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Sealing Ability of the Formed Apical Calcified Bridge in Open Apex Roots

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Abstract

A successful endodontic treatment requires that the apex of the treated tooth be completely and densely sealed with root canal filling material. One of the most difficult endodontic problems is the management of necrotic immature tooth due to the blunderbuss apex and the difficulty in achieving a tight seal between the root canal system and the external surface of the tooth. The aim of this study was to evaluate the sealing ability the apical calcified bridge formed by calcium hydroxide paste, white MTA or gray MTA during apexification procedure.

Thirty premolars with single root canals were prepared to simulate an open apex. These roots were divided into 3 groups as follow: Group A: 10 roots filled with $\text{Ca}(\text{OH})_2$ paste, Group B: 10 roots filled with white MTA, and Group C: 10 roots filled with gray MTA. Each root was placed in a polyethylene vial containing 25 ml of synthetic tissue fluid (STF) and incubated at 37°C for 3 months. After 3 months and the formation of calcified bridge, each root was immersed in 2% freshly prepared Methylene blue dye in 5 ml plastic vial for seven days. After the leakage period, the roots were removed from the dye and the leakage in all roots was examined by measuring the linear extent of dye penetration from the apical end of the canal preparation to the coronal direction by means of a light stereomicroscope at (40 X) magnification with calibrated grid.

$\text{Ca}(\text{OH})_2$ paste group has the highest mean value of apical dye penetration followed by WMTA, while GMTA group shows the lowest mean value of apical dye penetration. There was a highly significant difference in the apical dye penetration ($p < 0.01$) among these groups, statistically a high significant difference is found ($p < 0.01$) between $\text{Ca}(\text{OH})_2$ group and WMTA group, and between $\text{Ca}(\text{OH})_2$ group and GMTA group; whereas, significant difference is found ($p < 0.05$) between WMTA group and GMTA group.

The apical calcified bridge formed by GMTA has the best sealing ability followed by that formed by WMTA. While the apical calcified bridge formed by $\text{Ca}(\text{OH})_2$ paste has the lowest sealing ability as compared with that formed by WMTA and GMTA.

Keywords: Sealing ability of apical calcify bridge, open apex roots, $\text{Ca}(\text{OH})_2$ paste, WMTA, GMTA.

Introduction

The objective of endodontic treatment is to render the affected tooth biologically acceptable, symptoms

free, functional, and without any diagnosable pathology⁽¹⁾.

The development of a fluid-tight

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seal at the apical foramen and total obliteration of the root canal space are considered as essential factors for successful endodontic therapy. Physically it is impossible to achieve this objective through ordinary procedure in open apex cases in which standard instrument techniques can not create an apical stop to facilitate effective obturation of the canal⁽²⁾.

Apexification had been found to be high effective in the management of immature, necrotic permanent teeth. It is the induction of an apical calcific barrier across an open apex against which filling material can be packed⁽³⁾.

Many materials had been used to stimulate hard tissue formations during apexification procedure. The material of choice used for apexification for many years is calcium hydroxide but recently a single appointment technique by using mineral trioxide aggregate (MTA) has been introduced⁽⁴⁾.

Failed apexification cases usually have one common cause which is the bacterial contamination. Frequently, the cause of bacteria is loss of apical seal or inadequate debridement⁽⁵⁾. So it is obvious to select a material stimulates an apical calcific bridge which will provide best apical seal.

Materials and methods

Thirty freshly extracted human premolars with single straight root canals and closed apices were used in this study. The crown portion of each tooth was removed at the cemento-enamel junction (CEJ) of the buccal surface to permit ideal access to the root canal⁽⁶⁾.

The patency of each canal was checked by passing No. 10 K-type file through the apical foramen and the working length was determined by subtracting 1mm from the length at

which the tip of the file just appeared at the apical foramen and standardized to 12 mm length⁽⁷⁾.

