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Comparison of Micro-Leakage around Temporary Restorative Materials Placed in Complex Endodontic Access Cavities: An In-Vitro Study

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ORIGINAL ARTICLE

Comparison of Micro-Leakage around Temporary Restorative Materials Placed in Complex Endodontic Access Cavities: An *In-Vitro* Study

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ABSTRACT

Objective: To compare mean micro-leakage around 3 types of temporary restorative materials *in-vitro*, when placed adjacent to permanent restorations (amalgam) in complex endodontic access cavities.

Study Design: Randomized controlled trial.

Place and Duration of Study: Dental Clinics, Dental Laboratory and Research Laboratory at The Aga Khan University Hospital, Karachi, from January to June 2014.

Methodology: After random allocation of 60 teeth into 3 experimental groups, each group had conventional class II cavities prepared and amalgam placed. After 14 days, endodontic access cavities were made in these teeth, followed by placement of Cavit, IRM and CLIP (depth of 4 mm each). After thermo-cycling and immersion in 0.5% methylene blue dye, the teeth were sectioned mesio-distally and observed under stereoscopic microscope (magnification x4) along 2 interfaces 'a' and 'b' (tooth-temporary restoration and temporary restoration-primary restoration), respectively. Depth of dye penetration was measured in millimeters.

Results: IRM was leakiest at interface 'a', cavit had highest dye penetration at interface 'b', while CLIP exhibited least micro-leakage at 'a' and 'b'. The mean dye penetration for Cavit was 0.80 ±0.23 mm at 'a', and 2.24 ±0.48 mm at 'b'. For IRM, it was 1.82 ±0.09 mm at 'a', and 0.44 ±0.13 mm at 'b'. For CLIP, the mean dye penetration was 0.43 ±0.05 mm at 'a', and 0.32 ±0.12 mm at 'b'. The difference in dye penetration observed between the 3 groups at both interfaces was statistically significant.

Conclusion: In a complex access cavity made adjacent to a pre-existing amalgam restoration, CLIP exhibits the least micro-leakage, followed by IRM and Cavit.

Key Words: *Temporary filling materials. Complex endodontic access cavity. Micro-leakage.*

INTRODUCTION

Temporization of the endodontic access cavity is a crucial part of the endodontic treatment as this procedure seals the tooth temporarily, impeding the contamination of root canal space by oral fluids, microorganisms and other debris,[1,2] until the time the endodontic procedure is completed and the definitive coronal restoration is placed. Hence, the importance of this step should not be undermined. The ability of temporary filling materials to form an effective seal, and thus prevent fluid penetration, is crucial to the success of endodontic treatment.[3,4] Inadequate temporization during endodontic therapy is considered the second most common contributor to endodontic flare-up.[5]

Many teeth requiring endodontic treatment have large, permanent coronal restorations of acceptable quality, and the decision to retain the permanent restoration can be due to functional or aesthetic reasons. Numerous studies have assessed the coronal seal provided by temporary filling materials when they are placed in a standardized endodontic access cavity made through an already present satisfactory coronal restoration surrounded by tooth structure.[2,3,5-7]

Use of temporary filling materials placed in a complex endodontic access cavity, as compared to a standardized one, is an area of interest warranting research. A complex access cavity is the one that is made for endodontic procedures, but which is extended to include a multi-surface defect.[8] Contradictory data exists regarding fluid penetration around various temporary restorative materials when placed in complex access cavities, in contact with a previously placed restoration.[5,6,9]

The rationale behind this experiment is that the results will aid in determining which temporary restorative material exhibits the least amount of micro-leakage at their interface when used adjacent a permanent restoration, i.e. amalgam, and also adjacent the tooth and hence, to formulate clinical recommendations for the use of temporary filling materials. The null hypothesis was that there is no statistically significant difference in the micro-leakage at the tooth-temp interface compared to temporary-permanent filling interface of the 3 materials.

