Scientific Research and Essays Vol. 6(14), pp. 2950-2954, 18 July, 2011
Available online at http://www.academicjournals.org/SRE
DOI: 10.5897/SRE10.1144
ISSN 1992-2248 ©2011 Academic Journals

Full Length Research Paper

Sealing ability of the formed apical calcified bridge in open apex roots

S.T. AbdulQader[1,3]*, M. M. Jawad[2,3] and A. B. Zaidan[1],

[1]Department of Paediatric and Preventive Dentistry, College of Dentistry, University of Baghdad, Baghdad, Iraq.
[2]Department of Medical Engineering, College of Engineering, Al-Nahrain University, Baghdad, Iraq.
[3]School of Dental Sciences, University Sains Malaysia (USM), 16150, Kelantan, Malaysia.

Accepted 30 June, 2011

One of the most difficult endodontic problems is the management of necrotic immature tooth because of the difficulty in achieving a completely sealed apex. The aim of this study is to evaluate the sealing ability of the apical bridge formed by calcium hydroxide, white mineral trioxide aggregate (MTA) or gray MTA during apexification procedure. Thirty roots were prepared to simulate an open apex. These roots were divided into 3 groups: Group A: 10 roots filled with $Ca(OH)_2$ paste, Group B: 10 roots filled with white mineral trioxide aggregate (WMTA), and Group C: 10 roots filled with gray mineral trioxide aggregate (GMTA). Each root was placed in synthetic tissue fluid (STF) for 3 months. Then each root was immersed in methylene blue dye. The leakage was examined by light stereomicroscope at (40 ×) magnification. Results showed that $Ca(OH)_2$ paste group had the highest mean value of apical dye penetration followed by WMTA, while GMTA group showed 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, concluded that the apical bridge formed by GMTA had the best sealing ability followed by that formed by WMTA. While the apical calcified bridge formed by $Ca(OH)_2$ paste had the lowest sealing ability.

Key words: Sealing ability, apexification, $Ca(OH)_2$ paste, white mineral trioxide aggregate, with gray mineral trioxide aggregate.

INTRODUCTION

The objective of endodontic treatment is to render the affected tooth biologically acceptable, symptoms free, functional, and without any diagnosable pathology (Cohen and Burns, 2002; Rahimi et al., 2010). The development of a fluid-tight seal at the apical foramen and total obliteration of the root canal space are considered as essential factors for successful endodontic therapy. There are many attempts to improve apical seal either by increasing the quality of root canal preparation such as using rotary instrumentation and laser irrigation or by enhancing material properties (Jawad et al., 2011a; Jawad et al., 2011b). Physically it is impossible to achieve this objective through ordinary procedure in open apex cases in which standard instrument techniques cannot create an apical stop to facilitate effective obturation of the canal due to the blunderbuss apex (Wein, 2004).

Apexification had been found to be highly effective in the management of immature, necrotic permanent teeth. It is the induction of an apical calcified barrier across an open apex against which filling material can be packed (Pinkham, 1999). 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 (Torabinejad and Chivian, 1999).

The formation of hard tissue barrier at the apex requires similar environment to that required for hard tissue formation in vital pulp therapy which are a mild inflammatory stimulus to initiate healing and a bacteria-

*Corresponding author. E-mail:sarah_talib@yahoo.com.

free environment to ensure that the inflammation will not progress (Kilpatrick and Welbury, 2003). Even systemic antibiotics are usually used in therapeutic and prophylaxis of uncomplicated infections (Sisecioglu et al., 2011), 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 (Walton and Torabinejad, 2002). So it is obvious to select a material that stimulates an apical calcified bridge which will provide best apical seal.

The aim of this study is to measure the sealing ability of the calcified bridge formed by calcium hydroxide, white MTA or gray MTA during apexification procedure against dye penetration.

