ORIGINAL ARTICLE ASIAN JOURNAL OF MEDICAL SCIENCES

# SEM study of resin tags depth for filled pit and fissure sealants using subpressure and adhesive system - An experimental analysis

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Submission: 07-04-2023 Revision: 28-07-2023 Publication: 01-09-2023

ABSTRACT

**Background:** Pit and fissure caries account for about 90% of the caries of permanent posterior teeth and 44% of caries within the first teeth in children and adolescents. Sealant application may be a preventive conservative approach. However, it is still challenging to bolster the retention of the filled sealant and to chop back the microleakage. **Aims and Objectives:** To evaluate and compare the depth of resin tags of three filled pit and fissure sealants (PFS) using subpressure and adhesive system under scanning electron microscope (SEM). **Materials and Methods:** This study was *in vitro* experimental study. Forty-five orthodontically extracted premolars were prepared for resin tag depth measurement and divided according to materials and subgroups. Group A- Resin-based filled PFS, Group B- Resin modified glass ionomer-based filled PFS, Group C- Giomer based filled PFS. Subgroup 1- Only sealant application, Subgroup 2- Subpressure application, Subgroup 3-Adhesive system + Subpressure application. Samples were subjected to thermocycling. The sectioned tooth fragments were polished using a carbide stone and then mounted under SEM for analysis. Photographs of the sections were obtained and the resin tag lengths were measured. Unpaired t-test and one-way analysis of variance test used for analysis. Results were considered significant when $P<0.05$. **Results:** The depth of resin tags of the tested materials differed significantly for Giomer-based and resin-modified glass ionomer-based filled PFS group with $P<0.05$. Whereas Resin-based filled PFS group was not found significant $P>0.05$ for the depth of resin tags. **Conclusion:** This study concludes that Giomer based filled PFS group and Resin-modified glass ionomer-based filled PFSs showed the highest Resin tag depth respectively when compared with Resin-based filled PFSs. The Subpressure application group was more effective followed by Adhesive+subpressure application group and Control group.

**Key words:** Pit and fissure sealant; Subpressure; Adhesive; Scanning electron microscope; Resin tag depth

**Access this article online**
**Website:**
http://nepjol.info/index.php/AJMS
**DOI:** 10.3126/ajms.v14i9.53974
**E-ISSN:** 2091-0576
**P-ISSN:** 2467-9100



## INTRODUCTION

Pit and fissure caries account for about 90% of the caries of permanent posterior teeth and 44% of caries in the primary teeth in children and adolescents The plaque-retentive nature of pits and fissures makes them difficult to clean, thereby causing them to be more susceptible to caries than smooth surfaces and possibly not to be protected by fluoride administration Pit and fissure sealant (PFS) application is a preventive conservative approach involving the introduction of sealants into the pits and fissures of caries-prone teeth; this sealant then bonds to the tooth micromechanically, providing a physical barrier that keeps bacteria away from their source of nutrients.[1] The unfilled sealants have a lower viscosity so provide greater penetration into fissures and better retention but over a period these sealants undergo abrasive wear and hence filler particles have been added to sealants to increase their wear and abrasion

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resistance. The addition of filler particles lowers the sealant's ability to penetrate fissures and micro porosities of etched enamel.[2] Filled PFSs have greater wear resistance but they have limited flow and less retention due to high viscosity. Therefore, it is still challenging to enhance the retention of the filled sealant and to reduce the microleakage.

The bonding of the sealing material to the tooth surface creates a mechanical connection, acting as a physical barrier against bacterial biofilms. This effectively reduces the detrimental impact of pathogenic microorganisms on the tooth surface. The efficacy of fissure sealants in a clinical setting relies on their ability to remain in place, withstand abrasion, and ensure sufficient sealing on the tooth surface.[3,4]

The subpressure technique can effectively enhance the bonding of the sealant-enamel and reduce the microleakage on the interface of the sealant-enamel.[5] The use of adhesive systems beneath fissure sealants can increase the retention.[6] Certain studies have indicated the beneficial effects of adhesive systems on the longevity of fissure sealants. The components within the adhesive can enhance the penetration into the pores of the enamel, thereby enhancing the adhesive strength.[2,7,8] Currently, resin-based sealants are the most commonly utilized type of sealant material and exhibit superior retention compared to other alternatives.[9] After etching the enamel, the prismatic enamel becomes visible, and the resin-based sealants penetrate the microporosities. This process results in the formation of resinous tags and establishes mechanical anchoring once the sealants have been polymerized.[10] Hence, the study was selected to evaluate and compare the effect of subpressure and adhesive system on filled PFSs by evaluating the depth of resin tags under a scanning electron microscope (SEM) (Figures 1-3).

