Research Article

Submitted: Jun 28, 2021
Accepted: Apr 20, 2022
Published: May 19, 2022

Evaluation of Intraorifice Sealing Materials for Coronal Microleakage in Obturated Root Canals – An In Vitro Study

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ABSTRACT

Introduction: For the success of endodontic treatment, studies have emphasised the importance of adequate coronal seal. Failure of treatment results from poor coronal seal in various clinical situations. Roghanizad and Jones suggested an intraorifice barrier that can protect the root canal system from contamination, by saliva, in the event of loss of coronal restoration.

Objective: To evaluate and compare three flowable composite (Denfil flow, Filtek™ Z350 XT, and Dyad flow) and coloured glass ionomer cement (Fuji VII) as intraorifice barrier material, for the prevention of coronal microleakage in absence of coronal restoration.

Materials and Method: In this in vitro study, decoronation of 90 extracted human incisors without fractures or defects, severe attrition, caries, apical resorption, and previously root canal treated, was done. They were then divided into four experimental (n = 20) and two control groups (n = 5) using "Simple randomisation allocation". The four experimental materials were applied as a 4-mm intraorifice barrier, and a 2% methylene blue dye leakage test was carried out along with thermocycling for 100 cycles. Dye leakage was evaluated with a stereomicroscope under 10X magnification, photographed, and measured using Adobe Photoshop CS version 8.0.

Result: Significant microleakage were observed in Dyad flow and Fuji VII compared to Filtek™ Z350 XT and Denfil flow which didn't show a significant difference between them. Fuji VII, on the other hand, also showed significant microleakage from Dyad flow.

Conclusion: Flowable composites that include a separate 'etch and rinse' step, could seal the orifice better against coronal leakage.

Keywords: Coronal microleakage; Glass ionomer cement; Flowable Composite; Intraorifice barrier.

Citation
Rai A, Ghiraiya U, Prajapati K. Evaluation of intraorifice sealing materials for coronal microleakage in obturated root canals – An in vitro study. J Nepal Dent Assoc. 2021 Jul-Dec;21(33):110-6.

INTRODUCTION

Apart from the quality of the root canal preparation and obturation, studies have emphasised the importance of adequate coronal seal regarding the success of endodontic treatment.[1] Insufficient coronal seal may occur in a different clinical situation, like fracture of tooth structure, missing of temporary filling materials, marginal leakage of the final restoration, and recurrent carries, resulting in failure of the treatment.[2] Intraorifice barrier suggested by Roghanizad and Jones can protect the root canal system from contamination, by saliva, in the event of loss of coronal restoration.[3]

Since then, a number of restorative materials have been tested from zinc oxide eugenol to glass ionomer cement and composite resins. However, none of the materials have shown conclusive evidence of an ideal orifice barrier. Glass ionomer cement can be considered a good intraorifice barrier, however, newer composite resin is being advocated over GIC and other temporary restorative materials, as a better intraorifice barrier.[4-6] Therefore, this study aimed to evaluate and compare three flowable composite (Denfil flow, Filtek™ Z350 XT and Dyad flow) and coloured glass ionomer cement (Fuji VII) as an intraorifice barrier material, for the prevention of coronal microleakage in absence of coronal restoration.

MATERIALS AND METHOD

Approval for the research was taken from Institutional Review Board (IRB), Institute of Medicine (Ref. 355(6-11-E)/0569/070) to conduct an in vitro study in the Department of Conservative Dentistry and Endodontics, People's Dental College and Hospital, Nayabazar, Kathmandu and Nepal Academy of Science and Technology, Khumaltar, Lalitpur from May 1st to November 31st, 2013. Ninety extracted intact permanent single-rooted teeth were selected after examining clinically by an explorer, under 3.5X magnification, for fractures or defects, along with severe attrition, caries, apical resorption and previously root canal treated.

All the teeth were thoroughly cleaned with an ultrasonic scaler (NSK -Varios 560/560 LUX, Japan), placed in sodium hypochlorite for two hours for surface disinfection, and then stored in distilled water until use. Teeth were decoronated at cementoenamel junction using diamond discs under copious irrigation such that the lengths for all the roots were 13 mm. A number 10 K file was inserted into the canal till its tip became visible at the apical foramen and working length was established one millimetre short of that length. Glide path was confirmed using a 15 K-file and the canal orifices were uniformly enlarged with Gates Glidden drills to a size number four, up to a depth of four millimetres. Canals were then prepared using ProTaper files (Dentsply, USA), according to manufacture instructions, to size F2. Throughout the instrumentation, canals were lubricated with 19% EDTA and irrigated with 2.5% NaOCl. Finally, the root canals were flushed with saline solution and were then dried with paper points.

