ORIGINAL RESEARCH

Evaluation of Microleakage of Different Types of Pit and Fissure Sealants: An *In Vitro* Comparative Study

Tanuja Prabahar[1], Nagalakshmi Chowdhary[2], Kiran Ningappa Konkappa[3], Rajashekar Reddy Vundela[4], Subaranjana Balamurugan[5]

Abstract

Aim: Compare and evaluate the microleakage of different types of pit and fissure sealants, 3M ESPE Clinpro, GC Fuji Triage Capsule, and 3M ESPE Filtek Z350 XT.

Materials and methods: A total of 54 freshly extracted maxillary and mandibular premolar teeth were used and randomly divided into three groups of 18 teeth each, and the following pit and fissure sealants were used: group I—Clinpro, group II—GC Fuji Triage Capsule, and group III—Filtek Z350 XT. Samples underwent thermocycling at 5° and 55°C with a dwell time of 10 seconds for 250 cycles. The apices of the teeth were sealed with impression compound, and two coats of fingernail polish were applied and immersed in 5% methylene blue dye for 24 hours and then sectioned. The sectioned specimens were then analyzed at 4× magnification under a stereomicroscope for dye penetration and were evaluated based on Williams and Winters' criteria.

Results: The data were collected for statistical analysis. Descriptive statistics included mean, standard deviation (SD), frequency, and percentage. Inferential statistics included the Chi-squared test and one-way analysis of variance (ANOVA), followed by the *post hoc* Tukey's test. The level of significance was set at 0.05 at a 95% confidence interval, and the results revealed that the mean difference of the sealants was GC Fuji Triage (2.1667), Clinpro (0.7778), and Filtek Z350 XT (0.1667).

Conclusion: Filtek Z350 XT exhibited the least microleakage when compared to Clinpro and GC Fuji Triage, with their mean difference statistically significant. Hence, Filtek Z350 XT can be a promising sealant and a restorative material.

Keywords: 3M ESPE Clinpro, Filtek Z350 XT (3M ESPE), GC Fuji Triage capsule, Microleakage, Pit and fissure sealants.

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Introduction

Dental caries begins when there is a variance between the commensal organism and cariogenic organisms. The cariogenic bacteria involve *Streptococcus mutans*, *Actinomyces* species, and *Lactobacillus*, which produce several acids by the metabolism of carbohydrates, and these acids, in turn, demineralize the enamel surface. This acidic environment creates a drop in pH level below 5.5, resulting in the demineralization of hydroxyapatite crystals, which then leads to the formation of dental caries.[1] Molar and premolars are the most vulnerable teeth to be affected with caries, and the high susceptibility of these teeth to be affected with caries is directly related to the morphology of the occlusal surface. These teeth exhibit a variable morphology in the pit and fissures, which are classified as (Y, IK, V, U, and I) and these shapes with crevices and irregularities are the areas in which food residues and bacteria get mechanically trapped.[2] It was found that fissure caries accounts for about 90% of caries in permanent posterior teeth and 44% of caries in primary teeth.[3]

Pit and fissure sealant, as described earlier, is a material that is usually found in the occlusal pits and fissures of caries susceptible teeth, thus incorporating a micromechanical bonded protective layer cutting the access of caries-producing bacteria from their origin of nutrients. Pit and fissure sealant is an effective way to prevent caries in both primary and permanent teeth.[4]

The major problem in clinical practice is microleakage around dental restorative material, and it is termed as the passage of bacteria, fluids, molecules, or ions between the cavity wall and the sealant or material placed. More attention has been given to the problem of microleakage and it has been implemented on a variety of conditions, including recurrent caries, tooth discoloration, hypersensitivity, pulpal damage, and hastening of the breakdown of the following filling materials.[5]

The materials used in the present study include GC Fuji Triage capsule (white), which is a radiopaque glass ionomer. It is a low-viscosity, flowable, and high fluoride-releasing-based fissure sealant.[6] The next material used is 3M ESPE Clinpro sealant, which is an unfilled pit and fissure sealant and has a unique color-changing feature. Finally, 3M ESPE Filtek Z350 XT, which is a flowable easy-to-use nanofilled restorative used as pit and fissure sealant because of its excellent mechanical properties.[3] Although many studies have investigated the microleakage of different pit and fissure sealants, not many studies have been performed comparing conventional

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sealant and glass ionomer-based sealant with a flowable composite as a sealant. Hence, the present study was conducted to evaluate and compare the microleakage of 3M ESPE Clinpro, GC Fuji Triage capsule, and 3M ESPE Filtek Z350 XT under a stereo microscope.

