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Original Research

Comparative Evaluation of Sealing Ability of Four Different Restorative Materials Used as Coronal Sealants: An *In Vitro* Study

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Abstract:

Background: The purpose of the present study was to evaluate and compare the sealing ability of glass ionomer cement (GIC), composite resin, gray mineral trioxide aggregate (GMTA) and white mineral trioxide aggregate (WMTA) when placed coronally as double - sealing material over gutta-percha in root canal treated teeth.

Materials and Methods: A sample of 70 freshly extracted human single rooted teeth were cleaned, shaped and obturated with gutta-percha and AH Plus. The gutta-percha was reduced to a depth of 4 mm from the cemento enamel junction using hot plugger and standardized access cavities with 4 mm depth were prepared at the coronal ends of the roots. The specimens were randomly divided into four groups containing 15 teeth each depending on the restorations they received in the coronal cavity. A positive control group of five teeth received no restorative barrier over gutta-percha. All root surfaces were covered with two coats of nail varnish, leaving only the access openings uncovered except teeth in the negative control group, which were completely covered with nail varnish. All teeth were immersed in India ink, cleared and observed under stereomicroscope for the depth of dye penetration.

Results: The results were tabulated and analyzed using Kruskal–Wallis test and multiple comparison between each group was carried out using Mann-Whitney test. The groups sealed with GMTA and WMTA showed least dye penetration than other groups and the difference was statistically significant. Highest dye penetration was seen with groups sealed with GIC and was statistically significant compared with other three groups.

Conclusion: The results showed that the GMTA and WMTA provided significantly better coronal seal when compared to other two restorations. The composite resin also showed significantly better seal than the unsealed group and the group sealed GIC, which showed highest leakage that was equivalent to that of unsealed group.

Key Words: Coronal microleakage, coronal seal, double-seal technique, mineral trioxide aggregate

Introduction

One of the major causes of endodontic failure is the microleakage occurring in obturated canals, leading to microbial reinfection. The potential gateway for the microorganisms is through the coronal or apical regions of the tooth.[1] Coronal microleakage is shown as one of the major cause of nonsurgical endodontic failure.[2] Factors like delay in placement of a permanent restoration, fracture of the coronal restoration and/or tooth, inadequate thickness of the temporary restoration, and preparation of the post space with inadequate remaining apical filling have been attributed to the potential means of coronal recontamination of obturated root canals.[2] The efficiency of coronal seal depends on the obturating material and the coronal restorative material used.

Over the years, several restorative materials referred to as "intra-orifice barriers" have been used in an attempt to produce a coronal barrier with varying results.[3,4] one of the recent materials mineral trioxide aggregate (MTA; Dentsply Tulsa Dental, Tulsa, OK) has been evaluated for a wide variety of applications like pulp capping, apical barrier, perforation repair, root-end filling and as an orthograde root-filling material.[5] MTA expands on setting and thus helps to achieve a good seal. This expansion is said to be the cause for the superior sealing ability of MTA resisting leakage as well as providing superior marginal adaptation.[5]

In recent years, a new MTA formulation that is white in color, rather than gray, has been made available. The only chemical difference between the gray mineral trioxide aggregate (GMTA) and white mineral trioxide aggregate (WMTA) is the reduced iron content in WMTA, resulting from a difference in manufacturing process.[6] In addition, the particle size of the WMTA is smaller to enhance handling and placement characteristics. Despite the wide range of potential applications, minimal attempts have been made to evaluate MTA as a barrier to prevent coronal leakage.[7,8]

Despite research supporting the effectiveness of coronal barriers, a universally accepted protocol that incorporates a coronal barrier after root canal therapy is non-existent.

Hence, this study evaluated and compared the sealing ability of GMTA and WMTA against commonly used restorative materials glass ionomer cement (GIC) and light cure composite resin when used in a double-seal technique, as coronal sealants in root canal treated teeth.

Materials and Methods

Seventy freshly extracted human pre-molar teeth were collected for the study from the Department of Oral and Maxillofacial Surgery, extracted due to periodontal or orthodontic reasons (Figure 1). The procedure for preparation and obturation was standardized for all groups and performed by a single operator.

