Original Article

Comparative Evaluation of the Viscosity and Length of Resin Tags of Conventional and Hydrophilic Pit and Fissure Sealants on Permanent Molars: An *In vitro* Study

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Abstract

Background: The World Health Organization considers sealing the pit and fissures as a primary preventive measure and is one of the most effective, least invasive means to ensure the complete protection of the occlusal surface from the carious phenomenon. *In vitro* tests play a vital role in providing the necessary information regarding the efficacy of newer brands of sealants in a short period. Therefore, the aim of the present study was to evaluate and compare the viscosity and length of resin tag of conventional and hydrophilic sealant on permanent molars. **Materials and Methods:** Twenty extracted third molars were randomly divided into two groups: Group I: Conventional sealant (Clinpro 3M ESPE) and Group II: Hydrophilic sealant (UltraSeal XT Hydro). Occlusal surfaces of each tooth were pretreated with the acid etchant, and the respective sealants were placed. Both the groups were then subjected to thermocycling and sectioned longitudinally. The sectioned tooth specimens were examined under scanning electron microscope for resin tag length measurements. Viscosities were evaluated using an Anton Paar viscometer. Independent *t*-test was used to compare the difference in mean resin tag length of Group I and Group II sealants. **Results:** Viscosity measurements of Group I and Group II were found to be 0.9 mega Pascal (MPa) and 0.7 MPa and the mean resin tag length of Group II (10.03 ± 1.00 µm) was found to be higher than Group I (7.46 ± 0.95 µm) and was found to be significant statistically ($P = 0.001$). **Conclusion:** Based on the results of the present study, it can be concluded that Group II sealant exhibited lower viscosity and formed resin tag of sufficient length than that of Group I sealants. Therefore, hydrophilic sealant showed better results as compared to a conventional sealant.

Keywords: *Anton Paar viscometer, pit and fissure sealants, resin tag, scanning electron microscope, viscosity*

Introduction

Dental carious lesions and cavities commonly occur in pits and fissures of the occlusal surfaces in primary and permanent posterior teeth.[1] A recent review of the literature shows that about 90% of carious lesions come from pits and fissures in the occlusal surface of the posterior elements.[2] The World Health Organization considers the pit and fissure sealants as the primary preventive measure, one of the most effective and least invasive means available to ensure the complete protection and the preservation of the total occlusal from the carious phenomenon.[3,4] From a secondary prevention perspective, there is evidence that sealants also can inhibit the progression of noncavitated carious lesions.[5]

The requirements of a sealant consist of a series of organoleptic, bio-compatibility, ease of use, and affordability that, held them all together, make this material an ideal product.[4] In particular, regarding the chemical-physical characteristics, the sealant material must possess a high degree of wettability and a degree of viscosity so as to allow the penetration into microcracks of the etched enamel.[4] This property is expressed by "coefficient of penetration" which is directly proportional to the surface tension of the liquid and indirectly proportional to the viscosity of the material itself.[4] It is clear, therefore, that the lower is the viscosity of a sealant, the greater will be its coefficient of penetration and therefore will be greater its retention and its effectiveness.[6] The retention in resin-based

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pit and fissure sealant is through micromechanical interlocking between the resin and the enamel. Mechanical retention of the sealant is the direct result of resin penetration into the porous enamel-forming resin tags.[7] Therefore, the viscosity of the sealant influences the penetration of sealants and length of the resin tag. This necessitates the rationale for the present study.

Newer brands of pit and fissure sealants continue to be developed, despite the lack of scientifically based information addressing the microleakage properties of these materials. Laboratory *in vitro* tests play a vital role in providing the necessary information regarding the efficacy of new products in a short period of time. Although few *in vitro* studies have investigated the penetration capacity (resin tag) property of Clinpro 3M ESPE sealant compared with different sealant materials,[8] no comparative studies have been performed comparing the viscosity and length of resin tag of these two pit and fissure sealants. Hence, this present study was designed to evaluate and compare the viscosity and length of resin tag of conventional and hydrophilic sealant on permanent molars.

Materials and Methods

Study design

This was an experimental, randomized *in vitro* study.

Sample size determination

The sample size was calculated based on the study done by Prabhakar *et al.*[9] using G*Power 3.1.2 software. The minimum sample size of each group was calculated, following these input conditions: power of 95% and alpha error of 0.05. Mean differences in resin tag length between two groups were also used for the calculation (Embrace WetBond [mean ± standard deviation (SD) Group I – 10.14 ± 4.84] and Guardian's Seal [mean ± SD Group II – 5.8 ± 1.8]). Therefore, the sample size arrived was ten teeth per group with a total sample of 20.

