Original Article

Leakage Values of Access Cavity Restored with Different Restorative Material: An *In Vitro* Study

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ABSTRACT

Introduction: The importance of coronal leakage in the prognosis of pulp space therapy has been emphasized in studies where canals were obturated *in vitro* and *in vivo* under ideal conditions. After endodontic therapy, a coronal restoration that fails to provide a seal could permit the movement of microorganisms or their toxins along the canal walls or through voids in the root canal filling to periapical tissue resulting in failure. The aim of the present study is to evaluate the coronal microleakage values of access cavities restored with the different access restorative material.

Materials and Methods: A total of 48 freshly extracted human single rooted teeth were collected and randomly sampled into five experimental groups having eight specimens each and a control group with eight specimens. All specimens were decoronated just apical to the cementoenamel junction and obturated with gutta-percha using zinc oxide eugenol (ZOE) sealer. Experimental groups receive silver amalgam, glass-ionomer cement (GIC), composite resin, glass-ionomer with mineral trioxide aggregate (MTA) base, composite resin with MTA base, and control group received ZOE as 3 mm coronal barrier. Then, the experimental and control group specimens are incubated, thermocycled and submerged in molten sticky wax, coated with two layers of nail varnish and were stored in 2% methylene blue solution. Then, the specimens are run under tap water and are then placed in 35% nitric acid. After which the specimens were filtered, centrifuged and then spectrophotometric analysis done. The results were subjected to statistical analysis. Data were statistically analyzed using ANOVA and Tukey's Honestly significant test.

Result: Group of specimens sealed using composite with resin showed statistically least Coronal leakage and specimens with amalgam showed maximum coronal leakage values. Intergroup comparison showed the high statistically significant difference between specimens using composite and MTA with GIC when compared with other access restorative material.

Conclusion: The results of the study show that composite with MTA as base showed least apical leakage and maximum leakage was seen in amalgam, and none of the access restorative materials showed a fluid impervious seal. It was observed that MTA with composite and MTA with GIC were highly significant.

Keywords: Access cavity, Access cavity restoration, Composite restorations, Leakage values, Silver amalgam

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INTRODUCTION

The importance of coronal leakage in the prognosis of pulp space therapy has been emphasized in studies where canals were obturated *in vitro* and *in vivo* under ideal conditions.[1] It was found that after only 3 days of exposure, there was extensive coronal leakage of a tracer dye through apparently sound root canal fillings. This demonstrated that leakage of this nature should be taken into account as a potential etiological factor in the failure of endodontic treatment. Other studies have confirmed the importance of coronal leakage as a cause

of failure of endodontic treatment. It was found that 50% of endodontically treated single rooted teeth, when exposed to a microbial challenge, were contaminated with bacteria along the entire length of the root canal after 19-42 days depending on the test microorganism.[2] After endodontic therapy, a coronal restoration that fails to provide a seal could permit the movement of microorganisms or their toxins along the canal walls or through voids in the root canal filling to periapical tissue resulting in failure. Traditionally, the prevention of coronal leakage has been accomplished by intermediate access restorative materials. Several investigators have studied permanent access restorative materials and their ability to control coronal leakage.[3]

