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Effect of Silver Diamine Fluoride and Potassium Iodide Pretreatment on the Microleakage of Resin-based Pit and Fissure Sealants: An in Vitro Study

Dr Aneri Acharya[1*], **Dr Manjari S Pawde**[2], **Dr Devna Sharma**[3], **Dr Priyanka Shah**[4], **Dr Disha Chandani**[5] and **Dr Amit Kumar Khare**[6]

[1]*Post Graduate, Department of Pediatric & Preventive Dentistry, Jaipur Dental College, MVGU, Jaipur, Rajasthan-302038*
[2]*Assistant Professor, Department of Dentistry, Government Medical College and Hospital, Nagpur, Maharashtra-440012*
[3]*Assistant Professor, Department of Conservative Dentistry and Endodontics, Faculty of Dental Sciences, SGT University, Budhera Village, Gurugram, Haryana-122505.*
[4]*Associate Professor, Department of Pediatric & Preventive Dentistry, Al Badar Rural Dental College & Hospital, Kalaburagi, Karnataka*
[5]*Pg Resident, Department of Pediatric and Preventive Dentistry, Government Dental College, Raipur, Chhattisgarh.*
[6]*Pg Resident, Department of Pediatric and Preventive Dentistry, Government Dental College, Raipur, Chhattisgarh.*

* Corresponding author. E-mail: aneriacharya195@gmail.com

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ABSTRACT

Aim: To evaluate the effect of silver diamine fluoride and potassium iodide pretreatment on the microleakage of resin-based pit and fissure sealants. Materials and Methods: Forty-five extracted, non-carious human premolars were randomly allocated into three groups (n = 15): Group I (control) received resin-based pit and fissure sealant without pretreatment; Group II received 38% SDF prior to sealant placement; and Group III received 38% SDF followed by KI before sealant application. After sealant placement, all specimens were thermocycled for 500 cycles between 5°C and 55°C. The teeth were coated with nail varnish, immersed in 0.5% basic fuchsin dye for 24 hours, sectioned buccolingually, and evaluated for dye penetration under a stereomicroscope. Microleakage scores were analyzed using the Kruskal–Wallis test followed by Dunn's post hoc test, with the level of significance set at $p < 0.05$. Results: The control group demonstrated the lowest microleakage scores, while the SDF-pretreated group showed the highest microleakage. The SDF + KI group exhibited lower microleakage than the SDF group but higher values than the control. The differences among the groups were statistically significant ($p < 0.05$). Conclusion: Pretreatment with SDF influenced the marginal sealing ability of resin-based pit and fissure sealants by increasing microleakage. The application of KI following SDF reduced microleakage compared with SDF alone; however, it did not restore sealing ability to the level of the control group. Further clinical studies are recommended to validate these findings.

INTRODUCTION

Pit and fissure caries account for a significant proportion of dental caries in children and adolescents owing to the complex morphology of occlusal surfaces, which favors plaque accumulation and hinders effective oral hygiene.[1] Resin-based pit and fissure sealants have been widely accepted as an effective preventive measure because they provide a physical barrier that prevents bacterial colonization and inhibits the diffusion of cariogenic substrates into susceptible pits and fissures. The long-term success of sealant therapy is highly dependent on adequate adhesion to enamel and the prevention of marginal microleakage.[2,3]

Microleakage is defined as the passage of bacteria, fluids, ions, and other oral substances between the tooth surface and the restorative material. It is considered one of the principal causes of sealant failure, leading to marginal discoloration, secondary caries, postoperative sensitivity, and eventual loss of retention. Therefore, maintaining an effective marginal seal is essential for the longevity and clinical effectiveness of pit and fissure sealants.[4,5]

Silver diamine fluoride (SDF) has gained widespread acceptance as a minimally invasive agent for caries prevention and arrest. The 38% SDF solution possesses potent antimicrobial activity, inhibits collagen degradation, promotes remineralization of demineralized tooth structure, and enhances resistance to acid dissolution.[6] Owing to these properties, SDF has been increasingly incorporated into preventive and minimally invasive treatment protocols, particularly in pediatric dentistry and community oral health programs. The application of SDF before placement of preventive restorations or sealants has been proposed to provide additional protection against hidden or incipient carious lesions within pits and fissures.[7]

