https://doi.org/10.48047/AFJBS.7.8.2025.317-341

African Journal of Biological Sciences

Journal homepage: http://www.afjbs.com

Research Paper Open Access

Effect of Surface Pre-treatment with Silver Diamine Fluoride on Micromorphological Patterns and Microshear Bond Strength of Universal Adhesive to Dentin

Department of Conservative Dentistry

Faculty of Dentistry

Mansoura University

Roaa Nahi Alwan1, Youniss S. Harp2, Hamdi H. Hamama3, Salah H.Mahmoud4

IB. Dent, Postgraduate student in Conservative Dentistry Department, Faculty of Dentistry, Mansoura University, Egypt

2Lecturer, Conservative Dentistry Department, Faculty of Dentistry, Mansoura University, Egypt

3Profesor, Conservative Dentistry Department, Faculty of Dentistry, Mansoura University, Egypt

4Professor, Conservative Dentistry Department, Faculty of Dentistry, Mansoura University, Egypt

Volume:7, Issue,8Aug2025

Received:15Jun,2025

Accepted:22July,2025 Published:01Aug2025

doi:10.48047/AFJBS.7.8.2025.317-341

Objectives: This in vitro study aimed to investigate and compare the effect of su rface pretreatment with Diamine Silver Fluoride (DSF) and silver fluoride (SF) on the microshear bond strength (µSBS) of universal adhesives to dentin and micro morphological analysis of tooth restoration interface.

Methods:Sixty freshly extracted sound human molars were selected and randomly divided into three groups(n=20)according to the surface pretreatment applied as following: control group (no pretreatment applied),DSF group and SF group. Each group was further subdivided into imme diate and aged subgroups(n=10). After mid-dentin exposure and pretreatment, universal adhesive and resin composite were applied and light-cured separately. µSBS was tesed using a universal testing machine.Micromorphological analysis of the dentin-resin interface was performed using Scanning Electron Microscope (SEM) for selected samples from each group.Two-way Anova was conducted and followed by Tukey's post-hoc multiple comparison tests were conducted. **Results**:Regarding µSBS,twoway Anova test revealed statistically significant differences among the study subg roups($p<0.05$).Tukey's post-hoc multiple comparison test revealed no significant dif ferences between the three immediate subgroups($p>0.05$).while within the aged s ubgroups,the control subgroup showed significantly higher µ SBS compared to D SF and SF subgroups($p<0.05$).There were no significant differences between the i mmediate and aged subgroups($p>0.05$)except for the control group that demonstr ated statistically significant increase in the µ SBS of the aged subgroup compar ed to the immediate one($p<0.05$).

Conclusion:

Surface pretreatment with either DSF or SF had adverse effect on the bonding a bility or durability of the universal adhesive to dentin.**Keywords**: Diamine silver fl uoride, silver fluoride, microshear bond strength,micromorphological analysis, univ ersal adhesive.

Dental caries is one of the most common preventable diseases which is recognized as the primary cause of oral pain and tooth loss. It is a majo r public health oral disease that hinders the achievement and maintenance of oral health in all age groups.(1) Although technological advances and nov el discoveries in dental materials are made each year, dental caries persists as a public health problem worldwide.(2)

Deep dentin lesions are the main reasons for going to endodontic int ervention and loosing teeth.(3) Traditional caries removal by conventional rot ary pathway and placement of a restorative material does not address the u ltimate cause of caries and is complicated by subjects with multiple advance d lesions.(4) Minimal Intervention Dentistry (MID)supports the removal of onl y the outer infected carious layer,while leaving the inner layer of soft caries within the pulpal floor "selective caries removal in

permanent teeth(SCRiPT)”.(3)

A non-invasive,brush-on treatment for dental caries, named diamine silver fluoride (DSF) has been adopted in the last decade. Diamnine silver fluoride ha s been entitled "silver fluoride bullet" due to rapidity of its action.(5)

Silver containing compounds such as silver nitrate, silver fluoride (not s tabilized by amine groups), silver foils, and silver sutures have been used as ant imicrobial agents for hundreds of years around the world to prevent and treat i nfections, but their popularity in the US has waned over time.(6)

Diamine silver fluoride was originally developed as a caries-arresting age nt in Japan (7) later on, it becomes a compound of interest in the United Stat es in recent years as research has shown it to be a cost-effective and simple p roduct to use, resulting in favorable outcomes in the treatment of dental caries.
(6)

By limiting the progression of active lesions, ideally this compound woul d be used to treat carious lesions non-traumatically as an alternative to removin g tooth structure.(8) While DSF's exact mode of action is uncertain,it has effect on caries arrest. Diamine silver fluoride reacts with hydroxyapatite to form calciu m fluoride and silver phosphate which hardens the structure of existing lesions.(9) Furthermore,silver and fluoride ions together inhibit formation of carious lesio ns better than the sole use of silver nitrate or sodium fluoride.

