ISSN 1807-5274
Rev. Clín. Pesq. Odontol., Curitiba, v. 6, n. 2, p. 129-134, maio/ago. 2010

EFFECT OF CALCIUM HYDROXIDE-BASED DRESSING ON APICAL SEALING IN IMMATURE TEETH FILLED WITH MTA

Efeito da medicação à base de hidróxido de cálcio no selamento apical de dentes imaturos obturados com MTA

Augusto Bodanezi[a], Etiene de Andrade Munhoz[b], Juanita Fierro Villacis[c], Norberti Bernardineli[d], Clovis Monteiro Bramante[d], Ivaldo Gomes de Moraes[d], Roberto Brandão Garcia[d]

[a] PhD, Faculty of Dentistry, Universidade de São Paulo (USP), Bauru, SP - Brasil, e-mail: aboda@usp.br
[b] PhD, Faculty of Dentistry, Universidade de São Paulo (USP), Bauru, SP - Brasil.
[c] DDS, Endodontist, Bauru, SP - Brasil.
[d] PhD, Professor of Endodontics, Faculty of Dentistry, Universidade São Paulo (USP), Bauru, SP - Brasil.

Abstract

OBJECTIVES: To evaluate the effects of a calcium hydroxide-based intracanal dressing on the initial apical adaptation and leakage of fillings performed with mineral trioxide aggregate (MTA) in teeth with open apices. **STUDY DESIGN**: A total of 24 canals were manually prepared and randomly divided into two groups (n = 12). In the experimental group, root canals were dressed with calcium hydroxide-based paste for 21 days; in the control group, no medication was applied prior to the filling of root canals with mineral trioxide aggregate. Apical sealing was evaluated on the basis of rhodamine B penetration and the detection of microscopic apical defects at the filling interface (SEM). The data obtained were compared by means of *t*- and Fisher's Exact tests ($\alpha = 0.05$). **RESULTS**: The difference in mean dye leakage between the experimental (5.03±1.97 mm) and control (4.14±1.13 mm) groups was not statistically significant ($\varrho < 0.05$). The number of microscopic fissures at the experimental group interface (2/12) was significantly lower than that observed for the control group (9/12) ($\varrho < 0.05$). **CONCLUSIONS**: The use of a calcium hydroxide-based intracanal dressing did not interfere with the initial apical sealing of immature teeth filled with MTA.

Keywords: Calcium hydroxide. Mineral trioxide aggregate. MTA: Root canal apexification.

Resumo

***OBJETIVOS**: Avaliar os efeitos da medicação intracanal à base de hidróxido de cálcio sobre a adaptação apical inicial e selamento de obturações realizadas com agregado de trióxido mineral (MTA) em dentes com ápice aberto. **PLANEJAMENTO DO ESTUDO**: Um total de 24 canais foram manualmente preparados e aleatoriamente divididos em dois grupos (n = 12). No grupo experimental, canais radiculares foram preenchidos com pasta à base de hidróxido de cálcio por 21 dias; no grupo controle, nenhuma medicação foi aplicada antes da obturação dos canais com agregado de trióxido mineral. O selamento apical foi avaliado com base na penetração de rodamina B e na detecção microscópica de defeitos apicais na interface das obturações (MEV). Os dados obtidos foram comparados por intermédio dos testes "t" e Exato de Fisher ($\alpha = 0,05$). **RESULTADOS**: A diferença nos níveis médios de infiltração entre os grupos experimental (5.03±1.97 mm) e controle (4.14±1.13 mm) não se mostrou estatisticamente significante ($\rho < 0,05$). O número de fendas microscópicas na interface das obturações do grupo experimental (2/12) apresentou-se estatisticamente inferior ao detectado para o grupo controle (9/12) ($\rho < 0,05$). **CONCLUSÕES**: O uso de medicação intracanal à base de hidróxido de cálcio não interferiu no selamento apical inicial de dentes imaturos obturados com MTA.*

***Palavras-chave**: Hidróxido de cálcio. Agregado de trióxido mineral. MTA: Apicificação do canal radicular.*

INTRODUCTION

Successful treatment of immature pulpless teeth requires special manoeuvres for adequate debridement and sealing of the typically thin and divergent root canal walls. Historically, long-term calcium hydroxide dressings have been applied to provide additional disinfection and induce the formation of a mineralised barrier in the apex of immature teeth, so that condensation of gutta-percha in the canal can be properly achieved (1).