These root canals were instrumented by using conventional hand instrumentation technique with circumferential filing action starting with size No. 10 K- type file to the master apical file No.100 until the tip of the master apical file extended 1mm beyond the apex. Two coats of clear nail polish were applied to the entire external root surface except the apical foramen, and allowed to dry at room temperature⁽⁸⁾.

On the base of filling materials, the roots were divided into 3 groups as follow: Group A: 10 roots filled with Ca(OH)₂ past (Medical, Promedica, GermanyTM), Group B: 10 roots filled with white MTA (Pro Root MTA, Dentsply Tulsa Dental, U.S.ATM), and Group C: 10 roots filled with gray MTA (Pro Root MTA, Dentsply Tulsa Dental, U.S.ATM).

Ca(OH)₂ paste filling was carried out by placing the needle of the syringe in the canal 2 mm shorter than the working length and slowly withdrawn while the paste was being injected. A radiograph was taken immediately to assess the quality of the obturation and the extent of the filling material. Then, a pledget of cotton was placed in the cervical cavity over the paste, and the cervical access was sealed with amalgam⁽⁹⁾.

WMTA and GMTA filling were carried out by mixing the MTA powder with distilled water according to the manufacturer's instructions in 3:1 (powder/liquid) ratio on a clean dry glass slab into a putty consistency and carried to the canal with the aid of an endodontic messing gun. The nozzle of the messing gun was placed into the canal 4 mm shorter than the working length to form 4mm plug then depressed with plunger. Roots were radiographed to ensure that an adequate apical obturation had been performed. Then the blunt end of a large paper point was

moistened with distilled water and left in the canal for 3-4 hours to promote setting. After that the paper point was removed and an endodontic plugger was introduced inside the canal and was lightly tapped against the MTA plug to confirm a hardened set. The rest of the canal was obturated with gutta-percha and ZOE sealer using lateral condensation technique ⁽⁴⁾. The roots were radiographed to determine if the root canals were properly filled then the cervical access of each canal was sealed with amalgam.

Each root was placed in a polyethylene vial containing 25 ml of synthetic tissue fluid (STF) and incubated at 37°C for 3 months. STF has the following composition: 1.7 gm of potassium dihydrogen phosphate (KH_2PO_4), 11.8 gm of disodium hydrogen phosphate (Na_2HPO_4), 80.0 gm of sodium chloride (NaCl), and 2.0 gm of potassium chloride (KCl) in 10 liter of distilled water ^{(10), (11)}.

After 3 months, the apical calcified barrier in all samples was formed. The roots that filled with $\text{Ca}(\text{OH})_2$ paste were taken out and the rest of the canals were obturated with gutta-percha and ZOE sealer using lateral condensation technique then the cervical access of each canal was sealed with amalgam. Each sample was immersed in 2% freshly prepared Methylene blue dye in 5 ml plastic vial. All the samples were stored in an incubator at 37°C for seven days ⁽¹²⁾.

The dye solution was prepared from dissolving 2 gm of Methylene blue dye powder in 100 ml of distilled water ⁽¹²⁾.

After the leakage period, the roots were removed from the dye and washed under running water in a position apposite to the apical foramen ⁽¹³⁾.

Longitudinal shallow grooves were made on the mesial and distal surface without penetrating into the pulp space with a rotating diamond disk of small diameter under continuous water

cooling. Each tooth was splitted in two halves by placing the edge of lacron carver in the groove and applying a gentle pressure, care was taken to include the apical foramen in the fracture line ⁽¹⁴⁾. Finally, the filling material was removed by grasping it with a tweezer from the coronal side and pulling it laterally ⁽¹⁵⁾.

The leakage in all roots was examined. The linear extent of dye penetration from the apical end of the canal preparation to the coronal direction was measured by means of a light stereomicroscope at (40 X) magnification with calibrated grid ⁽¹⁶⁾. Apical leakage was measured independently by two evaluators one of them was unaware of the materials used and the average of the two measurements of each tooth was considered for statistical analysis.

Results

The summery of mean values and the standard deviations, and maximum and minimum values of apical dye penetration in roots filled with $\text{Ca}(\text{OH})_2$ paste, WMTA, and GMTA is listed in table 1.