A recent study suggested that fluoride ions released locally into the inte rface of composite restoration with bioactive bonding materials could

decrease the formation of caries, but the amount of fluoride available to deep tissue from this source is limited.(10) Additionally, DSF may be a beneficial anti cariogenic pretreatment compound for dental tissue prior to the placement of r estorative material, preventing formation of recurrent caries.(11-13)

The unique caries arresting ability of DSF has been attributed to its effe ctiveness in reducing the load of cariogenic bacteria on surfaces of demineralize d dentin and within dentinal tubules, which supports its use in treating active l esions.(14-16) A study by Beltran et al 2015,which examined the effects of vari ous fluoride containing agents in preventing collagen breakdown and demineraliz ation of dentin determined DSF to be the most effective, concluding that DSF may promote dentin health in caries-affected teeth.

Universal adhesives were introduced to the market in 2013 and gained p opularity among dental professionals, owing to their unique properties, such as the potential to bond to different kinds of clinical dental substrates and fewer t echnical steps. They can bond to dental substrates,ceramic,composites and metal substrates. Therefore, they are also referred to as "multi-mode"adhesives.(22) U niversal adhesives can generally be applied as one-step (self-etch) or two-step (etch and rinse) when phosphoric acidisused.Additionally,they contain, in their co nstitution,specific carboxylate and/or phosphate monomers that ionically bind to the calcium contained in hydroxyapatite.

Bonding of restorative materials to tooth substrate has improved significantly w ith the development of dental adhesives over the past several decades.(16) The presence of the functional monomer in contemporary adhesives allowed chemical bonding to calcium in hydroxyapatite.(17)

Bonding to sound dentin is much more reliable than carious ones because of th e loss of minerals, high water content and weak nature structure .(19)However, it is possible to use anti microbial before placing a restoration;to inhibit the car ies progression rather than removing the diseased tissues or increasing the risk of pulp exposure.(20,21) **Aim of the study:** This in vitro study aimt to investigat e and compare the effect of surface pretreatment with Diamine Silver Fluoride (DSF) and silver fluoride (SF) on the microshear bond strength (µSBS) of univers al adhesives to dentin and micromorphological analysis of tooth restoration inter face immediately and after six months water storage.

Null Hypotheses

This study designed to test the null hypothesis that there is no adverse effect of Diamine Silver Fluoride surface pretreatment on micro shear bond strength o f universal adhesives to dentin and there is no adverse effect on micromorphol ogical analysis of tooth restoration interface.

1.Materials

The material utilized in the current study were: Diamine Silver Fluoride (Riva star, SDI, Australia), Silver Fluoride (Riva star aqua,SDI,Australia), one Nanoh ybrid resin composite (Luna, SDI,Australia) and one universal adhesive (Zipbond, SDI, Australia). The materials are presented in table 1

Roaa Nahi Alwan/*Afr.J.Bio.Sc. 7(8) (2025*) Page 322

Product name	Manufacturer	Lot number	Composition
Riva star (Diamine Silver Fluoride)	SDI, Australia	1218958	Silver,Fluoride,Ammonia and Potassium Iodide
Riva star aqua (Silver Fluoride)	SDI, Australia	1221725	Silver,Fluoride,Water and Potassium Iodide.
Luna (Nanohybrid universal composite)	SDI, Australia	8452010	22.5%wt(39%vol.) multifunctional methacrylic ester. 77%wt(61%vol.)inorganic filler(40nm-1.5micron).
Zipbond (Universal adhesive)	SDI, Australia	8100502	Adhesive monomers including MDP,ethanol,water,fluoride

2.Methods

2.1.Sample size calculation

Sample size calculation was based on the mean shear bond strength a mong group in a previous study studying the effect of Diamine Silver Fluoride Surface Pre-treatment on the bond strength of universal adhesive to dentin.23 Using G power program version 3.1.9.7 to calculate sample size based on effec t size of 1.56, using 2-tailed test, a error=0.0and pOWer=80.0%,the total calcul ated sample size was 8 in each group that that was elevated to 10.

