Indian Journal of Dental Education
Volume 5 Number 1, January - March 2012

Original article

Electrical and dye leakage comparison of three different root-end materials: A comparative in vitro study

Praveen S. Byakod*, Preeti B. Astagi, Mohan Sakri****

INTRODUCTION

Indenatl treatemnt cases where there is a strong possibility of failure from non surgical treatment or failure has resulted from non surgical endodontic treatment or treatment is impossible or would not achieve a better result, or persistent presence of chronic inflammation at the root apex has hindered the better prognosis of the endodontic treatment , apicoectomy followed by retrograde filling is a well established procedure[1]. Endodontic surgery usually consists of exposure of the involved apex, root resection, root end preparation and root-end filling. The ideal root-end filling material should be easy to manipulate, radiopaque, dimensionally stable, non-absorbable, and not affected by the presence of moisture or blood directly. It should also adhere to the preparation walls and seal the root canal system, be biocompatible, be non-toxic, well tolerated by the periapical tissues and promote healing[2]. Many materials have been suggested for root-end filling material including amalgam, reinforced zinc oxide eugenol, composite resin, gutta percha, zinc oxide eugenol, gold foil and glass ionomer cement. Dental amalgam is a successful material but not so popular, perhaps because of its marginal leakage and expansion on setting when used as a root-end material[3]. A new material, mineral trioxide aggregate, is found to be absolutely non cytotoxic whereas gallium alloy has displayed little cytotoxicity and ketac silver (a metal modified glass ionomer cement), super EBA and amalgam showed higher levels of toxicity, when used as root-end filling materials[4]. Hence, in this present study, we are going to evaluate the electrical and dye leakage tests of the most commonly used retrograde filling materials like mineral trioxide aggregate (Pro Root MTA-Dentsply), reinforced zinc oxide eugenol cement -super ethoxy benzoic acid cement (regular set, Harry Bosworth Co. Skokie,IL), and a metal modified glass ionomer cermet cement (Ketac Silver Applicap- 3M ESPE).

REVIEW OF LITERATURE

Kumar et al (2004)[5].

Have compared the various techniques of detecting micro leakage and concluded that though dye penetration is the most accepted method, there is scope to try newer techniques in certain situations.

S*hipper et al (2004)* [6].

In their study compared the marginal adaptation of MTA and amalgam root-end fillings in extracted teeth under low-vacuum (LV) versus high-vacuum (HV) scanning electron microscope (SEM) viewing conditions. They reported that MTA showed better marginal adaptation than amalgam under all SEM conditions.

Valois and Costa (2004)[7].

Conducted the study to compare the ability of different thicknesses of MTA to prevent apical leakage through the use of a protein-dye complex with Coomassie Brilliant Blue G. They found that 1mm-thick MTA was least effective in preventing apical leakage, with no significant difference between 2-and 3mms-thick MTA, whereas 4mm-thick MTA was the most effective.

MATERIALS AND METHODS

The study included fifty extracted human maxillary central incisors, which were

Author's Affilation: Faculty in the Dept of Conservative Debntistry and Endodontics, Rural Dental College, Loni, Maharashtra.

Reprints Requests: Dr. Praveen S. Byakod, Reader, Department of Conservative Dentistry, Rural Dental Collge Loni, Dist- Ahmednagar.Tel: 9923020311.

E-mail: pbyakod25@gmail.com.

(Received on 13.02.2010, accepted on 26.04.2010)

randomly divided into four groups. The first three groups contained fifteen teeth each where as the last group contained five teeth. The apical cavities were restored with the following retrofilling materials:

Group I: Mineral trioxide aggregate

Group II: Super EBA

Group III: Metal modified glass ionomer cermet cement

Five teeth were used as negative control

Group IV: Root end completely covered with varnish

This study was conducted in the Department of Electronics, KLES's Institute of Engineering, Belgaum.

Armamentarium and materials used

Kavo airotor and micro motor handpiece

Straight fissure diamond point

Diamond disk

Normal saline

Gauze

Mixing pad and spatula

Plastic filling instrument

Probe

Explorer

#10 K files (Thomas)

Gates glidden drills

Peeso reamers

Glass ionomer cement type II (GC Fuji II)

Instruments for biomechanical preparation

*Profile NiTi rotary endodontic files (Dentsply).

Materials for obturation

*Obtura II- thermoplastisized gutta percha technique.

