# Retrospective study of clinical and radiographic procedures in traumatized teeth submitted to apexification

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DOI: https://doi.org/10.14436/2358-2545.9.2.029-035.oar

**ABSTRACT**

**Introduction:** Traumatic injuries may result in pulp necrosis in immature permanent teeth. **Objective:** This study aimed at evaluating the clinical and radiographic procedures for treatment of the non-vital immature teeth after apexification. **Material and Method:** This is a cross-sectional study that used the medical records of a center of reference in dental trauma, from 2005 to 2015. Thirty permanent teeth with pulp necrosis and open apex were included in this study whose treatment adopted was the apexification and filling of the root canal. The following parameters were analyzed: age, gender, type of trauma, impacted tooth, Nollas stage, periapical lesion, apex shape, type of the treatment used, and the radiographic evaluation of the apical barrier. Fishers Exact Test ($p<0.05$) was applied to evaluate possible associations between the total apical barrier formation and the variables of this study. **Results:** Most of them were male. The age group involved was from 6 to 10 years old; the most affected tooth was the central upper incisor, and the complicated fracture was the most prevalent. Of these teeth, 36.7% had a periapical lesion; the majority was at Nollas stage 9 and with a convergent apex (46.66%). For the treatment of immature teeth, calcium hydroxide (63.3%) and MTA (6.7%) were used as intracanal medication. Investigations on possible associations between the complete apical barrier formation and other variables were carried out, but without statistically significant results ($p>0.05$). **Conclusion:** Both calcium hydroxide and MTA were able to induce apexification, as well as tissue repair of the traumatized teeth evaluated.

**Keywords:** Endodontics. Tooth Apex. Calcium Hydroxide

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**How to cite**: Marques IV, Santana RG, Morais CAH, Queiroz AF, Pavan NNO, Nunes MCP, Endo MS. Retrospective study of clinical and radiographic procedures in traumatized teeth submitted to apexification. Dental Press Endod. 2019 May-Aug;9(2):29-35. DOI: https://doi.org/10.14436/2358-2545.9.2.029-035.oar

» The authors report no commercial, proprietary or financial interest in the products or companies described in this article.

» Patients displayed in this article previously approved the use of their facial and intraoral photographs.

Submitted: March 02, 2017. Revised and accepted: November 17, 2017.

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## Introduction

The International Association of Dental Traumatology reported that one in two children suffer a dental injury most often between 8 and 12 years of age.[1] Dental trauma is currently considered a public health problem, and its prevalence will increase in the future, due to the greater exposure of individuals to situations of risk,[2] such as sports practices, traffic accidents and some forms of violence. These injuries mainly affect children and young people, where pulp and periodontal formation and maturation processes have not yet been completed.[3]

The sequelae caused by dental trauma include pulp and periodontal damage. In cases of pulp necrosis, in permanent teeth with incomplete rhizogenesis, root formation ceases and apical closure cannot be achieved; so the treatment becomes a barrier to be overcome. Differently from a mature tooth that reached Nolla's stage 10, where the presence of apical constriction facilitates the endodontic maneuvers of preparation and filling; in permanent teeth with an open apex, the root canal usually has an hourglass shape. In these teeth, the foramen aperture has a larger diameter, the root walls are thin and fragile, contraindicating the conventional chemical-mechanical preparation and impeding the safe filling of these canals.[4,5] Moreover, the affected children are young and may present resistant behavior, which complicates the provision of dental care.[6]

One of the forms of treatment for these teeth with incomplete rhizogenesis and pulp necrosis is the apexification. This is the process by which an immature permanent non-vital tooth, which has lost its capacity for root development, is induced to form a calcified barrier at the apex.[7] The technique consists of emptying the canal, then perform the instrumentation, and subsequently using an intracanal medication to induce the formation of a mineralized tissue barrier at the apex of devitalized teeth with incomplete rhizogenesis. The formation of this apical barrier is necessary to allow filling of the root canal without the risk of overfilling.[5,8]

Over time, several substances were used as intracanal medication in necrotic teeth with incomplete root formation. Among them, stands out the zinc oxide paste with cresol, iodoform and thymol.[9] Other materials such as: antiseptic pastes, antibiotic pastes, ceramic tricalcium phosphate, osteogenic protein 1 (OP-1), mineral trioxide aggregate (MTA) and calcium hydroxide [$Ca(OH)_2$] associated with different substances are also employed. Despite this, treatment with calcium hydroxide became the gold standard.[10,11]