2.2.Ethical considerations and teeth selection

The present study comprised 60 sound human molars that had been freshly extracted due to periodontal diseases. The teeth were extracted from patients ranging in age from 45 to 55 years old. The teeth were collected fr om Oral and Maxillofacial surgery Clinic at Faculty of Dentistry, Mansoura Uni versity after obtaining written informed consents from the patients to use the ir extracted teeth in the study. The protocol of the current study was approv ed by the Ethics Committee of the Faculty of Dentistry Mansoura University (A0208024CD).All teeth were cleaned fromn any hard or soft tissue remnants using a hand scaler (Nordent,lvory #2-3, USA) and examined for exclusion of any crack or defect using a stereomicroscope at 20x magnification (Labomed magna, Model:6129001,Labo-America INC, Fremont CA, USA). The teeth were disinfected in 0.5% chloramine-T solution for 24 hours and stored in distilled water in an incubator (BIC, Egypt) until used. The storage procedure of teeth was conducted following the standard international and local infection control protocol.

2.3.Study design

For µSBS test, the collected teeth were randomly divided into 3equal groups (n=20) based on the dentin pretreatment performed as following: control gro up (no dentin pretreatment), DSF group (dentin pretreatment with DSF)and S F group (dentin pretreatment with SF). Each group was further subdivided int o 2 subgroups (n=10) based on the time of testing either immediate or after 6 months of water storage. Only 5specimens in each subgroup were subject ed to micromorphological analysis test. The study design of the current study is illustrated in

figures1,

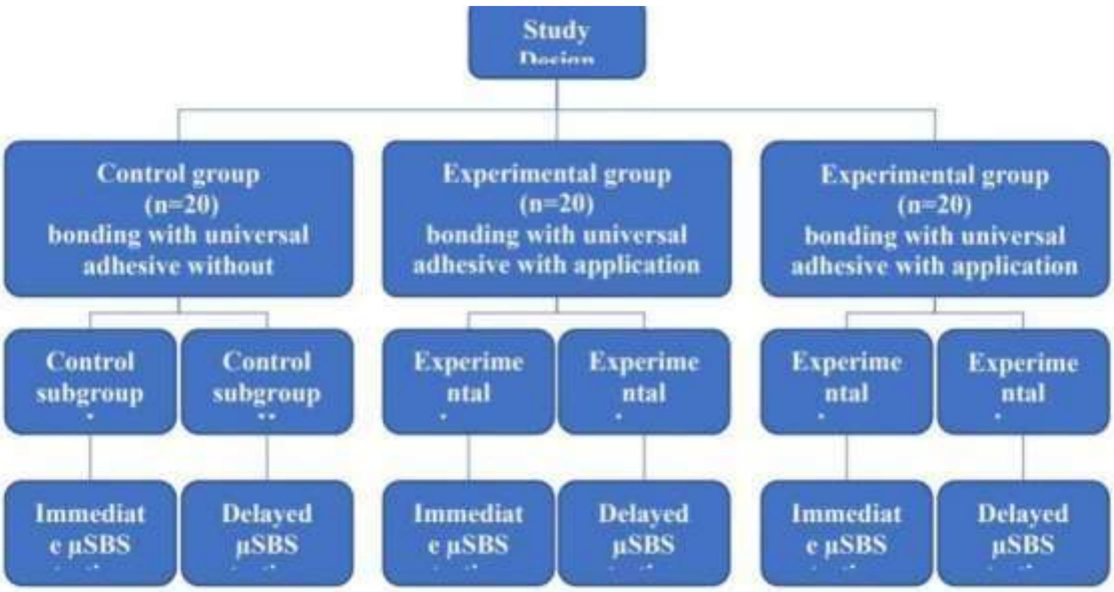
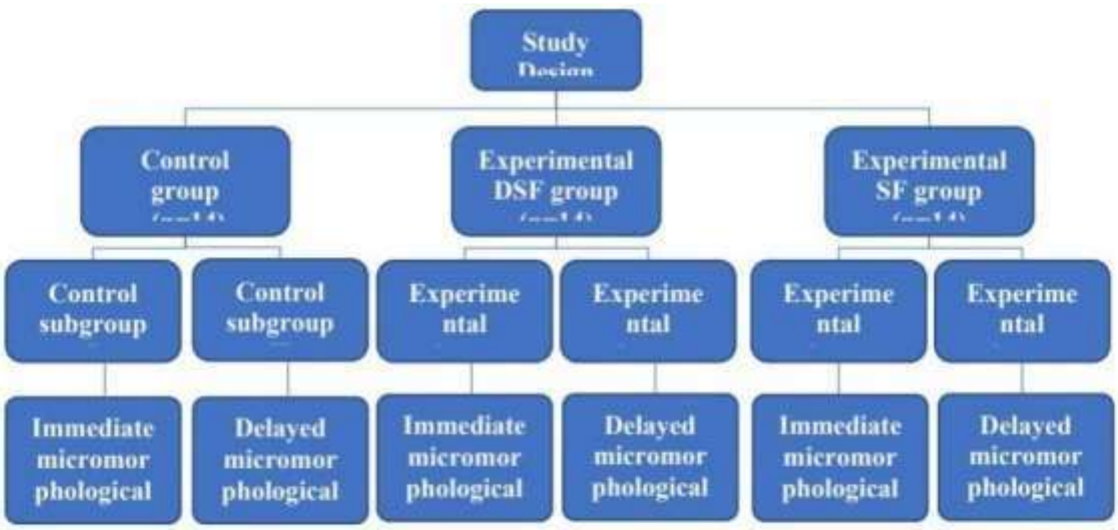

