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Effect of silver diamine fluoride and potassium iodide pretreatment on the microleakage of universal adhesives in two different modes of application – An invitro study

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Abstract

Background: The use of Potassium Iodide (KI) to mask the discolouration caused by Silver Diamine Fluoride (SDF) had been advocated, but does this SDF+KI combination affect the microleakage and bond strength of resin composite to dentin.

Aim: To evaluate the effect of KI on microleakage of SDF pre-treated Class V cavities restored with composite resin and to compare the microleakage values of Self-etch (SE) and Etch and Rinse (ER) mode of adhesives on SDF+KI pre-treated Class V cavities using stereomicroscope.

Methods: Standardised Class V cavities were prepared on thirty freshly extracted teeth selected for this study, and were divided into 4 groups: Group A – Pre-treatment with SDF+KI followed by SE adhesive bonding (n=10), Group B – Pre-treatment with SDF+KI followed by ER adhesive

bonding (n=10), Group C – SE adhesive bonding without pre-treatment (n=5), and Group D – ER adhesive bonding without pre-treatment (n=5). All the cavities were restored with resin composite. After 24 hours' storage and immersion in 2% methylene blue dye solution, specimens were sectioned bucco-lingually and evaluated for marginal microleakage under stereomicroscope at 30x magnification.

Statistical Analysis: One-way ANOVA followed by Tukey's post hoc multiple comparison tests were applied ($p<0.05$).

Results: Pretreatment of SDF+KI significantly reduced microleakage under both SE and ER adhesives. Among Group A and B, less microleakage was seen in SDF+KI pretreated cavities under SE adhesives, though not statistically significant.

Conclusion: SDF+KI decrease microleakage without adversely affecting the bond strength of resin composite to dentin.

Keywords: Etch-and-rinse adhesives, microleakage, potassium iodide, self-etch adhesives, silver diamine fluoride, stereomicroscope.

Introduction

Dental caries continues to be a prevalent disease both in developed and developing nations. In the recent years, advancement in understanding the carious process and the development of adhesive restorative materials has led to the era of minimal invasive dentistry. The best strategy for caries management is to focus on improving the remineralizing process with the help of remineralizing agents[1].

One such remineralizing agent is Silver Diamine Fluoride (SDF) used since 1970 to arrest caries. Each constituent of SDF has been known to contribute the following benefits; silver salts stimulate dentin sclerosis/calcification by deposition of calcium fluoride and protein precipitation within the dentinal tubules promoting the tubule occluding property, thereby reducing microleakage and fluoride induces remineralization and aids in the prevention of secondary caries[2,3,4]. At 38% concentration, SDF is primarily a cariostatic agent by inhibiting matrix metalloproteinases (MMP-2, MMP-8, MMP-9) and promotes biofilm formation[3,5,6]. In addition, SDF increases the microhardness of carious dentin by reducing the loss of calcium and phosphate ions and decreasing the destruction of collagen fibrils[3]. SDF is also a potent antibacterial agent through the formation of silver nitrate, which causes protein denaturation and bacterial cell apoptosis. It also has a wide range of antibacterial spectrum against Streptococcus, Lactinobacillus and Actinomyces species[7].

All these properties make SDF a beneficial material which can be placed under restorations to prevent secondary caries. However, the question remains whether its use under restorations to prevent secondary caries might interfere with the bonding. Quock et al reported that pre-treatment with 38% SDF did not adversely affect the bond strength of resin composite to dentin[8]. Uzel et al reported that application of SDF under resin restorations did not affect the microleakage of the restorations[9].

However, under such restorations, SDF causes black discoloration of dentin and that limits its use in the esthetic zones. To counter this staining, researchers have suggested the use of Potassium iodide (KI)[10]. There are very few studies done evaluating the effect of the combination of SDF and KI on the microleakage under resin restorations.

Hence, the aim of the current study was to evaluate the effect of Potassium Iodide (KI) on microleakage of pre-treated Silver Diamine Fluoride (SDF) dentin restored with composite resin. The adhesive mode of application can also affect the microleakage under resin restorations,

so the present study also compared the microleakage values of Self etch (SE) and Etch and Rinse (ER) mode of adhesives on SDF+KI pre-treated Class V cavities using stereomicroscope.