In contrast to traditional gutta-percha, mineral trioxide aggregate (MTA) is a powder that hardens and releases calcium ions in the presence of moisture. It is thus able to seal the root canal (2-4) and concomitantly induce apical hard tissue deposition (5, 6). For these reasons, MTA is currently the material of choice for one-visit apexification because it minimises the deleterious risks involved in $Ca(OH)_2$ multiple appointment therapy (e.g., coronal leakage and tooth fracture) (7-10).

To improve the bacteriostatic and biological performance of MTA in the root canal, a calcium hydroxide dressing is usually advocated prior to the filling (5, 6). When this procedure is performed before root canal filling with gutta-percha and sealer, however, it has been shown contradictorily to both improve (11-12) and impair (13) the quality of sealing. Considering the scarcity of evidence clarifying this issue and the increasing use of mineral trioxide aggregates for the obturation of immature teeth, this laboratory study sought to determine whether prior calcium hydroxide-based dressing affects apical adaptation and sealing due to obturation of an open apex tooth via MTA.

MATERIALS AND METHODS

Specimen preparation

This research was approved by the local ethics committee, which is in accordance with the Declaration of Helsinki (DoH). A total of 24 mandible immature third molar teeth were selected according to the following inclusion criteria: the mesial root was straight or slightly curved and 8±3 mm long, the tooth exhibited only one canal, and the apex was open. After surgical extraction, the teeth were kept into 0.5% thymol solution until use.

The mesial root of each tooth was cut from the remaining structure, and the canal was initially instrumented with Gates Glidden burs no. 4,3,2 and 1 (Denstply Maillefer™, Tulsa, OK, USA) in a crown-down manner until the no. 1 size bur could pass through the apical foramen. Root canal length was assessed by placing a size 50 K file (Dentsply-Maillefer, Ballaigues, Switzerland) inside each canal, until the tip perforated through the apical foramen. The instrument was withdrawn 1mm to record the working length, and canals were then sequentially enlarged with K-type files (Denstsply Maillefer,

Ballaigues, Switzerland) to size 100. Irrigation with 5 ml of 1% sodium hypochlorite (Biodinâmica™, Ibiborã, PR, Brazil) was used throughout instrumentation, and this was followed by 3 minutes of irrigation with 17% EDTA (Biodinâmica, Ibiborã, PR, Brazil) and a final flush with 3 ml of distilled water, before drying with sterile no. 80 paper points (Tanari®, Manacapuru, AM, Brazil).

The roots were then double-coated with a layer of epoxy-based adhesive (Araldite™, Brascola, Joinville, SC, Brazil) and a layer of a nail varnish (except for the apical 1 mm). After drying, specimens were placed into saline-soaked sponges (Scothbrite™, 3M do Brasil, Sumaré, SP, Brazil) to simulate a moisturised periapical environment.

The experimental group was formed with 12 randomly chosen roots that were filled with a paste composed of $Ca(OH)_2$ (Inodon™, Porto Alegre, RS, Brazil) with 25% iodoform by weight (Inodon, Porto Alegre, RS). The powder was mixed with propylene glycol (Sinth™, Diadema, SP, Brazil) in a powder-to-liquid ratio of 3:1. The paste was inserted using a lentulo spiral carrier (Dentsply Maillefer, Ballaigues, Switzerland) in a slow-speed handpiece, and completeness of filling was checked with the aid of radiographs. The roots were then sealed with Cimpat (Septodont™, Saint-Maur-des-Fossés, Cedex, France) and stored at 37ºC and 100% humidity for 21 days. In the control group, the root canals were instrumented but not dressed.

Following the removal of experimental group dressings by irrigation with 1% NaOCl and reaming with a size 100 k-type file, root canals from both the control and experimental groups were then filled with mineral trioxide aggregate (MTA, Ângelus™, Londrina, PR, Brazil). For this procedure, a small amount of MTA was picked up with a number 50 spatula (SSWhite Duflex™, Rio de Janeiro, RJ, Brazil) and delivered into the canal with a lentulo spiral (initially set at 2.0 mm from the established working length). The back of a n. 80 paper point was then used to condense the material in the apical third of each canal. Thereafter, the MTA inserted into the middle and coronal parts of the canal were gently packed with a Paiva n. 3 plugger until the filling, confirmed with radiographic analysis, was complete.

Immediately, the apical 4 mm of each root were placed inside a flask containing 1 ml of 0.2% rhodamine buffered solution (Merck™, Darmstadt, Germany), and the set was incubated at 37ºC during the 4 hours necessary for MTA hardening. Later, specimens were washed with running water for 60 minutes to remove excess ink before being left to dehydrate at room temperature (25±3ºC) for 72 hours.