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This study aimed to determine the difference in micro-leakage around different temporary restorative materials when they are placed in a complex access cavity adjacent to a satisfactory permanent restoration.

METHODOLOGY

The study was conducted at the Dental Clinics, Dental Laboratory and Research Laboratory at the Aga Khan University Hospital, Karachi, completed in 6 months (from January till June 2014) and was an *in-vitro* laboratory experiment. All procedures were completed by the single primary investigator. All extracted teeth, satisfying the inclusion criteria (any human maxillary and mandibular molar teeth), were retrieved from the tooth bank, maintained at the clinics after the approval of the Institute's Ethical Review Committee (ERC#1567-Sur-ERC-2010). Teeth with visible multi-surface carious decay, fractures and/or pre-existing restorations at the time of extraction were excluded.

The selected teeth were cleaned with ultra-sonic scaler to remove all soft tissues and debris. They were disinfected with 5.25% Sodium Hypochlorite for 24 hours and were then stored in normal saline at 37°C until experimentation. All the teeth were numbered from 1 to 40 with black marker and then randomly allocated into experimental and laboratory control groups by random number table. The teeth in the control group were further randomly allocated into positive and negative controls using coin-toss method. In all the teeth of the experimental group and the positive control group, standardized mesial class II cavity preparations with occlusal extensions were made.

The teeth in experimental group were restored with class II amalgam restorations. All specimens were placed in normal saline at 37°C for 14 days in a humidifier. Endodontic access was made through the pre-existing coronal amalgam restoration, without completely removing it. All the root canal orifices were identified in each tooth and the access cavity was modified accordingly. The occlusal cusps of the teeth were flattened and a small cotton pellet was placed in each pulp chamber to prevent the plugging of the canal orifices. The teeth in the experimental group were again randomly sub divided into 3 groups by random number table. Three different temporary restorative materials, i.e. Cavit, IRM (Intermediate Restorative Material) and CLIP (manufacturers and composition given in Table I) were placed in the endodontic access cavity in the 3 groups, with uniform thickness of 4mm, as measured with a periodontal probe. The temporary restorative materials were condensed with a plastic instrument. The teeth with CLIP were exposed to an LED curing light for 30 seconds. All samples were subjected to thermo-cycling (150 cycles) at 5°C - 55°C ±2°C with 30 seconds dwell time in a thermo-cycler.

Afterwards, all the teeth were air dried and covered with 2 layers of nail polish, except 1mm around access area. All specimens were immersed in 0.5% methylene blue at 37°C and 100% humidity for 10 minutes, after which they were washed and dried. A thin layer of dental plaster was applied to the specimens except on the occlusal surfaces to ease sectioning and stabilize the permanent restoration. After sectioning the teeth mesio-distally with slow speed diamond saw, the split segments were examined using a stereoscopic microscope (magnification x4) along two interfaces (tooth-temporary restoration and temporary restoration-primary restoration) labelled as 'a' and 'b', respectively (Figure 1). The outcome variable (micro-leakage around temporary restoration) was assessed by the primary investigator by measuring depth of dye penetration in millimeters (mm) after digital images of the sectioned specimens were captured and analyzed using computer software (Image tool software version 3.0) (Figure 2).

SPSS version 19.0 was used for data analysis. Mean and standard deviation of quantitative variables (such as dye penetration in mm) was computed. Paired t-test was applied to determine the mean difference in fluid penetration at interface 'a' and 'b' for each of the 3 restorative groups (Cavit, IRM and CLIP). P-value of 0.05 was taken as statistically significant.

Figure 1: Digital image of section of specimen with IRM as seen under microscope.