Study
Control group
(n=20)
bonding with universal
adhesive without
Experimental group
(n=20)
bonding with universal
adhesive with application
Experimental group
(n=20)
bonding with universal
adhesive with application
Control
subgroup
Control
subgroup
Experime
ntal
Experime
ntal
Experime
ntal
Experime
ntal
Immediat
e μSBS
Delayed
μSBS
Immediat
e μSBS
Delayed
μSBS
Immediat
e μSBS
Delayed
μSBS

Figure1


Study
Control
group
Experimental
DSF group
Experimental
SF group
Control
subgroup
Control
subgroup
Experime
ntal
Experime
ntal
Experime
ntal
Experime
ntal
Immediate
micromor
phological
Delayed
micromor
phological
Immediate
micromor
phological
Delayed
micromor
phological
Immediate
micromor
phological
Delayed
micromor
phological

2.4.Micro-shear bond strength test

2.4.1.Teeth mounting and specimen preparation

Each tooth was mounted vertically in a Polyvinyl Chloride ring (PVC,1. 4-2.5 cm) filled with auto -polymerizing acrylic resin(Acrostore,Egypt) with occ lusal Surface of the tooth Facing upwards. After acrylic resin setting,the speci mens were removed. Digital periapical radiographs were taken for all teeth t o ensure almost equal coronal dentin thickness between all teeth with an ac cepted deviationof±5%..With The help of the digital scale software,the mid c oronal dentin of each specimen was marked on radiograph. The distance fro m a fixed cusp tip reference point to mid-coronal dentin point was measure d.With the help ofa premeasured reference (4-mmn piece of percha),the actu al distance from the selected cusp tip reference point to the mid-coronal de ntin point was measured and marked on the buccal surface of each tooth.

The previously marked mid-coronal dentin was exposed by sectioning the tooth at the marked level by using a low-speed diamond saw (ISOMET 4000;Buehler,Lake Bluff, Illinois, USA) under water cooling system in order to get a flat dentin surface. To standardize the smear layer,the exposed dentin Surfaces were polished for 60 seconds Using 600-grit silicon carbide paper u nder continuous water irrigation.

2.4.2.Dentin surface pretreatment and restorative procedures

In the control subgroups, no pretreatment was performed on expos ed dentinal surface. For the DF subgroups, the silver fluoride solution was applied to the exposed dentin surface using a microbrush (Fine,SDI,Australia) followed by immediate application of the potassium iodide Solution over the silver fluoride until the creamy white precipitate turned clear. The surf ace was blot dried to remove any solution material before any restorative procedures. For SF group, the Riva star aqua was applied in 2 steps as in the DSF subgroup.