The dry specimens were coated with 300 μm of gold and observed under a scanning electron microscope (Jeol/JSM-T220A™, Tokyo, Japan). The apex of each root was examined at 150 X original magnification, and the obtained images from the MTA/dentin interface were randomly assessed by an examiner for the presence of any defect (e.g., cracks or fissures).

Afterwards, the roots were sectioned longitudinally, and the two resulting halves were serially digitalised near a slide caliper (727 Starrett™, Mount Airy, NC, USA) using a professional photocamera (D70, Nikon™, Tokyo, Japan) with a 105 mm micro-lens (Nikkor, Nikon™, Tokyo, Japan). Obtained images were imported into open source software (Image Tool v. 3.0™ for Windows, UTHSCSA, San Antonio, TX, USA). The leakage extent was evaluated from the apical root end of each hemisection to the most coronal extent of dye penetration by one blinded examiner. A digital caliper set at 1 mm was used as a standard reference for measurements.

Data obtained from dye penetration were statistically compared by means of the t-test, whereas categorical differences in the number of fillings with apical microscopic defects for each group were determined using Fisher's Exact test. Both tests were adjusted to the 95% significance level and were performed with SPSS software (SPSS v.11 · 0 for Windows™, Chicago, IL, USA).

RESULTS

The experimental group demonstrated apical dye penetration of 5.03±1.97 mm, which was not significantly different from the 4.14±1.13 mm detected for the control group ($\varrho < 0.05$).

The number of fillings with defects in the apical interface was significantly lower in the experimental (2/12) than control (9/12) group ($\varrho < 0.05$). Representative micrographs are presented in Figures 1, 2.

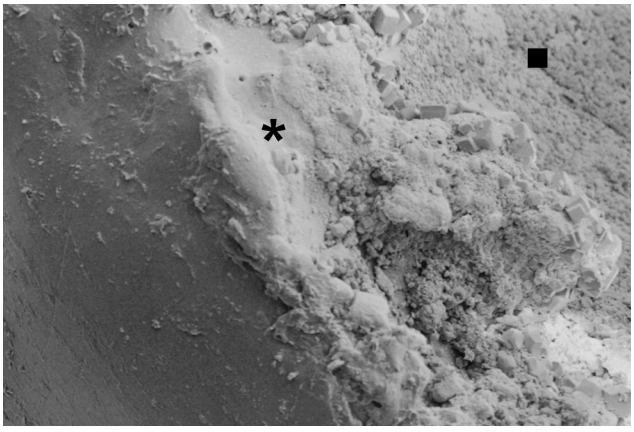

Figure 1 - Representative scanning electron micrograph of an experimental filling apex at an original magnification of 150x. Note the absence of defects at the interface (✱) between root canal walls and mineral trioxide aggregate fillings

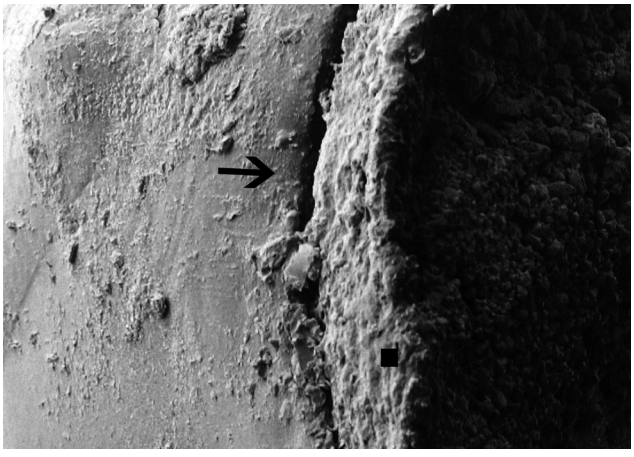

Figure 2 - Representative scanning electron micrograph of a control filling apex at an original magnification of 150x. Note a fissure at the interface (arrow) between the root canal walls and mineral trioxide aggregate (■)

DISCUSSION

In contrast to studies using mature teeth to simulate open apices (2, 4, 14-16), this investigation evaluated the sealing ability of MTA for extracted immature teeth. In these teeth, natural features add realistic value to this research. Since there is no current standard protocol for evaluating the sealing ability of teeth with divergent apices, a combination of methods was applied: scanning electron microscopy and examination of dye leakage.

The apical leakage detected for MTA fillings dressed with calcium hydroxide paste was not significantly lower than that in fillings not dressed, a result already reported in other investigations (14, 16) but in contrast to results observed for gutta-percha fillings (11, 12). This inconsistency may be explained simply by the decolourisation that methylene blue dye, adopted in those studies, suffers in the presence of hydroxide (17, 18). Thus, it may have produced apparently lower levels of dye leakage.