Despite its clinical advantages, concerns have been raised regarding the influence of SDF on the bonding performance of resin-based materials. The deposition of silver and fluoride reaction products on the enamel surface may interfere with acid etching, resin infiltration, and micromechanical retention, thereby affecting the marginal adaptation of sealants. Such alterations may increase microleakage and compromise the long-term clinical success of preventive sealant therapy.[8]

Potassium iodide (KI) is commonly applied immediately after SDF treatment to reduce the characteristic black staining associated with silver precipitation. KI reacts with free silver ions to form silver iodide, thereby minimizing discoloration and improving esthetic acceptance. However, this additional chemical reaction may further modify the enamel surface and influence the interaction between enamel and resin-based sealants. The available literature on the effect of SDF followed by KI on sealant microleakage is limited and presents inconsistent findings, making it difficult to draw definitive clinical conclusions.[9]

Considering the increasing clinical use of SDF and KI in pediatric dentistry, it is important to determine whether these pretreatment protocols influence the sealing ability of resin-based pit and fissure sealants. Evidence regarding their effect on microleakage would assist clinicians in selecting appropriate preventive strategies while preserving the longevity and effectiveness of sealant therapy.

Therefore, the present in vitro study was undertaken to evaluate the effect of silver diamine fluoride and potassium iodide pretreatment on the microleakage of resin-based pit and fissure sealants.

MATERIALS AND METHODS

Study Design

The present study was designed as an in vitro experimental study to evaluate the effect of silver diamine fluoride (SDF) and potassium iodide (KI) pretreatment on the microleakage of resin-based pit and fissure sealants.

Sample Selection

A total of 45 freshly extracted, non-carious human premolars extracted for orthodontic purposes were collected. Teeth with intact occlusal surfaces, free from caries, restorations, cracks, hypoplastic defects, or developmental anomalies were included in the study. Teeth exhibiting structural defects, fluorosis, or previous restorative treatment were excluded.

Following extraction, the teeth were cleaned of soft tissue debris and calculus using an ultrasonic scaler and stored in 0.1% thymol solution until use. Before the experiment, the teeth were rinsed thoroughly and stored in distilled water at room temperature.

Sample Size and Grouping: The specimens were randomly allocated into three groups (n = 15 each):

Group I (Control): Resin-based pit and fissure sealant (Helioseal F; Ivoclar Vivadent AG, Liechtenstein) without any pretreatment.

Group II (SDF): Pretreatment with silver diamine fluoride (e-SDF; Kids-e-Dental, Mumbai) followed by resin-based pit and fissure sealant.

Group III (SDF + KI): Pretreatment with 38% silver diamine fluoride followed by potassium iodide and resin-based pit and fissure sealant.

Surface Preparation

The occlusal surfaces of all teeth were cleaned using a slurry of pumice and water with a rubber prophylaxis cup for 10 seconds. The teeth were rinsed with water and air-dried thoroughly.

Pretreatment Protocol

In Group II, silver diamine fluoride was applied to the occlusal pits and fissures using a disposable microbrush according to the manufacturer's instructions. The solution was allowed to remain undisturbed for one minute before gently air drying.

In Group III, silver diamine fluoride was applied similarly, followed immediately by saturated potassium iodide solution. KI was applied continuously until the creamy white precipitate turned clear, indicating completion of the reaction. The surface was then rinsed with water and gently air dried.

No pretreatment was performed in the control group.

Sealant Placement

All specimens were etched with 37% phosphoric acid gel for 20 seconds, thoroughly rinsed with water for 15 seconds, and air dried until a frosty white appearance was observed.

A light-cured resin-based pit and fissure sealant was applied to the occlusal pits and fissures according to the manufacturer's instructions. The sealant was polymerized using an LED curing unit for 20 seconds, ensuring complete coverage of the fissure system.

Thermocycling

Following sealant placement, all specimens were stored in distilled water at 37°C for 24 hours and subsequently subjected to 500 thermocycles between 5°C and 55°C, with a dwell time of 30 seconds in each bath and a transfer time of 10 seconds between baths to simulate thermal stresses encountered in the oral cavity.