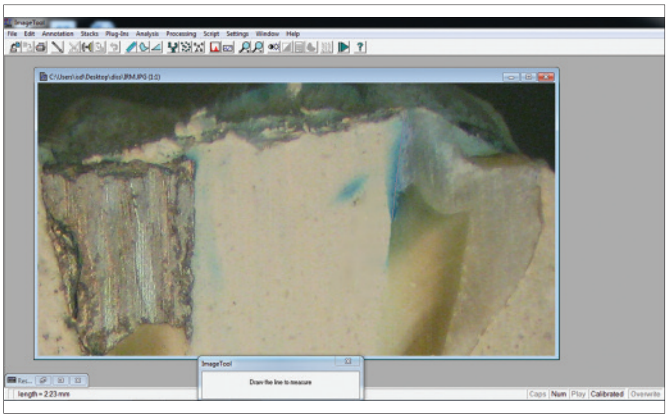

Figure 2: Measuring dye penetration in millimeters using image tool software.

RESULTS

All sections from the positive control group exhibited complete dye penetration while all sections from the negative control group exhibited no dye penetration.

Table II demonstrates the comparison of mean micro-leakage and dye penetration. There was a statistically significant difference between Cavit, IRM and CLIP in terms of dye penetration at both the interfaces 'a' and 'b' ($p < 0.05$).

Table I: Composition and manufacturers of the temporary filling materials used .

CLIP	Hydroethylmethacrylate, butylhydroxytoluene, acrylate esters, polymers	Voco, Cuxhaven, Germany
CAVIT	Zinc oxide, calcium sulphate, zinc sulphate, glycol acetate, polyvinyl acetate resin, polyvinyl chloride acetate, triethanolamine, colour pigment	3M ESPE, Seefeld, Germany
IRM	Zinc oxide-eugenol	Dentsply, Milford DE, USA

Table II: Comparison of mean dye penetration in millimeters at interfaces 'a' and 'b' for the experimental groups.

Temporary restorative material	Interfaces	Mean dye penetration (in mm)	Standard deviation	p-value
CAVIT (n=20)	a	0.80	±0.23	<0.001
	b	2.24	±0.48	
IRM (n=20)	a	1.82	±0.69	<0.001
	b	0.44	±0.13	
CLIP (n=20)	a	0.43	±0.05	<0.001
	b	0.32	±0.12	

'a' refers to tooth-temporary restoration interface and
'b refers to temporary restoration-primary restoration
n=60
± Paired t-test was applied with level of significance kept at 0.05

DISCUSSION

In this study, the sealing ability of 3 different temporary filling materials were observed, 2 of which (Cavit and IRM) are routinely used in dental practice. The third material CLIP is relatively a new resin-based, pre-mixed and light-curved product. The dye penetration was measured in millimeters by calibrating digital images captured through the microscope. This methodology has been adapted in very few studies.[6] The quantitative measurements aid in a more accurate determination of the micro-leakage as assessed by the dye.

A minimum thickness of 3.5 mm to 4 mm of the temporary filling material is said to be required when placing in an endodontic access cavity to ensure adequate sealing and for the prevention of micro-leakage.[10,11] Some studies that observed the sealing ability and micro-leakage in temporary filling materials, placed them at a thickness of 5 mm.[2,12,13] In a practical setting, it is not always possible to achieve this thickness of the temporary restorative material due to severely broken down tooth or in a tooth with severe wear. This can lead to problems like micro-leakage during the inter-appointment period as well as loss of all or some parts of the temporary filling. The authors tried to simulate this common clinical scenario in this study, where molar teeth may not have adequate tooth structure due to previous caries or wear, and hence the depth of the access cavity may not be the ideal 5 mm. Also, it is common clinical practice to place a small cotton pellet to occlude the root canal orifices before placement of the temporary restorative material, so that temporary filling material may not enter and block the canals. This cotton pellet would also take up space in the access cavity, decreasing its depth. Therefore, it is important that its thickness should not be such that it takes up a significant portion of the access cavity. The remaining space for the temporary filling material should be at least 3 mm.[14] In this study, the thickness of the temporary fillings was kept at 4 mm.