Calcium hydroxide has been widely used to induce apexification.[4,12] Its advantages include antimicrobial activity, induction and formation of hard tissue through alkaline phosphatase, besides the low cost and easy handling. The success of calcium hydroxide in different vehicles as intracanal medication in apexification has been reported in the literature. The duration of successful apexification was variable,[8] and several clinical visits and a long period of time are required for the end of treatment. In addition, prolonged use of $Ca(OH)_2$ may alter the physical properties of dentin, and may reduce the hardness and modulus of elasticity of dentin as demonstrated in vitro. Moreover, long-term therapy can make dentin walls fine and even more prone to fractures.[13]

Another alternative for the treatment of teeth with incomplete rhizogenesis is the use of an mineral trioxide aggregate (MTA) apical plug.[14] It has a high pH and antibacterial qualities similar to $Ca(OH)_2$, is biocompatible, and induces the formation of hard tissue.[12] The advantage of MTA over calcium hydroxide is the lower number of dental visits, since intracanal medication with $Ca(OH)_2$ needs to be changed frequently, varying according to the associated vehicle. The apical plug with MTA allows a reduction in treatment time[15] in addition to the properties of inducing the formation of cement-like tissue.[16] The disadvantage of MTA over calcium hydroxide is its higher cost.[17]

## Objective

This study aimed to perform a retrospective and documentary evaluation of the clinical and radiographic procedures of the treatment by apexification of the patients treated in a center of reference in dental trauma.

## Material and methods

This work was approved by the research ethics committee, with certificate of presentation for ethical evaluation (CAAE) 603116.6.0000.0104.

 

## Object of study

This is a retrospective cross-sectional documentary study on 788 records of a center of reference in dental trauma, between 2005 and 2015.

Sample selection: inclusion and exclusion criteria

This study included in only the cases of permanent teeth with incomplete root formation diagnosed with pulp necrosis, whose treatment was the apexification. On the other hand, improperly filled records, poorly processed or nonexistent radiographs were excluded from this study. Patients who abandoned treatment before completing apexification and root canal filling were also excluded.

## Variables analyzed: personal, clinical and radiographic information

Data was collected by a single examiner, and transferred to a spreadsheet in Excel (Microsoft Office Professional Plus 2010).

The following parameters were evaluated: age, gender, ethnicity, type and cause of trauma, impacted tooth, Nolla's stage, periapical lesion and apex shape. The apex shape was classified similarly to the study of Dominguez-Reyes et al.[11] into: convergent, parallel or divergent. The type of treatment applied to the tooth with incomplete root formation was analyzed, whether the changes of intracanal medication with calcium hydroxide, or the mineral trioxide aggregate (MTA) apical plug. Information on intracanal medication was also recorded: type, number of changes of intracanal medication with calcium hydroxide and total duration of the changes (months). According to Lopes and Siqueira,[18] the type of apical barrier formed was classified as: I. Single/double sealing (Fig 1), II. Total calcification of the apical portion (Fig 2), III. Closing in a semicircle (Fig 3), IV. Thin calcification (Fig 4).

Further, the total treatment time from crown opening to filling and finally control of this traumatic element was observed (Table 1).

## Statistical analysis

Fisher's exact test ($p < 0.05$) checked for possible associations between total apical barrier formation and some variables, such as type of dental trauma, apex shape, periapical lesion, number of calcium hydroxide changes, total period of calcium hydroxide changes, total time of treatment and control.

**Figure 1.** Single sealing.

**Figure 2.** Total calcification of the apical portion.

**Figure 3.** Closing in a semicircle.

**Figure 4.** Thin calcification.

**Table 1.** Variables and subdivisions analyzed in the present study.

| | Variables and subdivisions |
|---|---|
| **Variables** | **Variables subdivisions** |
| Age | 0 = 6 years; 1 = 7 years; 2 = 8 years; 3 = 9 years; 4 = 10 years |
| Gender | 0 = Female; 1 = Male |
| Ethnicity | 0 = Leucoderma; 1 = Melanoderma; 2 = Xantoderma |
| Type of trauma | 0 = Crown fracture without exposure; 1 = Crown frac-ture with exposure; 2 = Subluxation ; 3 = Intrusive lux-ation; 4 = Extrusive luxation; 5 =Avulsion |
| Tooth | 0 = #11; 1 = #21; 2 = #12; 3 = #22 |
| Nolla's stage | 0 = Stage 8; 1 = Stage 9 |
| Periapical lesion | 0 = no; 1 = yes |
| MTA | 0 = no; 1 = yes |
| Open apex shape | 0 = Convergent; 1 = Parallel; 2 = Divergent |
| Number of medi-cation changes | 1 = Up to 4; 2: More than 5 |
| Apical barrier formation | 0 = Total calcification of the apical barrier; 1 = Other categories |
| Duration of changes of $Ca(OH)_2$ | 1 = 0-12 months; 2 = ≥ 13 months |
| Total treatment time | 1 = 0-12 months; 2 = ≥ 13 months |
| Control | 0 = No control; 1 = With control |