Materials and Methods

A. Specimen selection and preparation

Thirty extracted human permanent premolars with fully formed root apices, free from caries, fluorosis, restorations and fractures were collected and stored in 10% aqueous formalin until use. The teeth were cleaned of soft tissue and hard tissue debris and class V cavities were prepared on the buccal surface with standardised cavity dimensions of 3mm in length x 2mm in width and 2mm in depth (1mm above and below the CEJ) using tungsten carbide burs at high speed.

B. Grouping of the samples and preparation

The teeth were randomly divided into 2 experimental groups (n=10 each) and control groups (n=5 each):

- **Group A** – Pretreatment with SDF+KI with SE adhesive bonding, followed by resin composite restoration.
- **Group B** – Pretreatment with SDF+KI with ER adhesive bonding, followed by resin composite restoration.
- **Group C** – SE adhesive bonding without SDF+KI pretreatment, followed by resin composite restoration.
- **Group D** – ER adhesive bonding without SDF+KI pretreatment, followed by resin composite restoration. (Refer Table 1)

The materials and application protocol are given in Table 2. The specimens were stored in distilled water at 37^{o}C for 24 hours after finishing and polishing procedures. Root ends were sealed with a layer of composite resin and all the samples were colour coded with 2 layers of nail varnish, which was applied to the teeth leaving 1mm surrounding the restorations. All the specimens were immersed in 2% methylene blue solution for 24 hours.

C. Stereomicroscopic analysis

After removal from the dye, the teeth were washed and sectioned longitudinally using a diamond disc and were examined under a stereomicroscope at 30x magnification. Depth of the dye penetration was analysed according to a 0-3 scale scoring system suggested by Silveira de Araujo et al[11] (Figure1). Figure 2 shows the representative images of each group using the scoring system mentioned above.

D. Statistical Analysis

The results were statistically analysed using one-way ANOVA to check mean differences between groups. Post hoc analysis was done by Tukey's HSD test. The chi-square test was done to check the differences in proportions. P value less than 0.005 was taken to be statistically significant and the data was analyzed using SPSS Package Version 20.1 (Chicago, USA Inc.).

Results

The mean overall microleakage values of all the four groups are given in Table 3. Group A and B showed less microleakage values than Group C and D which were statistically significant. Figure 3 clearly states that Pre-treatment with SDF+KI (Group A and B) reduces microleakage under resin restorations than without SDF+KI pretreatment (Group C and D), regardless of the mode of adhesive system used. Among SE and ER mode of adhesive application, SE showed less microleakage scores than ER, but the values are not statistically significant.

Figure 4 shows the comparison between mean occlusal and gingival microleakage among all the groups. On comparison of mean occlusal microleakage scores, there was statistically significant difference between Group A and Group C, with Group A showing the least microleakage of 0.8+/-0.52 and highest for Group B which

is 1.77+/-1.2. On comparison of mean gingival microleakage scores, there was statistically no significant difference between the groups, but the least microleakage was seen for Group A (0.95+/-0.75) and highest for Group B (2+/-1.32). From this, it can be inferred than SDF+KI combination significantly reduced occlusal and gingival microleakages under self-etch adhesives. Overall, there was more microleakage gingivally than occlusally.

Discussion

Due to the increasing need of aesthetic demands, bonded composite resin has become the common choice for most of the restorations. Composites fail due to the development of interfacial defects as a result of long time thermal and mechanical stresses, polymerisation shrinkage, and physical and chemical properties of the material. These interfacial defects predispose to microleakage at the tooth-restoration interface which is considered as a major factor influencing the longevity of dental restorations leading to staining at the margins, recurrent caries at the tooth/restoration interface, hypersensitivity, and ultimately the development of pulpal pathology.

In this study, class V cavities were selected because cervical lesions have been a restorative challenge for any kind of restorative material due to their complex morphology where the margins are partly in enamel and partly in dentin/cementum. The primary problem associated with the restoration of class V cavities is microleakage at gingival margins located in dentin[12].