Ethical clearance

Before the start of the study, ethical clearance was obtained from the Institutional Ethics Committee, Saveetha University (STP/SDMDS13PHD43).

Randomization

Computer-generated block randomization with a block size of five was used to generate the assignment schedule well in advance by a third person who was not related to the study. All the molars were randomly allocated to two groups of 10 molars each using computer-generated randomization sequence with five blocks of two letters (A, B). Group I: conventional sealant (Clinpro 3M ESPE) and Group II: hydrophilic sealant (UltraSeal XT Hydro) were tested in the present study [Table 1 and Figure 1].

Figure 1: Armamentarium

Sample selection

Recently extracted human third molar teeth for orthodontic or surgical reasons were used in the study.

Inclusion criteria

- Teeth with intact occlusal surface.

Exclusion criteria

- Teeth with developmental defects
- Teeth with occlusal surface involving caries.

Storage of extracted human third molars

The teeth were cleaned by soaking them in 5% sodium hypochlorite. The remaining periodontal tissue and calculus were removed. All the teeth were then microscopically examined for caries and other possible cracks or defects.

The specimens that were not fulfilling the inclusion criteria were rejected, while those fulfilling were stored in 10% formalin solution until further use.

Study area

The present *in vitro* study was conducted in the Department of Public Health Dentistry. Length of resin tags was evaluated using a scanning electron microscope (SEM) at the Central Institute of Plastics Engineering and Technology, Guindy, and viscosity of the sealants was evaluated using an Anton Paar viscometer at the Council of Scientific and Industrial Research-Central Leather Research Institute.

Application of sealant

Occlusal surfaces of the teeth were etched with 37% orthophosphoric acid for 30 s and rinsed with water. The teeth were then dried with a mild oil-free air stream to achieve a characteristic frosty white, chalky appearance of enamel for Clinpro 3M ESPE sealant (Group I). With UltraSeal XT Hydro (Group II), the typical dull, frosted appearance of the etched surface is not desired. Rather, the surface should be lightly dried and very slightly moist with a glossy appearance. The sealant was then applied and cured for 30 s.

Procedure for the measurement of resin tag length

Thermocycling

Both the groups were then subjected to thermocycling at a temperature range of 5°C–55°C for 500 cycles, with a dwell time of 30 s.

Tooth sectioning

All the molars were sectioned longitudinally in a mesiodistal direction through the center of the sealant with a diamond wheel measuring 0.02 mm in thickness. The root portion of the teeth was then sectioned and removed.

Scanning electron microscope evaluation (Carl Zeiss Pvt. Ltd., UK. Model: EVO MA 15)

Polishing, decalcification, and drying of tooth specimens

The tooth sections were polished using a carbide stone. The polished sections were then decalcified using 37% phosphoric acid for 15 s to etch away any enamel mineral component not protected by sealants and then rinsed and stored in distilled water. The tooth sections were dried thoroughly under the heat lamp.

Mounting of tooth specimens

Tooth specimens were mounted on brass rings using a nonconductor tape made of carbon. This was then applied to the sections, in the areas that did not need scanning.

Gold spluttering

These mountings were then placed inside an ion-sputtering device for 30 min using vacuum evaporation at 200–300 Å.

Measurement of resin tag length

The gold-sputtered sections were then placed inside the SEM of 20 kV capacity and photographs of the sections were obtained. The resin tag lengths were then measured. The average of each photograph was calculated [Figures 2 and 3].

Preparation of the samples for viscosity measurement

The viscosity was checked by diluting the sealant with methyl methacrylate monomer liquid. The viscosity of the monomer liquid was evaluated first. The liquid was placed in the sample holder of the Anton Paar, DMA 5000 M, and Lovis 2000 M viscometer [Figure 4]. 0.5 ml of the sealant is drawn out of its container and diluted with 5 ml of methyl methacrylate.

The quantity of liquid required (approximately 1 ml) was transferred to the apparatus by a syringe; care was taken not to introduce bubbles in the tube to prevent errors in the measurements. In this range of viscosity values, the diameter of the capillary was 1.59 mm, and the error for this capillary was <0.01%. Care was taken to see that the light exposure of the sealant was minimal.