The crowns were removed at the cemento enamel junction (CEJ) using high-speed diamond points with air water spray coolant at a plane perpendicular to the long axis of the tooth. The teeth were randomly divided into four experimental groups of 15 teeth each and a positive and negative control group of five teeth each (Figure 2).

Root canal was debrided and patency of canal was determined with size 10 k file. To determine working length a size 10 k file was inserted until it was visible at the apical foramen and 1 mm subtracted from this length. The root canals were instrumented in a step back manner using K-files up to master apical file size 40 file with constant alternate irrigation with 2.5% sodium hypochlorite and saline solution. Coronal and mid segments of the canals were flared using gates glidden burs numbers three to one in a step down technique. Before obturation standardized access cavities were prepared at the coronal ends of the roots with diamond bur with 2.5 mm in diameter and 4 mm in depth (Figures 3 and 4).

Figure 1: Study sample.

The canals were dried with absorbent paper points and obturated with gutta-percha and AH Plus sealer using cold lateral condensation method. Excess gutta-percha was removed with hot instrument and the coronal gutta-percha was vertically condensed. The gutta-percha level was reduced using hot plugger to a depth of 4 mm from the CEJ.

The coronal 4 mm of the canal over the gutta-percha received the following restorations over gutta-percha obturation (Diagram 1 & Figure 5).

- Group I: 4 mm light cure composite resin.
- Group II: 4 mm GMTA.

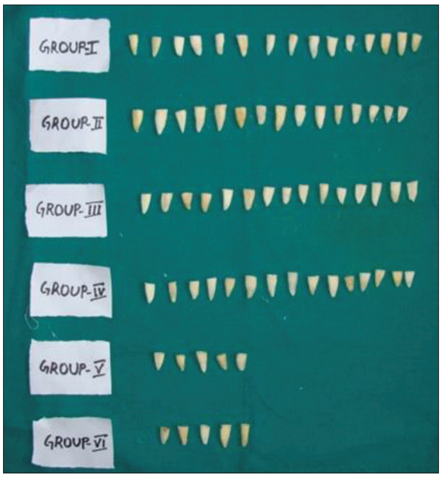

Figure 2: Study sample-decoronated.

Figure 3: Coronal access cavity preparation.

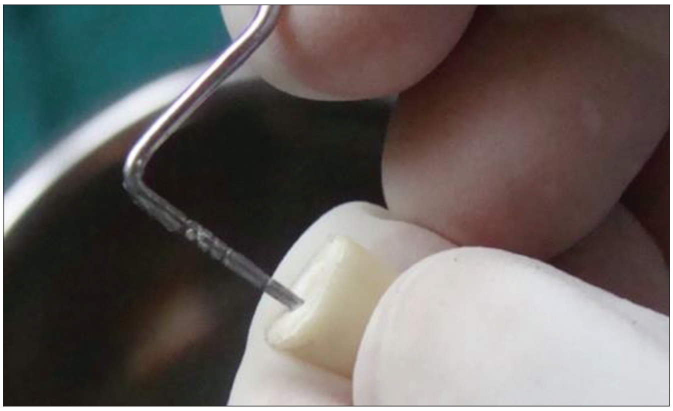

Figure 4: Measuring depth of the cavity.

- Group III: 4 mm GIC Type II.
- Group IV: 4 mm WMTA.
- Group V: Positive control group, five instrumented and obturated teeth with gutta-percha at the level of the orifice (Diagram 2 & Figure 6).
- Group VI: Negative control group, five instrumented and obturated teeth with coat of nail polish sealing the entire tooth (Figure 7).

For groups sealed with MTA over gutta-percha, the moistened cotton pellet was placed over MTA for 4 h. All root surfaces of both experimental and positive control groups were carefully coated with two layers of finger nail polish from root apex to the level of CEJ without including the canal orifices. Teeth in the negative control group were completely coated with nail polish including the canal orifice. The roots were placed in India ink for 48 h, rinsed with tap water and the finger nail polish was completely removed. The following technique was then used to clear the teeth. The roots were demineralised by placing them in 5% nitric acid for 72 h with daily changes of the acid. After rinsing with tap water, the roots were dehydrated by placing in 99.8 % ethyl alcohol for 3 days with daily changes of the alcohol. Finally, the roots were stored in methyl salicylate to complete the clearing process.