0.3 inch diameter platinum wire

Retrograde materials

Mineral trioxide aggregate (Pro Root MTA, Tulsa dental)

Super EBA (Regular set, Harry Bosworth Co. Skokie,IL)

Metal modified glass ionomer cermet cement (Ketac silver Applicap, 3M ESPE)

Spartan MTS ultrasonic retro preparation kit

Varnish (GC Fuji varnish)

Defibrinated horse blood

Temperature controlled electrochemical water bath

End connectors

100-ohm resistance

Fig 1. Armamentarium

Fig 2. Spartam MTS for root end preparation

Fig 3. Retro preparation tips

Fig 4. Rotary master

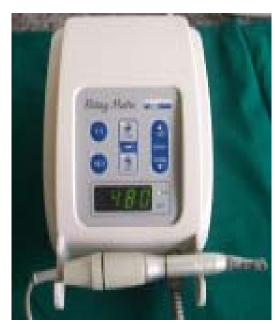

Fig 5. Pro root MTA

Fig 6. Ketac silver applicap (MMGIC)

Fig 7. Rotary preparation files (Profile)

1% Potassium Chloride solution

Sensitive multimeter.

Methylene blue

The Method of theStudy

Selection and preparation of the specimens

Root canal instrumentation and obturation

Anode placement through the orthograde entrance of the root canal

Root-end preparation

Root-end (retro) filling

Preparation of control specimen

Immersion of specimens into the defibrinated horse blood

Examination of specimens for micro leakage through electrical and dye penetration method

Immersion into methylene blue dye and its examination.

selected so as to ensure adequate length for preparation of the specimen.

Selection and preparation of the specimens

Fifty freshly extracted human,maxillary central incisros with mature apices were selected for the study.Teeth root or coronals caries,fracture,deep root concavities or evidence of resorptive processes were excluded.Roots with significant apical cuvature were omitted.Only those teeth that had a mimimum of 17mm of root length were selected so as to ensure adequate lenght for perparation of the specimen.

The selected teeth were placed in 5.25% sodium hypochlorite for 72 hours to dissolve soft tissue tags and then stored in normal saline until the start of the experiment.

The anatomic crowns of all the teeth were removed at the level of cemento-enamel junction (CEJ) with the diamond disk in a high-speed hand piece, with constant water spray. The surface was cut parallel to the horizontal plane.

Root canal instrumentation and obturation

In order to ensure apical patency and root canal length, #10 K file was inserted into the root canals 1mm beyond the apical foramen and then withdrawn until the file was 0.5mm within the canal.

The working length was measured using radiographic method with the appropriate file size initially binding at the apex.

The canals were then chemomechanically instrumented using crown down technique incorporating Profile NiTi rotary instruments with 1ml of saline and 1ml of 2.5% sodium hypochlorite alternatively as irrigants after each file. The apical portions of the canals were enlarged to three times the initial master apical file.

Obturation was accomplished using thermoplastisized gutta percha (Obtura II) technique. Zinc oxide eugenol sealer was used and the quality of the obturation was checked radiographically.

Anode placement through the coronal (orthograde) entrance of the root canal and application of varnish

Peeso reamers were used to remove the gutta percha from the orthograde entrance of the root canal so that a 10mm length of gutta percha remained in the roots. 0.3 inch diameter platinum wires were selected as anodes and 3.5 inch length wire was sectioned for each root. One end of the wire was placed through the coronal opening, about 10mm from the root tip so as to avoid contact with the retro filling material. The absence of contact was later confirmed radiographically. The wires were stabilized at the coronal opening with conventional Glass ionomer cement (GC Fuji II). To prevent dehydration throughout these procedures, the roots were held in water-moistened gauze. The entire surface of each tooth was given 3 coats of varnish (GC Fuji varnish) with 24 hours between each application.

Root end preparation

Apical 3mm of the roots were resected perpendicular to the long axis of the tooth with a diamond disk operated at high speed with constant water spray. The cut surface was made without bevelling to enhance measurement accuracy of the apical cavity depth and also to eliminate the possibility of leakage through exposed dentinal tubules.

Class I apical cavity preparation parallel to the long axis of the root, 3mm deep, centered in the root including the entire apical root canal system. Preparation was done with SPARTAN MTS ultrasonic retro preparation tips. Root-end preparations were cleaned with saline rinse and specimens were placed back into the saline solution.

Root-end (retro) filling

The samples were randomly divided into four different groups

Group I: The apical cavities were filled with mineral trioxide aggregate (Pro Root MTA, Dentsply Tulsa). Three parts of MTA were mixed with one part distilled water and made into a paste following which it was condensed into the apical cavity.