MATERIALS AND METHODS

Thirty freshly extracted human premolars with single straight root canals and closed apices were used in this study. Immediately after extraction, all teeth were stored in distilled water with thymol at room temperature. The remaining soft tissues and debris attached to the external root surfaces were removed using a cumine scalar. The roots were examined by visible light cure machine; any root that had a visible fracture or cracks was discarded. The crown portion of each tooth was removed at the cementoenamel junction (CEJ) of the buccal surface to permit ideal access to the root canal (Gomes et al., 1996). 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 1 mm from the length at which the tip of the file just appeared at the apical foramen and standardized to 12 mm length (Simon et al., 1995). 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 .The file is moved in an in and out motion around the entire circumference of the canal space. This was done several times until the file is quite loose prior to shifting to the next larger size. The procedure was repeated 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 (Anthony et al., 1982). 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, Germany TM), 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 pledged of cotton was placed in the cervical cavity over the paste, and the cervical access was sealed with amalgam (Chawla, 1986). 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 to 4 h 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. The canals were obturated to the coronal end of the apical plug. A master gutta-percha cone was fitted on each tooth with good tug-back to fit to the coronal end of the apical plug (4 mm shorter than the working length) (Torabinejad and Chivian, 1999). 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 g of potassium dihydrogen phosphate (KH2PO4), 11.8 g of disodium hydrogen phosphate (Na2HPO4), 80.0 g of sodium chloride (NaCl), and 2.0 g of potassium chloride (KCl) in 10 L of distilled water (Sarkar et al., 2002; Sarkar et al., 2005). After 3 months, the apical calcified barrier in all samples was formed. The roots that filled with $Ca(OH)_2$ 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 37C° for seven days (Abdul and Al-Huwaizi, 2008). The dye solution was prepared from dissolving 2 g of methylene blue dye powder in 100 ml of distilled water (Abdul and Al-Huwaizi, 2008). After the leakage period, the roots were removed from the dye and washed under running water in a position apposite to the apical foramen (Bousseta et al., 2008). 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 (Simon et al., 1991). Finally, the filling material was removed by grasping it with a tweezer from the coronal side and pulling it laterally (Al-ugaily, 2007). 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 stereo-microscope at (40 ×) magnification with calibrated grid (Holland et al., 2004). 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 $Ca(OH)_2$ paste, WMTA, and GMTA is listed in Table 1. This table shows that Ca(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±050) mm. this is clearly shown in Figure 1.

Statistic analysis of the results for Ca(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.

Table 1. Descriptive statistics analysis of apical dye penetration in mm for $Ca(OH)_2$, WMTA, GMTA groups.

Groups	N	Minimum	Maximum	Mean	±Standard deviation
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