Figure 5: Sealed experimental group.

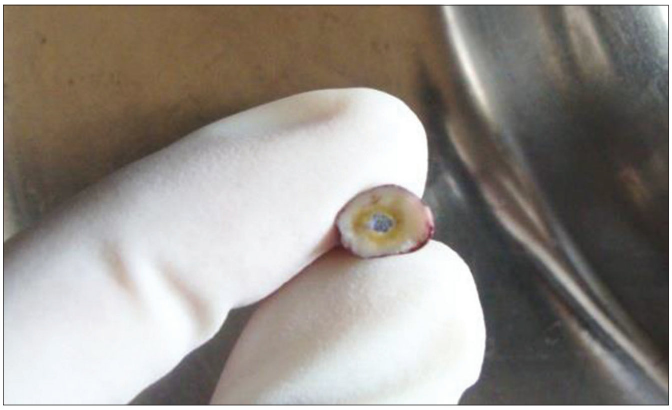

Figure 6: Unsealed positive control group.

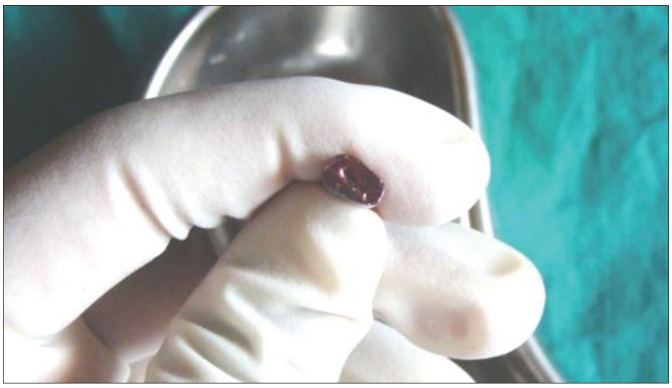

Figure 7: Negative control group coated with nail varnish completely.

The maximum point of coronal dye penetration was measured from the CEJ under stereomicroscope at ×10 magnification (Figure 8, Tables 1 and 2). The data were analyzed using Kruskal–Wallis test and multiple comparisons using Mann–Whitney test.

Results and Observations

The difference in the leakage rates among the groups is statistically significant (test statistic = 52.403, df = 4, $P \leq 0.001$) using Kruskal–Wallis test (Table 3).

From the Mann–Whitney test results, we notice that there is a significant difference between all the groups except group two, four, and group three and positive group (Table 4).

Discussion

The goal of all the endodontic treatments is to achieve a three-

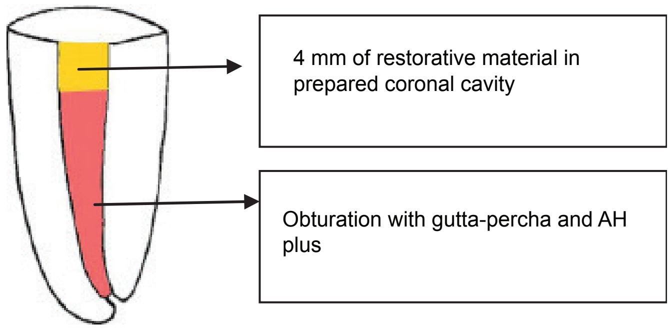

Diagram 1: Diagram showing placement of restorations. Over gutta-percha as double seal.