Group II: The apical cavities received super ethoxy benzoic acid (Super-EBA regular set, Harry J Bosworth Co, Skokie, IL) as root-end filling material. One scoop of powder was mixed with one drop of liquid to a stiff consistency; due to difficulty in the material handling, optimal placement was possible with a wiping motion rather than by condensation.

Group III: This group of apical cavities received metal modified glass ionomer cermet cement (Ketac Silver Applicap-3M ESPE) as a root-end filling material. It is available in the form of capsule from which the liquid capsule has to be crushed by the gun provided and then has to be put in the vibrator for correct manipulation of the material. The vibrator has to move in a medium speed so that there is enough working time for the condensation of the material into the prepared retro cavity. After manipulation of the material in the vibrator, the capsule is taken out from the vibrator, then placed in a piston provided and locked, the nozzle is straightened to facilitate the flow of the material out of the capsule, piston is then pressed gently to squeeze the mixed material out of the capsule directly into the prepared retro cavity.

Acceptable clinical standards of root-end fillings were confirmed with the radiographs for all the test groups.

Preparation of control specimen:

Five teeth were used randomly selected for the negative control group.

Group IV: Five teeth were conveniently filled with thermoplastisized gutta-percha technique using zinc oxide eugenol as sealer. The apical cut surface of these roots was painted with three coats of varnish (GC Fuji Varnish) to completely seal the opening of the canals. This group served as negative control to prove that the electrolyte can be prevented from apical penetration.

Immersion of specimens into the defibrinated horse blood

The tooth apices were suspended in defibrinated horse blood (venous blood) at 37°C for 24 hours before the start of the experiment to simulate setting conditions. Both the setting of the cement and the experiment took place in wet conditions. Horse blood was used as it is physiologically similar to human blood and is readily available. Then the specimens were washed in water and positioned in 1 % Potassium Chloride solution extending to the CEJ.

Examination of specimens for micro leakage through electrical and dye penetration method.

The electrochemical method is based on the principle that an electric current will flow between two pieces of metal when both are immersed in an electrolyte and are connected to an external power source.

The galvanic cell consists of specimens (group I to III and a control group) with platinum wire (anode) placed through the coronal opening of the root canal. The free end of this wire is connected to one input of the electric source. The other part of the galvanic cell is a platinum wire (cathode) connected to the other input and submerged in 1% Potassium Chlorite electrolyte solution. The galvanc current in this system flows only when there has been leakage into the root canal. A continuous electrolyte path has thus been established and can be measured by a sensitive multimeter (CARE BIO Co)

The time elapsed between immersion and current flow accurately denotes the Potassium chloride penetration rate and the magnitude of the current will indicate the degree of leakage.

The roots were arranged concentrically around the cathode in the electrochemical bath at 37°C using a temperature regulator (CARE BIO Co). The transformer supplied a constant 20 V direct current. The current flowing through the tooth represents leakage. Values (in mv and V) were recorded daily for 70 days.

The electrical leakage results were tabulated and statistically analysed by the application of Analysis of variance (ANOVA) and student's t-test. The readings were taken daily, but for statistical simplicity the readings were applied on days 1, 2, 5, 15, 30, 45 and 70. The statistical significance was considered if pd"0.005.

Immersion into methylene blue dye and its examination.

At the end of the 70 days, the teeth were removed and immersed in 1% methylene blue dye for 72 hours at 37°°C. The teeth were sectioned horizontally at the cemento-enamel junction. The roots were then split longitudinally; the lingual and facial surfaces were grooved with a diamond disk and a scalpel was used as a wedge.

Dye leakage was assessed for each tooth by the following criteria: 0= no leakage; 1= slight leakage reaching the apical portion of the root end restoration; 2 = moderate penetration to the middle of the root end restoration; 3 = extensive penetration to more than half the thickness of the root end restoration; and 4 = gross leakage involving the whole restoration or further into the canal.

RESULTS

The values obtained from the present study were analyzed for statistical inference using analysis of variance (ANOVA) and student's t-test. The readings were taken daily for 70 days, but for simplicity statistical tests were applied for 1, 2, 5, 15, 30, 45 and 70 days.

The descriptive statistics are computed and presented in Tables II, III, IV, V comprising of mean, Standard deviation and standard error of the electrochemical, leakage readings for the 15 teeth in each test group and 5 teeth for negative control groups over 70 days test period. Table VI gives the total mean and standard deviation of each experimental group.