All the materials were utilized according to manufacturer's instructions except for IRM's in which a higher powder/liquid ratio was used, for better sealing of the restoration margins and decreasing micro-leakage without compromising the structural strength.[15,16] In this situation, the powder/liquid ratio would be 6 g/ml as compared to the manufacturer's instructions, which state a powder/liquid ratio of 2 g/ml.

The thermo-cycling regime which was followed in this study, is the most commonly used in studies determining micro-leakage and sealing ability of various restorative materials.[1,6,8] The number of cycles for the thermo-cycling regime was 150, representing approximately 4 to 6 days of thermal changes occurring inside the mouth. This is usually the time period given between appointments, during endodontic procedures, in order to allow for any intra-canal medicament to exhibit its anti-microbial effect.[17]

There were statistically significant differences in the ability of the temporary restorative materials to seal against fluid ingression at the 2 different interfaces that were observed; hence, the null hypothesis was rejected. A greater degree of dye penetration was noted at the tooth surface and temporary restoration interface as compared to the interface between the temporary filling and the permanent restoration. This is similar to other studies comparing micro-leakage and sealing ability of temporary restoration placed adjacent to various permanent filling materials.[2,6] This suggests that the reasoning behind removing a recently placed or intact permanent restoration during the preparation of an endodontic access cavity for the sole purpose of preventing micro-leakage may not be justified in all cases. This particular interface may not be the primary reason for oral fluids and bacteria leaking into the endodontic access cavity, in cases of satisfactory permanent restorations. If deemed satisfactory, the remaining permanent restoration can aid in isolation, placement of rubber dam, confinement of the irrigant and the retention of the subsequently placed temporary restoration.[6,18] But if the permanent restoration is inadequate, in danger of dislodgement after endodontic access cavity is made, hindering in straight-line vision into the access cavity, or in diagnosis of tooth fracture, then it must be removed at the beginning of the endodontic treatment.[18] It is important to check the retention of any permanent restoration after the endodontic access cavity is made, especially those that are not bonded to the tooth structure, and are placed in a cavity where they are not completely surrounded and supported by tooth structure. In this study, it was found that the amalgam restoration stayed intact, even after the bulk of the restoration from the occlusal surface was removed and only the mesial box remained. Hence, if the endodontic access cavity is made judiciously, in a tooth that has a pre-existing class II amalgam restoration, then it may remain stable during the time that the endodontic treatment is in progress, following which it can be removed completely and replaced by any permanent restoration according to the clinical indication. This was different from the previous studies, where class I cavities had been restored with permanent fillings, endodontic access cavities were made through them and then various temporary restorative materials were placed.[6,7,16]

The micro-leakage of the dye observed in the experimental group showed that at interface 'a', Cavit and CLIP showed better and comparable sealing ability than IRM. Because Cavit has hygroscopic properties, allowing it to absorb water, it expands during setting when it comes in contact with water. This expansion could be the reason for better adaption to the endodontic access cavity walls and any pre-existing permanent restoration, providing an adequate seal.[19] In fact, the coefficient of linear expansion exhibited by Cavit is almost twice that of IRM.[6] But as this temporary filling material is weak mechanically, the seal it provides can only exist for a shorter period of time as compared to other temporary restorative materials with better mechanical properties and wear resistance. This hydrophilic nature of Cavit was also demonstrated by the fact that the dye had been absorbed by the bulk of the material placed in the access cavity. The decreased micro-leakage observed at the CLIP-tooth interface could be because of this material's better handling properties and the ability to be compacted and rapidly set on curing, which decreased the chance of dye penetration and provides better sealing.