Materials and Methods

Preparation of Specimens

A total of 54 freshly extracted maxillary and mandibular premolar teeth were used in this study (Fig. 1). The teeth were first disinfected with hydrogen peroxide (VL Products, Maharashtra, India), cleaned off from gross debris with pumice slurry using brushes with a slow-speed handpiece, then the teeth were rinsed with air-water spray, and a sharp explorer tip was passed through all the pits and fissures to remove the remaining pumice. After the following tooth preparation, the teeth were then rinsed and placed in an artificial saliva solution (Wet mouth solution, ICPA Health Products Ltd.).[7] The specimens were then randomly divided into three groups of 18 teeth each, and these were the following pit and fissure sealants used group I—Clinpro (3M ESPE), group II—GC Fuji Triage Capsule, and group III—Filtek Z350 XT (3M ESPE). These pit and fissure sealants were then applied according to the manufacturer's instructions (Fig. 2).

Group I—Clinpro (3M ESPE sealant)

The occlusal surfaces were etched for 20 seconds with Eazetch gel (37% phosphoric acid) and were rinsed with water for 30 seconds and blow-dried. The teeth were then rinsed and dried to achieve a characteristic matte frosty white and chalky appearance of enamel for Clinpro. Then, using the syringe needle tip, the sealant was applied to the pits and fissures, and its excess was removed by an applicator. Curing of the sealant was done by a light curing unit (blue phase, woodpecker) for 20 seconds. There was a change from pink to opaque off-white.

Group II—GC Fuji Triage capsule (Tokyo, Japan)

The GC cavity conditioner was applied on the occlusal surfaces with a brush applicator for 10 seconds and then dried with a mild airflow. GC Fuji Triage capsule (Tokyo, Japan) was tapped well about two to three times and then activated before mixing for 10 seconds at high-speed (approximately 4000 rpm) in the capsule mixer. Immediately after removing the mixed capsule from the mixer, load it in the GC Capsule applier. Two clicks were done to prime the capsule and then the syringe. The material was then extruded on the tooth surface and then brushed to get a thin film.

Group III—Filtek Z350 XT (3M ESPE)

The occlusal surfaces were etched for 20 seconds with Eazetch gel (37% phosphoric acid) and rinsed with water for 30 seconds and blow-dried. The teeth were then rinsed and dried to achieve a characteristic matte frosty white and chalky appearance of enamel for Filtek Z350 XT. Then Single bond 2 Adhesive (3M ESPE Adper™) was applied and curing of the sealant was done by a light curing unit (Blue phase, Dentsply) for 10 seconds. Then using the syringe needle tip, the sealant was applied to the pits and fissures, and its excess was removed by an applicator. Curing of the sealant was done by a light curing unit for 20 seconds. After the placement of all the sealants, the samples were placed in an artificial saliva solution for 24 hours.

Thermocycling

Thermocycling was carried out in the Department of Microbiology, Coimbatore Medical College and Hospital (Coimbatore, Tamil Nadu, India). The purpose of thermocycling was to stimulate the oral environment and all three groups with artificial saliva solution, and the tooth was immersed into borosil glass beakers (Microsidd, India) and subjected to thermocycling at 5° and 55°C with a dwell time of 10 seconds for 250 cycles. Temperature check was done periodically and care was taken to ensure that all teeth were completely immersed. Thereby placing the samples in an artificial saliva solution for 24 hours after thermocycling.[8]

Dye Penetration Study

The apices of the teeth were sealed with impression compound. Two coats of fingernail polish were applied on the crown and root surfaces of the teeth so that the 1 mm peripheral margin of the sealant remained exposed (Fig. 3). The teeth were then immersed in 5% methylene blue dye (SD Industries, Mumbai, Maharashtra, India) for 24 hours to allow the dye penetration to enter into the possible existing gaps between the tooth surface and the sealant material. Following dye exposure, teeth were washed with running tap water for 30 seconds and then dried (Fig. 4). The specimens were then sectioned longitudinally in a buccolingual direction through the center, using a diamond disk (25 mm in size) (Fig. 5).

