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In vitro Evaluation of Microleakage in Contaminated Fissures Sealed with GC Fuji Triage Glass Ionomer Cement

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Abstract. The aim of this *in vitro* study was to evaluate the microleakage of Fuji Triage glass ionomer in contaminated pits and fissures, and to compare it with the microleakage of resin-based pit and fissure sealant. Sixty-four extracted human premolar teeth were randomly assigned into two main groups according to the fissure sealant used (Fuji Triage or Clinpro^{TM}). Each group was divided into four subgroups according to the different surface conditions as follows: (1= dry condition; 2= water contamination; 3= saliva contamination; 4= saliva contamination and air-drying). The teeth were subjected to thermal cycling (500 cycles at 5^{o}C-55^{o}C) with a dwell time of 30 seconds. The teeth were then immersed in 1% methylene blue for 24 hours, embedded in acrylic resin and sectioned longitudinally in a buccolingual direction. The sections were analyzed for microleakage using a stereomicroscope. Microleakage was evaluated on a three-point rating scale and was analyzed using *t* and ANOVA tests. Both materials, under different conditions, exhibited dye penetration to some extent. However, Fuji Triage cement showed less microleakage in wet conditions compared to Clinpro^{TM} group. Whenever wet (water or saliva) contamination is apparent, the use of Fuji Triage cement as a sealing material would be beneficial to decrease microleakage.

Introduction

The use of pit and fissure sealants has been widespread, as they are considered an effective preventive method in blocking the development of caries on the occlusal surfaces (Frazier, 1984). The resin-based sealants are the most commonly used in clinical practice (Bouncier, 1971). The introduction of the glass ionomer cement into dentistry was mainly as a restorative, luting and lining material (Ovrebo and Raadal, 1990). Fissure sealing with glass ionomer cement was firstly introduced by McLean and Wilson in 1974.

The important advantage of using glass ionomer cement as a pit and fissure sealant is the fluoride release which results in an increased resistance of the fissures to demineralization. This fluoride release continues even when the sealants appear to have been lost clinically because of the remnants left at the bottom of the fissures (Seppa and Forss, 1991; Kupietzky *et al*., 1994; Arrow and Riordan, 1995).

Numerous clinical studies have documented the efficacy of pit and fissure sealants in caries prevention, with sealants retention being the primary factor in the continued efficacy (Rock and Bradnock, 1981). The marginal sealing ability of sealing materials is extremely important for successful treatment. Lack of sealing allows the occurrence of marginal leakage, i.e., the passage of bacteria, fluids, and ions through the tooth-material interface, which can prompt caries lesion progression underneath the sealant (Going *et al*., 1978; Jensen and Handelman, 1980; Handelman, 1982). Saliva contamination of etched enamel surface before sealant placement is cited as the most common reason for sealant failure (Simsonsen, 1981; Ripa, 1985).

Many studies have suggested that the use of adhesive systems improves the effectiveness of sealants placed in fissures after different contamination circumstances (Hebling and Feigal, 2000; Duangthip and Lussi, 2003; Borsatto *et al.*, 2004; Hevinga, 2007), however this will add more

clinical steps which are inconvenient particularly with young and management problem children.

It has been claimed by the manufacturer that Fuji Triage glass ionomer cement neither needs isolation nor bonding agent; it works in a moist field and releases six times the amount of fluoride as compared to other high-strength glass ionomer cements when it is used as a pit and fissure sealant.

Considering the difficulty of obtaining isolation in young children, management problem children, recently erupted teeth and the multiple steps involved in the placement of resin-based sealant, glass ionomer cement can be quickly and easily placed into the pits and fissures.

The aim of this study was to evaluate microleakage of Fuji Triage glass ionomer cement in contaminated pits and fissures, and to compare it with microleakage of a resin-based pit and fissure sealants.

Material and Methods

Sixty-four non-carious extracted human premolars collected during 3 months period were used in this study. Teeth were cleaned with water/pumice slurry in a dental prophylactic cup and then were stored in a distilled water at 4°C. The teeth were then randomly assigned into two main groups (32 teeth each) according to the fissure sealant used. One resin-modified glass ionomer cement; as experimental material and one resin-based pit and fissure sealant; as a control were used in this study. The sealant systems employed in this study are shown in Table 1.