Statistical analysis

Data were entered into Microsoft Excel spreadsheet and analyzed using Statistical Package for the Social Sciences (SPSS) software (IBM SPSS Statistics,

Figure 2: Scanning electron microscope (Carl Zeiss Pvt. Ltd., UK. Model: EVO MA 15)

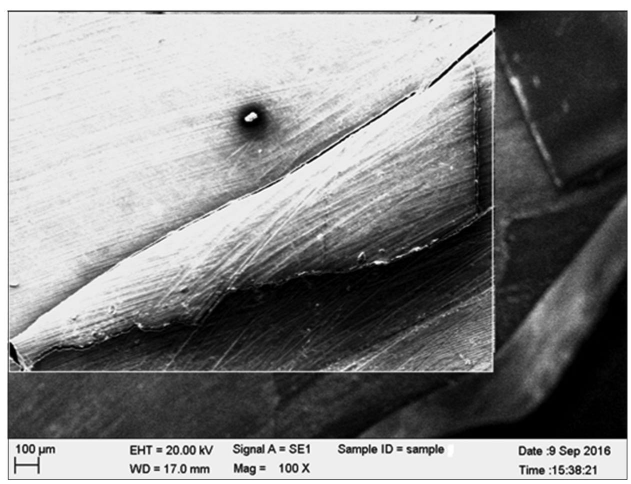

Figure 3: Scanning electron microscope image for Group I sealant

Table 1: Tested materials

Material	Group I (Clinpro)	Group II (Ultraseal XT Hydro)
Type	Unfilled resin based	53% highly filled resin based
Principal ingredient	Triethylene glycol dimethacrylate, BISGMA, Tetrabutylammonium tetrafluoroborate, dichloride methylsilane, silica, dye	Triethylene glycol dimethacrylate, diurethane dimethacrylate, aluminum oxide, methacrylic acid, titanium dioxide, sodium monofluorophosphate
Manufacturer	3M ESPE	Ultradent

Version 20.0, Armonk, NY: IBM Corp). Descriptive statistics were used for the data summarization and presentation. Shapiro–Wilk test employed to test normality of the dataset. Independent *t*-test was used to compare the difference in mean resin tag length between the groups. The level of statistical significance was set at a value of $P < 0.05$.

Results

The resin tag length measurements of each sample are shown in Table 2. The mean difference between the groups was found to be −2.56 and *t*-value of −5.86 [Table 3]. Independent *t*-test showed that $P = 0.001$ revealed a statistically highly significant difference in mean resin tag length between the groups, which in turn signifies that Group II sealant (10.03 ± 1.00 µm) was found to be superior to the Group I sealant (7.46 ± 0.95 µm). Viscosity measurements of Group I and Group II at room temperature were found to be 0.9 MPa.s and 0.7 MPa.s, which signifies that Group I sealant was found to be highly viscous than the Group II [Figure 5]. Figure 6 shows the compiled data of mean resin tag length and viscosity measurement. Group I showed a higher viscosity measurement of 0.92 µm with less resin tag length value of 7.46 MPa.s, whereas Group II showed a lesser viscosity measurement of 0.72 µm with increased resin tag length value of 10.03 MPa.s.

Discussion

The first clinical study on sealant retention was by Cueto and Buonocore in 1967. They found an 86.3% reduction in caries 1 year after application of sealant.[10] Therefore, pit and fissure sealants were found to be an outstanding adjunct to oral healthcare preventive strategies in the decrease of occlusal caries initiation and progression.[11] The cariostatic properties of sealants are attributed mainly to the physical obstruction of the pit and fissures. This prevents colonization of the pits and fissures with new bacteria and also prevents the penetration of fermentable carbohydrates to any bacteria remaining in the pits and fissures.[12] Studies have shown a strong correlation between the sealant and absence of caries.[13] For a sealant to be effective and retained for a longer duration, the viscosity measurement and resin tag formation are the important parameters that need to be addressed. Laboratory *in vitro* tests play a vital role in providing the necessary information regarding the efficacy of new products in a short period of time.

Table 2: Distribution of resin tag length measurements of Group I and Group II

Tooth specimens	Group I	Group II
1	7.43	10.62
2	8.2	9.73
3	7.9	8.41
4	6.51	10.73
5	7.24	10.42
6	5.42	9.98
7	8.7	8.95
8	8.33	10.65
9	7.32	11.75
10	7.6	9.1
Mean	7.46	10.03

