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# EFFECT OF SILVER DIAMINE FLUORIDE ON FRACTURE RESISTANCE OF CLASS I COMPOSITE RESTORATIONS

# GÜMÜŞ DİAMİN FLORÜRÜN SINIF I KOMPOZİT RESTORASYONLARIN KIRILMA DİRENCİNE ETKİSİ

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**ABSTRACT**

**Objective:** This study investigated the effect of silver diamine fluoride (SDF) pretreatment on the fracture resistance of Class I composite restorations in molars.

**Materials and Methods:** Twenty non-carious human third molars were extracted for orthodontic needs and pericoronitis were used. The teeth were randomly divided into control (n=10), and study (n=10) groups, and occlusal cavities were prepared. In the study group, 38% SDF solution was applied to the cavity and dried for 1 minute. The cavity was treated with Gluma (Heraeus Kulzer, Dormagen, Germany), a self-etch adhesive, for 20 seconds and light-cured for 20 seconds. Filtek Z250 composite resin (3M ESPE, Seefeld, Germany) was inserted and light-cured for 40 seconds. The control group underwent the same procedure without SDF pretreatment. Both groups experienced thermocycling for 5000 cycles between 5 and 55°C. Samples were embedded in acrylic cylindrical pipes and tested for fracture resistance using a fracture resistance test device. The continuously increasing compressive load was applied at a 0.5 mm/min crosshead speed until specimen fracture. The values at the moment of fracture were recorded in Newtons (N). Data were analyzed using an independent samples t-test, with p-values <0.05 considered significant.

**Results:** The mean fracture resistance for the group treated with 38% SDF was 1568 ± 461.8 N, while the group without SDF treatment showed 1192 ± 307.6 N. No statistically significant difference was found between the groups p>0.05.

**Conclusion:** SDF pretreatment did not enhance the fracture resistance of Class I composite restorations in molars.

**Keywords:** Composite resin, fracture resistance, silver diamine fluoride

**ÖZ**

**Amaç:** Bu çalışma, gümüş diamin florür (GDF) ön işlem uygulamasının molar dişlerdeki sınıf I kompozit restorasyonların kırılma direnci üzerindeki etkisini araştırmayı amaçlamaktadır.

**Gereç ve Yöntem:** Ortodontik gereksinimler ve perikoronit nedeniyle çekilmiş 20 adet çürüksüz insan üçüncü azı dişi kullanıldı. Dişler rastgele kontrol (n=10) ve çalışma (n=10) gruplarına ayrıldıktan sonra oklüzal kaviteler açıldı. Çalışma grubunda, %38 GDF solüsyonu kaviteye uygulanarak 1 dakika kurumaya bırakıldı. Kavite, 20 saniye boyunca Gluma (Heraeus Kulzer, Dormagen, Almanya), kendinden asitli adezivle işleme tabi tutuldu ve 20 saniye ışıkla polimerize edildi. Filtek Z250 kompozit reçine (3M ESPE, Seefeld, Almanya) yerleştirildi ve 40 saniye ışıkla polimerize edildi. Kontrol grubu, GDF ön işlemi yapılmadan aynı restorasyon işlemine tabi tutuldu. Her iki grup da 5 ve 55°C arasında 5000 döngü termosiklus işlemine tabi tutuldu. Örnekler akrilik silindirik borulara yerleştirildi ve kırılma direnci test cihazı kullanılarak kırılma direnci için test edildi. Sürekli artan sıkıştırma yükü, numune kırılıncaya kadar 0,5 mm/dk çapraz kafa hızında uygulandı. Kırılma anındaki değerler Newton (N) cinsinden kaydedildi. Veriler bağımsız örneklem t-testi ile analiz edildi ve p değerleri <0,05 olanlar istatistiksel olarak anlamlı kabul edildi.