Table 1. Sealant materials used in the study

Material	Description	Manufacturer
Fuji Triage	Resin-modified glass ionomer	GC Fuji Triage, GC Corporation, Tokyo, Japan
Clinpro™	Resin-based pit and fissure sealant	Clinpro™ , 3M ESPE, St Paul, USA

Preparation of the occlusal surfaces

Occlusal surfaces of the experimental group were conditioned with 40% polyacrylic acid (G C Corporation, Tokyo, Japan) for 10 seconds then rinsed with water for 10 seconds then dried, while the occlusal surfaces of the control group were acid etched with 37% phosphoric acid gel (3M ESPE, St. Paul, USA) for 15 seconds, then rinsed with water for 10 seconds and air dried until a forested appearance of the occlusal surface appeared. As represented in Table 2, each group was then subjected to four different surface contamination conditions as follows:

Dry Condition: No contamination at all. A dry surface was available for sealing.

Water Contamination: a drop of water was applied on the occlusal surface of the enamel and left undisturbed for 10 seconds. The excess of water was then blotted with small sponge leaving moist enamel surface.

Saliva Contamination: A drop of fresh human saliva from a single donor was applied on the occlusal surface of the enamel and left undisturbed for 10 seconds. The excess of saliva was then blotted with small sponge leaving moist enamel surface.

Saliva Contamination and Air-drying: A drop of fresh human saliva from a single donor was applied on the occlusal surface of the enamel for 10 seconds then the surface was air dried.

For the experimental group, Fuji Triage was triturated for 10 seconds then applied directly on the occlusal surface and carefully spread with small soft brush, and light cured for 40 seconds using a halogen curing light (3M ESPE, Elipar™ 2500). Clinpro™ sealant was applied to the occlusal surface of the control group with a needle tip syringe and carefully spread with small soft brush, and light cured for 20 seconds.

Table 2. Surface contamination conditions of experimental and control groups with their coding

Subgroup	Materials	No. of Teeth	Surface Condition	Coding
1	Fuji Triage	8	Dry condition	FDC
2	Fuji Triage	8	Water contamination	FWC
3	Fuji Triage	8	Saliva contamination	FSC
4	Fuji Triage	8	Saliva contamination and air-drying	FSD
5	Clinpro	8	Dry condition	CDC
6	Clinpro	8	Water contamination	CWC
7	Clinpro	8	Saliva contamination	CSC
8	Clinpro	8	Saliva contamination and air-drying	CSD

Table 3. Microleakage scores per section side, for experimental and control groups under different contamination conditions

	Experimental Group (Fuji Triage)				Control Group (Clinpro™)			
Score	**Subgroup 1 (FDC)**	**Subgroup 2 (FWC)**	**Subgroup 3 (FSC)**	**Subgroup 4 (FSD)**	**Subgroup 5 (CDC)**	**Subgroup 6 (CWC)**	**Subgroup 7 (CSC)**	**Subgroup 8 (CSD)**
Score 0	5 (15.6%)	6 (18.8%)	6 (18.8%)	5 (15.6%)	22 (68.7%)	2 (6.3%)	2 (6.3%)	4 (12.5%)
Score 1	10 (31.2%)	16 (50%)	14 (43.7%)	8 (25%)	7 (21.9%)	11 (34.3%)	7 (21.9%)	6 (18.8%)
Score 2	17 (53.2%)	10 (31.2%)	12 (37.5%)	19 (59.4%)	3 (9.4%)	21 (65.6%)	23 (71.8%)	22 (68.7%)
Total	32 (100%)	32 (100%)	32 (100%)	32 (100%)	32 (100%)	32 (100%)	32 (100%)	32 (100%)

The teeth were then subjected to thermocycling (Thermocycler THE 1100/1200, Huber, Germany), for 500 cycles in water baths held at 5°C and 55°C with a dwell time of 30 seconds. Following thermocycling, the root apices of the teeth were sealed with self-curing acrylic resin and the teeth were coated with two layers of nail paint-polish, except for a 1 mm of tooth structure around the sealant. The teeth were then immersed in 1% methylene blue for 24 hours and then were cleaned and rinsed with tap water.

The teeth were embedded in a self-curing resin and then sectioned in three parts with two parallel cuts in a bucco-lingual direction using water-cool diamond saw (Precision Saw, Isomet 2000, BUEHLER, USA), obtaining three sections of 1 mm thick from each tooth, with 4 section sides available for inspection.