### Aims and objectives

To evaluate and compare the depth of resin tags of three filled PFSs using subpressure and adhesive system under SEM.

## MATERIALS AND METHODS

The present experimental *in vitro* study was carried out during the period of 6 months in the Department of Pediatric and preventive dentistry, school of dental sciences, KIMSDU, Karad, after due approval of the institutional ethical committee (protocol number 161/2019–2020, dated; December 30, 2019). The calculated Sample sizes were 5 per each parameter, subgroups, and groups to have significant results (Table 1).

Premolar teeth, required for orthodontic treatment, were obtained from various dental clinics. As the responsible dental clinic ensured appropriate procedures, including obtaining informed consent, there was compliance with ethical standards in the collection process.

**Figure 1:** Scanning electron microscope


**Figure 2:** Subpressure apparatus

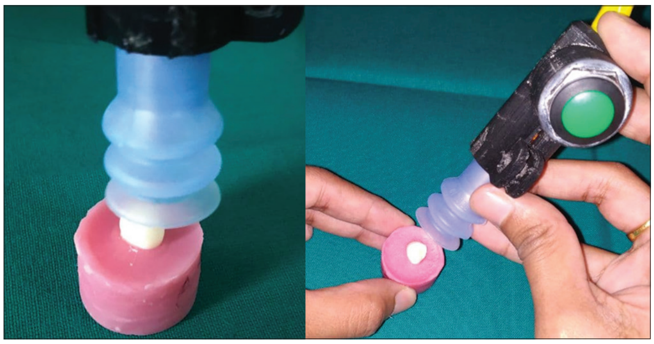


**Figure 3:** Subpressure application

### Inclusion criteria

Morphologically intact 45 non-carious, non-hypoplastic, non-restored premolars which are extracted for therapeutic orthodontic treatment.

**Table 1: Distribution of sample size per subgroups and groups**

| Group | Filled pit and fissure sealant | Sample size | Subgroup-1 | Subgroup-2 | Subgroup-3 |
|---|---|---|---|---|---|
| | | | Only sealant application (CONTROL group) (15) | Subpressure application (15) | Adhesive system+subpressure application (15) |
| | | | Resin tag depth | Resin tag depth | Resin tag depth |
| A | Resin based | 15 | 5 | 5 | 5 |
| B | Resin modified glass ionomer based | 15 | 5 | 5 | 5 |
| C | Giomer based | 15 | 5 | 5 | 5 |

**Table 2: Profiles of materials investigated**

| Materials | Manufacture | Curing method |
|---|---|---|
| Helioseal F (Resin based filled pit and fissure sealant) | Ivoclar | Light cure |
| Vitremer 3M (Resin modified glass ionomer based filled pit and fissure sealant) | 3M ESPE | Light cure |
| BeautiSealant (Giomer based filled pit and fissure sealant) | Shofu | Light cure |

### Exclusion criteria

Teeth with morphological variations and fractured crowns.

### Sample preparation

Teeth will be collected and stored in 0.5% Chloramine-T solution for 48 h for disinfection, then stored in saline until further use and scaling and cleaning with water/pumice slurry and a rubber cup at low speed.

Teeth embedded in self-curing acrylic resin up to 1 mm below the cemento-enamel junction, using a PVC cylinder (2 cm in height and 2 cm in diameter) and fistulotomy will be standardize by extending the fissure entrance to the diameter of half-length of micro narrow taper fissure carbide bur (Fissurotomy® Micro NTF, SS White) throughout the fissures then prepared samples divided according to materials and subgroups. Then prepared samples were divided according to materials and subgroups.

### Only sealant application

The enamel surface to be sealed was thoroughly cleaned. An etching gel was applied to the enamel and allowed to react for 30–60 s. The enamel surface was rinsed and dried with water-free and oil-free air. After drying the sealant was applied directly with the disposable brush and waited for approximately 15 s. The sealant was cured with a suitable polymerization light for 20 s (Table 2).

### Subpressure application

The enamel surface which was sealed was cleaned thoroughly. The etching gel was applied on the enamel surface and allowed it to react for 30–60 s. The etching gel was rinsed thoroughly and dried with oil-free and water-free air. With the help of a disposable brush the sealant was applied directly on the enamel surface. During this time, subpressure was applied and waited for approximately 15 s. The sealant was cured using an appropriate polymerization light for 20 s (Table 2).

### Adhesive system + subpressure application

The enamel surface which was sealed was cleaned thoroughly. The etching gel was applied on the enamel surface and allowed it to react for 30–60 s. The etching gel was rinsed thoroughly and dried with oil-free and water-free air. A layer of universal adhesive was applied with a micro brush for 20 s and thinned with compressed air for 5 s cured with a LED curing unit for 20 s. The sealant was applied directly with the disposable brush and waited for approx. 15 s, during this time subpressure was applied (Figure 3). The sealant was cured using an appropriate polymerization light for 20 s (Table 2).

