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Continued Root-End Growth and Apexification Using a Calcium Hydroxide and Iodoform Paste (Metapex®): Three Case Reports

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Abstract

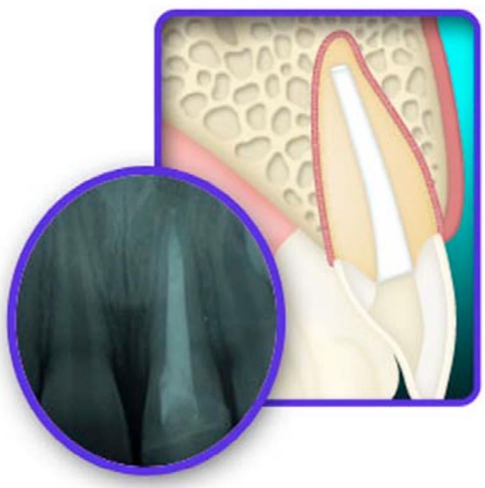
Aim: The aim of these case reports is to present a treatment to promote root-end growth and apexification in nonvital immature permanent teeth in children.

Methods and Materials: Three cases were presented where the calcium hydroxide and iodoform paste Metapex® was placed in the root canals of immature permanent teeth using disposable plastic tips. The teeth involved were evaluated radiographically at regular intervals for the first 12 months after placement of the paste. At the end of 12 months all the cases showed continued root growth and apical closure (apexification) with no evidence of periapical pathology. Conventional endodontic treatment was then performed.

Results: In all three of the clinical cases presented, a combination of calcium hydroxide and iodoform paste (Metapex®) was used and showed promising results in inducing root-end growth and closure after 12 months.

Conclusion: In these three clinical cases, the calcium hydroxide and iodoform paste Metapex® (Meta Biomed Co. Ltd., South Korea) was found to induce apical closure when assessed radiographically. Over a period of 12 months all the cases showed continued root growth.

Clinical Significance: The calcium hydroxide and iodoform paste Metapex® promoted continued root-end growth with apexification in the nonvital immature permanent teeth treated.



Keywords: Apexification, apical closure, endodontics, Metapex®, calcium hydroxide

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Introduction

The completion of root development in permanent teeth takes a minimum of three years after

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eruption. Consequently, any pulpal injury that occurs during this period can impair root development and apical closure, and apical closure then becomes a challenge to manage appropriately for the clinician. Apexification is defined as "a method to induce a calcific barrier in a root having an open apex or the continued root development of an incomplete root in teeth with necrotic pulp."[1] Success in achieving apexification depends on an accurate diagnosis, an understanding of the biological processes involved, and ideal case selection.

Root development begins when enamel and dentin formation has reached the future cementoenamel junction (CEJ). At this stage the inner and outer enamel epithelia are no longer separated by stratum intermedium and stellate reticulum, but develop as a two-layered epithelial wall to form Hertwig's epithelial root sheath (HERS). When the differentiation of radicular cells into odontoblasts has been induced and the first layer of dentin has been laid down, HERS begins to disintegrate and loses its continuity and close relationship to the root surface. However, HERS remains persist as an epithelial network of strands or tubules near the external surface of the root.[2]

HERS also is responsible for determining the shape of the root. The epithelial diaphragm surrounds the apical opening to the pulp and eventually becomes the apical foramen. An open apex is found in the developing roots of immature teeth until apical closure occurs approximately three years after eruption.

Traumatic injuries to young, permanent teeth are not uncommon, and they can adversely affect root development. The majority of these injuries occur before root formation is complete, which may result in pulpal inflammation and necrosis. The root sheath of Hertwig is sensitive to trauma, but because of the degree of vascularity and cellularity in the apical region, root formation can continue even in the presence of pulpal inflammation and necrosis.[3,4] Because HERS plays an important role in root formation after pulpal injury, every effort should be made to maintain its viability. HERS also is thought to provide a source of undifferentiated cells that give rise to hard tissue formation. It also may protect against ingrowth of periodontal ligament cells into the root canal that can lead to intracanal bone formation and the arrest of further root development.[5]