Sections were then inspected under a stereomicroscope with magnification of X 40. Microleakage per section side was scored on a 3-point rating scale: score 0= no dye penetration visible, score 1= dye penetration up to the half of the fissures, score 2= dye penetration more than half of the fissure, (Fig. 1, Hevinga, 2007). The complete scoring was carried out by one trained (and blinded) examiner. The final score established as the highest score obtained after examination of both the buccal and the lingual inclined cuspal planes in each section side.

To determine intra-examiner reliability, the examiner re-examined 10 (15.5%) randomly selected teeth for microleakage scoring.

The data were statistically analyzed using SPSS version 13. Microleakage scores were analyzed per section side given 4 scores (4 sides) for each tooth. The total number of sections' surfaces examined for dye penetration was 256. The sum of the scores in each tooth was obtained to give a microleakage value ranging between 0 and 8. To compare between the two materials under the same contamination condition, *t* test was performed. ANOVA analysis was conducted to test whether there were significant differences in the microleakage values among the different subgroups of both experimental and control groups.

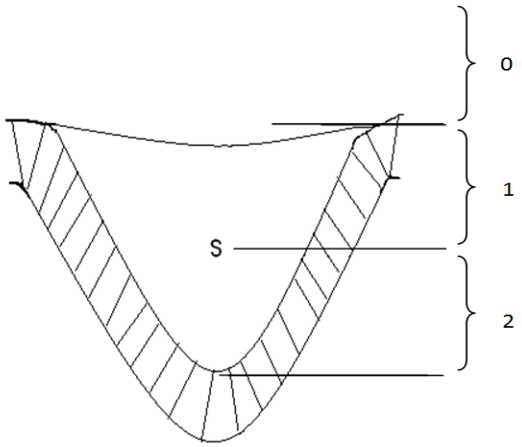

Fig. 1. Diagram of bucco-lingual section of a premolar tooth, illustrating the scoring of microleakage in a sealed fissure. 0= no dye penetration visible, 1= dye penetration up to the half of the fissures, 2= dye penetration more than half of the fissure, S= sealant.

Results

For microleakage scoring, Kappa test showed an intra-examiner reliability of 0.91.

The microleakage scores per section side for subgroups of both experimental and control groups are shown in Table 3. Both materials in different contamination conditions showed some level of microleakage, (Figs. 2 and 3). Fuji Triage scored medium level of microleakage under different contamination conditions, while Clinpro™ showed better performance in dry condition without any contamination. In comparison to Clinpro™ in dry

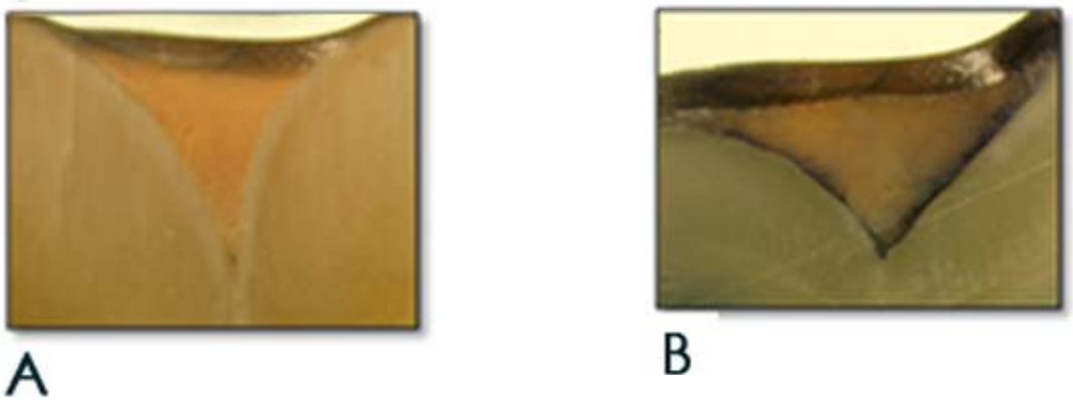

Fig. 2. Fuji Traige group. (A) No dye penetration in FWC. (B) Complete dye penetration in FDC.