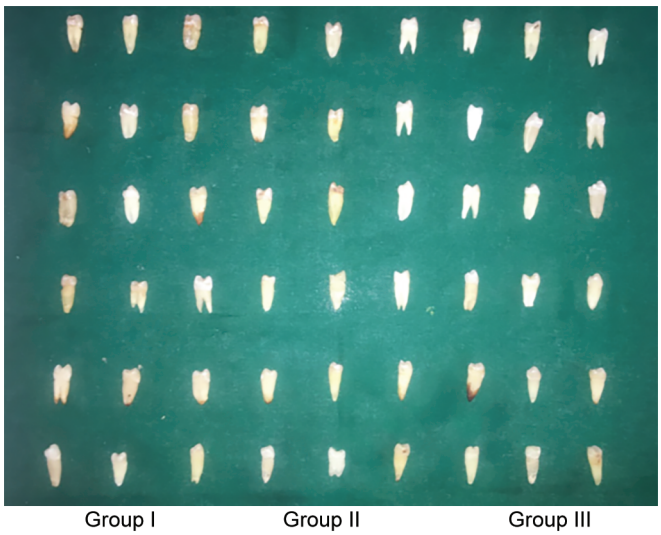

Fig. 1: Tooth samples used in the study

Fig. 2: Sealants used in the study

The sectioned specimens were then analyzed at 4× magnification under a stereo microscope (Olympus) for dye penetration and was evaluated based on the Williams and Winters' criteria.[7]