Obturation was done with F2 gutta-percha cone and resin sealer after drying the canal. The excess gutta-percha at the orifice was removed with a heated instrument and the coronal gutta-percha was vertically condensed. The teeth were then divided into four experimental (n = 20) and two control groups (n = 5) using "Simple randomisation allocation" (Table 1). In all the experimental groups

Table 1: Allocation of samples.

Group	Materials	Sample size
Group I	Microhybrid Composite (Denfil Flow) – Vericom, Korea.	20 Teeth
Group II	Nanohybrid Composite (Filtek™ Z350 XT Flow) – 3M ESPE, USA.	20 Teeth
Group III	Self-Adhering Composite (Dyad) – Kerr, USA.	20 Teeth
Group IV	Glass Ionomer Cement (GC Fuji VII) – GC Corporation, Japan.	20 Teeth
Positive control		5 Teeth
Negative control		5 Teeth

(Group I – IV), gutta-percha was removed to a level of four millimetres below the cementoenamel junction with the help of a heated hand plugger and this reduction was verified by a graduated probe.

For group I, the prepared cavity in the samples were etched with 37% phosphoric acid for 15 seconds, rinsed with water and the excess moisture removed with the help of a cotton pellet. Bonding agent (BC plus, Vericom) was applied to the dentine using a saturated disposable brush. The excess was removed by a quick air spray and then cured for 20 seconds with a halogen curing unit. The composite (Denfil Flow, Vericom) was injected into the cavity in two increments of two millimetres each and cured for a time of 40 seconds each by the same curing unit.

For group II, the samples in this group were prepared and restored in the same way as the samples in Group I, with a change in the bonding agent (Adper™ Single Bond 2, 3M ESPE) and restorative material (Filtek™ Z350 XT flow, 3M ESPE).

For group III, the prepared cavity in the samples of this group was injected with the composite (Dyad flow, Kerr) in two increments of two millimetres each and cured for a time of 40 seconds each.

For group IV, a prepared cavity in the samples was conditioned with the GIC liquid as a conditioner for 10 seconds, rinsed and excess moisture removed with a cotton pellet. Mixing of GIC (GC Fuji VII, GC Corporation) was done according to the manufactured instruction and was inserted into the cavity in bulk with the help of a plastic filling instrument and condensed with the condenser.

No further treatment was done for the samples in the positive control group while teeth in the negative control group were air-dried and covered by three layers of nail polish. Teeth in the experimental and positive control groups were air-dried and covered by three layers of nail polish, with the exception of the access areas.