Furthermore, in those studies that adopted Indian ink as a tracer, calcium hydroxide-medicated roots filled with gutta-percha showed significantly more leakage than non-medicated roots (13). Calcium hydroxide does not interfere with rhodamine labelling. Since iodoform and propylene glycol were also present in the dressing compound, however, their potential to neutralise the potency of the rhodamine tracer should not be ignored.

To justify the expressive leakage in the experimental group, we suggest that complete removal of the calcium hydroxide intracanal dressing was not possible using only a file and alternating irrigation (19), as performed in this experiment. It is possible that paste remnants may have acted as mechanical obstacles to MTA and generated spaces at the filling interface, at which tissue fluids could leak via dissolution (13, 16).

Another possible explanation for the statistical equivalence in leakage levels between groups resides in the methodological procedures employed. The adhesion between mineral trioxide aggregate and dentin after physical contact occurs in a slow and progressive way (20, 21). In contrast to similar studies in which MTA samples were left to set for as much as 168 h before dye immersion (2, 4, 14, 16), this research sought to reproduce the actual clinical situation in which wound exudates might be present on periodontal tissues. In this research, therefore, roots were filled and immediately placed into the dye tracer solution so that the initial adhesion between MTA and the root canal walls could take place under a completely wet environment. These conditions may have permitted deep penetration of rhodamine, especially in the control group.

Independently of prior dressing with calcium hydroxide-based pastes, we reinforce the

recommendations of other authors suggesting that one-session MTA apexification with at least 5 millimetres of apical filling thickness should provide an adequate seal against leakage (4, 22, 23).

Given the lower number of apical microscopic deficiencies detected in the experimental group, a subsequent reduction in dye leakage was expected to occur; however, this was not noticed. To explain this finding, we suggest that deficiencies were in fact not detected by SEM because they were filled with paste remnants unable to prevent dye penetration. In addition, the cracks and fissures present in both groups were more likely related to the manual placement of MTA (15, 23) than the presence of calcium hydroxide paste residue at the moment of filling. Although sample dehydration was conducted without heating, prior to gold coverage for scanning microscopic analysis, the interference of inherent artefacts (surface cracks or enlargement of interface fissures) should be taken into account upon quality assessment. Thus, when investigating the adaptation of MTA fillings, methods that do not require dehydration for sample analysis are preferred.

The leakage and adaptation defects detected during setting in this experiment do not necessarily conflict with the remarkable sealing behaviour of MTA (2, 14-16, 20, 23). In a recent study, it was observed that the seal of an MTA orthograde apical plug improved after specimens were immersed in phosphate buffered saline for 4 weeks (20). When immersed in saline, mineral trioxide aggregate spontaneously precipitates carbonate apatite (21). Thus, it is hypothesised that greater amounts of this precipitate could form an interfacial layer at the cement-dentin interface that might be able to minimise leakage (21). If this theory is confirmed, this property could compensate for the undesirable deficiencies generated during insertion, compaction and hardening of this material inside root canals.

To date, the effects of calcium hydroxide dressings on the biological performance of MTA have not been scientifically proved. When intracanal medication is performed, more efficient ways to remove the paste or insert and condense MTA into root canals (the incorporation of ultrasonic streaming) offer valid methods for improving the sealing ability of MTA fillings applied for one-appointment apexification (21-24).

CONCLUSIONS

The use of calcium hydroxide-based paste as an intracanal dressing did not interfere with the initial apical sealing of immature teeth filled with mineral trioxide aggregate.

REFERENCES

1. Cvek M. Treatment of non-vital permanent incisors with calcium hydroxide: I - follow-up of periapical repair and apical closure of immature roots. Odontol Revy. 1972;23(1):27-44.

2. Matt GD, Thorpe JR, Strother JM, McClanahan SB. Comparative study of white and gray mineral trioxide aggregate (MTA) simulating a one- or two-step apical barrier technique. J Endod. 2004;30(12): 876-9.

3. De Leiburg ML, Angeretti A, Ceruti P, Lendini M, Pasqualini D, Berutti E. MTA obturation of pulpless teeth with open apices: bacterial leakage as detected by polymerase chain reaction assay. J Endod. 2004;30(12):883-6.

4. Al-Kahtani A, Shostad S, Schifferie R, Bhambhani S. In-vitro evaluation of leakage of an orthograde apical plug of mineral trioxide aggregate in permanent teeth with simulated immature apices. J Endod. 2005;31(12):117-21.