The following observations were made from the descriptive statistics.

Group I had a mean micro leakage value of 1.2232±0.678V.

Group II had a mean micro leakage value of 1.921 ± 0.715V.

Group III had a mean micro leakage value of 1.557 ± 0. 50 V.

Group IV had a mean micro leakage value of 0.339 ± 0.396V.

Table I. Experimental root-end filling material and the number of specimens used in each group.

Group number	Experimental material	No of specimens
Group I	MTA	15
Group II	S-EBA	15
Group III	MMGIC	15
Group IV	Negative control	5

Table II. Mean apical microleakage, standard deviation and standard error for Group I: MTA

	N	Mean	Std. Dev.	Std. Error
1	1	0.6439	0.6351	0.200455
2	2	0.4562	0.1061	0.032989
3	5	0.608	0.0529	0.017089
4	15	1.160	0.2559	0.082428
5	30	1.716	0.17991	0.056798
6	45	1.774	0.18501	0.059897
7	70	2.203	0.24959	0.089761
Total	70	1.223	0.688942	0.082436

Table IV. Mean apical microleakage, standard deviation and standard error for Group III: MMGIC

	N	Mean	Std. Dev.	Std. Error
1	1	0.8868	0.333134	0.105352
2	2	1.021	0.197614	0.062593
3	5	1.658	0.392912	0.124134
4	15	1.691	0.392399	0.092454
5	30	1.748	0.225610	0.070235
6	45	1.948	0.357088	0.113149
7	70	2.105	0.200394	0.03389
Total	70	1.576834	0.510616	0.060964

Table III. Mean apical microleakage standard deviation and standard error for Group II: Super EBA

	N	Mean	Std. Dev.	Std. Error
1	1	1.0091	0.593349	0.18639
2	2	0.9994	0.437994	0.143694
3	5	1.5992	0.191036	0.0693
4	15	2.0876	0.218091	0.083799
5	30	2.3699	0.206129	0.063496
6	45	2.8341	0.22729	0.071491
7	70	2.4929	0.225634	0.071661
Total	70	1.91317	0.747966	0.090456

N: Test days applied for statistical analysis

Table XI. Comparison of difference in mean values using student's t-test (electrochemical method)

	Groups (in V)	t value	Df	P-value
I	MTA & SEBA	-5.5801	138	0.001
II	MTA & MMGIC	-3.3459	138	0.0011
III	SEBA & MMGIC	3.1168	138	0.0022
IV	MTA & Neg cont	8.5513	138	0.0001
V	SEBA & Neg cont	14.5079	138	0.0001
VI	MMGIC & neg cont	14.6602	138	0.0001

Table XIII. Comparison of difference in mean values using

Student's t-test (Dye leakage)

	Groups (in V)	t value	Df	P-value
I	MTA & SEBA	-6.2125	141	0.001
II	MTA & MMGIC	-4.3652	141	0.0011
III	SEBA & MMGIC	2.3254	141	0.0022
IV	MTA & Neg cont	6.4879	141	0.0001
V	SEBA & Neg cont	12.1598	141	0.0001
VI	MMGIC & neg cont	13.9589	141	0.0001

In the dye leakage test, MTA provided a better seal than did sEBA and MMGIC (Graph VII numbring). The mean value of mean MTA was 0.88 and that for MMGIC was 2.48, which is statistically highly significant. There was significant difference between the sEBA and MMGIC group. Again, their was non statistically highly significant difference between the MTA and the negative control for which mean was 0.67.

DISCUSSION

Root resections and placement of the root - end fillings have been performed since the middle of eighteenth century[8]. According to Weine[9], the most common cause of endodontic failure is the lack of apical seal. The quality of root-end filling is an important determinant of healing after periapical surgery[10]. The purpose of placing a retrograde filling is to provide a tight, biocompatible apical seal, which inhibits the leakage of residual irritants from the root canal into the periradicular tissue. Although a plethora of materials is available, no material has been found which fulfils all or most of the properties of ideal retrograde filling material.

The assessment of the linear penetration of dyes or radioisotopes has been the most common in-vitro method of examining the adaptation of the canal walls[9-11-12].

In the study, the order of leakage increased from MTA, MMGIC, sEBA. All the three materials exhibited significantly lower leakage, of which MTA performed better than sEBA and MMGIC. MTA is biocompatible material which has antibacterial property. Its physical properties are superior to that of the existing materials used as root-end filling[17].