After dentin Surface pre-treatment, the universal adhesive was appli ed through scrubbing the adhesive over the dentin surface for 10seconds. Then leaving it undisturbed for an additional 10 seconds.After that,the surf ace was gently air-dried until it appeared glossy without any wavy movem ents of the adhesive. Light_curing of the adhesive was performed using a LED light curing device (Demi Ultra, KerrTM,output 1100-1330 mW/cm2, wa velength 250-470 nm) for 10 seconds.

After adhesive application and light curing, 3 transparent tygon tube s (1mm internal diameter and 2mm height) placed on the central area of dentin surface using addition silicon (polyvinylsiloxane) impression material i n super light consistency (Ghenesyl, Super Light Body,Lascod,Florence, Italy) act as mold for fixed tygon, the tygon tubes were filled with resin compos ite material (luna, SDI, Australia) then covered with a clear celluloid strip f ollowed by a transparent glass slide and light cured with the same LED cu ring unit for 20 seconds. The tip of the light guide was kept in intimate c ontact with the glass slide to ensure standardized curing distance. To remo ve the tygon tubes from around the restoration,two parallel cuts were care fully made longitudinally using a scalpel

(Paragon,Shieffield, England) to facilitate their gentle detachment from around the set material without stressing the adhesive interface.

The micro cylindrical specimens were checked with a stereomicroscope (SZ-PT, Olympus,Japan) for detection of interfacial defects.Finally,the specimens were stored in deionized water in an incubator 24 hours before µSBS testing for immediate subgroups and 6 months for aged subgroup

2.4.3.Microshear bond strength testing

The mechanical µ SBS test was performed in a universal testing mac hine (Instron3345, Canton, Massachusetts, UJSA). (Figure 8) Each specimen wit h the composite microcylindrical tubes was placed in the lower fixed comnpa rtment of the universal testing machine. A thin orthodontic wire (diameter 0. 14mm) was looped around each microcylindrical tube as close as possible to its base. The wire was aligned with the loading axis of the upper movable c ompartment of the testing machine to ensure proper distribution of shear lo ad. Shear force was applied to each specimen at a crosshead speed of 0.5m m/min until failure occurred. The µSBS values (expressed in MPa)were calcul ated from the maximum failure load (expressed in Newton)divided by the bo nded surface area (mm2).

2.4.5 Failure mode analysis:

The failure mode was identified by examining the dentin surface of th e debonded specimens under a stereomicroscope (SZ2-ILST,Olympus,Japan) at approximately 40x magnification. Representative samples from each failure pat tern were sputter-coated with gold and examined by SEM (JSM-6510LVSEM,JE OL.Ltd, Tokyo, Japan) at approximately 35x magnification for the verification o f the fracture pattern.

 The failures were classified as following:

·Adhesive (faiure at interface).

·Cohesive (failure within the resin composite or with the tooth).

·Mixed (combination of adhesive and cohesive failure).

3.Micromorphological analysis:

Micromorphological analysis of the dentin/composite interface was co nducted using a SEM. Five representative specimens were randomly selected from the second half of the teeth after sectioning,for each aging condition with DSF surface pre-treatment and without surface pre-treatment.These sp ecimens were then undergoing specific cleaning procedures. These procedure s involve ultrasonic cleaning for a duration of 10 minutes.Following the clea ning process, an acid-base challenge will be performed on the specimens. T his challenge entails exposing the specimens to a 10%orthophosphoric acid solution for 5 seconds, followed by a 5% sodium hypochlorite solution for 5 minutes.24 To prepare the specimens for analysis,a thin layer of gold was applied using a gold sputtering technique. The coated specimens were the n be examined under the SEM at specific magnification levels of x50,,X500, X1,000and x2,000.The study design for Micromorphological analysis of all mn aterial sub-groups is represented.