Composite resins are the most common choice for restoring access cavities following endodontic procedures.[4] They can be bonded to tooth structure and the most restoratives and can provide a good match of color and surface gloss. Bonded composite materials can also strengthen existing coronal or radicular tooth structure, in anterior teeth.[5] Traditional glass-ionomer cements (GICs) are self-cure and have limited polymerization shrinkage; composite resins shrink to a greater extent. Both hybrid glass-ionomers and hybrid composite resins are used as permanent access restorative materials. Mineral trioxide aggregate (MTA) has been found to have very good biological properties.[6] It was also shown to have good sealing properties when placed apically. However, the effectiveness of MTA when placed over a root canal filling and sealed with traditional access restorative material is untested.[7] Endoaccess restoration should provide a satisfactory coronal seal. Preferably a double barrier created could result in greater clinical success. Placing glass-ionomer/composite under the set MTA placed against orifices ending in gutta-percha could be a better option for an effective barrier.[8] Dye leakage studies can be used to assess the integrity of these materials and their interface with tooth structure to provide the basis for their clinical use. Dye leakage studies have been the most popular method to measure penetration along a root filling. Methylene blue, India ink and silver nitrate are among the most frequently used tracers. Dyes represent agents of a smaller molecular size comparable to bacterial cell components, and/or nutritive fluids, making this technique the most critical indicator. Endodontic obturation is often thought of only in terms of an effective apical seal.[9] However, the coronal seal may be equally important for the ultimate success of endodontic treatment.[10] The apical seal may be adversely affected if coronal seal is lost or becomes defective. The coronal seal is influenced by the restoration thickness, quality of condensation and total contact surface between intact tooth structure and restorative material.[11] Deroofing the pulpal floor is an integral step in the preparation of an ideal access cavity. Cleanliness of the access cavity before placing an access restoration is significant. Most clinician bevel the cavosurface margin of access cavities to effectively bond composite especially in anterior teeth. After obturation with gutta-percha, one is expected to remove excess gutta-percha and sealant to the orifice level before placing access restorative material.[12]

Hence, there is a need to conduct a study to assess the coronal microleakage with permanent access restorative materials with an intra-orifice barrier. The aim of the present study is to evaluate the coronal microleakage values of access cavities restored with the different access restorative material.

MATERIALS AND METHODS

About 48 freshly extracted human single rooted teeth were collected and randomly sampled into five experimental groups having eight specimens each and a control group with eight specimens. All specimens were decoronated just apical to the cementoenamel junction and obturated with gutta-percha using zinc oxide eugenol (ZOE) sealer. Experimental groups receives silver amalgam, GIC, composite resin, glass-ionomer with MTA base, composite resin with MTA base and control group received ZOE as 3 mm coronal barrier. Then, the experimental and control group specimens are incubated, thermocycled and submerged in molten sticky wax, coated with two layers of nail varnish and were stored in 2% methylene blue solution. Then, the specimens are run under tap water and are then placed in 35% nitric acid. After which the specimens were filtered, centrifuged and then spectrophotometric analysis done.

Inclusion Criteria

Teeth with no/minimal caries and non-fused, well-developed diverging roots.

Exclusion Criteria

Teeth with cracks, open apices, root caries, and fused roots.

Experimental Group

Group 1: Silver amalgam
Group 2: GIC
Group 3: Composite resin
Group 4: Glass ionomer with MTA base
Group 5: Composite resin with MTA base.

Control group: ZOE.

Statistical Analysis

The values obtained for each specimen were then entered into SPSS 16 and were subjected to statistical analysis.

Means of the six groups were compared using ANOVA and Tukey test was used to find a significant difference between groups. The level of significance was set at 0.05.

RESULTS

The data obtained evaluating the coronal seal was subjected to statistical analysis using ANOVA test. The computed value of $P < 0.05$ indicates statistically significant difference among groups under study. In the Table 1 and Figure 1 showed coronal leakage transmission value of 43.37 and standard deviation of 2.38 for group I. Group II (GIC) showed an coronal leakage transmission value 47 and standard deviation of 2.39.Group III (COM) showed an coronal leakage transmission value 46.62 and standard deviation 2.06.Group IV (MTA/GIC) showed an coronal leakage transmission value of 47.12 and standard deviation 1.12.Group V (MTA/COM) showed an coronal leakage transmission value of 48.5 and standard deviation 1.92.Group VI showed an coronal leakage transmission value of 47.37 and standard deviation 1.76. Highest transmission mean leakge value was seen for group V (MTA/COM) and lowest transmission value was seen for Group I (Ag).