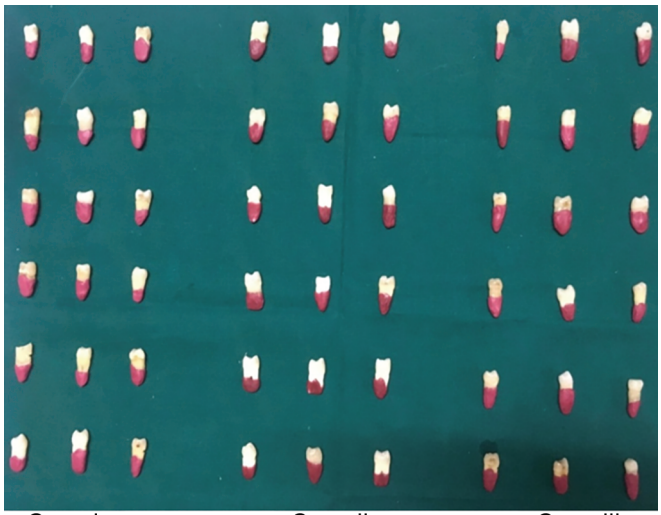

Fig. 3: Samples with impression compound

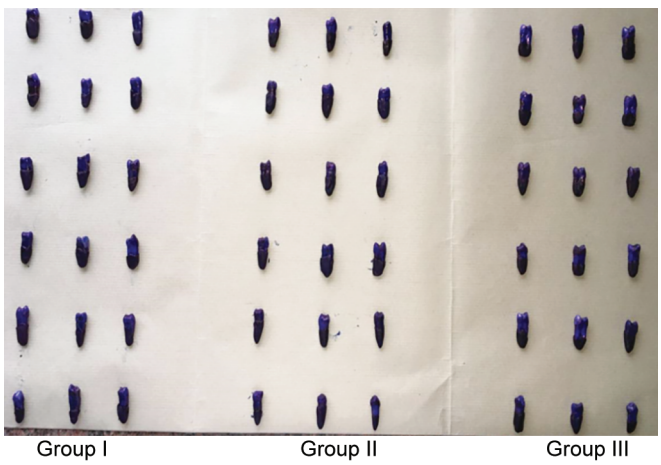

Fig. 4: Tooth samples after immersion in methylene blue dye

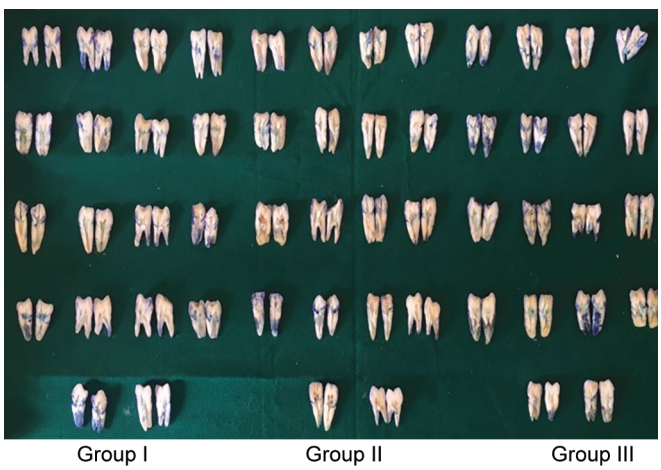

Fig. 5: Prepared samples after sectioning with a diamond disc

According to the criteria, microleakage was scored as follows:

- 0—no dye penetration (Fig. 6).
- 1—dye penetration up to one-third of the fissure total height (Fig. 7).
- 2—dye penetration between one-third and two-thirds of the fissure's total height (Fig. 8).
- 3—dye penetration between two-thirds and a total height of fissure (Fig. 9).[8]

Results

The present *in vitro* study was undertaken to evaluate and compare the microleakage of pit and fissure sealants Clinpro, GC Fuji Triage, and Filtek Z350 XT under a stereomicroscope. A total of 54 samples were used, with 18 in each group.

The data was collected, coded, and fed in the Statistical Package for Social Sciences (SPSS) (IBM Version 23) for statistical analysis. Descriptive statistics included mean, SD, frequency, and percentage. Inferential statistics included the chi-square test and one-way ANOVA, followed by the *post hoc* Tukey's test. The level of significance was set at 0.05 at a 95% confidence interval (Figs 10 and 11).

Table 1 shows the percentage of dye penetration scores using the Chi-squared test. According to Winters' criteria 0, Clinpro showed (six teeth, 33.3%), GC Fuji Triage capsule showed (two