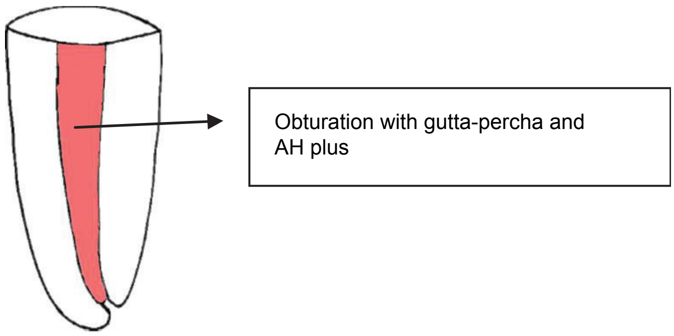

Diagram 2: Control group without double-seal.

dimensional fluid tight seal. The failures seen in root canal treatments are usually caused when microorganisms and/or their products gain access into the canals due to an improper seal leading to microleakage into the canals. Thus, we need to take utmost care in creating best of the seals in all the three directions apically, coronally, and laterally.

To prevent loss of the crucial coronal seal, we need to place a good restoration after the endodontic treatment. This post endodontic restoration should have the ability to prevent recontamination of the root canal system from food debris, oral fluids and microorganisms in the oral cavity.[9] Various

Figure 8: Stereomicroscope.

Table 1: Dye penetration in six groups in mm.

Sample number	Group I	Group II	Group III	Group IV	Positive control	Negative control
1	8.00	3.00	8.50	3.50	12.50	0.00
2	8.20	2.60	9.00	2.50	11.76	0.00
3	6.10	2.00	7.50	2.60	10.99	0.00
4	5.50	3.20	6.50	3.70	9.87	0.00
5	6.70	2.40	9.50	2.80	13.50	0.00
6	6.50	2.00	8.00	3.00		
7	4.50	3.40	9.50	3.75		
8	6.00	3.20	7.00	3.80		
9	4.60	2.10	12.40	2.50		
10	6.50	3.00	10.50	3.50		
11	7.50	2.50	11.50	2.25		
12	4.60	3.00	11.10	3.60		
13	5.20	4.10	12.00	4.50		
14	8.60	5.90	13.05	6.50		
15	5.50	3.50	12.00	3.25		

materials have been used to achieve a coronal seal like cavit, intermediate restorative material, GIC, zinc oxide eugenol cement, resin modified GIC, compomer, composites and recently MTA. Each of these materials has their own benefits and limitations.[9,10]

By analyzing the results in the present study, it has been observed that there was a statistically significant difference found among the groups tested. At this point, it would be interesting to compare the results obtained in the study with the results obtained in previous studies using these materials. There are very few studies available at present using the above materials as coronal sealants. The results of the study were compared with various other leakage studies using these materials, either alone or in combination.

In the present study, Group I specimens were restored with light cure resin composite as double seal restorative material. Coronal microleakage shown by the specimens in this group was more than GMTA and WMTA groups, but less than Group III restored with Type II GIC.

Though composites are widely used to restore anterior and posterior teeth as conservative tooth coloured restorative material, which can be bonded to the tooth structure when used with an adhesive, polymerization shrinkage stresses are a major problem with these restorations. If the bond between tooth and resin is unable to withstand the forces from polymerization shrinkage, micro-gaps are likely to be formed and the seal of the restoration will deteriorate.[11] Leakage in composites may also be attributed to the C-factor or configuration factor of the root canals, which refers to the ratio of bonded to unbonded surfaces, which may increase the polymerization shrinkage.[11] However, the leakage in group I specimens were significantly less than Group III specimens restored with Type II GIC and positive group.

In Group II, specimens were restored with GMTA above gutta-percha as double seal material. The specimens in this group showed the least leakage when compared to remaining three groups. MTA introduced in 1998 that consists of 75% Portland cement, 20% bismuth oxide, and 5% gypsum by weight.[12] Bismuth oxide powder has also been added to provide radio opacity. The hydrophilic particles tend to set in presence of moisture. Hydration of the powder results in a colloidal gel

Table 2: Descriptive statistics.

	Statistic						Skewness	
	N	Range	Minimum	Maximum	Mean	Standard deviation	Statistic	Standard error
Group I	15	4.10	4.50	8.60	6.2667	1.33880	0.351	0.580
Group II	15	3.90	2.00	5.90	3.0600	0.98691	1.743	0.580
Group III	15	6.55	6.50	13.05	9.8700	2.10049	−0.098	0.580
Group IV	15	4.25	2.25	6.50	3.4500	1.04676	1.810	0.580
Positive control	5	3.63	9.87	13.50	11.7240	1.39048	−0.108	0.913
Valid N (listwise)	5							

Table 3: Kruskal-Wallis test result.