4.Statistical Analysis

Statistical Software Package Program (SPSS, V.22, IBM Armonk,New Yo rk, United States) was used for the statistical analysis of the collected data. The data were tabulated and statistically evaluated using three-way analysis of variance (ANOVA) followed by Tukey honestly significant difference post-hoc multiple comparison tests. The level of significa nce was set at$p<0.05$ **1.Micro-shear bond strength test results**

The Shapiro-Wilk test results revealed a normal distribution pattern i n the µSBS data($p>0.05$).The two-way ANOVA test revealed significant diffe rences in the µ SBS mean values among the study groups(($p<0.05$).(Table2) Tukey's post-hoc multiple Comparison test was performed to Compare bet ween the subgroups. Within immediate subgroups, there were no Significan t differences between the three subgroups($p>0.05$).Among the delayed subg roups, the control subgroup showed significantly higher µSBS mean value Compared to the DSF and SF subgroups($P<0.05$)However,there were no signi ficant differences between the delayed DSF and SF subgroups($p>0.05$). In a ddition,there were no significant differences in the µSBS mean values bet ween the immediate and delayed subgroups in the same group except for the control group where the delayed control subgroup presented significantl y higher µSBS mean value compared to immediate one($P<0.05$).

2.Micromorphological analysis

·Micromorphological evaluation was performed using Scanning Ele ctron Microscopy (SEM) to assess the structural integrity of the hy brid layer and resin tag formation at the dentin-adhesive interface following various surface pre-treatments. Specimens were analysed from each control subgroups, DSF subgroups, and SF subgroups un der both immediate and aged conditions.Hybrid layer morphology i n the control immediate subgroups was showed continuous, unifor m, and welldemarcated with an average thickness ranging between 24µm. This morphology is consistent with optimal adhesiv e infiltration and hybridization of the superficial collagen matrix.

After aging, SEM revealed visible degradation of the hybrid layer,characterized by micro-fractures and discontinuity,suggesting hydrolytic breakdown typical of resin - dentin interfaces subjected to long-term aqueous storage. Resin tag was appeared Prominent,elongated resin tags pen etrating deeply into the dentinal tubules were evident in t he immediate subgroup. These structures diminished in den sity and continuity in the aged subgroup,indicating partial d emineralzation and potential enzymatic degradation over tim e.

Hybrid layer in DSF immediate subgroups demonstrated a disrup ted and non-homogeneous hybrid layer with a thickness often <2µm or entirely absent in localized regions. The surface show ed irregular deposition of granular or globular silver-rich precipit ates. These deposits appeared to interfere with adhesive mono mer penetration, preventing effective micromechanical interlockin g and hybrid layer formation.

In the aged subgroup, the interface exhibited severe morphological deterioration with no distinguishable hybrid layer and extensive collapse of the collagen network. This is likely due to the persistent silver ion residues and the cytotoxic effect on dentin matrix proteins, which impair the bonding substrate's inte grity. Resin tag was minimal to absent in both immediate and a ged subgroups. The obstructive nature of silver deposits and pos sible denaturation of tubular walls were hypothesized to hinder monomer diffusion and polymerization within tubules.DSF treated surfaces exhibited substantial silver precipitation at the dentin en trance, especially at intertubular regions. These zones lacked the characteristic funnel-shaped resin tags,suggesting a barrier effect of silver compounds against adhesive infiltration.

Hybrid layer in SF immediate subgroups showed a partially conti nuous hybrid layer with a more regular architecture compared to DSF. The average thickness was estimated at 2-3µm.Despite the presence of surface precipitates, they were less abundant and more diffusible,likely due to the aqueous-based vehicle and absen ce of ammonia stabilizers.

After aging, moderate degradation of the hybrid layer was observ ed,but with residual structural preservation in contrast to DSF.The se results indicate that SF allows better long-term interface stabil ity .Resin tags in SF subgroups were visibly shorter and fewer th an in the control group but were better developed than in DSF specimens. In aged SF samples, remnant tags were still detectable, albeit fragmented,indicating partial resistanc e to hydrolytic and enzymatic degradation.SF application produced fin er silver deposits that were more easily rinsed from the dentin surfa ce.Consequently,intertubular and peritubular infiltration by adhesive m onomers was partially preserved, especially in the immediate conditio n.The methodology adopted in this study was carefully designed to evaluate the effect of silver-containing pretreatments-Silver Diamine Fluoride (SDF) and Silver Fluoride (SF)-on the microshear bond strength (µSBS) of a universal adhesive to dentin. The use of freshly extracted,sound human molars provided a clinically r elevant substrate that closely mimics natural tooth behavior. Compared to bovin e or synthetic analogs,human dentin exhibits greater structural and chemical simi larity tothe clinical environment,including dentinal tubule density,water content,an d organic matrix composition.Standardization was further enhanced by radiograph ically confirming dentinthickness,ensuring uniformity across all specimens.(23)