## Results

### Characterization of patients, teeth and other variables investigated

A total of 30 teeth with incomplete rhizogenesis were evaluated in 27 patients, 19 males (70.4%) and 8 females (29.6%). The age group involved was 6 to 10 years old. The most affected age was 8 years (50%), followed by 10 years (30%). The ethnicities of the patients were leucoderma (90%), melanoderma (6.67%) and xantoderma (3.33%). Of the 30 investigated teeth, 13 were upper right central incisor,[11] 2 upper right lateral incisor,[12] 14 upper left central incisor[21] and 1 upper left lateral incisor.[22] Among these teeth, eleven had a periapical lesion (36.7%) and the majority (83.3%) was at Nolla's stage 9. The types of root apex were classified similarly to Dominguez Reyes et al.[11] into convergent (46.66%), parallel (36.66%) and divergent (16.66%) walls. The injuries found consisted of crown fracture without pulp exposure (25.7%), crown fracture with pulp exposure (33.3%), subluxation (3.33%), intrusive dislocation (3.33%), and extrusive dislocation (13, 33%) and dental avulsion (20%). Among the causes of these injuries, we observed a higher percentage of falls (73.33%), followed by collision (23.33%) and run over (3.33%).

For the treatment of teeth with incomplete rhizogenesis, calcium hydroxide (63.3%), formocresol and calcium hydroxide (30%) and calcium hydroxide and MTA (6.7%) were used as intracanal medication. The number of changes of calcium hydroxide-based medication ranged from 1 to 9. The frequency of changes in most patients was monthly and the mean duration of these changes was 5.8 months. The mean total treatment time from crown opening to root canal filling was 11 months.

### Association between the complete formation of the apical barrier and other variables investigated

Investigations on possible associations between complete apical barrier formation and other variables were performed, but none of them showed statistically significant results ($p > 0.05$) (Table 2).

## Discussion

Treatment of permanent teeth with incomplete rhizogenesis is one of the most challenging endodontic procedures.[19] These teeth usually have large canals, thin dentinal walls, and open apices, which makes it difficult to determine the working length, besides in-

**Table 2.** Analysis of associations between variables analyzed and tissue repair.

| | | TISSUE REPAIR | | | | |
|---|---|---|---|---|---|---|
| | | Total Calci-fication of the apical portion | Single/double sealing | Semicircle calcification | Thin calci-fication | p va-lue |
| Open apex shape | Convergent | 9 | 1 | 1 | 3 | 0,0577 |
| | Parallel | 5 | 2 | 2 | 2 | |
| | Divergent | 0 | 2 | 0 | 3 | |
| Periapical lesion | Yes | 5 | 1 | 3 | 2 | 1,000 |
| | No | 9 | 4 | 0 | 6 | |
| Type of trauma | Crown fracture without exposure | 4 | 1 | 2 | 1 | 0,3906 |
| | Crown fracture with expo-sure | 5 | 2 | 0 | 3 | |
| | Subluxation | 0 | 0 | 0 | 1 | |
| | Intrusive Luxation | 1 | 0 | 0 | 0 | |
| | Extrusive Luxation | 3 | 0 | 1 | 0 | |
| | Avulsion | 1 | 2 | 0 | 3 | |
| Duration of changes of $ca(oh)_2$ | 0-12 months | 14 | 5 | 3 | 6 | 0,4851 |
| | ≥13 months | 0 | 0 | 0 | 2 | |
| Total treatment time | 0-12 months | 10 | 4 | 2 | 5 | 0,6887 |
| | ≥13 months | 4 | 1 | 1 | 3 | |
| Control | No | 2 | 0 | 0 | 3 | 1,000 |
| | Yes | 12 | 5 | 3 | 5 | |

creasing the chance of overflow of irrigators and filling material to periapical tissues.[5,19] Dental trauma is an important factor to be considered in the incidence of pulp necrosis in immature permanent teeth. According to Andreasen & Ravn,[20] approximately 22% children suffer from trauma in permanent dentition, between 7 and 10 years of age, more frequent in boys and affecting the upper central and lateral incisors. Although old data, they are in accordance with the present study, indicating that there were no significant modifications.