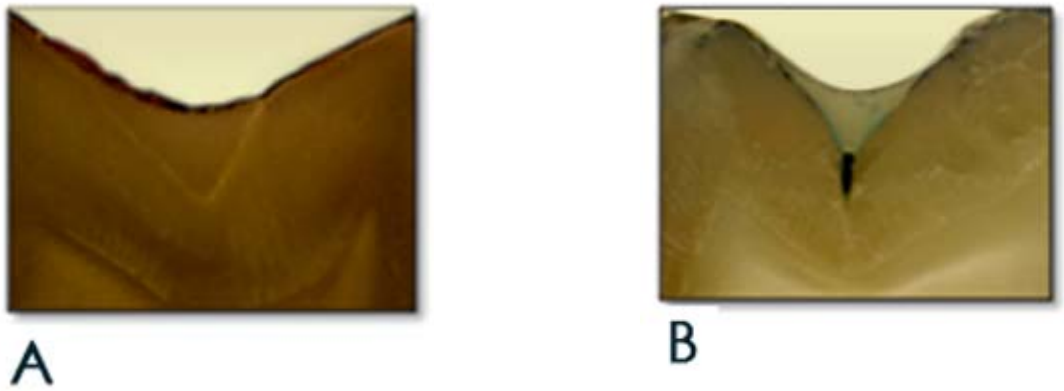

Fig. 3. Clinpro group. (A) No dye penetration in CDC. (B) Complete dye penetration in CSC.

conditions, no microleakage was seen in 5 section surfaces (15%) in Fuji Triage group (FDC) compared to 22 (68.7%) in Clinpro™ group (CDC). More than 50% of dye penetration was seen in water and saliva contamination subgroups in Fuji Triage group (FWC & FSC) in 6-section surfaces for both (18.8%) compared to 21- and 23-section surfaces in Clinpro™ group (CDC & CSC) respectively (65.6%, 71.8%). The microleakage of saliva contamination and air drying subgroups of both materials (FSD & CSD) showed almost the same score. Mean and standard deviations of microleakage values of all subgroups are shown in Fig. 4. Comparison between the two materials under the same contamination condition is shown in Table 4. Significant difference was found between both materials in dry, water contamination, and saliva contamination conditions (p = 0.000). ANOVA analysis was used to compare the microleakage values of the eight subgroups (Table 5). Dry condition in Clinpro™ group (CDC) scored the least microleakage value with statistical difference in comparison with all other subgroups in both groups. Table 5 shows also that all the subgroups in Fuji Triage showed medium level of microleakage with no statistical difference. Wet conditions in Clinpro™ [water (CW) and saliva (CS)] and saliva-air drying condition (CSD) showed a high level of microleakage without statistical difference. However, wet conditions in Fuji Triage showed statistical difference in microleakage values when compared to wet conditions in Clinpro™.

Discussion

In the present study, the microleakage of the resin-modified glass ionomer (Fuji Triage) in different contamination conditions was evaluated and compared to the microleakage of the resin-based sealant (Clinpro™). The findings in the present study disclosed that the Fuji Triage cement yielded no difference when used as a pit and fissure sealant, under dry or wet contamination conditions. It can be speculated that Fuji Triage is insensitive to moisture contamination. In general, moisture sensitivity and the low early strength of conventional glass ionomer cement are the result of slow acid-based setting

Table 4. Microleakage differences between experimental and control materials under the same contamination condition

	Microleakage Value		
Contamination Conditions	**Fuji Triage**	**Clinpro™**	**P value**
Dry condition	5.50	1.62	0.000
Water contamination	4.50	6.38	0.001
Saliva contamination	4.75	6.62	0.001
Saliva contamination and air-drying	5.75	6.25	NS