Flat mid-coronal dentin surfaces were created using a diamond disc unde r water cooling, followed by polishing with 600-grit silicon carbide paper to sim ulate the clinical smear layer. This preparation step was crucial,as surface rough ness and smear layer characteristics significantly influence adhesive interaction wi th dentin. Embedding the specimens in self-cure acrylic within PVC rings ensure d mechanical stability during bonding and testing,thus reducing the risk of opera tor-related variability.(24)

To simulate clinical application, SDF and SF pretreatments were applied s trictly according to the manufacturer's instructions. The dual-step protocol for SD F (silver solution followed by potassium iodide) and the two-step SF application (blue and green capsules) mirrored real-world usage. This approach strengthens the clinical applicability of the findings.However, it should be acknowledged that the high operator sensitivity of these materials-particularly in the application ti ming, rinsing, and drying protocols-could introduce variability in clinical outco mes.(25)

The use of microshear bond strength testing (μSBS) provided an app ropriate and sensitive method for evaluating dentin adhesion.This test allows for the assessment of small, localized areas of adhesion and can detect subt le differences between groups, particularly important when testing chemical pretreatments that may influence surface energy or microstructure.Unlike trad itional macro tests, μ SBS minimizes the impact of substrate variability and avoids the introduction of microcracks that often occur during sectioning for microtensile testing.(26)

Tygon tubing molds were used to build consistent composite cylinders (1 mm in diameter and 1 mm in height), which helped standardize the bon ded area. This uniformity was essential for precise calculation of bond streng th values and minimized discrepancies due to inconsistent stress distribution. The use of a looped orthodontic wire for loading,instead of a chisel blade,fu rther ensured uniform force application and avoided stress concentration at t he loading site-an improvement supported by the literature for minimizing pr emature failures.(27)

Limitations of the study:

1.the study was conducted under controlled laboratory conditions, which do not fully replicate the complex biological environment of the oral cavity.Fact ors suchas salivary enzymes, masticatory forces,pH fluctuations,microbial biofi lm, and thermal changes were not accounted for.

2. Only one universal adhesive (Zipbond, SDI) and one nanohybrid resin co mposite (Luna, SDI) were evaluated. The outcomes may differ with alternativ e adhesive systems or restorative materials,limiting the generalizability of the fi ndings.

3.The study exclusively investigated bonding to sound mid-coronal dentin.Caries-a ffected dentin, enamel, and deep dentin were not considered,although they are commonly encountered in clinical practice.

4.Aging was simulated using six-month water storage.However,intraoral conditi ons involve additional challenges such as thermal cycling,mechanical fatigue, and chemical challenges, which were not reproduced.

5.The application of silver-containing agents (DSF and SF) is highly technique-sen sitive. Variations in application duration, rinsing protocols,and drying procedures may affect outcomes but were not systematically analyzed.

6.Micromorphological evaluation was performed on a relatively small number of specimens(n=5per subgroup), which may not fully represent the structural variat ions across all samples.

7.Important clinical considerations such as esthetic outcomes (e.g.,black stainin g from DSF) and biological responses (e.g., pulp irritation or biocompatibility) w ere not evaluated in this study.

Within the limitations of this in vitro study,the following conclusions can be dra wn:

1.Surface pretreatment of dentin with Diamine SilverFluoride (DSF) or Silver Fluo ride (SF) negatively affected the microshear bond strength (µSBS) of universal adhesives. This effect was evident in both immediate and aged conditions. 2.Ag ing further exacerbated the reduction in bond strength,especially in DSF-treat ed groups, indicating compromised long-term adhesion and resin-dentin interf ace stability.

3.SEM analysis revealed disrupted or absent hybrid layers,reduced resin tag f ormation, and silver precipitate deposition in DSFand SF groups.These morph ological changes likely interfered with monomer infiltration and polymerizatio n.

4.While DSF and SF are beneficial for caries prevention, their application pri or to adhesive restorative procedures may compromise adhesive performance .Therefore,caution is advised when using silver-containing pretreatments in cli nical settings that require strong and durable adhesion.

5.Additional long-term clinical studies are recommended to evaluate the imp act of DSF and SF on different adhesive systems, various tooth substrates,an d under simulated oral conditions to establish comprehensive clinical guidelin es.