Complete destruction of HERS results in cessation of root development. This doesn't mean that there is no end to deposition of hard tissues in the region of the root apex. Once the root sheath is completely destroyed, there can be no additional source for odontoblast differentiation. However, hard tissue can be formed by cementoblasts normally present in the apical region, by fibroblasts of the dental follicle, and by periodontal ligaments that undergo differentiation after an injury to become hard tissue–producing cells.[6]

Methods and Materials

Materials Used for Apexification

Calcium Hydroxide

A variety of materials have been used for induction of the apical barrier in necrotic young permanent teeth. The use of calcium hydroxide reportedly was first introduced by Kaiser in 1964, who proposed that when mixed with camphorated parachlorophenol (CMCP), calcium hydroxide would induce the formation of a calcific barrier across the apex.[7] This procedure was popularized by Frank,[7] who emphasized the importance of reducing contamination within the root canal by instrumentation, medication, and a temporary decrease in the canal space made with a resorbable paste seal. A number of studies reported a high success rate using calcium hydroxide and CMCP.[8–10] Klein and Levy[11] described successful induction of an apical barrier using calcium hydroxide and cresatin. Cresatin had been shown to have minimal inflammatory potential as a root canal medicament and to be significantly less toxic than CMCP.[12]

Because the calcium ions at the apical region come from the bloodstream, the mechanism of action of calcium hydroxide in barrier formation is still considered controversial.[13,14] Mitchell and Shankwalker[15] studied the osteogenic potential of calcium hydroxide when implanted into the connective tissue of rats. It was concluded that calcium hydroxide had the potential to induce heterotopic bone in this situation. It also has been demonstrated that an apical barrier is more successful in the absence of microorganisms[16] and

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the antibacterial efficacy of calcium hydroxide has been established.[17] This antimicrobial activity actually is related to the release of hydroxyl ions from the calcium hydroxide that are highly oxidant and show extreme reactivity. These ions cause damage to the bacterial cytoplasmic membrane, protein denaturation, and damage to bacterial DNA.

Despite its popularity for the apexification procedure, calcium hydroxide has some inherent disadvantages, including variability of treatment time, unpredictability of apical closure, difficulty in patient follow-up, and delayed treatment.[18] Calcium hydroxide also has some tissue-altering and dissolving effects.[19] Therefore, the search continues for procedures and materials that will allow for more natural continued root growth and apical closure in teeth with immature apices.

Mineral Trioxide Aggregate (MTA)

Although calcium hydroxide has been the material of choice for apexification, clinical trials have been conducted using a variety of other materials. In the 1970s investigators used tricalcium phosphate for barrier formation and found it to be successful.[20,21] In recent times interest has centered around use of mineral trioxide aggregate in the form of the commercial product, Proroot MTA (Dentsply Tulsa, Tulsa, OK, USA), for apexification. This material was first introduced in 1993 and received Food and Drug Administration (FDA) approval in 1998. MTA is a powder consisting of hydrophilic particles of tricalcium silicate, tricalcium oxide, and silicate oxide. MTA has demonstrated good sealability and biocompatibility.[22] MTA has a pH of 12.5 after setting, which is similar to calcium hydroxide, and is reported to have some antimicrobial properties.[23]

Morse et al.[24] defined one-visit apexification as the nonsurgical condensation of a biocompatible material into the apical end of the root canal to establish an apical stop that would enable the root canal to be filled immediately. There have been a number of reports describing the use of MTA in apexification. For example, Witherspoon and Ham[25] stated that MTA provides scaffolding for hard-tissue formation and the potential for a better biological seal. It was concluded that MTA is a viable option for treating immature teeth with necrotic pulps and should be considered as an effective alternative to calcium hydroxide.

As to the cost-effectiveness of MTA, the product is expensive and once the pouch is open it has to be used immediately, and it cannot be stored for a long period of time. Also MTA absorbs moisture from its surroundings and sets into a hard mass. Thus, MTA has certain disadvantages that should be considered despite its good clinical success.