### Thermocycling

Samples of microleakage and shear bond strength evaluation subjected to thermocycling 2000 cycles of increasing temperature from 5°C to 55°C at a dwell time of 30 s per temperature.

Forty-five sample teeth were prepared for resin tag measurement by decorating from acrylic resin and sectioned buccolingually into two fragments with a diamond disc.

The sectioned tooth fragments were polished using a carbide stone and then mounted under SEM (Figure 1) for analysis. The photographs of the sections were obtained and the resin tag lengths were measured.

## RESULTS

Table 3 shows inter subgroup comparison of the depth of resin tags of three filled PFSs. The one-way analysis of variance (ANOVA) revealed that the depth of resin tags of the tested materials differed significantly for subpressure application group with $P<0.05$. The depth of resin tags in the control group and the group receiving Adhesive+Subpressure application did not show a significant difference ($P>0.05$).. Subpressure application group was more effective followed by the control group and adhesive+subpressure application group.

Table 4 shows intergroup comparison of the depth of resin tags of three filled PFSs. The one-way ANOVA revealed that the depth of resin tags of the tested materials differed significantly for Giomer-based and resin-modified glass ionomer based filled PFS group with P<0.05. Whereas Resin-based filled PFS group was not found significant P>0.05 for depth of resin tags. Giomer-based filled PFS group and resin-modified glass ionomer-based filled PFS group were more effective than resin-based filled PFS group, respectively.

Graph 1 shows the comparison of mean values obtained for the depth of resin tags between three filled PFSs. Giomer-based filled PFS group showed the highest resin tag depth for subpressure application followed by resin-modified glass ionomer based filled PFS over the subpressure application and adhesive+subpressure application groups. Giomer based filled PFS group and subpressure application group was more effective than any other groups and subgroups, respectively.

## DISCUSSION

The pits and fissures of posterior teeth have been recognized for their high caries susceptibility over many years due to the unique morphology of the pits and fissures. The morphology renders the mechanical means of debridement inaccessible. Other factors such as lack of salivary access to the fissures, the close proximity of fissure base to the dentin-enamel junction and remnants of debris and pellicle in the fissures increase caries susceptibility of fissures by many folds. Therefore, to prevent the initiation of caries in these fissures, the concept of PFSs evolved.[4]

In a study conducted by Zhang et al.,[11] on the improvement of pit-and-fissure sealant bonding to enamel with subpressure treatment, they concluded that the subpressure technique the subpressure method successfully improves the bond between the sealant and enamel while minimizing microleakage at the sealant-enamel interface. By eliminating gaps at the enamel-sealant interface, subpressure treatment proved to be highly effective in enhancing the bond strength and reducing potential voids.[5]

In a study conducted by Tian et al., on effects of subpressure on the sealing ability of dental sealant *in vitro*, they concluded that subpressure technique could effectively enhance the penetration of sealant into pits and fissures, avoid serious microleakage and protect enamel from artificial demineralization.[12] The results were concurrent with the present study, sub-pressure application group was more effective following the control group and adhesive+sub-application group for tested materials.

In the current study, we combined adhesive+subpressure technique which showed fewer effective results than subpressure technique and control group for depth of resin tags.

Godhane et al., stated that generally, resin-based materials are recommended with the advantage of better retention, and glass-ionomer-based materials are recommended with the advantages of fluoride release and lower moisture sensitivity. Recently developed Giomer-based fissure sealant

**Table 3: Inter subgroup comparison of depth of resin tags of pit and fissure sealants**

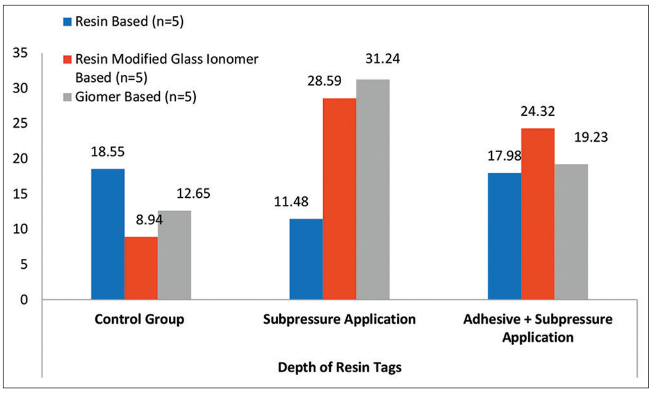
| Pit and fissure sealants | Depth of resin tags | | |
|---|---|---|---|
| | Control group | Subpressure application | Adhesive+subpressure application |
| Resin based (n=5) | 18.55±14.19 | 11.48±4.12 | 17.98±11.24 |
| Resin modified glass ionomer based (n=5) | 8.94±2.08 | 28.59±6.63 | 24.32±8.59 |
| Giomer based (n=5) | 12.65±5.92 | 31.24±10.23 | 19.23±9.98 |
| ANOVA F-value | 0.99 | 10.43 | 0.38 |
| P-value | 0.40 | 0.0024* | 0.7 |