On the other hand, IRM is hydrophobic due to the addition of poly-methyl-methacrylate, and thus cannot absorb water like Cavit. Hence, there is no role of hygroscopic expansion in its adaption to the endodontic access cavity walls. But this hydrophobic nature allows it to maintain its structural integrity inside the moist environment of the oral cavity. IRM does, however, have the unique property of being inherently anti-bacterial due to the presence of eugenol, which is released during hydrolysis of the material.[5] Therefore, this temporary filling material has a better role in preventing bacterial leakage into the access cavity. IRM is also more wear resistant than Cavit and is relatively strong.[4] Some studies have demonstrated that temporary filling, based on calcium sulphate, disintegrated with diminished sealing ability when they were subject to mechanical stressed *in-vitro*.[20] Hence, Cavit has a better seal against fluid penetration but have increased wear and deterioration under occlusal loading, while IRM has a lower sealing ability but has more structural integrity. One method, proposed in order to overcome the short-comings of both these materials, is the use of 'double seal', where Cavit can be placed in the deeper layer of the access cavity, with IRM on the top.[4] The advantages would include an anti-bacterial material with better mechanical strength on the surface, the presence of a better sealing restoration in the depth of the access cavity, and gaining the benefits of both temporary restorative materials.

In terms of the degree of dye penetration observed at the temporary restoration-amalgam interface, CLIP provided the best seal followed by IRM and Cavit. Although there can be no chemical bonding between CLIP and amalgam due to the difference in composition of these two materials, the decreased dye penetration could be attributed to numerous factors. These may include the better handling characteristics of CLIP like being pre-mixed, having better compaction, immediate command setting, and improved mechanical properties. Also, the presence of microscopic irregularities on the surface of the remaining amalgam restoration, formed during the creation of the access cavity, could allow the development of micro-mechanical adhesion between the two materials; rendering this interface less leaky. The dye penetration seen at both interfaces did not have a statistically significant correlation in all 3 materials.

In this study, the occlusal loading of the samples was not performed due to lack of availability and access to the required equipment. Because of this limitation, no signs of wear could be established on the occlusal surfaces of the temporary restorations. The temporary restorations were completely intact with no surface cracks or disintegration. This fact must be taken into account when interpreting the results and findings of this study, as absence of occlusal loading does not mimic the actual clinical situation. Also, the lack of saliva tends to create differences in findings as compared to *in-vivo* studies, which must be taken into consideration.

The type of permanent restoration, already present in a tooth requiring endodontics, is also an important aspect to consider because the presence of a resin-based restoration like composite would warrant the use of a resin-based temporary filling material. This would result in a better seal due to the similar components in both materials and hence would result in significantly reduced micro-leakage between the two materials. Another essential consideration is the final restoration being planned for the tooth. After the endodontic treatment is completed, and both the temporary restorations, and in case of amalgam, the previously placed permanent restoration is removed, the type of temporary restoration that was previously placed may affect the choice of the permanent restoration subsequently used. Studies recommend that if IRM has been placed in the endodontic access cavity for temporization, the subsequent placement of composite as permanent restoration is not advisable because the presence of residual eugenol on the endodontic access cavity walls has shown to have detrimental effects on not only the bond strength of composite to the cavity walls, but it also influences colour stability, hardness and abrasion resistance of the final composite restoration.[21] Other studies have shown that the use of IRM, both with or without eugenol, yields similar micro-leakage.[22] Hence, it is the residual cement physically adhering to the cavity walls that prevents the close adaption of the composite restoration and causes micro-leakage. But due to contradictory results, the placement of composite restoration in the endodontic access cavity that had IRM as temporary restoration is not recommended.[5]

CONCLUSION

Although, at the tooth-temporary restoration interface, Cavit and CLIP showed comparable results for dye penetration, the difficulty in the availability and cost of resin-based temporary filling materials would still make Cavit a better choice in such situations. But in clinical scenarios, where permanent restorations like amalgam or composite are a part of the access cavity, or the final restoration would be composite, CLIP would be the material of choice to decrease the chances of micro-leakage and fluid penetration at the temporary restoration and permanent filling interface.

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