Calcium Hydroxide and Iodoform Paste (Metapex®)

A viscous paste mixture of calcium hydroxide and iodoform has been used as a root canal filling material in primary teeth. Several studies have been conducted, mainly in Japan,[26,27] the United States,[28] and South America,[29] that demonstrated good clinical and radiographic success. A commercial product named Metapex® (Meta Biomed Co., Ltd, Korea) has been used as a root canal filling material in primary teeth. It contains iodoform (40.4 percent), calcium hydroxide (30.3 percent), and silicone oil (22.4 percent). However, very few studies have reported on the efficacy of this material when it is used for apexification.[30,31]

This article reports on three cases in which the calcium hydroxide and iodoform paste Metapex® was used successfully to promote root-end growth and apical closure (apexifcation) in the permanent teeth of children.

Case Reports

Case 1

An 8-year-old child reported with the chief complaint of pain in the mandibular right and left posterior regions with a history of pain onset when eating food or any cold beverages and the pain lasts for several hours. A clinical examination revealed deep carious lesions in the mandibular right first molar (tooth 46) and the left first molar (tooth 36) extending into the pulp.

The radiographic examination of tooth 46 confirmed pulpal and periapical involvement (Figure 1). The root apices were formed but not completely closed. It was decided to induce root completion by using the calcium hydroxide and iodoform paste Metapex®. Complete pulp removal was performed and then Metapex® was placed into the root canals using the disposable plastic tips provided in the kit. The occlusal surface was sealed with a provisional material (Cavit,™ 3M ESPE, St. Paul, MN, USA). An immediate

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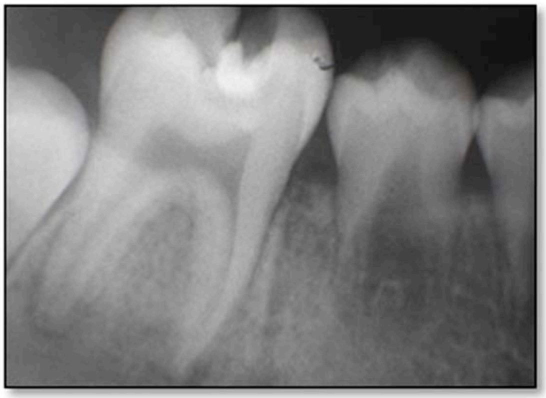

Figure 1. Periapical radiograph of the mandibular right first molar (tooth 46) showing a deep carious lesion in dentin with periapical involvement.

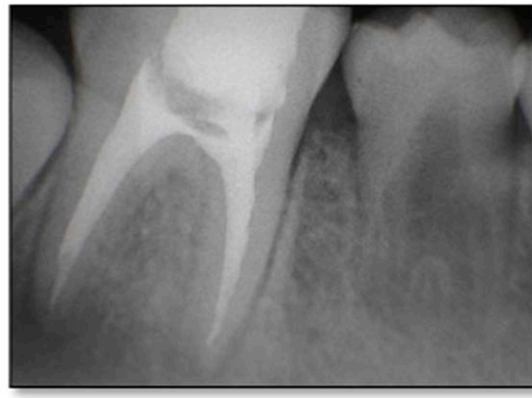

Figure 2. Radiograph taken immediately after placement of Metapex® and sealing the tooth with a provisional restoration.

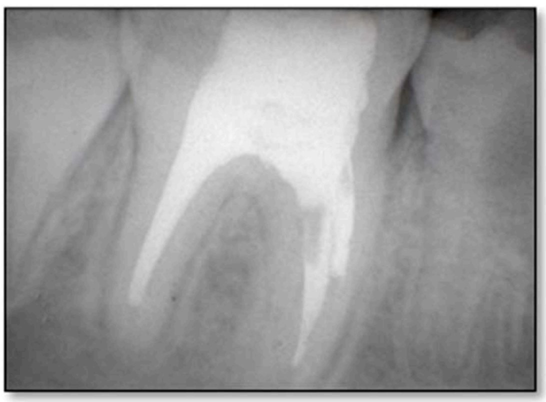

Figure 3. Continued root formation was evident in this radiograph taken 12 months after placement of Metapex®.