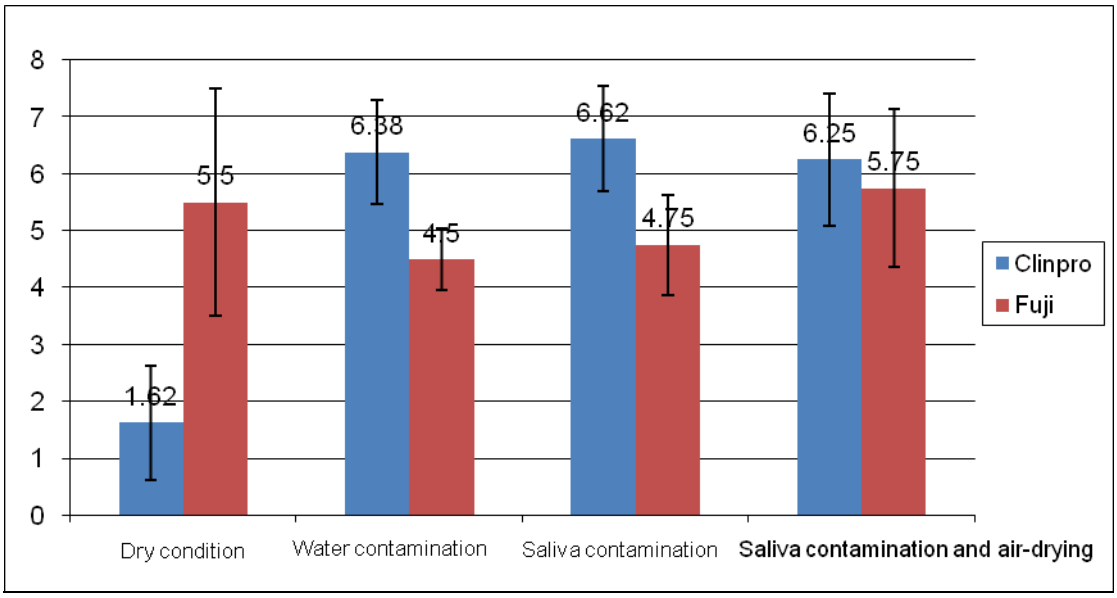

Fig. 4. Mean of microleakage values and standard deviation of Fuji Triage and Clinpro in different contamination conditions.

Table 5. Microleakage values of all subgroups in different contamination conditions

Subgroup	**(CDC)**	**(FWC)**	**(FSC)**	**(FDC)**	**(FSD)**	**(CSD)**	**(CWC)**	**(CSC)**
Microleakage value	1.62	4.50	4.75	5.50	5.75	6.25	6.38	6.62

P = 0.05
Values joined by a line indicate no significant difference

reaction. Adding polymerizing functional groups (as in the case of the Fuji Triage) allows rapid curing when activated by light or chemicals and still allows for the acid-base reaction to take its course long after polymerization, making the material less sensitive to moisture contamination (Anusavice, 2003).

However, wet contaminations adversely affected the marginal sealing when resin-based sealant (Cinpro™) was used. Most of the porosities normally present are plugged with moisture when the enamel is wet. This caused the lack of resin penetration, which results in tags of insufficient number and length to give adequate retention of the resin to enamel and subsequently, had a high level of microleakage (Hormati *et al.*, 1980). Among all subgroups, saliva contaminated surface in Clinpro™ group showed the highest level of microleakage. Saliva produce an organic film that can penetrate into the enamel microporosities created by acid etching and, thereby interfering with the bonding of the sealant material into the etched enamel (Silverstone *et al.*, 1985).

Under wet contamination conditions, Fuji Triage cement showed less microleakage than its counterpart Clinpro™ sealant. This result is consistent with Borsatto *et al.* (2004), who found that the glass ionomer provided better marginal sealing than the resin-based sealant under saliva contamination. In contrast, dry condition in the Clinpro™ group

showed significantly lower microleakage when compared to dry condition in the Fuji Triage group. This result was consistent with the result of Ganesh and Shobha (2007), which showed that resin-based sealant performed better in terms of sealing ability (in dry condition) than did the Fuji VII glass ionomer sealant, however, it was in disagreement with the result of Ashwin and Arathi (2007), which revealed that there was no difference in microleakage between the Fuji Triage and the resin-based pit and fissure sealant. Under dry condition, the Clinpro™ group showed the least microleakage score among all subgroups in both materials, as resin-based pit and fissure sealants work exceptionally well, and serve their function for many years when placed properly (Feigal, 1998). Their clinical limitation is in the difficulty of handling the resin sealant in a moist environment. Even when stringent moisture control procedures are attempted during clinical sealant application, contamination can occur. In addition, minute contamination also occurs in other areas where total isolation is not possible, such as buccal or lingual grooves which originate subgingivally. These contaminations are the likely cause of the sealant failure (Hitt and Feigal, 1992).

Many studies have confirmed that resin-based sealants have greater retention than the glass ionomer sealants, but these studies were all conducted under conditions of good isolation and moisture control. The results of this study suggest that Fuji Triage glass ionomer can be used as an alternative choice to the resin sealant especially where resin sealants are contraindicated. Clinical situations in which glass ionomer may serve as a good sealant include the treatment of children who are unable to comply with rigorous isolation methods (i.e., very young patients or children with special needs), the treatment of children whose primary molars have deeply pitted or fissured surfaces, where isolation may be difficult; the treatment of permanent first or second molars that are partially erupted and in situations where a "transitional" sealant may be considered before placement of a "permanent" resin sealant (Berg, 2002). Additionally, Fuji Triage sealant material could be placed easily when the sealant preventive programs are performed under undesirable conditions (e.g., in mobile clinics or without an assistant).