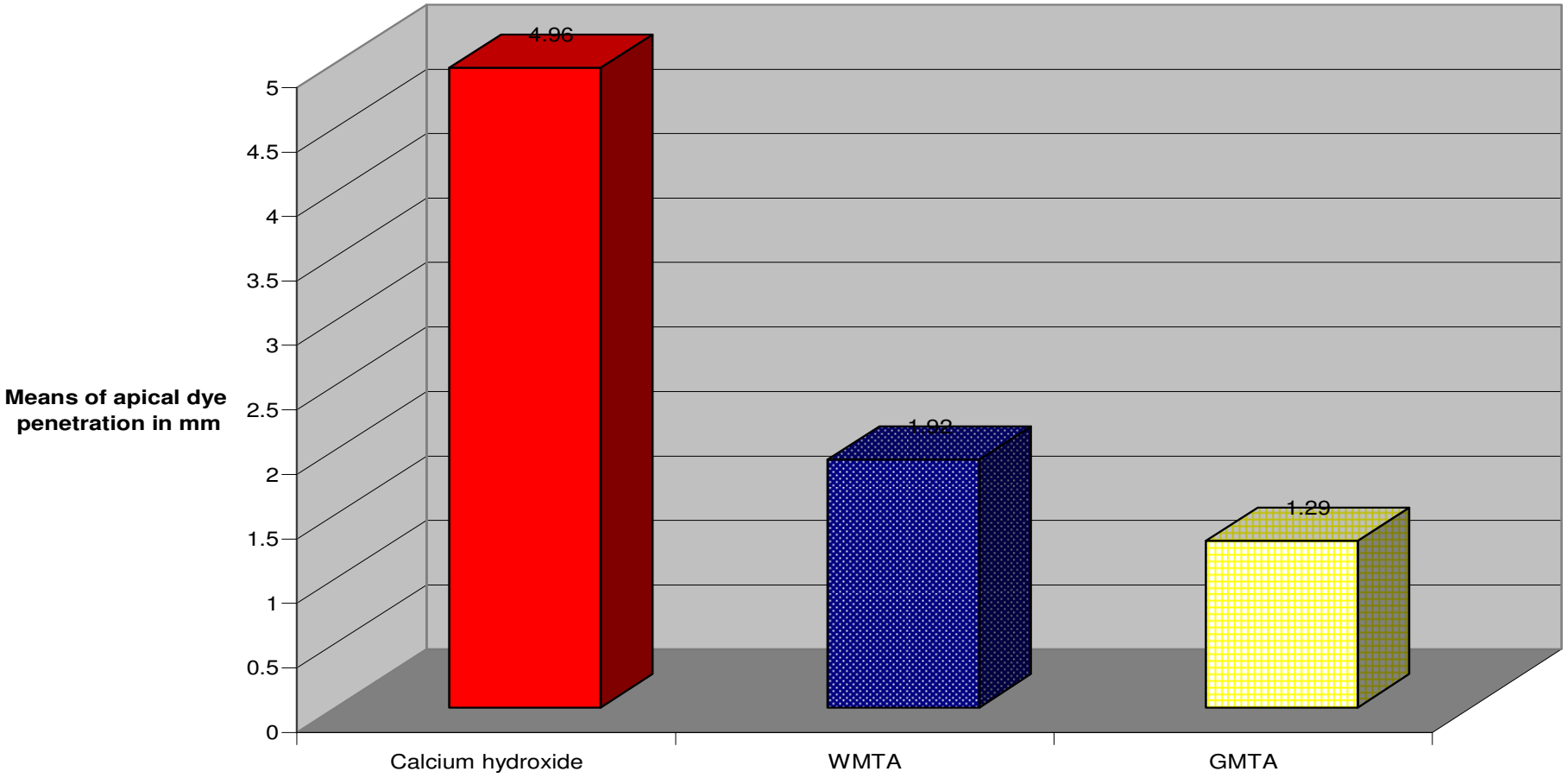

Figure 1. The difference in the means of apical dye penetration in mm for Ca(OH)2, WMTA, GMTA groups.

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

	df	Sum of squares	Mean square	F	Significance
Between groups	2	77.025	38.512	93.435	0.000 **
Within groups	27	11.129	0.412		
Total	29	88.154			

**P<0.01 highly significant difference.

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

Group	Mean difference	Standard error	Significance
Group A and B	3.0400 -3.0400	0.2871	0.000 **
Group A and C	3.6700 -3.6700	0.2871	0.000 **
Group B and C	0.6300 -0.6300	0.2871	0.037 *

**P<0.01 highly significant difference.*P<0.05 Significant difference.

The results shows that statistically a high significant difference is found ($p<0.01$) between $Ca(OH)_2$ group and WMTA group, and between $Ca(OH)_2$ 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 Weisenseel et al. (1987).

STF was chosen as an appropriate storage media for $Ca(OH)_2$ and MTA specimens to stimulate the calcified bridge formation in vitro as reported by Ritwick et al. (2002); Welch et al. (2005); Sarkar et al. (2005).

The prepared methylene blue dye was used as leakage indicator as recommended by Boussetta et al. (2003) and Matt et al. (2004).