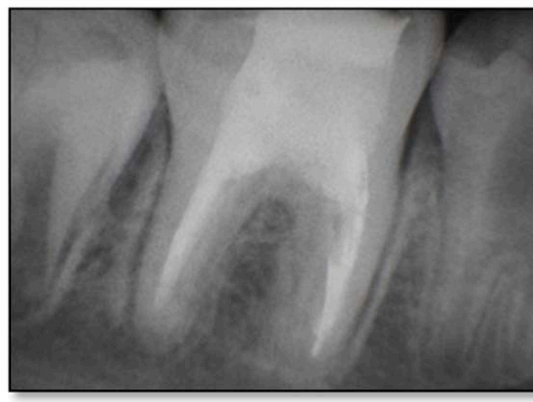

Figure 4. Postoperative radiograph following completion of conventional root canal therapy.

postoperative radiograph was taken to assess the extent and placement of the material in the root canals (Figure 2).

The child's progress for apexification was followed for 3, 6, and 12 months (Figures 3 and 4). At the end of 12 months there was an increase in the root length, so conventional root canal treatment was performed. The tooth was then restored with a stainless steel crown.

The patient's mandibular left first molar (tooth 36) had the same diagnosis, was treated similarly, and also was reexamined at 3, 6, and 12 months. There also was an increase in root length at the end of one year (Figures 5, 6, and 7).

Case 2

This 7-year-old male child reported pain in the mandibular right posterior region. After thorough examination it was decided to initiate apexification for the mandibular right first molar (tooth 46) because the root apices had not closed completely. The affected tooth was treated with Metapex® in an attempt to initiate apexification. Follow-up appointments and examinations took place at 3, 6, 9, and 12 months. At the end of one year there was radiographic evidence of continued root formation (Figures 8, 9, and 10).

Case 3

This 10-year-old male child complained of pain in the maxillary anterior region for approximately one

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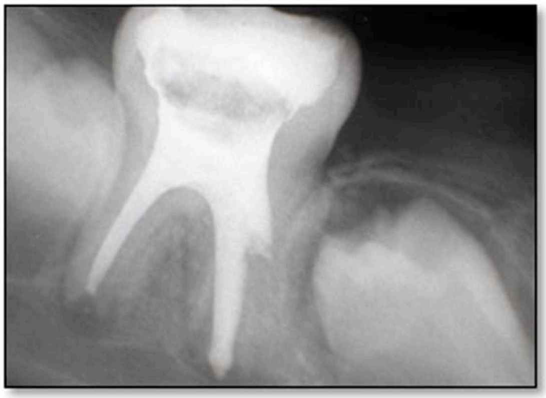

Figure 5. Periapical radiograph of the mandibular left first molar (tooth 36) at baseline.

Figure 6. Periapical radigraph of tooth 36 at 6 months.

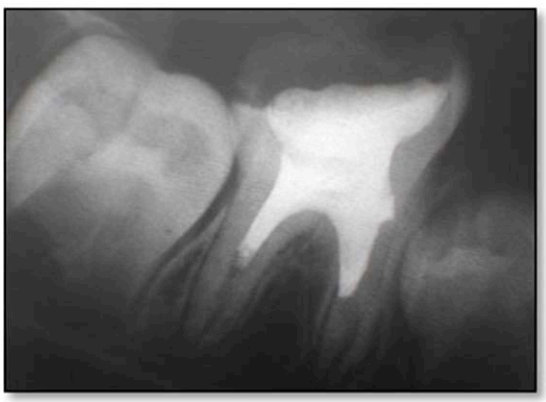

Figure 7. Periapical radiograph of tooth 36 at 12 months.

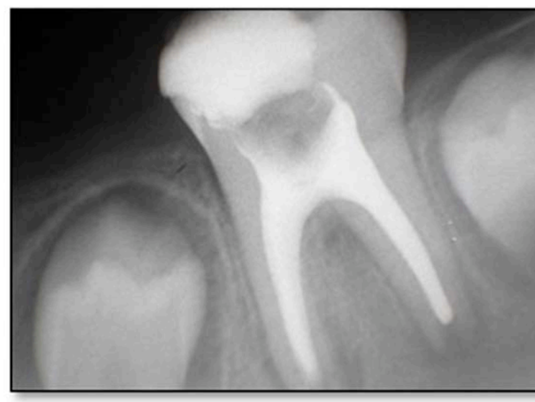

Figure 8. Periapical radiograph of the mandibular right first molar (tooth 46) after treatment with Metapex® for a baseline reference.

