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## Revascularization of immature permanent teeth with periapical lesions—report of three consecutive cases

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### ABSTRACT

The treatment of teeth with non-vital pulps and incomplete root development is challenging. The shortened root, with its thin walls, predisposes these teeth to fracture. The traditional apexification procedure requires multiple treatment sessions, creating problems with patient compliance. There is increasing evidence to show that revascularization procedures may provide a more predictable outcome, while rendering mature root formation at the same time. This article describes three consecutive cases of successful revascularization.

**Key words:** Apexification; Periapical diseases; Root canal therapy

### Introduction

Traditional treatment of immature teeth with pulpal involvement can be classified into two categories: partial pulpotomy and apexification. Partial pulpotomy attempts to preserve the remaining vital pulp tissue for continuing physiological root maturation<sup>1</sup>. A high success rate (96%) has been reported<sup>1</sup>.

In cases where lesions of pulpal origin have already developed, Hertwig's root sheath is presumed destroyed, and continued root formation is no longer possible. In these cases, treatment aims to control the periapical infection; cleaning, shaping and sealing up the existing root canal. Apexification creates an environment enabling a calcified barrier at the root apex to be created to provide resistance for compaction of the gutta-percha root filling<sup>2</sup>. This involves long-term dressing of the root canal with non-setting calcium hydroxide (Ca[OH]<sub>2</sub>) that usually lasts up to 24 months. The problems with repeated Ca(OH)<sub>2</sub> dressing include poor patient compliance and root fracture during and after treatment<sup>3</sup> (Fig 1). Although apexification with mineral trioxide aggregate (MTA) allows shortening of the treatment period, the resulting immature root remains as fragile as it does with Ca(OH)<sub>2</sub>. The combined use of dentine bonding and polyethylene fiber reinforcement seems to increase the immature root's fracture resistance in vitro<sup>4</sup>, but the clinical evidence for this is still lacking.

Iwaya *et al.*<sup>5</sup> demonstrated that continued root development is possible in immature

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**Figure 1** Traditional apexogenesis using calcium hydroxide dressing. Apical closure established but large canal remains. (a) Tooth with vertical root fracture. (b) Buccal and (c) lingual views (arrows) 10 years after treatment

teeth with necrotic pulp. The group also coined the term 'revascularization' to describe their new procedure. This involves disinfection of the infected root canal using two antibiotics—a mixture of ciprofloxacin and metronidazole, instead of  $\text{Ca(OH)}_2$ . Afterwards, a blood clot is induced, retained, and permanently sealed in the root canal as scaffolding for continuous root maturation. Banchs and Trope<sup>6</sup> later adopted Sato *et al.*'s protocol<sup>7</sup>, and added minocycline to the antibiotic mixture. The following cases, where a tri-antibiotic paste was used, demonstrate that this new procedure offers predictable success when conditions are suitable and cases are correctly selected.

## Case reports

Three patients, each with one non-vital pulp in a permanent mandibular second premolar, were treated using identical methods over different periods in time. As all were treated in private practice, parental availability and preferences caused variations in their attendance schedules.

All the patients had been referred by their private general dentists for treatment of buccal discharging sinuses and each patient had only one infected tooth, with the rest developing normally. They had no congenital disease, no relevant medical history, and no drug allergies. Their pulpal status was reconfirmed using electric pulp tests and test cavity preparations. No abnormal periodontal probing was detected. All were diagnosed with periapical lesions of endodontic origin.

All patients attended for three visits of active treatment. Initial success was confirmed by the complete resolution of the swelling and buccal discharging sinus during the second

visit. No repeated dressing was necessary.

## Treatment

### First visit

The use of surgical operating microscope was preferred for the treatment. After dental rubber dam isolation, the root canal was accessed without local anesthetic. It was irrigated with 2.5% sodium hypochlorite with the use of a 27G endodontic irrigation needle (Max-i-Probe; Dentsply-Rinn, Elgin [IL], USA). The blunt-ended side-exiting needle also acted as a probe for cleaning the apical margin of the canal wall of any debris that resisted mechanical irrigation. A total of 30 mL of hypochlorite was used for each tooth. Care was taken not to allow the needle to disrupt the apical tissue.

