological evidence that the MTA pulpotomy procedure can retain pulp viability of a tooth with irreversible pulpitis and demonstrate that an irreversible pulpitis tooth treated with MTA pulpotomy can achieve a successful outcome. In the current case, the carious tooth structures and contaminated bacteria in diseased pulp tissues were totally removed before placement of MTA. MTA has very good biocompatibility and sealing ability; not only can it serve as an inert capping material, but it can also induce dentin bridge formation. Because there is no further irritant coming from the pulp-surrounding environment, the residual inflamed pulp tissue finally has the chance to recover from its diseased status.

In this case report, continuous bleeding was found after pulpotomy and the bleeding could not be controlled by dry cotton pellet compression. This suggests that there is definite hyperemia in the inflamed pulp tissue. Moreover, the inflamed pulp tissue finally recovered from irreversible pulpitis, indicating the regenerative potential of adult pulp tissue. The authors also found very few odontoblasts beneath the dentin bridge, and pulp treated with MTA appeared to be slightly more hyperemic than normal pulp. The pH of MTA (12.5) is only slightly less than the pH of calcium hydroxide (12.8). However, the MTA may set within four to six hours in a moist condition but calcium hydroxide does not set. Therefore, irritation from MTA to residual pulp tissue is transient and milder than that from calcium hydroxide. This can explain why pulp treated with MTA has less chronic inflammation than pulp treated with calcium hydroxide. In addition, although MTA is very biocompatible, there is still mild hyperemia in residual pulp tissue 10 months after treatment.

In cases of vital inflamed pulp, it is difficult for clinicians to clinically determine whether pulp inflamma-

tion is reversible or irreversible. Moreover, clinical findings generally do not correlate with histological findings.[13] Therefore, when teeth with either reversible or irreversible pulpitis are treated, the most complicating factor is that clinicians do not know the degree of pulpal damage to teeth with these clinical diagnoses. It is hoped that as much of the pulp tissue as possible is preserved. An MTA pulpotomy may be the best procedure to provide an environment in favor of preserving viability of the pulp. It would be important to know whether human, fully-developed vital permanent teeth with irreversible pulpitis can still maintain their pulp viability after MTA pulpotomy. Thus, large-scale clinical or histological studies are needed to verify whether apex-closed vital permanent teeth with irreversible pulpitis can preserve their pulp viability after MTA pulpotomy.

CONCLUSIONS

In this case report, the authors adopted aseptic clinical procedures and successfully treated an apex-closed permanent second premolar having irreversible pulpitis with MTA pulpotomy. The authors suggest that, when caries and bacterial contamination can be mostly eliminated from the dentin-pulp complex and a hermetic coronal seal is built, the inflamed pulp of a human permanent tooth with irreversible pulpitis may have a chance to return to a healthy, functional status after MTA pulpotomy.

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