Furthermore data was subjected to Tukey's Honestly significant test to determine intergroup comparison. This test was done to compare the five experimental groups.It was observed that there was statistical significant difference (p>0.05) when Group I (Ag) was compared with Group II (GIC),Group III (COM) and Group IV (MTA/COM) and Group V (MTA/GIC). When intercomparison was done it was proved Group IV (MTA/GIC) & Group V (MTA/GIC) were highly significant.

Table 2 of the results indicate volumetric dye penetration values by groups of all specimens with respect to absorbance in 640 nm and transmission. By applying kruskalwallis test it was found that there was significant difference (p=0.002) among the 6 groups such as silver amalgam , glass ionomer cement , composite resin, mineral trioxide aggregate with glass ionomer cement, mineral trioxide aggregate and with composite and zinc oxide eugenol.

Table 3 indicates the mean and standard deviation values of volumetric dye penetration in groups with reference to absorbance and transmission. The ANOVA test result for the experimental groups which shows source variation F=6.062 (p<.001) which is very highly significant. When intergroup comparison was done it was observed that mineral trioxide aggregate with composite resin and mineral trioxide aggregate with glass ionomer cement were highly significant.

Results showed that Group V (MTA/COM) exhibited least amount of leakage and maximum amount of coronal leakage was seen in Group I (Ag).

DISCUSSION

In endodontics until the last 10 years, clinicians focused only on three-dimensional obturation of the pulp space giving significant importance to apical one-third of the pulp space.[13] However, off late most clinical researchers have stressed on a fluid impermeable seal from the orifice

Table 1: The mean and standard deviation values of volumetric dye penetration in groups with reference to absorbance and transmission

Group	Absorbance		Transmission	
	Mean	SD	Mean	SD
Silver amalgam	0.36863	0.021387	43.3750	2.38672
GIC	0.33175	0.022846	47	2.39046
Composite resin	0.33180	0.024980	46.6250	2.06588
MTA/GIC	0.33350	0.016527	47.1250	1.12599
MTA/COM	0.31387	0.019672	48.5000	1.92725
ZOE	0.32825	0.021559	47.3750	1.76777

SD: Standard deviation, GIC: Glass ionomer cement, MTA: Mineral trioxide aggregate, ZOE: Zinc oxide eugenol

Table 2: ANOVA test result for the experimental groups which shows source variation

Dependent variable: Transmission	
Source of variation	**Value of significance**
F=6.062	*P*<0.001 VHS

VHS: Very highly significant

Table 3: Tukey HSD Tukey's honestly significant test results of different access restorative materials when intercompared

Group	Inter group	Mean difference	*P*
I - Silver amalgam	Composite	−3.2500	0.025 S
	MTA with GIC	−3.7500	0.006 HS
	MTA with composite	−5.1250	<0.001 VHS
II - GIC	Silver amalgam	3.6250	0.009 HS
	Composite	0.3750	0.999
	MTA with GIC	−0.1250	1.000
	MTA with	−1.5000	0.662
	Composite ZOE	−0.3750	0.999
III - Composite resin	Silver amalgam	3.2500	0.025 S
	MTA with GIC	−0.5000	0.996
	MTA with	−1.8750	0.426
	Composite ZOE	−0.7500	0.974
IV - MTA with GIC	MTA with composite	−1.3750	0.738
	ZOE	−0.2500	1.000
V - MTA with composite resin	ZOE	1.1250	0.866

Level of significance set at 0.05. GIC: Glass ionomer cement, MTA: Mineral trioxide aggregate, ZOE: Zinc oxide eugenol, VHS: Very highly significant, HS: Highly significant, S: Significant