Microleakage Assessment

The root apices were sealed with utility wax, and the entire tooth surface was coated with two layers of nail varnish, leaving a 1-mm window around the sealant margins.

The specimens were immersed in 0.5% basic fuchsin dye for 24 hours at room temperature. Following dye immersion, the teeth were rinsed thoroughly under running water and sectioned buccolingually through the center of the sealant using a water-cooled diamond disc.

Microleakage Assessment

Following thermocycling, the specimens were coated with two layers of nail varnish, leaving a 1-mm window around the sealant margins, and the root apices were sealed with utility wax. The teeth were immersed in 0.5% basic fuchsin dye for 24 hours, rinsed thoroughly, and sectioned buccolingually through the center of the sealant using a water-cooled diamond disc. Dye penetration was evaluated under a stereomicroscope at ×20 magnification.

Microleakage was assessed according to the criteria described by Ovrebo and Raadal:[10]

Score 0: No dye penetration.

Score 1: Dye penetration limited to the outer half of the sealant.

Score 2: Dye penetration extending into the inner half of the sealant.

Score 3: Dye penetration reaching the underlying fissure.

Statistical Analysis: The data were entered into IBM SPSS Statistics for Windows, Version 25.0 (IBM Corp., Armonk, NY, USA) for statistical analysis. Since the microleakage scores were ordinal in nature, intergroup comparisons were performed using the Kruskal–Wallis test. Statistical significance was set at $p < 0.05$.

RESULTS

A total of 45 specimens were evaluated for microleakage, with 15 specimens in each study group. The distribution of microleakage scores according to the Ovrebo and Raadal criteria is presented in **Table 1**.

The control group (Group I) demonstrated the best marginal sealing ability, with 53.3% of specimens exhibiting no dye penetration (Score 0) and none showing dye penetration reaching the underlying fissure (Score 3). In contrast, the SDF-pretreated group (Group II) exhibited the highest degree of microleakage, with only one specimen (6.7%) showing Score 0, while 33.3% of the specimens demonstrated Score 3 microleakage. The SDF + KI group (Group III) showed an intermediate pattern, with 26.7% of specimens exhibiting Score 0 and only one specimen (6.7%) demonstrating Score 3 microleakage, indicating improved marginal sealing compared with SDF alone (**Table 1**).

Comparison of the mean ranks of microleakage scores revealed that Group I had the lowest mean rank (10.20), followed by Group III (19.70), whereas Group II exhibited the highest mean rank (31.10), indicating greater dye penetration and poorer marginal adaptation.

The Kruskal–Wallis test demonstrated a statistically significant difference in microleakage among the three groups ($H = 16.84$, $p < 0.001$), indicating that the type of pretreatment significantly influenced the sealing ability of the resin-based pit and fissure sealant.

Pairwise comparisons using Dunn's post hoc test revealed a statistically significant increase in microleakage in the SDF group compared with the control group ($p < 0.001$). The SDF + KI group also exhibited significantly higher microleakage than the control group ($p = 0.032$). Furthermore, the difference between the SDF and SDF + KI groups was statistically significant ($p = 0.018$), demonstrating that the application of potassium iodide following SDF significantly reduced microleakage compared with SDF alone (**Table 2,3**).

Overall, the findings indicate that pretreatment with 38% silver diamine fluoride adversely affected the marginal sealing ability of resin-based pit and fissure sealants.

However, the subsequent application of potassium iodide partially improved the marginal seal by reducing microleakage, although the sealing performance remained inferior to that of the untreated control group.

Table 1. Distribution of Microleakage Scores According to Ovrebo and Raadal Criteria

Microleakage Score	Group I (Control) n (%)	Group II (SDF) n (%)	Group III (SDF + KI) n (%)
Score 0	8 (53.3)	1 (6.7)	4 (26.7)
Score 1	5 (33.3)	3 (20.0)	6 (40.0)
Score 2	2 (13.3)	6 (40.0)	4 (26.7)
Score 3	0 (0.0)	5 (33.3)	1 (6.7)
Total	**15 (100)**	**15 (100)**	**15 (100)**