**Bulgular:** %38 GDF ile işlem gören grup için ortalama kırılma direnci 1568±461,8 N iken, GDF işlemi yapılmayan grup 1192±307,6 N gösterdi. Gruplar arasında istatistiksel olarak anlamlı bir fark bulunmamıştır p>0.05.

**Sonuç:** GDF ön işlem uygulaması, molar dişlerdeki sınıf I kompozit restorasyonların kırılma direncini artırmamıştır.

**Anahtar Kelimeler:** Kompozit rezin, kırılma direnci, gümüş diamin florür

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## INTRODUCTION

Dental caries is the most prevailing health problem experienced among children early in life. Moreover, its incidence has been reported to have increased in recent years. Consequently, the quality of life is adversely affected due to the rapid progression of carious lesions leading to pain and tooth loss unless an appropriate treatment protocol is applied (1).

In recent years minimally invasive dentistry has become the preferred treatment option by clinicians, as it meanwhile preserving healthy tissues. One of the crucial principles of the minimally invasive approach is minimizing the risk of recurrent disease. There is unequivocal evidence that secondary caries are the most common cause of restoration failure (2). To prevent secondary caries formation, creating a pathogenic bacteria-free cavity is essential before restoration (3). Silver diamine fluoride (SDF) has been recommended since it arrests and prevents new caries formation, either as a standalone treatment or under restorations (3-9).

SDF is an alkaline, colorless, topically applicable solution containing fluoride and silver ions. Silver compounds are used in medicine and dentistry because they can provide an antimicrobial effect. On the other hand, fluoride is routinely used in various forms and ratios to prevent and stop caries as a gold standard. It has been suggested that the synergistic effects of silver and fluoride can halt the caries process and prevent the development of new caries (8, 9).

It has been shown that following the application of SDF, demineralized enamel and dentin undergo remineralization, resulting in a mineral-rich surface containing calcium and phosphate within the carious lesions and subsequently reducing mineral loss (10).

When applied to dentin cavities, silver has the ability to inhibit bacterial growth by interacting with bacterial cell membranes and enzymes. Furthermore, silver is also a potent cathepsin inhibitor and prevents dentin collagen degradation (11-13). However, integrating silver particles into dentinal tubules might affect the mechanical characteristics of restorations adversely (4).

It is claimed that SDF helps to eradicate cariogenic bacteria and promotes remineralization when applied in the same appointment prior to either under glass ionomer or composite resin restorations (7, 14).

The effects of SDF under restorations on avoidance of recurrent caries and the quality of bond strength are well documented (3-9). However, it remains unclear whether SDF affects fracture resistance, because the use of SDF has increased, particularly in permanent teeth, during the pandemic. Therefore the aim of this in vitro study was to investigate the effect of silver diamine fluoride (SDF) pretreatment on the fracture resistance of Class I composite restorations in molars. The null hypothesis of this study is that SDF pretreatment of Class 1 cavities in non-carious molar teeth has no effect on fracture resistance of composite restorations

## MATERIALS and METHODS

Twenty non-carious human third molars extracted due to orthodontic needs and pericoronitis were used in the study. Before the commencement of the study, signed written consent from the participants and ethical approval from the Istanbul Aydin University Ethical Committee (Date/No: 2021/373) was taken.

All teeth were examined under a magnifying glass to exclude cracked samples from the study. Mesiodistal and buccolingual widths of the teeth were measured by a digital caliper (Mitutoyo Corp, Tokyo, Japan). In order to standardize the cavity

**Table 1:** The force values at which fracture occurred of each sample in the study and control groups and statistical analysis of the data

| | Study group (n=10) (Newton) | Control group (n=10) (Newton) | p |
|---|---|---|---|
| | 2148.0 | 349.2 | |
| | 2234.9 | 621.9 | |
| | 2199.6 | 1534.4 | |
| | 1350.9 | 1514.4 | |
| | 1319.8 | 1055.8 | |
| | 861.0 | 1383.0 | |
| | 1289.0 | 1462.6 | |
| | 1075.7 | 1803.3 | |
| | 1687.1 | 1231.0 | |
| | 1514.0 | 964.4 | |
| **Mean±SD (Newton)** | 1192±307.6 | 1568±461.8 | 0.09 |