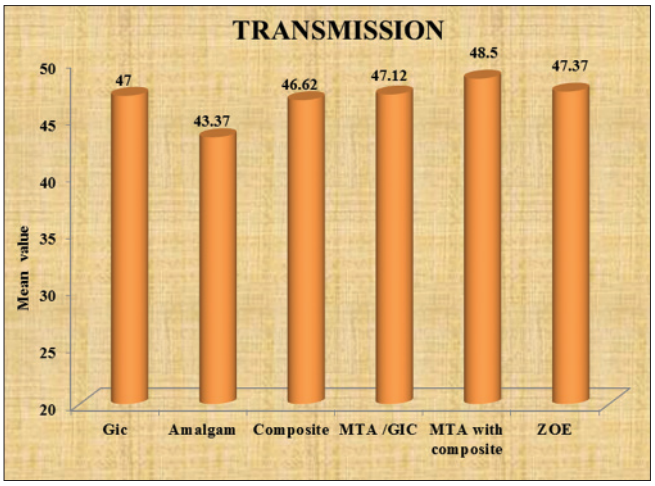

Figure 1: Mean transmission value under spectrophotometry using dye penetration test

to the apical constriction which includes the coronal endo access cavity restoration. Much has been written on coronal leakage from endo access cavity restoration depending on the type of material used by the clinician as endo access restorative material.[14] Presently plenty of *in vitro* research has been carried out with orifice barrier materials to restrict coronal microleakage in endodontically treated teeth.[15] secondary microleakage due to compromised coronal seal is one of the most important factors associated with endodontic failures. Intra-orifice barrier is an efficient alternative method to decrease coronal leakage in endodontically treated teeth.[16] This procedure includes placing additional materials into the canal orifice immediately after the removal of the coronal portion of gutta-percha and sealer. Endodontists have used several materials in an attempt to provide an intra-coronal seal to prevent microleakage. In the present study, we have utilized Silver amalgam, GIC, composite resin, GIC with MTA base, composite resin with MTA, and ZOE was used as the control group.[17]

MTA is a biomaterial introduced for endodontic application during the early 1990's by Torabinejad. MTA is now utilized as an orifice barrier material in endodontics. However, MTA has numerous applications. In the present study in Group IV and V, we utilized MTA as an orifice barrier material with GIC and composite resin as access restorative material, respectively.[18] In Group I, II and III, we utilized only access restoration materials silver amalgam, GIC and composite resin, respectively. One has to observe that the MTA has prolonged setting time.

Dental application for dye recovery methods was the first proposed by Douglas and Zakariasen1. This method minimizes the human error and determines the volume leakage measurements rather than linear measurements. Spectrophotometric analysis was shown to be a reliable and an effective method of quantitatively measuring apical leakage.

In the present study, we utilized an optical wavelength of 640 nm, time for dye leakage to take place 72 h and 15 ml of 35% nitric acid was used to dissolve the dye.

Interpreting the results of volumetric dye leakage studies, it has to be observed that it is done on the basis of transmission through spectrophotometry. The higher the transmission, and the lower the leakage values. An insight into the result obtained in the present study indicates that when MTA and the composite resin was used as the orifice barrier material, we could demonstrate least leakage values. When MTA and GIC combination was used, we could get comparable statistical values.

According to Tselnik *et al*.,[19] insufficient coronal seal may occur in a different clinical situation like fracture of tooth structure, loss of intermediate access restorative material, marginal leakage of final restoration and recurrent caries. All these conditions expose pulp space to oral environment with subsequent coronal microleakage.

Chailertvanitkul *et al*.,[13] evaluated the microbial coronal leakage in restored pulp chamber of a root canal in multirooted teeth and concluded resin reinforced glass ionomer lining material placed in the pulp chamber and canal opening was an effective barrier in preventing microbial leakage. In the present study where we utilized GIC alone as an endo access restorative material, we could demonstrate acceptable values. However, MTA with a combination of GIC as orifice material exhibited comparatively less microleakage while MTA with composite resin as an orifice barrier material yielded the least leakage value, in comparison to the other groups used in the present study. However ZOE when used alone as an access restorative material yielded fairly minimum leakage values next only to MTA and composite resin combination orifice barrier material. This is in agreement with the present study even though the authors[13] did different methodology in their study. As far as minimum leakage values obtained with ZOE, the present investigators have no explanation.