After the bleeding was stopped and excessive moisture blotted dry using x-coarse paper points, the antibiotics were inserted into the canal using a regular amalgam carrier. The access cavity was sealed with a zinc oxide eugenol (ZOE) temporary filling material over dry cotton wool.

### Second visit

The buccal sinuses had resolved completely by the second visit. After performing inferior dental nerve block anesthesia, the tooth was isolated and prophylaxis was performed. The antibiotic dressing was rinsed from the canal, initially using 10 mL of 17% ethylenediaminetetraacetic acid, followed by hypochlorite, until the canal was free of debris.

The apical tissue was pecked, using a sterile hand spreader, until bleeding filled the canal up to 2 mm below the cemento-enamel junction. The blood column was left to clot for 10 minutes while the canal opening was covered

with sterile gauze to prevent airborne infection.

A thick mix of white MTA was inserted onto the blood clot in small increments using a regular amalgam carrier. The MTA was blotted dry of excessive moisture and blood before the next increment was added. This was stopped at about 3 mm below the occlusal surface to leave room for the final restoration. Moist cotton wool was used to cover the MTA, followed by a ZOE temporary filling.

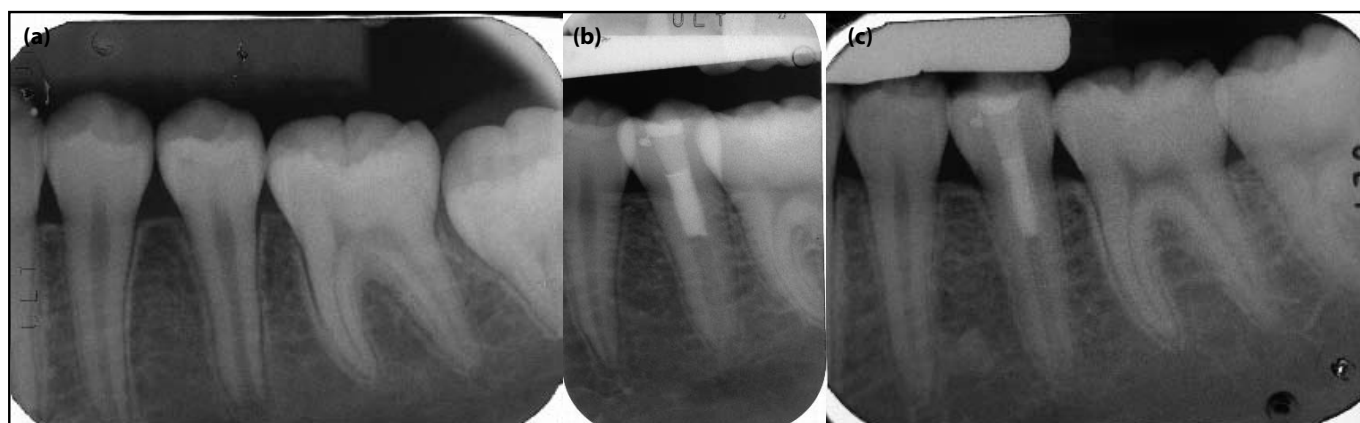
**Third visit**

At the third visit, the soft tissue was examined and none of the patients had any discomfort, recurrent swelling or sinuses. The MTA setting was confirmed under rubber dam isolation, without local anesthetic. The teeth were restored with acid-etch composite fillings over a glass ionomer base. The patients were scheduled for review every 6 months. The chronology of treatment is summarized in the Table and Figures 2-4.