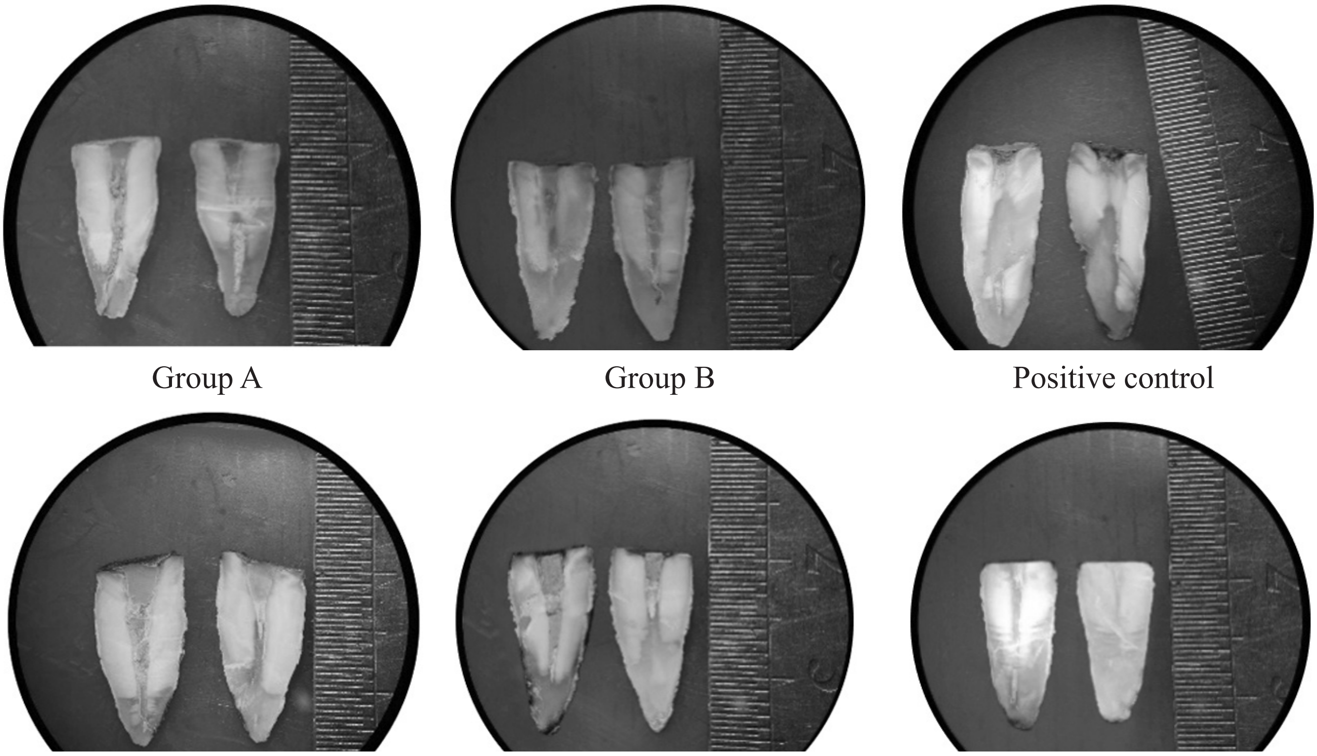
Next, all sample teeth were immersed in saline solution at 37°C until the beginning of thermocycling. The samples were then introduced into test tubes with an aqueous solution of 2% methylene blue dye and subjected to 100 cycles of thermal cycling. Each cycle consisted of submerging the samples for 30 seconds in the thermal bath at 55°C, withdrawing them for 30 seconds, and then again submerging them into the vat with ice (0°±5°C) for another 30 seconds, and this completed one cycle. Samples were then dried, and the cycle was repeated. After that, the samples were rinsed under running tap water for five minutes and the root specimens were longitudinally sectioned into two sections, using diamond discs under copious water spray.

Root sections obtained were observed using a stereomicroscope (Olympus SZ61) at 10X magnification and the photos were transferred to the computer. Depth of longitudinal dye penetration in mm was measured mesial and distal to intraorifice barrier material from the cavosurface margin inward on both sample sections and the highest reading was recorded as the dye penetration depth. Measurements for all specimens were done by one calibrated rater and were noted in the tenth of mm scale using Adobe Photoshop CS version 8.0.

RESULT

The measurements of linear coronal dye penetration of individual samples on a millimeter-scale were recorded and all positive control teeth showed extensive dye penetration while no dye penetration was recorded in the negative control group (Figure 1). Among the test groups, Denfil flow and Filtek™ Z350 XT flow had maximum samples with dye penetration of less than one millimetre. Similarly, maximum samples from Dyad flow and Fuji VII showed dye penetration of 1-2 mm and more than two millimetre respectively (Figure 2). Denfil flow shows the least mean microleakage value than the other three tested materials, while Fuji VII shows the highest (Table 2). Hence, microleakage exhibited by test materials in increasing order is: Denfil flow < Filtek™ Z350 XT flow < Dyad flow < Fuji VII.

One-way ANOVA analysis shows a P value of <0.001 which indicate that the test is very highly significant. Further, to analyse and evaluate the materials among themselves, Post Hoc test was applied (Table 3) and the authors found that there was no statistically significant difference in microleakage between Filtek™ Z350 XT and Denfil flow, while Dyad flow and Fuji VII had statistically significant microleakage than the other two groups, that is, Filtek™ Z350 XT and Denfil flow. Fuji VII, on the other hand, also showed significant microleakage from Dyad flow.



Group A

Group B

Positive control

Group C

Group D

Negative control

Figure 1: Observation of samples under stereomicroscope.

Table 2: Descriptive statistics of linear leakage results in millimetres for the four tested materials.