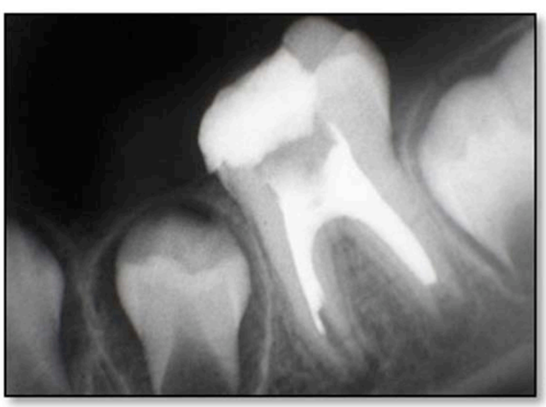

Figure 9. Periapical radiograph of tooth 46 six months after treatment with Metapex®.

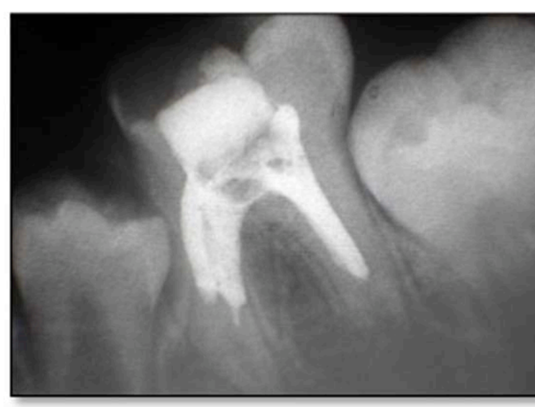

Figure 10. Periapical radiograph of tooth 46 12 months after treatment, with evidence of continued root formation.

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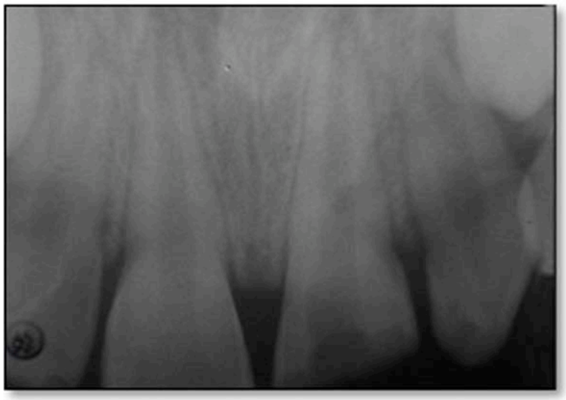

Figure 11. Pretreatment periapical radiograph of the fractured maxillary left central incisor (tooth 21).

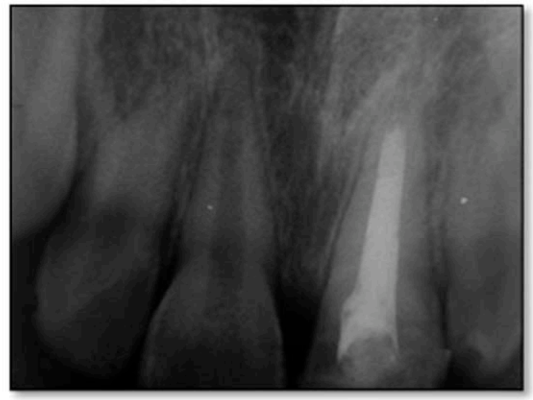

Figure 12. Periapical radiograph of tooth 21 at the six-month recall appointment.