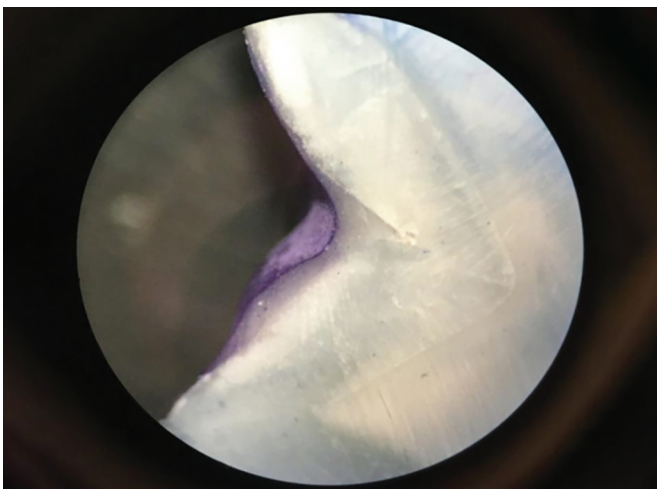

Fig. 6: Score 0—no dye penetration

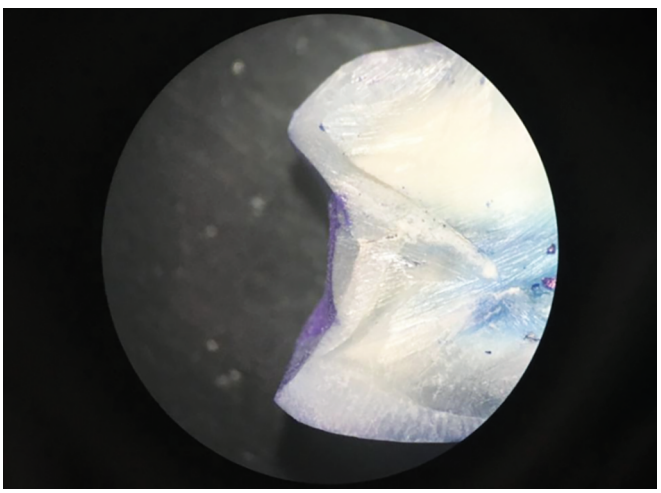

Fig. 7: Score 1—dye penetration up to one-third of fissure total height

teeth, 11.1%), and Filtek Z350 XT showed (15 teeth, 83.3%) with no dye penetration. Winters' criteria 1, Clinpro showed (10 teeth, 55.6%), GC Fuji Triage capsule showed (two teeth, 11.1%), Filtek Z350 XT showed (three teeth, 16.7%) with dye penetration up to one-third of fissure total height. Winters' criteria 2, Clinpro showed (two teeth, 11.1%), GC Fuji Triage capsule showed (five teeth, 27.8%), and Filtek Z350 XT showed (no teeth) with dye penetration between one-third and two-thirds of fissure total height. Winters' criteria 3, Clinpro showed (no teeth), GC Fuji Triage capsule showed (nine teeth, 50%), and Filtek Z350 XT showed (no teeth) with dye penetration between two-thirds and the total height of fissure.

From the above table, it can be interpreted that Filtek Z350 XT had the lowest microleakage and GC Fuji Triage capsule had the highest microleakage.

Table 2 shows the mean difference of the sealants using the *post hoc* Tukey's test, where the *F*-value of 34.302 for the mean difference between the three groups of pit and fissure sealants was highly significant ($p = 0.000$). The mean microleakage value for GC Fuji Triage capsule, Filtek Z350 XT, and Clinpro were 2.1667, 0.1667, and 0.7778, respectively. Hence, it can be inferred that the highest microleakage was seen in the GC Fuji Triage capsule and the least microleakage was seen in Filtek Z350 XT.

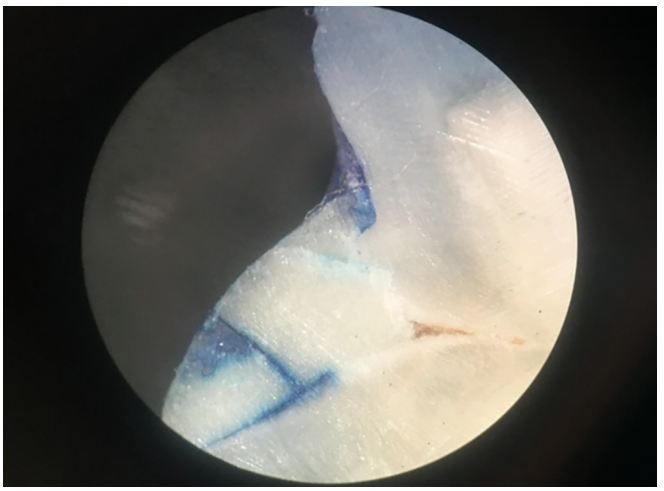

Fig. 8: Score 2—dye penetration between one-third and two-thirds of fissure total height