In the current study, the experimental groups (Group A and B) showed less microleakage than the control groups (Group C and D). Thus, pretreatment with SDF+KI was able to decrease microleakage under resin restorations regardless of the adhesive bonding system used. The results of this study are in par with a study conducted by Selvaraj et al[13]. The reason could be the tubule occluding property of SDF+KI. The silver iodide precipitate blocks the dentinal tubules, minimizes the outward fluid movement, and may prevent fluid contamination from the underlying dentinal tubules during the application of adhesives thereby reducing microleakage by improving the marginal adaptation. In SE adhesives, the silver iodide precipitate is not completely rinsed off, whereas in ER adhesives there are more chances of the precipitate to be rinsed off. This could be responsible for the significantly reduced microleakage under SE than ER adhesives[14]. However, Knight et al inferred that leaving the silver fluoride/KI precipitate on the surface significantly reduced the bond strength of auto cure glass ionomer cement to dentin, but on washing the precipitate away did not affect the bond strength[15].

All the groups exhibited more microleakage on the gingival margins than on the occlusal margins since the gingival surfaces are located in the dentin or cementum. These two structures do not have the appropriate conditions for the adhesion to resin composites making bonding to dentin/cementum much more technique-sensitive and substrate-sensitive than bonding to enamel which has better results[16,17,18].

SDF can cause black staining of tooth structure which may not be acceptable to many patients from the aesthetic point of view. The black discolouration is caused by the oxidation of ionized silver into metallic silver. A promising approach to solve this problem is to apply the KI solution immediately after SDF treatment to eliminate excess metallic silver in attempt to reduce discolouration[19].

$$Ag(NH3)2F(aq)+KI(aq)\rightarrow AgI(s)+2NH3(g)+F-(aq)$$

Silver iodide is yellow, and insoluble in water, but the AgI precipitate is easily rinsed away[20].

It has been noticed from present study that yellow precipitates and discoloration were seen after SDF+KI treatment, but the intensity of the discoloration was much ess than that of SDF treatment alone. One of the reasons might be that the amount of the applied KI solution was not sufficient enough leading to few remaining metallic silver ions responsible for the discoloration. Furthermore, silver iodide is considered to be highly photosensitive which can dissociate into metallic silver and iodine on exposure to light. It was also noticed that the curing light led to an immediate darkening of the SDF-treated areas, prompted by the photosensitivity of silver ions. This finding was in accordance to a study done by Irene Shuping Zhao et al[19].

Pretreatment with SDF+KI minimized microleakage by occluding the dentinal tubules regardless of the adhesive system used. However, further studies are needed to find the chemical nature of the silver iodide precipitate and its long term effect on the bond strength of resin composite to dentin.

Conclusion

Within the limitations of this invitro study, it can be concluded that pretreatment with SDF+KI significantly reduced microleakage under resin restorations especially with self-etch mode of adhesive bonding.

Abbreviations

Ag	Silver
AgI	Silver Iodide
ANOVA	One way Analysis of Variance
CEJ	Cementoenamal Junction
^{o}C	Degrees Celsius
ER	Etch and Rinse
F	Fluoride
HSD	Honestly Significant Difference
KI	Potassium Iodide
MMP	Matrix Metalloproteinases
NH_3	Ammonia
SDF	Silver Diamine Fluoride
SDF+KI	Combination of Silver Diamine Fluoride and Potassium Iodide
SE	Self etch
SPSS	Statistical Package for Social Sciences

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Legend Tables and figures

Table 1 : Grouping

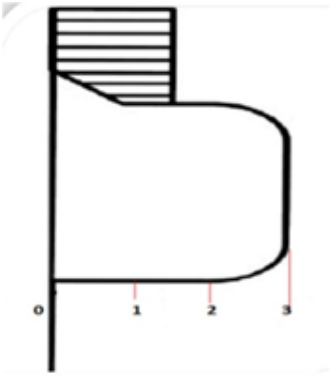
Groups		SDF+KI Application	Mode of Adhesive system	Acid Etching (37% Phosphoric acid)	Bonding Agent	Composite Buildup
Experimental group	Group A	✓	SE	X	✓	✓
	Group B	✓	ER	✓	✓	✓
Control group	Group C	X	SE	X	✓	✓
	Group D	X	ER	✓	✓	✓