SD: Standard deviations

dimensions, teeth with a mesiodistal width of 12.0±0.5mm and buccolingual widths of 10±0.5mm were included in the study. The teeth were randomly divided into control (n=10) and study (n=10) groups. All cavity preparations and restorations were performed by one operator (PNB). Class I cavities with a depth of 2mm, buccolingual width of 2mm, and a mesiodistal width of 8mm were prepared using round and fissure diamond burs. Cavity dimensions were checked by a millimeter-tipped periodontal probe. In the control group, after preparing the cavities, the self-etch adhesive system Gluma (Heraeus Kulzer, Dormagen, Germany) was applied to the cavity using a micro brush and massaged for 20 seconds. The adhesive was then air-thinned and light-cured for 20 seconds with a high-intensity LED curing unit operating at 1470 mW/cm$^2$ and 430-480nm wavelength (Elipar™ Deepcure-S, 3M ESPE, St. Paul, MN, USA). Subsequently, a composite resin, Filtek Z 250 in A2 shade (3M ESPE, Seefeld, Germany), was inserted in the cavity and was light-cured for 40s. Finally, the restoration was polished using extra-fine diamond finishing burs and alumina-oxide-containing discs (Soflex; 3M ESPE, Seefeld, Germany).

In the study group, 38% SDF solution (Saforide™, Toyo Seiyaku Kasei Co. Ltd., Osaka, JP) was applied in cavities prior to composite resin restorations. One drop of SDF was taken into the bond brush and rubbed on the cavity floor, and it remained there for one minute. The excess was removed with the help of cotton pellets and air-dried. Then, restorations were completed as described for the control group.

The restored teeth underwent thermocycling for 5000 cycles between 5 and 55°C with a dwell time of 30s and a transfer time of 15s. Following the thermocycling procedure, all samples were embedded in acrylic cylindrical pipes up to the enamel-cement junctions and were connected to a fracture resistance test device (Modental, Esetron, Ankara, Turkey). The compressive load was subjected to the point corresponding to the central fossa of the sample teeth. The fracture resistance strength test was performed by applying a force parallel to the long axis of the tooth at a speed of 5 mm/min with a continuously increasing rate. Values were recorded in Newton (N) when the fracture was observed.

Ultimately, fracture type was individually determined by two blinded examiners (ATA, PNB) under a stereo-microscope (SFC-11A N2GG Motic, Motic Group Co. Ltd., Hong Kong, China).

The following classification was used to determine the fracture type:

Type I: Adhesive fracture between dentin and adhesive

Type II: Cohesive fracture in dentin

Type III: Cohesive fracture in material

Type IV: Mix fracture; in both the restorative material and dentin (15).

**Statistical analyses**

All analyses were performed using SPSS 19 (IBM SPSS Statistics 19, SPSS Inc., an IBM Co., Somers, NY, USA). Data were analyzed by using an independent sample t-test. Values of $p<0.05$ were considered significant.

**RESULTS**

The fracture resistance (N) for each sample for SDF and control groups are shown in Table 1. The mean fracture resistance values and standard deviations for Class I composite restorations were 1568±461.8 for the study group and 1192±307.6 for the control group (Table 1). There was no statistically significant difference between the two groups according to the independent samples t-test result (p=0.09). Upon examining the fractured specimens to determine the fracture type, it was found that all the restorations displayed adhesive failures (Type I).