*Significant when *P*<0.05. ANOVA: Analysis of variance

**Table 4: Inter group comparison of depth of resin tags of pit and fissure sealants**

| Pit and fissure sealants | Depth of resin tags | | | ANOVA F-value | P-value |
|---|---|---|---|---|---|
| | Control group | Subpressure application | Adhesive + subpressure application | | |
| Resin based (n = 5) | 18.55 ± 14.19 | 11.48 ± 4.12 | 17.98 ± 11.24 | 0.67 | 0.52 |
| Resin modified glass ionomer based (n = 5) | 8.94 ± 2.08 | 28.59 ± 6.63 | 24.32 ± 8.59 | 13.13 | 0.009* |
| Giomer based (n = 5) | 12.65 ± 5.92 | 31.24 ± 10.23 | 19.23 ± 9.98 | 5.66 | 0.0195* |

*Significant when *P* < 0.05. ANOVA: Analysis of variance




**Graph 1:** Mean of the depth of resin tag values in experimental groups and subgroups

material represents advantages of resin-based and glass-ionomer-based sealants.[13]

El Motayam et al., utilized a SEM to examine nano leakage and resin tag length in three distinct types of PFSs. They observed a negative association between resin tag length and nano leakage, indicating that longer resin tags corresponded to reduced nano leakage and improved cariostatic effects of the PFSs.[14]

In the study of Zhuge et al., the application of subpressure technique successfully improved the infiltration of resin monomer into dentin tubules. When compared to the control group, the subpressure groups exhibited longer resin tags and a more compact distribution. This can be attributed to the subpressure technology, which facilitated the deep penetration of bonding agents into the dental tubules which marks the effectiveness of the application of subpressure techniques which also shows effective results in the present study.[5]

In inter group comparison of depth of resin tags of PFSs, the tested materials differed significantly for giomer based filled PFS and resin-modified glass ionomer-based filled PFS group with $P<0.05$. Whereas resin-based filled PFS group was not found significant $P>0.05$ for depth of resin tags. In inter subgroup comparison, the depth of resin tags of the tested materials differed significantly for the subpressure application group with $P<0.05$. Whereas the control group and Adhesive+Subpressure application group was not found a significant $P>0.05$ for the depth of resin tags.

In the current study, we compared resin-based, resin-modified glass ionomer-based and giomer based filled PFSs. Giomer-based group was more effective than other two.

Zhang et al.,[11] concluded that the application of subpressure technique resulted in enhanced bonding between the enamel and sealant, both immediately and after thermocycling. While the SBS values of samples in the sub-pressure groups decreased after thermocycling, they remained higher than those of samples in the non-sub-pressure groups before thermocycling. This observation suggests that the subpressure technique is an effective method to improve the bonding strength and resistance to aging. The results of this study was in line with the present study which concludes the subpressure application was effective and showed statistically significant results.

Mesa et al., and Bagherian et al., concluded that the use of adhesive systems beneath fissure sealants can increase the retention of fissure sealants.[2,6] Bao et al., also conducted research investigations that demonstrated the effectiveness of using an adhesive system to achieve satisfactory outcomes. They suggested considering re-etching or applying a universal adhesive on saliva-contaminated etched enamel before applying the sealant.[10]

### Limitations of the study

Although the study is providing encouraging results, however, there are certain limitations, the *in-vitro* studies have the limitations of laboratory and clinical setup errors.

## CONCLUSION

This investigation with the above limitations proved that Giomer-based filled PFS group and subpressure application showed statistically significant results. Subpressure technique significantly showed the highest resin tag depth.

## ACKNOWLEDGMENT

The authors would like to acknowledge Dr. Shashikiran N. D, Dean and HOD of the Department of Paediatrics and Preventive Dentistry, for his support in making this study a success. Mr. Lokesh Patil and Mr. Prashant Jadhav from RIT, Islampur for help regarding Subpressure apparatus. All staff members from the Department of Paediatrics and Preventive Dentistry, SDS, KIMSDU, Karad for constant support.

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**Author's Contribution:**
**SW-** Conceptualization, formal analysis, resources; **SND-** Validation; **SH-** Writing original draft, data curation; **NG-** Formal analysis, writing - review, methodology, resources; **SG-** Methodology, formal analysis.

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**Source of Support:** Nil, **Conflicts of Interest:** None declared.