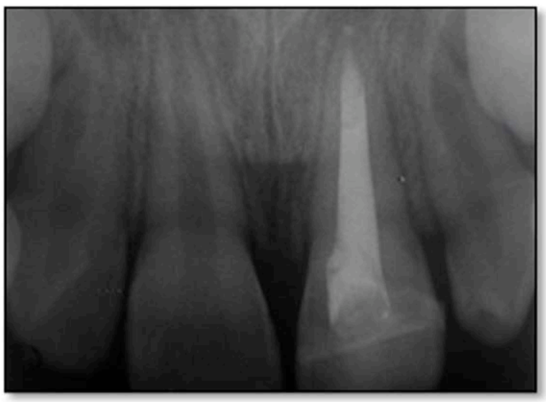

Figure 13. Periapical radiograph taken at the 12-month recall appointment with evidence of apexification.

month when he collided with a wall and broke his maxillary left central incisor (tooth 21). The patient was able to locate the broken tooth fragment and brought it with him to his dental appointment. Clinical and radiographic examinations revealed that there was an Ellis class III fracture of the incisor with obvious pulpal involvement (Figure 11). Pulp vitality tests indicated that the tooth was nonvital.

The fractured clinical crown was reattached using resin-based composite and a laminate veneer technique. After the clinical crown was restored, an access opening was created on the lingual aspect and complete pulp extirpation was accomplished using barbed broaches.

Because the root development was incomplete, Metapex® paste was placed inside the root in an effort to achieve apexification. The patient was reappointed for follow-up clinical and radiographic examination at 6 and 12 months. After complete root formation was achieved, the tooth was treated with conventional endodontic therapy and obturated with gutta percha (Figures 12 and 13).

Discussion

In apexification completion of root development can be achieved by placement of certain biocompatible materials in the root canals to the apical region. Use of calcium hydroxide and iodoform in apexification also has been reported.[31,32] Lu & Qin[30] compared an antibiotic paste and Vitapex® paste (calcium hydroxide and iodoform) for their use in apexification. Over a follow-up period of 30 months, they concluded that both materials showed the same level of radiographic success. But in those cases where periapical inflammation was present, the antibiotic paste produced superior results.
In another study, Weng[31] evaluated 64 younger permanent teeth with underdeveloped root apices and necrotic pulps. After the root canals were prepared and sterilized, Vitapex® paste was placed in an attempt to achieve apexification. All the teeth were observed for three years, and 24 teeth (37.5 percent) successfully achieved apexification, 37 teeth (57.81 percent) were in the process of root-end closure, and only 3 teeth (4.69 percent) failed to achieve apexification. Altogether the treatment was successful for 61 teeth, for an effective rate of 95.3 percent. Weng[31] concluded that Vitapex® paste was an effective material for achieving apexification for younger permanent teeth.

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Each of the three cases presented included clinical and radiographic evidence of success in achieving apexification. Unlike with barrier formation, continued root growth was observed for all of the treated teeth. A similar finding for Vitapex paste was reported by Gu et al.,[32] where there was complete root development and apical closure involving seven teeth.

Ghose et al.[33] described the barrier as a cap, bridge, or ingrown wedge that may be composed of cementum, dentin, bone, or osteodentin. This osteodentin, when present, appears to be formed by connective tissue at the apices where Hertwig's epithelial sheath is not seen. Torneck et al.[34] reported that a bonelike material was deposited on inner walls of the canal, while Steiner and Van Hassel[35] demonstrated apical closure by formation of a calcific barrier that satisfied the usual histological criteria for identification as cementum. Study of several sections gave the impression that cementum formation proceeds from the periphery of the original apex towards the center of the root in decreasing concentric circles. In these clinical cases it is believed that continued root formation took place because of the activity of Hertwig's epithelial sheath present at the apex.

Both clinical and radiographic follow-up of the teeth treated with Metapex® showed the absence of clinical symptoms and continued hard-tissue formation at the apex. Even though there are no other reports of such findings, these observations are consistent with the results reported by Weng.[31]

Conclusion

1. Based on these clinical observations, the following conclusions were made:
2. The cases treated with Metapex® showed good clinical and radiographic evidence of success in promoting continued root growth and inducing root-end closure in immature young permanent teeth.
3. Barrier formation was not evident in any of the three cases presented.
4. Metapex® can be used as a medicament to promote root growth and apexification.

Clinical Significance

The calcium hydroxide and iodoform paste Metapex® promoted continued root-end growth with apexification in the treated nonvital immature permanent teeth.

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