5. Tittle K, Farley J, Linkhardt T, Torabinejad M. Apical closure induction using bone growth factors and mineral trioxide aggregate. J Endod. 1996;22(4):198.

6. Shabahang S, Torabinejad M, Boyne PP, Abedi HR, McMillan P. A comparative study of root-end induction using osteogenic protein-1, calcium hydroxide and mineral trioxide aggregate in dogs. J Endod. 1999;25(1):1-5.

7. Felippe WT, Felippe MCS, Rocha MJC. The effect of mineral trioxide aggregate on the apexification and periapical healing of teeth with incomplete root formation. Int End J. 2006;39(1):2-9.

8. Andreasen JO, Munksgaard EC, Bakland LK. Comparison of fracture resistance in root canals of immature sheep teeth after filling with calcium hydroxide or MTA. Dent Traumatol. 2006;22(3):154-6.

9. Simon S, Rilliard F, Berdal A, Machtou P. The use of mineral trioxide aggregate in one-visit apexification treatment: a prospective study. Int End J. 2007;40(3):186-97.

10. Holden DT, Schwartz SA, Kirkpatrick TC, Schindler WG. Clinical outcomes of artificial root-end barriers with mineral trioxide aggregate in teeth with immature apices. J Endod. 2008;34(7):812-7.

11. Porkaew P, Retief H, Barfield RD, Lacefield WR, Soong S. Effects of calcium hydroxide paste as an intracanal medicament on apical seal. J Endod. 1990;16(8):369-74.

12. Holland R, Alexandre AC, Murata SS, Dos Santos CA, Junior ED. Apical leakage following root canal dressing with calcium hydroxide. Dent Traumatol. 1995;11(6):261-3.

13. Kim SK, KimYO. Influence of calcium hydroxide intracanal medication on apical seal. Int End J. 2002;35(7):623-8.

14. Hachmeister DR, Schindler WG, Walker WA, Thomas DD. The sealing ability and retention characteristics of mineral trioxide aggregate in a model of apexification. J Endod. 2002;28(5):386-90.

15. Aminoshariae A, Hartwell GR, Moon PC. Placement of mineral trioxide aggregate using two different techniques. J Endod. 2003;29(10):679-82.

16. Stefopoulos S, Tsatsas DB, Kerezoudis NP, Eliades G. Comparative in vitro study of the sealing efficiency of white vs grey ProRoot mineral trioxide aggregate formulas as apical barriers. Dental Traumatology. 2008;24(2):207-13.

17. Moraes IG, Moraes FG, Mori GG, Gonçalves SB. Influence of calcium hydroxide on dyes for dentin labeling, anlyzed by means of a new methodology. J Appl Oral Sci. 2005;13(3):218-21.

18. Tanomaru-Filho M, Figueiredo FA, Tanomaru JMG. Effect of different dye solutions on the evaluation of the sealing ability of mineral trioxide aggregate. Braz Oral Res. 2005;19(2):119-22.

19. Hosoya N, Kurayama H, Lino F, Arai T. Effects of calcium hydroxide on physical and sealing properties of canal sealers. Int End J. 2004;37(3):178-84.

20. Martin RL, Monticelli F, Brackett WW, Loushine RJ, Rockman RA, Ferrari M, et al. Sealing properties of mineral trioxide aggregate orthograde apical plugs and root fillings in an in vitro apexification model. J Endod. 2007;33(3):272-5.

21. Reyes-Carmona JF, Felippe MS, Felippe WT. Biomineralization ability and interaction of mineral trioxide aggregate and white portland cement with dentin in a phosphate-containing fluid. J Endod. 2009;35(5):731-6.

22. Lawley GR, Schindler WG, Walker WA, Kolodrubetz D. Evaluation of ultrasonically placed MTA and fracture resistance with intracanal composite resin in a model of apexification. J Endod. 2004;30(3):167-72.

23. Kim U, Shin S, Chang SW, Yoo H, Oh T, Park KS. In vitro evaluation of bacterial leakage resistance of an ultrasonically placed mineral trioxide aggregate orthograde apical plug in teeth with wide open apexes: a preliminary study. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2009;107(4):e52-e56.

24. van der Sluis LWM, Shemesh H, Wu MK, Wesselink PR. An evaluation of the influence of passive ultrasonic irrigation on the seal of root canal fillings. Int End J. 2007;40(5):356-61.

Received: 09/14/2009
Recebido: 14/09/2009

Accepted: 11/30/2009
Aceito: 30/11/2009