Beside its moisture insensitivity, the Fuji Triage glass ionomer has many advantages. Of great importance, its fluoride release which is six times as compared to other high-strength glass ionomer cements, when it is used as a pit and fissure sealant. This allows remineralization of enamel and provides an antimicrobial effect. The fluoride ions are taken up by the enamel, which renders the tooth structure less susceptible to acid challenge through disruption of bacterial activity (Croll and Nicholson, 2002). In addition, the ability of the glass ionomer to release other ions, notably calcium and aluminum will also promote remineralization of the tooth (Ngo *et al.*, 1997). Many studies showed that the formation of caries-like lesions in occlusal enamel adjacent to light-cured resin-modified glass ionomer sealants was lower than the fluoride-releasing conventional resin sealant (Donly *et al.*, 1999; Hicks and Flaitz, 2000).

Poor retention is one of the glass ionomer disadvantages. Studies have shown that even when the glass ionomer sealants are applied under ideal conditions, they may have poorer retention rates than their resin-based counterparts. However, small amount of sealant remaining in the fissures releases fluoride even after the sealant appear to have been lost (Seppa and Forss, 1991; Pardi, 2003). This provides a valuable caries preventive effect and of clinical advantage, particularly in some clinical situations in which the resin sealant should not be placed or contraindicated. The Fuji Triage glass ionomer could be placed during the most susceptible period (the first year after eruption), when the tooth is emerging and oral hygiene is difficult to maintain. After this period, the risk of dental caries is lower and the consequence of sealant loss is less important (Forss and Halme, 1998). Recently, in a clinical study, Kamala and Hegde (2008) evaluated Fuji III and Fuji VII glass ionomer sealants in terms of retention, and they reported that there was partial or complete retention of the sealant in 80% of the treated teeth in both groups at the one-year evaluation. Furthermore, Ganesh and Tandon (2006) showed that the clinical retention of Fuji VII in both primary and permanent molar teeth at time intervals of 6 months, 12 months and 24 months follow-up was comparable with the retention of the resin-based sealant. In the present study, the resin-modified glass ionomer and resin-based fissure sealant, however, were compared only with respect to marginal leakage under different contamination conditions. In this context, other parameters must be considered when comparing both materials such as long term retention, integrity of the sealant and shear bond strength of the sealant. Nevertheless, despite its limitations, this study provides some data to support further research into the use of resin-modified glass ionomer as a fissure sealant in pediatric dentistry.

Conclusion

1. When wet (water or saliva) contamination is apparent, the use of Fuji Triage cement as a sealing material would be beneficial to decrease microleakage.
2. When there is no wet contamination, based-resin sealant showed significantly less microleakage than Fuji Triage sealant.

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التقييم المعملي للتسرب الدقيق في شقوق الأسنان المبللة والمعزولة بمادة الأسمنت الزجاجي (فوجي ترايبج)

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ملخص البحث. هدفت هذه الدراسة إلى تقييم التسرب الدقيق في شقوق الأسنان المبللة والمعزولة بمادة الأسمنت الزجاجي (فوجي ترايبج) ومقارنته بالتسرب الدقيق لمادة الراتينج. تم اختيار ٦٤ سناً ضاحكاً مخلوعاً وتقسيمها عشوائياً إلى مجموعتين حسب المادة المستخدمة في العزل (فوجي ترايبج وكلينبرو). وقد عُزلت شقوق الأسنان بهاتين المادتين تحت أربعة معالجات سطحية: ١= الحالة الجافة، ٢= الملامسة بالماء، ٣= الملامسة باللعاب، ٤= الملامسة باللعاب بعد تجفيفه. بعدها عولجت الأسنان بالدوران الحراري (٥٠٠ دورة بدرجة حرارة من ٥-٥٥ °م) ثم صبغت بالميثلين الأزرق لمدة ٢٤ ساعة ثم وضعت في مادة إكريليكية ثم شُرحت إلى شرائح طولية، بعد ذلك تم قياس مدى اختراق الصبغة تحت المادة العازلة بمقياس من ثلاث درجات باستخدام المجهر. لوحظ التسرب الدقيق في كلتا المادتين وقد سجلت مادة فوجي ترايبج تسرباً أقل في الحالة المبلولة من مادة كلينبرو. يستنتج من هذه الدراسة أن استخدام مادة فوجي ترايبج تُقلل من التسرب الدقيق في حالة وجود البلل بسبب الماء أو اللعاب.