Material used	Group	Mean linear leakage ± standard deviation	Standard mean error	Range	P value
Denfil flow	I	0.94±0.37	0.08	0.4-1.5	<0.001
Filtek™ Z350 XT	II	1.08±0.48	0.11	0.4-2.0	
Dyad flow	III	1.38±0.43	0.1	0.7-2.1	
Fuji VII	IV	1.76±0.43	0.1	1.3-2.7	

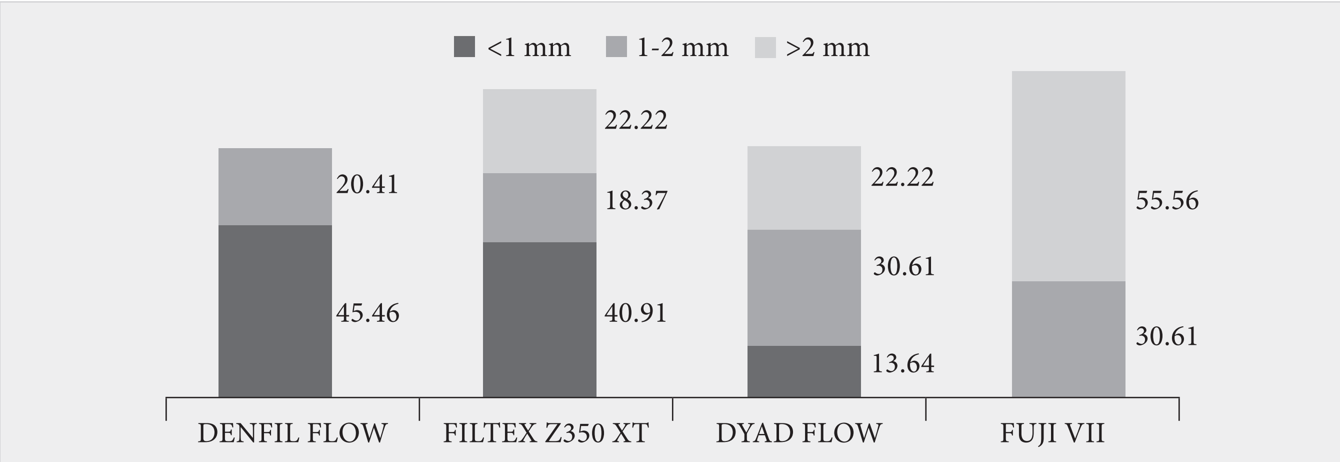


Figure 2: Percentage of categorical dye leakage shown by different groups.

Table 3: P value of post hoc test.

Materials Used	P Values			
	Denfil	Filtek™ Z350 xt	Dyad flow	Fuji VII
Denfil	-	0.320	0.002**	<0.001*
Filtek™ Z350 XT	0.320	-	0.027**	<0.001*
Dyad flow	0.002**	0.027**	-	0.007*
Fuji VII	<0.001***	<0.001***	0.007**	-

*P < 0.05%, ** P < 0.01; ***P < 0.001.

DISCUSSION

The results of this study indicate that some amount of microleakage can be seen in all the groups which can be due to the difference in coefficient of thermal expansion between the restorative material and tooth structure as confirmed by various studies.[7,8]

Better sealing ability of flowable composites (Denfil flow and Filtek™ Z350 XT) can be due to the better adaption of flowable composite to the cavity walls and the formation of resin tags. Further, Davalou suggested that smear layer removal may have a direct influence on the success of the seal of bonded resin.[9]

Composite curing presents a problem in cavities because of C-factor or configuration factor.[10,11] This is partially overcome by the incremental filling technique because the C-factor is more favourable when restored in increments rather than when filled in bulk. The incremental filling is time-consuming and technique sensitive especially deep within the chamber but it allows complete polymerisation of each increment, and lessens the stress from polymerisation shrinkage.[12,13]

Another factor that might contribute to decreased microleakage of flowable in the study is the use of resin sealer instead of eugenol-containing sealer. This can be confirmed by the study done by Jenkins et al. and Jiang et al., who found the sealing ability of flowable composites better after using a resin sealer while Sauaia et al. used a eugenol-based sealer and found an increased microleakage among flowable composites.[6,14,15]

Further, the adhesive system used may also affect the outcome of the study, as the self-adhering flowable composite couldn't seal as effectively as the adhesive system that includes the step of etching the tooth surface.