This table shows that $\text{Ca}(\text{OH})_2$ paste group has the highest mean value of apical dye penetration (4.96 ± 0.84) mm followed by WMTA group (1.92 ± 0.51) mm, while GMTA group shows the lowest mean value of apical dye penetration (1.29 ± 0.50) mm. this is clearly shown in figure 1.

Statistic analysis of the results for $\text{Ca}(\text{OH})_2$, WMTA, and GMTA groups using ANOVA test showed that there was a highly significant difference ($p < 0.01$) among these groups as shown in table 2.

Least significant difference test (LSD) was used to compare the apical dye penetration between each two groups to identify the presence of

statistically significant difference as shown in table 3.

The results shows that statistically a high significant difference is found ($p < 0.01$) between $\text{Ca}(\text{OH})_2$ group and WMTA group, and between $\text{Ca}(\text{OH})_2$ group and GMTA group. Whereas, significant difference is found ($p < 0.05$) between WMTA group and GMTA group.

Discussion

The root canals were instrumented to the master apical file No.100 to simulate an open apex as mentioned by Wesenseel et al.⁽¹⁷⁾

STF was chosen as an appropriate storage media for $\text{Ca}(\text{OH})_2$ and MTA specimens to stimulate the calcific bridge formation in vitro as reported by Ritwick et al.⁽¹⁸⁾, Welch et al.⁽¹⁹⁾, Sarkar et al.⁽¹¹⁾.

The prepared Methylene blue dye was used as leakage indicator as recommended by Boussetta et al.⁽¹³⁾ and Matt et al.⁽²⁰⁾.

Regarding sealing ability, calcium hydroxide paste group showed the lowest sealing ability as compared with WMTA and GMTA groups. There was a highly significant difference between calcium hydroxide paste group and both WMTA and GMTA groups. This can be attributed to that calcium hydroxide paste does not adhere to dentine and has tendency to dissolve and disintegrate over time as mentioned by Schuurs et al.⁽²¹⁾ and Aeinehchi et al.⁽²²⁾ while MTA material does not undergo solubility and disintegration thus space for microleakage does not develop as reported by Fridland and Rosada,⁽²³⁾.

Also, the sealing ability of MTA is due to hydroxyapatite crystals formation that fills the microscopic spaces between MTA and dentinal wall. Initially, this seal is mechanical then with time, there will be diffusion

– controlled reaction between the apatite layer and dentin leads to their chemical seal as mentioned by Sarkar et al.⁽¹¹⁾.

This result emphasizes the gross and microscopic evaluations of the apical barrier formed by calcium hydroxide paste which was not solid but maintained a swiss cheese configuration and the calcific closure was not complete but had minute communications with the periapical tissues as evaluated by Pinkham⁽³⁾.

Also, the quality of the hard tissue bridge formed by calcium hydroxide criticized by Estrela and Holland⁽²⁴⁾ who claimed that it had tunnels defects which compromised the protecting efficiency of the bridge and acted as a pathway for microleakage and reinfection.

The quality of the calcific barrier formed by MTA was more uniform and had greater consistency than that formed by calcium hydroxide as compared by Shabahang et al.⁽²⁵⁾, this can explain the higher sealing ability of WMTA and GMTA groups as compared with calcium hydroxide paste group.

There was a significant difference in the apical dye penetration between GMTA group and WMTA group. WMTA group showed more apical leakage than GMTA group. This can be attributed to that GMTA and WMTA have the same principle components except that WMTA lacks the tetracalcium aluminoferrite and the setting time is greater in WMTA than in GMTA as reported by Ferris and Baumgartner⁽²⁶⁾. Also the overall size of particles in GMTA appeared to be bigger than those in WMTA, suggesting that WMTA provides an overall smoother mixture as analyzed by Asgary et al.⁽²⁷⁾. These differences between GMTA and WMTA may cause volumetric shrinkage that lead to increase leakage between the material

and root dentin and affect the quality of the apical calcified bridge formed by WMTA. This finding is in agreement with Matt et al. ⁽²⁰⁾ who concluded that GMTA demonstrated significantly less apical dye leakage than WMTA.