Table	Treatment data summary		
	Case 1	Case 2	Case 3
Gender	Female	Female	Female
Age at commencement of treatment	11 years 5 months	11 years 11 months	12 years
Tooth No.	45	35	45
Date of initial opening	June 7, 2005	August 31, 2006	November 9, 2007
Date of mineral trioxide aggregate application	July 18, 2005	September 16, 2006	December 1, 2007
Date of final composite filling	July 25, 2005	September 27, 2006	December 15, 2007
Completion of root length formation (based on most recent radiographs)	August 15, 2006	October 23, 2007	January 10, 2009
Date of last review (time from finishing treatment)	January 19, 2010 (4 years 7 months)	February 6, 2010 (3 years 5 months)	January 16, 2010 (2 years 1 month)



**Figure 2** Radiographs of Case 1 (a) pre-surgery; (b) showing completion of root length formation; and (c) at follow-up. Notice canal obliteration that could complicate future root canal treatment if required



**Figure 3** Radiographs of Case 2 (a) pre-surgery; (b) showing completion of root length formation; and (c) at follow-up



**Figure 4** Radiographs of Case 3 (a) pre-surgery; (b) showing completion of root length formation; and (c) at follow-up

## Discussion

The incidence of dens evaginatus is above average in the Chinese population<sup>8</sup>. Pulpal necrosis may occur before complete root formation, resulting in tooth loss at a relatively young age due to root fracture even after successful apexification. Revascularization can cure the infection and allow continuous root formation at the same time. It has recently been shown in dogs that this new root growth is not the normal root structure<sup>9</sup>. The inside wall contains cementum-like tissue called ‘intracanal cementum’, and bone or bone-like tissue called ‘intracanal bone’. Connective tissue similar to the periodontal ligament was also present. Only one case showed partially vital pulp tissue with fibrous connective tissue<sup>9</sup>. Nevertheless, Banchs and Trope<sup>6</sup> showed that their samples responded to electric pulp testing. It is not known whether these differences will alter the long-term survivability of the tooth.

The use of a polyantibiotic cocktail as a root canal medicament is not new. Grossman<sup>10</sup> proposed the use of a polyantibiotic paste (named PCBS), and an antifungal version with the addition of nystatin (named PCBN). Iwaya *et al.*<sup>5</sup> used an antibiotic cocktail in the initial visit and Ca(OH)<sub>2</sub> during the final visit. Banchs and Trope<sup>6</sup> did not advocate Ca(OH)<sub>2</sub> due to its potentially damaging effect on the apical tissue. Instead the antibiotic cocktail suggested by Sato *et al.*<sup>7</sup>—a mixture of minocycline, ciprofloxacin, and metronidazole—was adopted.

Mineral trioxide aggregate is an ideal material for sealing a wet interface like a blood clot. It develops a good seal in a moist environment and has sufficient mechanical

properties to resist packing. It is compatible with both glass ionomer and composite resin materials<sup>11,12</sup>.

The blood clot provides the scaffolding for continued root formation. Besides acting as a physical scaffold, it may also contain other growth factors necessary for protein synthesis and hard tissue deposition like activated platelets<sup>13</sup>. It is believed that the new odontoblastic layer differentiates from stem cells originating from the periodontal ligament and bone marrow<sup>14</sup>, but this has to be further confirmed. The root develops from Hertwig’s root sheath. Apparently the root sheath at the apical end is still viable in young individuals, despite a necrotic pulp<sup>15</sup>. Revascularization may not be applicable in patients with complete tooth development<sup>16</sup>.

## Conclusion

Three patients with immature mandibular second premolar with necrotic pulps were successfully treated with revascularization. This new treatment seems to offer a predictable result in young patients when root formation has not yet been completed. The natural length of the tooth is restored, although not the normal histological structure. Compared with traditional apexification, the requirement for patient compliance is low and the treatment is not objectionable. The long-term outcome of this treatment, including tooth survival, is still uncertain, compared with teeth treated using conventional apexification. Nonetheless, the results of this and similar studies<sup>17,18</sup> are encouraging. With more clinical evidence and experience, revascularization may become the standard treatment for this age-group.

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