A Self Adhering Flowable Composite (Dyad flow), used in this study, was introduced in 2009 as an all-in-one material and Technical Bulletin Kerr/35104 (2010) shows that it contains Glycerol Phosphate Dimethacrylate (GPDM) and does not require adhesive material separately. GPDM is an adhesive monomer with an acidic phosphate functional group for etching and bonding to the tooth structure and two methacrylate functional groups for copolymerising with other methacrylate monomers to form the crosslinked polymeric network and to provide increased density and enhanced mechanical strength. This composite bonds with the tooth via two mechanisms: firstly, by forming a chemical bond between the phosphate functional group of GPDM monomer and Calcium ions of the tooth; and secondly through a micromechanical bond formed, between the polymerised monomer and collagen fibres (as well as the smear layer) of dentin, as a result of the formation of an interpenetrating network.[16]

The "self-etching" systems can be categorised as "strong" or "aggressive" (pH <1), "moderate" (pH 1–2) or "mild" (pH >2), with 'self-adhering flowable composite' having a pH 1.9 at the start and gets neutralised (pH 6,5-7) upon polymerisation.[17-19] A strong "self-etching" system along with phosphoric acid forms a hybrid layer of approximately 5 µm in thickness, whereas about 1 µ of the hybrid layer forms the mild systems.[19] Studies have found that the nanoleakage possibly occurred within a thin hybrid zone produced with the self-etching priming systems.[20] This nanoleakage increased over time with the resin/dentin interface. Nanospaces likely allow water penetration, which may cause hydrolytic degradation of the resin-impregnated zone. Further, water sorption of the bonding resins may facilitate degradation.[21]

Another problem with the “self-etching” adhesive systems is that they act as permeable membranes and allows the seepage of moisture from within the dentin to its interface with the restorative material, which is hydrophobic. Due to moisture penetration, the phenomenon of “emulsion polymerisation,” in which there is a poor adaptation between the adhesive and restorative material, occurs. Hence, the three-step adhesive system generally performs better than the ‘self-etching’ adhesive system.[17,19,22]

Although the application of this ‘self-adhering’ composite required fewer steps, it was not effective in preventing microleakage. The result of this study is further supported by Toida et al. who advised that removal of the smear layer by a separate etching step before bonding would produce a more reliable and durable bond to dentin.[23] Further, it was also found that the acid etching prior to the application of conventional and self-etching adhesive materials provided higher penetration of the adhesive into the tooth structure compared to that achieved solely by the application of self-etching adhesive.[24]

GIC exhibit a chemical bond to tooth structure but unlike resins, they form a “dynamic” bond. As the interface is stressed, bonds are broken and new bonds form. This is also one of the factors that allow glass ionomer cement to succeed clinically by sealing the cavity better and resisting microleakage over long periods of time.[25,26]

The present study showed leakage of Fuji VII to be higher than the flowable composite similar to the findings by Payne et al.[27] This increased microleakage could be explained by the fact that the intermediate layer, also called ‘ion-exchange’ layer formed between ‘pure’ GIC and ‘pure’ hydroxyapatite of the dentine got disturbed due to occluding dentinal tubules by resin sealer used.[28] Use of hand instrument for packing of GIC can also result in increased leakage as the syringe delivery system of flowable composites allows for its better adaptation to the cavity wall, while gaps and voids might have occurred on the samples restored with GIC. Another contributing factor to an increased microleakage could be the solubility and disintegration of the material in a water medium that is higher than the resin sealant. This has been confirmed in the study by Khanal et al. where they found resin-based sealant to be superior in terms of preventing microleakage to glass ionomer sealant (Fuji VII).[29]

CONCLUSION

Flowable composites that include a separate step of etching tooth structure, when placed as intraorifice barrier, could seal the orifice better against coronal leakage; compared to self-adhering flowable composite and glass ionomer cement. Within the limitation of this study, useful preliminary information on the sealing properties of the tested materials can be obtained from the data provided.

ACKNOWLEDGEMENT

This study was done in partial fulfillment of the Master of Dental Surgery (MDS) degree by Dr. Arbind Rai. The authors are grateful to People’s Dental College and Hospital and Tribhuvan University for granting the platform to work and conduct the study. The authors would also like to thank the National Academy of Science and Technology for providing Stereomicroscope to conduct this study.

Conflict of interest: None.

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