Based on the investigation, we found that amongst the materials tested-Mineral trioxide aggregate, super EBA and metal modified glass ionomer cermet cement-MTA showed the least apical microleakage as measured by electrochemical and dye penetration method followed by metal modified glass ionomer cermet ,cement indicating that MTA is a better apical sealant as compared to the other two materials [Table V].

SUMMARY AND CONCLUSION

Summary

This present in-vitro study was designed to compare the sealing ability of mineral trioxide aggregate (MTA), super ethoxy-bezoic acid cement (sEBA) and metal-modified glass ionomer cermet cement (KETAC SILVER APPLICAP-3M ESPE) as root-end filling materials under simulated oral conditions by using an electrochemical and dye penetration method of evaluation for microleakage.

Fifty freshly extracted human maxillary central incisors with mature apices were selected for the study. The anatomical crowns were removed at cemento-enamel junction. Teeth were chemomechanically prepared with crown down technique and obturation was done with thermoplastisized gutta percha technique. Anodes of platinum wire were sealed by removing the gutta percha into the orthograde entrance of the canal using conventional glass ionomer cement. The entire surface of each tooth was given three coats of varnish with 24 hours gap between each application. Apical 3mm of roots were resected and class one cavity prepared with SPARTAN MTS ultrasonic retro tips. These root-end cavities were restored with MTA (Group I), Super EBA (Group II), and metal modified glass ionomer cermet cement (Group III) and Group IV was used as negative controls respectively.

Following 24 hours setting in defibrinated horse blood, the specimens were placed in electrolyte bath containing 1% Potassium chloride solution maintained constantly at 37° C. apical leakage measurements were recorded in volts everyday for 70 days with a sensitive multimeter.

After the completion of 70 days of electrochemical study the specimens were immersed in 1% methylene blue stain for 72 hours and later the samples were sectioned longitudinally for measurement of the dye penetration, giving it grades from 0-4.

The readings were then tabulated and statistically analyzed using analysis of variance test (ANOVA) and students t- test. Results of the test indicate that there was "high significant difference" in values among all the three groups. Mineral trioxide aggregate showed the least apical microleakage, followed by metal modified glass ionomer cermet cement and super ethoxy-benzoic acid cement.

CONCLUSION

*Microleakage was noticed in all the groups

*Mineral trioxide aggregate showed the least apical microleakage followed by metal modified glass ionomer cermet cement and Super ethoxy benzoic acid (EBA).

*The hermatic seal remains an enigma; hence the search for an ideal retro/filling material has to go on.

REFERENCES

1. Martell B, Chandler NP. Leakage comparison of three root end filling materials. *Quintessence Int* 2002; 33: 30-34.
2. Torabinejad M, higa RK, McKendry DJ, Pittford PR. Effects of blood contamination on the dye leakage of four root end filling materials. *J Endod* 1994; 159-63.
3. Agra Bawij. Sealing ability of amalgam, Super EBA and MTA when used as retrograde filling material. *Br Dent J* 2000; 188:266-68.
4. Osario RM. Cytotoxicity of endodontic materials. *J Endod* 1998; 24(2): 91-6.
5. Kumar M, Mohan, Lakshminarayanan L. Methods of detecting microleakage. *J Cons Dent* 2004; 7: 79-88.
6. Schipper G, Grossman ES, Botha AJ, Cleaton, Jones TE. Marginal adaptationof MTA compared with amalgam as root end filling material. Low vaccum (lv) vs high vaccum (hv) SEM study. *Int Endod J* 2004; 37: 325-36.
7. Valois RA and Costa JR, Edison D. Influence of the thickness of MTA on sealing ability of root

end filling- In vitro. *Oral surg Oral med Oral pathol* 1997; 108-111.

8. Gutmann JL. Management of rescted root end – a clinical review. *Int Endod J* 1993; 33: 273-83.
9. Bondrad L. Leakage in-votro with IRM, high copper amalgam and EBA cememnt as root end filling materials. *J Endod* 1989; 15: 157-60.
10. Gutmann JL. *Surgical Endodontics*, ed. boston; Blackwell, 1999; 203-77.
11. Gagliani M et al. Root end preparation, influence of cutting angle and apical seal. *J Endod* 1998; 24: 726-30.
12. Mattison GD. Microleakage of retro grade amalgam. *J Endod* 1985; 11: 340-45.