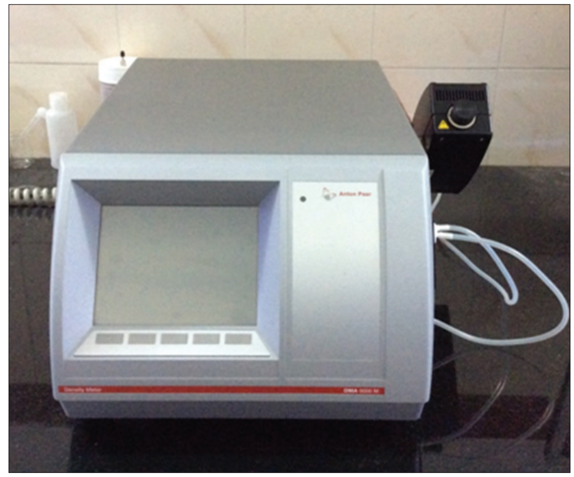

Figure 4: Anton Paar, DMA 5000 M, and Lovis 2000 M viscometer

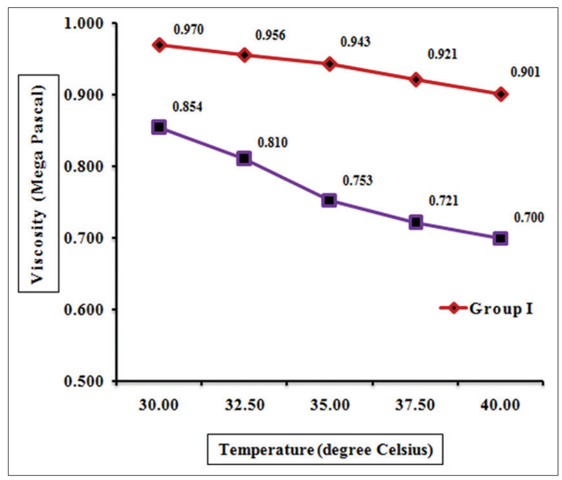

Figure 5: Viscosity measurements of Group I and Group II at various temperatures

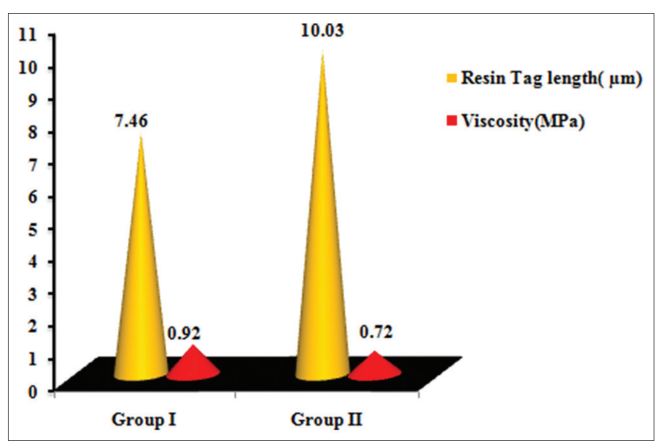

Figure 6: Mean resin tag length and Viscosity measurement (at room temperature) of Group I and Group II

Table 3: Mean difference in resin tag length measurements of Group I and Group II

Groups	Mean±SD	Degree of freedom	Mean difference	95% CI for mean	*t*	*P*
Group I	7.46±0.95	9	−2.56	6.78-8.14	−5.86	<0.001**
Group II	10.03±1.00	9		9.31-1.75		

**Highly significant at $P < 0.001$. Independent *t*-test ($P<0.05$). CI: Confidence interval; SD: Standard deviation

In the present study, UltraSeal XT is compared with conventional Clinpro 3M ESPE sealant. Although few *in vitro* studies have investigated the penetration capacity (resin tag) property of Clinpro 3M ESPE sealant with different sealant materials,[9] no comparative studies have been performed comparing the viscosity and length of resin tag of these two pit and fissure sealants. Hence, this present study was designed to compare and evaluate the viscosity and length of resin tag of conventional and hydrophilic sealants on permanent molars. The third molars extracted for therapeutic purpose, which were free of caries, developmental defects, enamel microfractures, and discoloration, were included in this study, as previous studies[14,15] have revealed that any preexisting alteration of surface morphology of the tooth directly influenced the caries progression. Conventional pumice prophylaxis was used for cleaning the tooth surfaces before etching. Some studies showed that pumice prophylaxis does not completely and consistently remove the pellicle and debris, especially in the depth of the fissure.[16] Studies by Blackwood *et al*. showed that between enameloplasty, air abrasion, and pumice prophylaxis, the least microleakage was seen with the conventional pumice prophylaxis.[17]

To mimic the temperature encountered intraorally, the tooth specimens were subjected to thermocycling procedure. Thermocycling is a method used widely in dental research, particularly when testing the performance of adhesive materials. It aims at thermally stressing the adhesive joint at the tooth–restoration interface by subjecting the restored teeth to extreme temperatures compatible with temperatures encountered intraorally.[18] A sealant can be effective in preventing dental caries, only when it is retained in the fissures for a longer period. Hence, the retention becomes an important factor, influencing the efficacy of the sealant. Retention of the sealant is mainly attributed to the factors such as viscosity and resin tag length. This necessitates the need for the study.