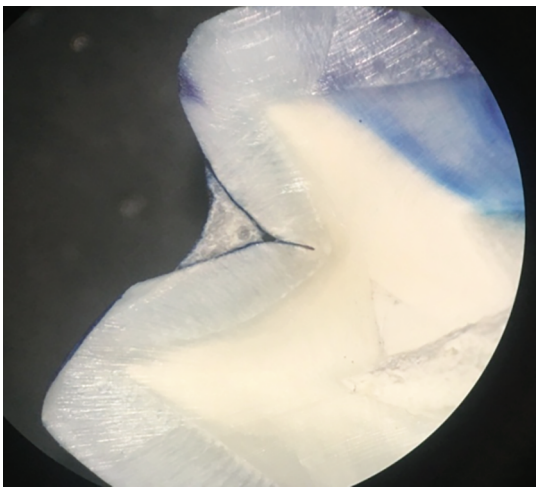

Fig. 9: Score 3—dye penetration between two-thirds and total height of fissure

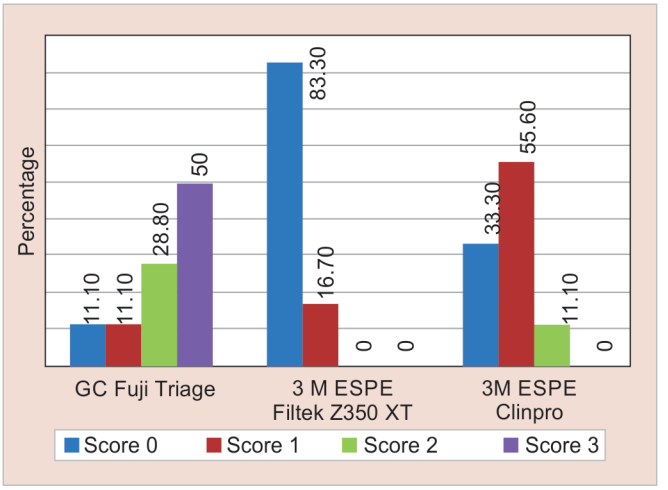

Fig. 10: Shows the amount of dye penetration scores in percentage

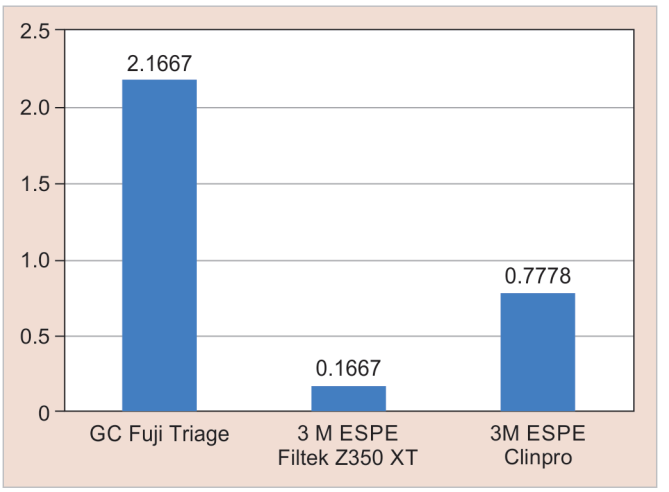

Fig. 11: Shows the mean differences of microleakage among the three groups and it revealed that the least microleakage is seen in 3M ESPE Filtek Z350 XT, followed by 3M ESPE Clinpro, and GC Fuji Triage capsule

Table 1: Shows the percentage of dye penetration scores using the chi-squared test

	Dye penetration (%)					
	0	*1*	*2*	*3*	*Chi-square value*	*Significance*
GC Fuji Triage capsule	2 (11.1)	2 (11.1)	5 (27.8)	9 (50)	42.594	**0.000 (H.S)**
3M ESPE Filtek Z350 XT	15 (83.3)	3 (16.7)	00	0 (0)		
3M ESPE Clinpro	6 (33.3)	10 (55.6)	2 (11.1)	0 (0)		

Table 2: Shows the mean difference of the sealants using *post hoc* Tukey's test

	Mean	*SD*	*F*	*Significance*
GC Fuji Triage capsule	2.1667	1.04319	34.302	**0.000 (H.S)**
3M ESPE Filtek Z350 XT	0.1667	0.38348		
3M ESPE Clinpro	0.7778	0.64676		

Bold value signifies the p <0.005 is highly significant

Discussion

Dental caries is the localized destruction of susceptible dental hard tissues by the acidic by-products formed from the bacterial fermentation of dietary carbohydrates. It is a chronic disease that progresses slowly, resulting from an ecological imbalance in the equilibrium between oral biofilms and tooth minerals. As time progresses, the process leads to either caries lesions or the repair and reversal of a lesion.[9] Permanent molars are more susceptible to dental caries because they vary in occlusal fissure morphology and long eruption phase. Hence the use of pit and fissure sealants reduces the chances of caries.[10]