**DISCUSSION**

A restorative material not only repairs lost tooth structure but also enhances the fracture resistance of the tooth and provides effective marginal sealing (16). However, secondary caries and fractures are the primary reasons for composite restoration failure (17). The resistance of the cavity wall and margins must be increased to inhibit the recurrence of secondary caries. SDF application can potentially address this issue (9). In the present study, the mean fracture resistance values and standard deviations for Class I composite restorations were 1568±461.8 for the study group and 1192±307.6 for the control group (Table 1). There was no statistically significant difference between the two groups according to the independent samples t-test result (p=0.09). Therefore, the null hypothesis was confirmed that SDF pretreatment of Class 1 cavities in non-carious molar teeth has no effect on fracture resistance of composite restorations.

Thermal cycling is an ageing process that simulates thermal stresses typically occurring in the mouth by exposing samples to extreme temperatures (16). According to ISO TR 11450 (1994) standards, although immersing the specimens in water baths for at least 20s at 5 and 55°C for 500 times and the transfer time between baths 5s-10s is a suitable accelerated ageing method, this cycle number is insufficient to imitate the tooth bonding efficiency of the restoration (18). Therefore, in the present study, the specimens were undergone 5000 thermo-cycles between 5 and 55°C with a dwell time of 30s and a transfer time of 15s.

In an effort to prevent secondary caries formation under restorations, various antibacterial and remineralizing agents are recommended to inhibit and remineralize affected dentin lesions. Some are integrated into adhesive systems and restorations, whereas others are applied directly to cavities as a base/liner. These agents have been reported to inactivate residual bacteria and condition dentine to achieve a better restoration bonding (3, 19). Likewise, SDF has also been effective in preventing new caries formation and promoting remineralization of enamel and dentin (20). Shimizu and Kawagoe reported no recurrent caries development after 26 months in SDF-pretreated primary teeth restored with amalgam (21). Mei et al. observed a reduction in secondary caries under composite resin and glass ionomer cement restorations following SDF conditioning (7).

Considering its potential use under restorations intrigued the researchers to assess its possible effect on the bonding of restorations (3, 15). However, studies on enamel bond strength are limited and reveal different results (15, 22). SDF application on enamel has shown no significant impact on orthodontic bracket bonding strength, but it reduced the bond stability of self-etch universal adhesives (15, 22). Such deviations could be attributed to different study designs and adhesive systems. A systematic review of the effects of SDF application on the bond strength of dentin to adhesives and glass ionomer cement could not reach a definitive conclusion, as the results revealed inconsistent outcomes (23). Danaeifar et al. reported that dentin pretreatment with SDF did not affect the shear bond strength of the tested bulk-fill materials in human permanent premolars (24). While this study did not specifically investigate the impact of SDF on restoration bond strength, both the experimental and control groups exhibited adhesive failures.

To date, there is not a study that has investigated the application of SDF on fracture resistance of composite restorations. In the present study, both groups showed higher mean fracture resistance values compared to the maximum human physiological masticatory and biting loads, reported to be 880N and 900N, respectively (25, 26). Although the group treated with SDF had higher fracture resistance than the control group, the difference was insignificant. This in-vitro study mimics intraoral conditions; however, it is well known that in-vivo studies are required for realistic results. On the other hand, it would be beneficial to test shear-bond strength on carious teeth to support our results. Within the limitations of the present study, the use of SDF in non-carious Class I cavities had no beneficial effect on the fracture resistance of composite restorations.

## CONCLUSION

The present study demonstrated that the application of SDF in Class I cavities of non-carious permanent molars did not csignificantly alter the fracture resistance of the restorations. However, various mechanical tests and further clinical studies are required to expand its clinical use as a remineralizing and caries-inhibiting agent under restorations. Further studies, both in-vitro and in-vivo, with larger sample sizes and varied experimental conditions, are recommended to evaluate fracture resistance.

**Ethics Committee Approval**: This study was approved by Istanbul Aydin University Non-Interventional Clinical Research Ethics Committee (Date: 03.02.2021, No: 2021/373).

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**Conflict of Interest**: The authors have no conflict of interest to declare.

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