Viscosity is the resistance of a liquid to flow. This resistance of the fluid to flow is controlled by internal frictional forces within the liquid. The viscosity is measured in units of MPa.s or centipoise.[19] A highly viscous fluid flows slowly. The viscosity of the sealant also influences the penetration of sealants.[20] In the present study, the Anton Paar viscometer is used, which has got an advanced measuring technology and efficient temperature control of digital viscometer and requires lesser sample volume to detect the viscosity. The retention in resin-based pit and fissure sealant is through micromechanical interlocking between the resin and the enamel. Mechanical retention of sealant is the direct result of resin penetration into the porous enamel-forming resin tags.[7] In the present study, SEM was used to measure the length of the resin tags as the SEM can produce very high-resolution images of a sample surface and can reveal details about <1–5 nm in size. Due to the very narrow electron beam, SEM images have a large depth of field yielding a characteristic three-dimensional appearance useful for understanding the surface structure of a sample.[21]

Timing of the sealant placement is critical. The teeth that have newly erupted are the ones that are most susceptible to caries and hence need protection from pit and fissures. However, isolating them is the most difficult. Until now, the only moisture-tolerant sealants were glass ionomers.[22] Their mechanism of adhesion is ionic bonding, not micromechanical retention to an acid etched enamel surface. Pardi *et al.* reported low-sealant retention rates with glass ionomer cement.[23] One such newer brand of sealant is UltraSeal XT Hydro sealant which is 53% highly filled resin with thixotropic (ideal viscosity) and advanced adhesive technology allows it to flow into pit and fissures and bond effectively without a drying agent to the tooth.[24]

In the present study, the mean length of the resin tags obtained ranged from 5.42 to 8.70 μm for Group I and 8.41 to 11.75 μm for Group II. Similar *in vitro* studies conducted by Prabhakar *et al.*[9] and dos Santos *et al.*[9] showed mean resin tag length in the range of 5–10 μm. Viscosity of Group I was found to be 0.92 MPa higher than Group II which was 0.72 MPa. Similar phenomenon was explained in a study done by Irinoda *et al.*,[19] who reported that higher viscosity of the sealant may cause poorer adaptation and incomplete penetration to the bottom of the pit and fissures, resulting in decreased retention. With low-viscosity sealants, there is a greater potential of the sealant to flow, spread more rapidly over the surface and penetrate. On the contrary, the study by Barnes *et al.*[25] has shown that the viscosity and flow properties of the fissure sealants do not affect their sealing ability.

Nonetheless, the findings of this study disclosed that the viscosity of Group II (UltraSeal XT Hydro) was found to be less compared to Group I (Clinpro) sealant, which resulted in better penetration and increased length of the resin tag. A possible explanation for such behavior could be attributed to three main reasons. First, the thixotropic nature of Group II (UltraSeal XT Hydro) chases moisture deep into pit and fissures on a microscopic level.[24] Second, the adhesive technology of Group II (UltraSeal XT

Hydro) creates higher bond strength. Hence, higher bond strength results in reduced microleakage and increased retention.[24] Third, the wet or moisture contaminations adversely affected the marginal sealing when resin-based sealant (Clinpro™) was used. Most of the porosities normally present are plugged with moisture when the enamel is wet. This causes 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.[26]

Limitations

The present study could be attributed to the lack of access to a cutting machine for tooth sectioning to provide more slices per tooth for a more detailed resin tag length assessment, and also, it should be noted that the results of the present study are valid for *in vitro* conditions. Depending on the environment, sealants may act differently due to variables such as fissure type, preparation, enamel etching, and contamination of prepared surfaces of fissures.

Conclusion

Based on the findings of the present study, it can be concluded that Group II sealant was found to be less viscous which resulted in better penetration of the sealant and formed tags of sufficient number and length which ultimately aided in better retention of the sealant when compared to Group I. Further, with the newly developed hydrophilic sealant Ultraseal XT Hydro, it is now possible to go ahead and seal the newly erupted teeth that were previously left unprotected due to moisture control problems.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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