*SE=Self -Etch Adhesives, ER=Etch-and-Rinse Adhesives

Table 2 : Materials and application protocol

S.No.	Material Used	Trade Name and Manufacturer	Application Protocol	Time of application	Whether rinsing is required
I.	38% Silver Diamine Fluoride	Fagamin, Tedequim SRL, Argentina	Damp a microbrush with 1-2 drops of SDF and apply as a thin liner and air dry	1-2 minutes	No rinsing
II.	Potassium Iodide(KI)	Lugol's solution (supersaturated KI)	Damp a microbrush with 2-3 drops and applied immediately following SDF application. KI reapplied till no more white precipitate is visible.	2-3 minutes	Rinsing required with copious amounts of water
III.	Single Bond Universal Adhesive	3M ESPE, St Paul, MN, USA	Can be used as SE and ER.	Applied according to manufacturer's instructions and	_

				light cured for 10-20 seconds.	
IV.	Resin Composite Buildup	Filtek Z350XT, 3M ESPE, St Paul, MN, USA	Built up incrementally to a height of 3mm and cured for 20-30 seconds.	_	_
V.	Curing Light	Halogen curing Light (600mW/cm^2), 3M ESPE, St. Paul, MN, USA	According to manufacturer's instructions	According to requirement	_



- Score 0—no dye penetration
- Score 1—penetration involving half the occlusal/gingival wall
- Score 2—penetration involving more than half the occlusal/gingival wall
- Score 3—penetration involving up to the axial wall

Figure 1

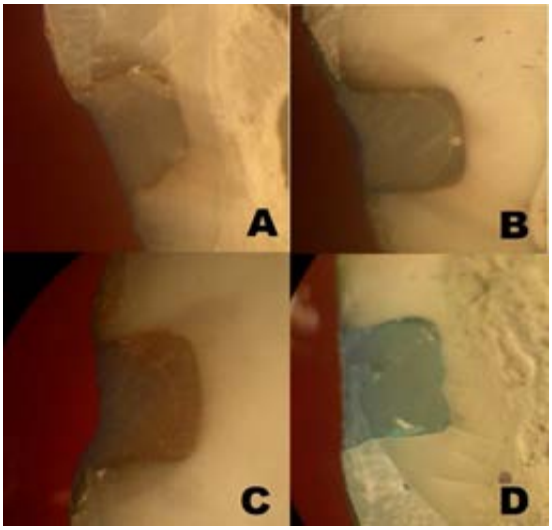


Figure 2

Table 3: Comparison of mean overall microleakage score among the four groups

			Multicomparison of Tukey HSD					
Groups	Mean ± SD	ANOVA	Group A v/s Group B	Group A v/s Group C	Group A v/s Group D	Group B v/s Group C	Group B v/s Group D	Group C v/s Group D
Group A (n=10)	0.80 ± 0.61	0.003†	0.982	0.027†	0.018†	0.056	0.037†	0.995
Group B (n=10)	0.90 ± 0.96							
Group C (n=5)	1.77 ± 0.97							
Group D (n=5)	1.87 ± 0.83							

*ANOVA, Analysis of Variance; HSD, Honestly Significant Differences; †significant at p<0.005