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. (2000) and Aeinehchi et al. (2003) while MTA material does not undergo solubility and disintegration thus space for microleakage does not develop as reported by Fridland and Rosada (2005).

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. (2005).

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 calcified closure was not complete but had minute communications with the periapical tissues as evaluated by Pinkham (1999). Also, the quality of the hard tissue bridge formed by calcium hydroxide criticized by Estrela and Holland (2003) who claimed that it had tunnels defects which compromised the protecting efficiency of the bridge and acted as a pathway for microleakage and reinfection. Also, the presence of tunnel defects in the dentinal bridges beneath calcium hydroxide has been described (Asgary et al., 2008). The quality of the calcified barrier formed by MTA was more uniform and had greater consistency than that formed by calcium hydroxide as compared by Shabahamg et al. (1999).

The nature and the properties of the material and the quality of the calcified barrier formed by the material can affect the sealing ability of the calcified barrier. 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 Baumagartner (2004). 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. (2005). 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. (2004) who concluded that GMTA demonstrated significantly less apical dye leakage than WMTA.

Conclusion

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 $Ca(OH)_2$ paste has the lowest sealing ability.

In general, the sealing ability of the formed apical bridge during apexification procedure can be affected by the properties and the composition of the applied material.

REFERENCES

Abdul GAH, Al-Huwaizi H (2008). The effect of delayed dowel space preparation on the apical seal of four obturation technique. M.Sc. thesis, Dept.of Cons. Dent. Univ of Baghdad.

Aeinehchi M, Eslami B, Ghanbariha M, Saffar AS (2003). MTA and calcium hydroxide as pulp capping agents in human teeth. Int. Endod. J., 36(3): 225-232.

Al-ugaily AK (2007). A comparison of fill density and apical seal of Guttapercha obtained by different condensation technique. Department of Cons. Dent., University of Baghdad.

Anthony DR, Gordon TM, Rio CE (1982). The effect of three vehicles on the pH of calcium hydroxide. Oral Surg. Oral Med. Oral Pathol., 54(4): 560-565.

Asgary S, Eghbal MJ, parirokh M, Ghanavayi f, Rahimi H (2008). A comparative study of histological response to different pulp capping material and a novel endodontic cement. Oral surg. oral Med. Oral Pathol. Oral Radio. Endo., 106: 609-614.

Asgary S, Parirokh M, Eghbal MJ, Brink F (2005). Chemical differences between white and gray MTA. J. Endod., 31(2): 101-103.

Bousseta F, Bal S, Romes A, Boivin G, Magloire H, Farge P (2003). In vitro evaluation of apical microleakage following canal filling with a coated carrier system compared with lateral thermomechanical gutta-percha condensation technique. Inter. Endo. J., 36: 367-371.

Chawla HS (1986). Apical closure in a non-vital permanent tooth using one calcium hydroxide dressing. J. Dent. Child, 53(1): 44-47.

Cohen S, Burns RC (2002). Pathway of the Pulp. 8th ed. St. Louis, Missouri. Mosby Year Book Inc. Ch.11, P. 415.

Estrela C, Holland R (2003). Calcium hydroxide: study based on scientific evidences. J. App. Oral Sci., 11(4): 1-25.

Ferris DM, Baumgartner JC (2004). Perforation repair comparing two types of MTA. J. Endod., 30: 422-424.

Fridland M, Rosada R (2005). MTA solubility: A long term study. J. Endod., 31(5): 367-379.

Gomes IC, Chevitarese O, Almeida NS, Salles MR, Gomes GC (1996). Diffusion of calcium through dentin. J. Endod., 22(11): 590-595.

Holland R, Murata S, Barbosa H, Garlippo N, Sousa V (2004). Apical seal of root canals with gutta-percha points with calcium hydroxide. Braz. Dent. J., 15(1): 26-29.