In the present study, we could also demonstrate the highest leakage value with silver amalgam compared to the other groups of the study. This was anticipated because we have only allowed silver amalgam to set for 72 h and within that period there is no 100% sealing of margins of silver amalgam, even though silver amalgam is considered as one of the standard access restorative materials. Two or three decades back silver amalgam was the benchmark endo access restorative material specially high copper amalgam.

Tewari and Tewari[15] evaluated the coronal microleakage of endodontically treated multirooted teeth and concluded that the best coronal seal in their study was observed when silver amalgam was used as an access restorative material. However, this is not in agreement with the present study.

Barrieshi-Nusair and Hammad[20] studying the intra-coronal sealing of MTA and GIC concluded that MTA produced much better seal than GIC. However in the present study, we did not use MTA alone taking into consideration that MTA takes a long time for setting and cannot be evaluated as a single orifice barrier material. In the present study, both MTA with GIC and MTA with composite resin combination yielded minimum leakage values compared to the other groups. The authors do not recommend MTA to be used alone as an orifice barrier material.

Jiang *et al*.,[21] proposed the criteria for an ideal intra-orifice seal as follows: (i) Easily placed, (ii) bonds to tooth structure, (iii) seals effectively against coronal microleakage, (iv) easily distinguished from natural tooth structure, (v) does not interfere with final restoration of the access preparation. Of the criteria sealing against coronal microleakage and bonding to the tooth structure are most important. In their study, they demonstrated that flowable composite seal as well as hybrid composite Z100 composite prevent microleakage. In the present study even though we did not utilize flowable composite, the hybrid composite combination with MTA as an orifice barrier material could record least leakage value.

Deepali and Hegde[22] studied the coronal microleakage of four restorative materials used in endodontically treated teeth as a coronal barrier and concluded that coronal seal obtained with GIC as intra-orifice barrier is better than the other groups tested. However in the present study, when GIC was used alone we could not record satisfactory result. However, when MTA and GIC used in combination we could record minimum leakage values.

Shetty *et al*.,[23] compared the sealing ability of MTA and three conventional restorative materials and concluded that MTA can result in the excellent coronal seal and can be preferred over GIC, composite resin or cavit as intra-orifice barrier following endotherapy.

In the present study, we utilized MTA with composite resin combination and MTA with glass ionomer combination and could record least leakage values compared to all other groups. However, in the present study, we utilized ZOE as control and recorded least leakage value next only to MTA and composite resin combination as an orifice barrier material.

Within the limitation of the study and being an *in vitro* study no conclusion can be drawn in ranking the intracanal orifice material in endodontically teeth. Much clinical research is required to substantiate the findings obtained on the laboratory bench before transferring to the clinical scenario.

Within the limitations of this *in vitro* study, we conclude that composite with MTA as base showed least apical leakage and maximum leakage was seen in amalgam. None of the access restorative materials showed a fluid impervious seal.

When intergroup comparison was done, it was observed that MTA with composite and MTA with GIC were highly significant.

CONCLUSION

In the present study, spectrophotometric evaluation was carried out to analyze the coronal leakage with different restorative material using dye penetration method. According to the results analyzed, dye penetration measurements showed that Group V had least dye penetration followed by Group VI and Group IV. Maximum dye penetration was seen in Group I (Ag). There was statistically significant difference when Group I was compared with Group II, Group III and Group IV and Group V (MTA/GIC). When intercomparison was done, it was proved Group IV (MTA/GIC) and Group V (MTA/GIC) were highly significant.

Spectrophotometry results revealed that Group V (MTA/COM) exhibited the least amount of leakage, and maximum amount of coronal leakage was seen in Group I (Ag). None of the access restorative materials showed fluid impervious seal in this study.

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