Historically, the treatment for necrotic teeth and with open apices is the use of calcium hydroxide[12] to induce apexification after disinfection of the root canal by the conventional method. In the present study, most of the changes were performed each month and the total duration of the changes was, on average, 6 months. This period was similar to that reported in other works,[7,13,21,19] who also needed multiple sessions lasting between 3 and 24 months. Prolonged use of calcium hydroxide can alter the physical properties of dentin and reduce root resistance.[13]

Another alternative for apexification is the preparation of the apical barrier of MTA,[14] which has shown satisfactory results,[21] reduces the duration of the treatment, with a better acceptance from the patient,[21] allows definitive restoration immediately[22] and prevent from possible fractures of the immature tooth.[23] Although this treatment reduces the number of visits, MTA apexification does not increase the root resistance, the thickness and length of root canal walls.[24] The study performed Lee et al[25] observed that the average root length of necrotic incisors and open apices treated with MTA was significantly lower than those treated with $Ca(OH)_2$ ($p < 0.001$). In the present study, the two cases treated with MTA presented apical barrier with thin calcification, which was confirmed by the tactile sensation.

As aforementioned, the formation of the apical barrier can be detected by the tactile[19,25] and radiographic[14,19,25] method. It was possible to investigate the apical barrier formation in the present study by radiographic analysis, and a few records contained the information about the use of endodontic instrument to check the apical closure. Chala et al,[5] in their systematic review and meta-analysis on success rate and apical barrier formation, compared the efficacy of MTA and calcium hydroxide in the treatment of immature teeth, and concluded that both materials can be used in the apexification of teeth with incomplete rhizogenesis.

In this study, most changes of calcium hydroxide medication were performed monthly. Nonetheless, Lengheden et al.[26] suggested periapical radiographs every 3 months to evaluate the formation of the hard tissue barrier and the presence or absence of calcium hydroxide inside the root canal. If absent, intracanal medication would be replenished; while in the presence of the calcium hydroxide, it would remain the same for another 3 months. Excessive changes of calcium hydroxide may delay tissue repair.[26] Other studies show besides the change every 3 months, the renewal of intracanal medication between 6 and 8 months.[27-29]

The complete apical barrier formation showed no significant association with the apex shape, but we observed that 9 out of the 14 teeth analyzed with convergent apex before the treatment showed total calcification of the apical portion (64.2%). Among the apices that were divergent before the treatment, none presented total calcification of the apical portion. Walia et al.[30] and Ghosh et al.[8] reported that the treatment was shorter in teeth with narrow apices of younger children and achieved a higher success rate. Moreover, in our study, no significant differences were detected regarding the presence of periapical lesion and apical barrier formation; despite of this, Dominguez Reyes et al[11] observed that the presence of apical pathology prior to treatment negatively influenced the length of treatment and the success of apical closure. Kleier & Barr[31] clinically and radiographically evaluated the success of apexification with calcium hydroxide in 48 patients with non-vital permanent teeth with open apices, and found statistically significant differences between the associations of the variables periapical lesion, presence or absence of signs and symptoms in the preoperative period and apical closure stage.

Dominguez Reyes et al[11] classified the formation of apical barriers into physiological, round and straight closure; the present study classified them as proposed by Lopes & Siqueira:[18] total calcification of apical portion, single/double sealing, semicircle closure and thin calcification. In the first study, 100% of the teeth with converging walls obtained apical closure similar to the physiological, in the present study, only 64.2% obtained total calcification of the apical portion, the remainder was divided into: single/double sealing (7.14%), semicircle closure (7.14%) and thin calcification (21.4%). Regarding the parallel wall, the first study also reported 100% apical closure similar to the physiological, and this study observed 45.4% with total calcification of the apical portion. As for the divergent walls, Dominguez Reyes et al.[11] recorded the presence of only 12.5% with physiological closure; in the present study, total calcification of the apical portion was not observed for any tooth.

Promising studies were introduced with the aim of seeking procedures and materials that could permit pulpal revascularization. Many case reports present clinical revascularization protocols consisting of disinfection and subsequent stimulation of the formation of a clot inside the root canal. It is important to consider some prerequisites that will guide revascularization, such as the frame, growth factors and stem cells that allow the continuation of root development.[32,33] Case reports showed an increase in the thickness and length of the dentin wall after application of different revascularization protocols.[32,34] Nevertheless, Alobaid et al.[35] observed that revascularization did not appear to be superior, after clinical and radiographic analysis, to traditional procedures of apexification. An interesting finding of the work of Alobaid et al[35] was the low incidence of root development observed radiographically in cases of revascularization. Statistically, there was no difference between the teeth treated by revascularization and apexification in relation to root length and thickness.

## Conclusion

Based on this retrospective study, it can be concluded that both calcium hydroxide and MTA were able to induce apexification and tissue repair of the traumatized teeth evaluated. Despite the limitations of a documentary study, it was observed that there was no statistical significance in relation to the variables such as: apex shape, periapical lesion, type of trauma, total time of calcium hydroxide changes, total time of treatment and control associated with the total calcification of the apical portion.

Although studies on the use of calcium hydroxide are widely discussed in the literature as well as those of MTA, clinical studies with a larger sample size, and longer periods of proservation at center of reference in dental traumatisms are suggested.

 

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