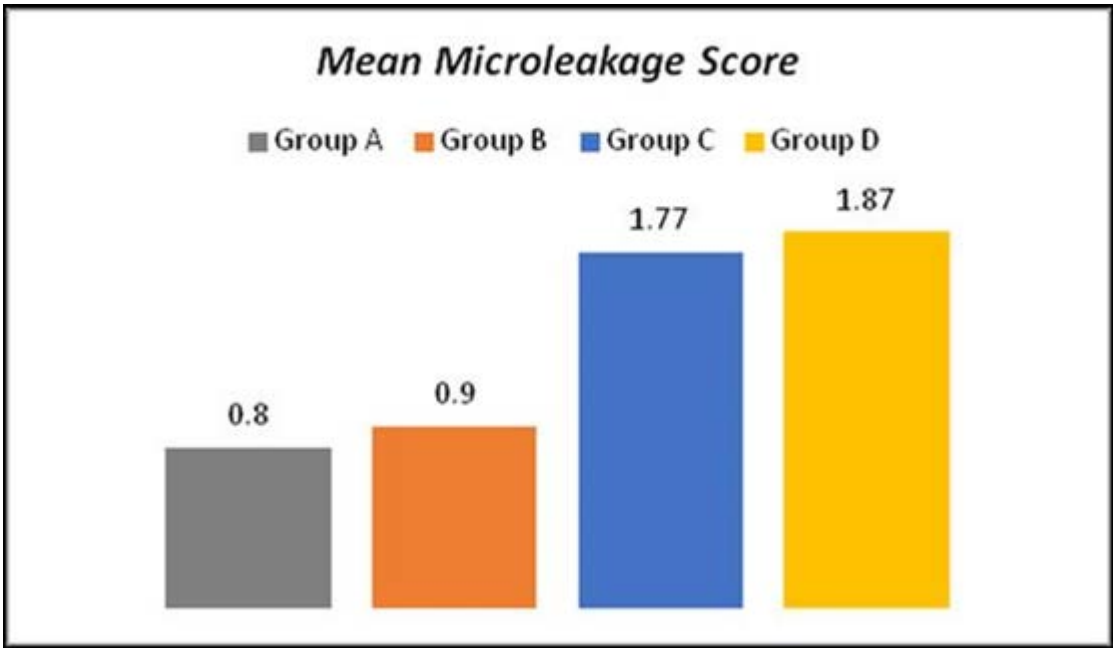


Figure 3

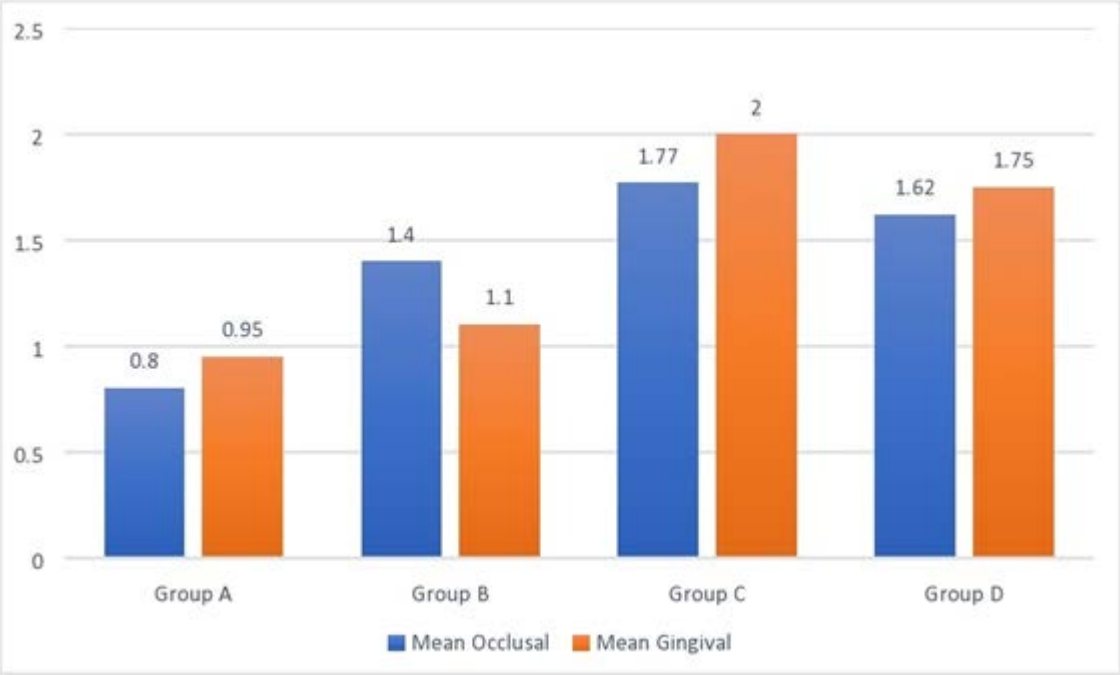


Figure 4