In the present study, the evaluation of microleakage of different types of pit and fissure sealants—an *in vitro* comparative study was done. The sealants used were resin-based unfilled sealant (Clinpro), chemically cured low viscosity high fluoride releasing glass ionomer sealant (GC Fuji Triage capsule), the use of flowable composite (Filtek Z350 XT) as fissure sealant, and a resin-based sealant.[6] In this study, a total of 54 freshly extracted maxillary and mandibular premolar teeth due to orthodontic reasons were collected from the Department of Oral and Maxillofacial Surgery, Sri Siddhartha Dental College, Tumakuru, after taking the patient's consent. The surfaces of the collected teeth for the study were cleaned off from debris with pumice slurry using a micromotor handpiece running at a slow speed. This is the most widely used method, which improves sealant retention and reduces microleakage.[11] After placing the sealants, the tooth samples were subjected to thermocycling at 5° and 55°C with a dwell time of 10 seconds for 250 cycles. Thermocycling is one of the commonly used methods to replicate the oral temperature and also to stimulate the long-term stresses to which the restorations are exposed. The apices of the teeth were sealed with impression compound and two coats of fingernail polish were applied on the crown and root surfaces of the teeth so that the 1 mm peripheral margin of the sealant remained exposed in accordance with Woody and Davis. We have used the qualitative technique of dye penetration to assess the microleakage. The specimens were stored in 5% methylene blue dye for 24 hours, which was in accordance with the studies conducted by Hatibovice et al. and Brikenfeld et al.[12,13] The teeth were then sectioned longitudinally following dye immersion and the microleakage was assessed with a stereo microscope at 40× magnification for dye penetration. This was evaluated based on Williams and Winters' criteria.[1] The data was collected and fed into the SPSS for statistical analysis. Descriptive statistics included mean, SD, frequency, and percentage. Inferential statistics included the chi-squared test and one-way ANOVA was followed by the *post hoc* Tukey's test. The level of significance was set at 0.05 at a 95% confidence interval and the results revealed that the mean difference of the sealants using *post hoc* Tukey's test was GC Fuji Triage capsule (2.1667), Clinpro (0.7778), and Filtek Z350 XT (0.1667) and the least microleakage was seen in Filtek Z350 XT, followed by Clinpro and GC Fuji Triage capsule with the highest microleakage. The *F*-value 34.302 for the mean difference between the three groups of pit and fissure sealants was significant (p = 0.000).

In our study, Filtek Z350 XT showed complete retention of pit and fissure sealant compared to Clinpro and GC Fuji Triage capsules. These results were significant to a study where Filtek Z350 XT showed better sealant retention when compared to other groups conducted by Hegde et al.[14] Clinpro pit and fissure sealant also showed slightly higher retention rates and clinically showed better performance than resin-based filled sealant in a study conducted by Reddy et al.[15]

According to some reports, it was found that a greater extent of microleakage was seen in glass ionomer sealant, which was attributed to the solubility of the material.[16] Ovrebo et al. in 1990 stated that glass ionomers were not used as pit and fissure sealants due to the notion of increased microleakage and lower retention rates, and this was due to the weakness of the glass ionomer sealant interface.[17]

Dhar et al., in 2000, found greater gaps existing between the tooth and the sealant at the interface in glass ionomer than resin-based sealants. Rahimian-Iman et al. evaluated marginal microleakage in conventional fissure sealants and composite-based sealants in permanent teeth and concluded that composite-based sealants could be used as pit and fissure sealants in permanent teeth.[18]

Ashwin and Arathi found that in a moisture-controlled environment, there is no difference between the resin-based sealant and Fuji GC sealant, which results in a gap between the sealant. However, glass ionomer sealants may have poorer retention rates than resin-based sealants, but a small number of sealant remnants on the fissures release fluoride and provides protection from caries attack.[6] Joseph et al. and Simsek et al. explained that glass ionomer sealants are more viscous than resin-based sealants, and so it is difficult for the sealant to be seated properly in the fissures, leading to more microleakage in glass ionomer-based sealants, in harmony with many comparative studies.[19]

Being an *in vitro* study, no such clinical problems, such as isolation, saliva control, and patient cooperation, were faced in this study. In summary, according to this study, GC Fuji Triage capsule showed higher microleakage when compared to the other two materials and this is because glass-ionomer cement-based sealants are thick and viscous and have a poor physical property when compared to the other sealants used in the study. Further elaborate clinical trials are to be researched with longer follow-ups to determine the effect of the sealants more precisely.

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