Group	n	Mean rank	Kruskal-Wallis Chi-square	df	P value
Group I	15	38.10	52.403	04	<0.001*
Group II	15	13.53			
Group III	15	53.03			
Group IV	15	18.53			
Positive	5	59.40			

*Denotes a significant difference

Table 4: Mann-Whitney test results.

Group	Z	P value
Group I Group II	−4.422	<0.001*
Group I Group III	−3.966	0.001*
Group I Group IV	−4.277	<0.001*
Group I Positive	−3.277	0.001*
Group II Group III	−4.670	<0.001*
Group II Group IV	−1.476	0.140
Group II Positive	−3.281	0.001*
Group III Group IV	−4.648	<0.001*
Group III Positive	−1.703	0.088
Group IV Positive	−3.276	0.001*

*Denotes a significant difference

which solidifies to a hard structure in about 3 h. MTA has a pH of 10.2 after mixing and rises to a pH of 12.5 after setting, which is responsible for its antimicrobial nature.[3] MTA expands on setting and thus helps to achieve a good seal as well as superior marginal adaptation.[3] MTA has the disadvantages of long setting time, difficulty in manipulation and is an expensive material.[13] The good sealing ability shown by GMTA is in agreement with studies done using MTA for various applications.[5,7,8,14]

In Group III, coronal cavities are restored with Type II GIC as double sealing restorative material. This group showed significant leakage and there was no statistically significant difference between the group and unrestored positive group. In endodontics GIC has been used as a root canal sealer, as a retrograde filling material, for repair of perforations and as a coronal sealing material.[9,10] The unique features of GIC are its excellent biocompatibility, fluoride release, aesthetic appearance and the ability to adhere chemically to the tooth.[15] The imperfect sealing of the GIC linings might be explained by their hydrophilic properties, micro-gaps, and/or porosities. Micro-gaps are frequently detected in the restorations lined with GIC. Dentinal fluid might flow through incompletely sealed dentinal tubules to the interfacial gap. During setting, GIC absorb a considerable amount of water, which may affect their sealing ability and other physical properties. Silica hydrogel forming around the glass particles is likely to act as a fluid reservoir. It also tends to undergo some amount of shrinkage during the setting, which can cause loss of the marginal integrity thus leading to microleakage.[11]

Group IV was restored with WMTA. WMTA was developed by Dentsply Tulsa Dental in 2002. This version improved esthetics because the original GMTA was prone to darken overlying tissues. WMTA differs from GMTA in that it has a significant reduction in the proportion of the tetracalcium aluminoferrite component.[6] WMTA samples were found to leak significantly more than GMTA when used as root apical barriers.[16] The WMTA used in the study was a formulation before the introduction of an improved WMTA available in late 2003. In response to complaints of poor handling properties, the manufacturer altered the particle size of WMTA in 2003. Newer leakage studies have shown that the improved WMTA behaved similarly to GMTA.[17,18] A study compared WMTA and GMTA using bacterial leakage method found small but insignificant differences between the two formulations, which were attributed to differences in setting expansion between them.[17]

In the present study, results showed that GMTA when used as a double sealing material showed the best sealing ability among the tested groups. Though samples sealed with WMTA showed slightly more leakage than GMTA, the difference was not statistically significant. Though the Group I restored with composite showed leakage, it was significantly less when compared to the Group III restored with Type II GIC and positive control or unsealed group. The group sealed with GIC showed highest leakage among all the restored groups and no statistically significant difference was found with that of unsealed group.

Conclusion

Though none of the combinations prevented the microleakage completely, the groups restored with MTA (both gray and white) as double seal were significantly better than the other two groups. Under the constraints of the present study, both GMTA and WMTA can be recommended as coronal sealing material to prevent microleakage in an endodontically treated tooth. Considering the fact that dye penetration may not always reflect the clinical situation the direct extrapolation of the results to clinical situation can be undertaken only after further *in vivo* investigations.

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