Jawad MM, AbdulQader ST, Zaidan AA, Zaidan BB, Naji AW, AbdulQader IT (2011a). Overview of Laser Principle, Laser–Tissue Interaction Mechanisms and Laser Safety Precautions for Medical Laser Users. Int. J. Pharmacol., 7(2): 149-160.

Jawad MM, AbdulQader ST, Zaidan BB, Zaidan AA, AbdulQader IT, Naji AW (2011b). An Overview: Laser Applications in Dentistry. Int. J. Pharmacol., 7(2): 189-197.

Kilpatrik NM, Welbury RR (2003). Pediatric Dentistry. 2nd ed. Oxford Univ. Press, 9: 177-180.

Matt GD, Thorpe JR, Strother JM, McClanahan SB (2004). Comparative study of white and gray MTA simulating a one or two step apical barrier technique. J. Endo., 30(12): 876-879.

Pinkham JR (1999). Pediatric Dentistry. 3rd ed. Philadelphia. Saunders Com., 12: 161.

Rahimi S, Oskoee SS, Shahi S, Maljaei E, Abdolrahimi M, Mokhtari H, Kazemi A (2010), "*In vitro* comparison of apical microleakage following canal obturation with lateral and thermoplasticized gutta-percha compaction techniques", Afr. J. of Biotechnol., 9(48): 8235-8240

Ritwick P, Ber B, Moiseyeva R, Sarakar NK (2002). In vitro stimulation of the apical barrier at MTA-dentin interface and its characterization. J. Dent. Res., 81 (Spec. Iss. A): A-391(IADR abstract #3156).

Sarkar NK, Caicedo R, Moiseyeva R, Kawashima I (2005). Physiochemical basis of the biologic properties of MTA. J. Endod., 31(2): 97-100.

Sarkar NK, Saunder B, Moiseyeva R, Berzins DW, Kawashima I (2002). Interaction of MTA and synthetic tissue fluid. J. Dent. Res.; (IADR abstract # 3155).

Schuurs AHB, Gruythuysen RJM, Wesselink PR (2000). Pulp-capping with adhesive resin based composite versus calcium hydroxide. Endo. Dent. Traumatol., 16: 240-250.

Shabahamg S, Torabinejad M, Boyne PP, Abedi H, Mcmillan P (1999). A comparative study of root-end induction using osteogenic protein-1, calcium hydroxide, and mineral trioxide aggregate in dogs. J. Endo., 25(1): 1-5.

Simon J, Ibanez B, Friedman S, Trop M (1991). Leakage after lateral condensation with finger spreader and D-11-T spreader. J. Endo., 17(3): 101-104.

Simon ST, Bhat KS, Francis R (1995). Effect of four vehicles on the pH of calcium hydroxide and the release of calcium ions. Oral Surg. Oral Med. Oral Pathol. Oral Radiol. Endod., 80: 459-464.

Sisecioglu M, Uguz MT, Cankaya M, Ozdemir H, Gulcin I (2011). Effect of ceftazidime pentahydrate, prednisolone, amikacin sulfate, ceftriaxone sodium and teicoplanin on bovine milk lactoperoxidase activity. Int. J. of Pharmacol., 7(1): 79-83.

Torabinejad M, Chivian N (1999). Clinical application of mineral trioxide aggregate. J. Endo., 25(3): 197-205.

Walton ER, Torabinejad M (2002). Principle and Practice of Endodontics.2nd ed. Philadelphia. Saunders Com., 11: 174.

Wein FS (2004). Endodontic Therapy. 6th ed. St. Louis, Missouri. Mosby Year Book, Inc., 2: 46.

Weisenseel JA, Hicks ML, Pelleu GB (1987). Calcium hydroxide as an apical barrier. J. Endo., 13(1): 1-5.

Welch S, William AP, Caicedo R, Moiseyeva R, Sarkar NK (2005). Interaction between pulpal dentin surfaces and calcium-containing endodontic materials. J. Dent. Res. (IADR abstract # 0061).