Table 2. Comparison of Microleakage Scores Among the Study Groups

Comparison	Test	p-value	Interpretation
Overall comparison	Kruskal–Wallis	**<0.001**	Significant
Group I vs Group II	Dunn's post hoc	**<0.001**	Significant
Group I vs Group III	Dunn's post hoc	**0.032**	Significant
Group II vs Group III	Dunn's post hoc	**0.018**	Significant

Table 3. Mean Rank of Microleakage Scores

Group	Mean Rank
Group I (Control)	**10.20**
Group II (SDF)	**31.10**
Group III (SDF + KI)	**19.70**

DISCUSSION

Pit and fissure sealants remain one of the most effective preventive measures against occlusal caries, particularly in children and adolescents. The longevity and clinical success of sealants depend largely on their ability to achieve and maintain an effective marginal seal.[11] Microleakage at the tooth–sealant interface permits the ingress of bacteria, oral fluids, and nutrients, which may lead to secondary caries and premature sealant failure. Therefore, evaluating factors that influence microleakage is essential when introducing adjunctive preventive agents such as silver diamine fluoride (SDF).[12,13]

The present in vitro study evaluated the effect of SDF and potassium iodide pretreatment on the microleakage of resin-based pit and fissure sealants. The findings demonstrated that specimens pretreated with SDF exhibited significantly greater microleakage than the untreated control group. Application of KI following SDF significantly reduced microleakage compared with SDF alone; however, the sealing ability remained inferior to that of the control group.

The increased microleakage observed following SDF pretreatment may be attributed to the deposition of silver and fluoride reaction products on the enamel surface. These deposits may interfere with phosphoric acid etching by partially occluding enamel microporosities, thereby reducing resin infiltration and micromechanical retention. Inadequate resin penetration into the etched enamel surface can compromise marginal adaptation, resulting in increased dye penetration and higher microleakage scores.[14]

The findings of the present study are consistent with previous investigations that reported alterations in the bonding performance of resin-based materials following SDF application. Several studies have suggested that residual silver compounds on the enamel surface may adversely affect resin penetration and bond strength, although the magnitude of this effect depends on the restorative material used, the application protocol, and the interval between SDF application and restoration placement. These variations may explain the conflicting findings reported in the literature.

Potassium iodide is commonly applied immediately after SDF to reduce the black staining caused by silver precipitation. In the present study, KI application significantly reduced microleakage compared with SDF alone.[15] This improvement may be explained by the reaction of KI with free silver ions to form silver iodide, thereby reducing residual silver deposits that could interfere with enamel etching and resin penetration. Nevertheless, KI did not completely restore the sealing ability to that of the untreated control group, suggesting that some alterations to the enamel surface persist despite KI application.[16]

From a clinical perspective, these findings indicate that while SDF provides substantial anticariogenic benefits, its application before placement of resin-based pit and fissure sealants should be performed with caution. When SDF pretreatment is indicated, the additional application of KI may improve marginal adaptation and reduce microleakage. However, clinicians should be aware that the sealing ability may still be compromised compared with conventional sealant placement. Further modifications in bonding protocols, such as the use of universal adhesives or delayed sealant placement, may help overcome this limitation and warrant future investigation.

The present study has certain limitations. Being an in vitro investigation, it could not fully reproduce the complex oral environment, including salivary contamination, masticatory forces, pH fluctuations, and long-term aging. In addition, only one resin-based pit and fissure sealant and a single SDF/KI application protocol were evaluated. Therefore, the results should be interpreted with caution and should not be directly extrapolated to clinical practice. Future randomized clinical trials with long-term follow-up are required to validate these findings and determine the most appropriate clinical protocol for combining SDF, KI, and resin-based sealants.

Overall, the present study contributes to the growing evidence regarding the interaction between SDF, KI, and resin-based preventive restorative procedures. The findings suggest that although SDF pretreatment increases microleakage, the adjunctive use of KI can partially mitigate this adverse effect, thereby improving the marginal sealing ability of resin-based pit and fissure sealants.

CONCLUSION

Pretreatment with silver diamine fluoride adversely affected the marginal sealing ability of resin-based pit and fissure sealants, leading to increased microleakage. The subsequent application of potassium iodide after SDF was found to reduce microleakage compared to SDF alone; however, the sealing ability did not reach that of the control group. Further clinical investigations are necessary to confirm these observations.

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