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Table 1: Descriptive Statistics analysis of apical dye penetration in mm for Ca(OH)₂, WMTA, GMTA groups.

Groups	N	Minimum	Maximum	Mean	±SD
A (calcium hydroxide)	10	3.70	6.00	4.96	0.84
B (WMTA)	10	1.10	2.50	1.92	0.51
C (GMTA)	10	0.50	2.00	1.29	0.50

Table 2: ANOVA test of apical dye penetration for Ca(OH)₂, WMTA, GMTA groups.

	df	Sum of Squares	Mean Square	F	Sig.
Between Groups	2	77.025	38.512	93.435	.000 **
Within Groups	27	11.129	.412		
Total	29	88.154			

**P<0.01 Highly significant difference

Table 3: Least significant difference (LSD) between each two groups.

	Mean Difference	Std. Error	Sig.
Group A&B	3.0400 -3.0400	.2871	.000 **
Group A&C	3.6700 -3.6700	.2871	.000 **
Group B&C	.6300 -.6300	.2871	.037 *

**P<0.01 Highly significant difference

*P<0.05 Significant difference

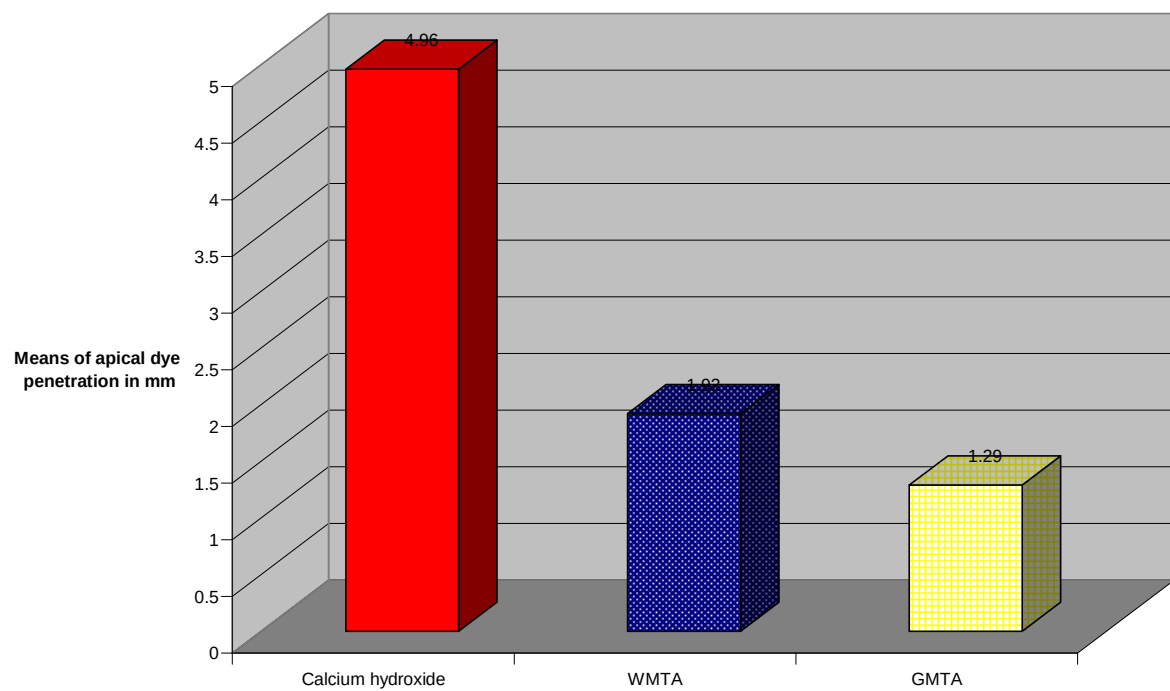


Figure 1: The difference in the means of apical dye penetration in mm for $\text{Ca}(\text{OH})_2$, WMTA, GMTA groups.