Recommendations

the following recommendations are proposed to guide future research and clinical application of silver-containing surface pre-treatments in conservative dentistry:

1.Exercise caution when using (DSF) Before adhesive restorations.

The present study demonstrated that pre-treating dentin with DSF signific antly reduces (µSBS) of universal adhesives, particularly after artificial ag ing.Therefore, DSF should not be routinely used prior to permanent adhe sive restorations in load-bearing areas where long-term bond durability is essential.

2.Consider selective use of DSF in high caries-risk or special populations.Des pite its negative impact on bond strength,DSF provides substantial antimicro bial and remineralizing benefits.

3.Avoid Silver Fluoride (SF) in Permanent Adhesive Restorations.

Silver Fluoride, though slightly less aggressive than DSF, still resulted in a n otable reduction in bond strength post-aging. It is therefore not recommend ed for use in permanent adhesive procedures, especially when using resin c omposites.

4.Evaluate the compatibility of adhesive systems with silver-based agents.The effect of DSF or SF varies depending on the adhesive system,its monomer content (e.g., MDP), and the bonding strategy (etch-and-rinse vs. self-etch).It is advised totest different adhesive systems before routine clinical use,consi der using an etch-and-rinse technique in cases involving DSF ,employ an intermediate liner, such as resin-modified gl ass ionomer cement, to enhance bonding

5.Encourage long-term slinical studies.While this study provided short-term in vitro insights, further randomized clinical trials and longitudinal research are needed to validate the findings under dynamic intraoral conditions in clude thermal cycling, masticatory forces, and saliva interactions.Assessclinic al outcomes such as marginal adaptation,discoloration,and secondary caries

6.Develop Standardized,Evidence-Based Clinical Protocols for DSF Application to ensure optimal outcomes and minimize adverse effects,there is a need to establish clinical protocols detailing application sequence and duration, rinsing steps post-DSF application,timing before adhesive placement,optional use of potassium iodide (KI) to mitigate staining and enhance bond stre ngth.

These recommendations aim to balance the antimicrobial advantages of sil ver-based agents with the mechanical demands of adhesive dentistry,while emphasizing the importance of clinical judgment,material selection,and cont inued research.

References

1.Bagramian RA,Garcia-Godoy F, Volpe AR. The global increase in dental caries. A pending public health crisis. Am J Dent.2009;22(1):3-8.

2. **Chu CH,** Lo EC. Promoting caries arrest in children with silver diamin e fluoride:a review.Oral Health Prev Dent. 2008; 6 (4): 315-21.

3. **Hass V, Cardenas AFM,Siqueira FSF,Pacheco RR, Zago PMW,Silva DO,e t** al.Bonding Performance of Universal Adhesive Systems Applied in Etchand-Rinse and Self-Etch Strategies on Natural Dentin Caries.Operative Den tistry. 2019;44 (5):510-20.

4. **Lutgen** P, **Chan D, Sadr** A. Effects of silver diammine fluoride on bon d strength of adhesives to sound dentin. Dental MAaterials Journal.2018; 37(6):1003-9.

5.Korwar A, Sharma S, Logani A, Shah N. Pulp response to high fluorid e releasing glass ionomer, silver diamine fluoride, and calcium hydroxide used for indirect pulp treatment: An in-vivo comparative study.Contempor ary clinical dentistry. 2015;6 (3): 288-92.

6.Rosenblatt A, Stamford TCM, Niederman R. Silver Diamine Fluoride**: A** Caries " Silver-Fluoride Bullet". Journal of Dental Research.2009;88(2):116-25.

7.Yamaga R, Nishino M, Yoshida S, Yokomizo I. Diammine silver fluoride and its clinical application. J Osaka Univ Dent Sch. 1972; 12:1-20.

8. **McDonald SP, Sheiham** A. A clinical comparison of non-traumatic met hods of treating dental caries. International dental journal.1994;44(5):46570.

9. **Lou YL, Botelho MG, Darvell** BW. Reaction of silver diamine fluoride with hydroxyapatite andprotein. Journal of Dentistry. 2011;39(9):612-8.

10.**Turkistani A, Nakashima S, Shimada Y, Tagami J, Sadr** A.Microgaps a nd Demineralization Progress around Composite Restorations.Journal of D ental Research. 2015;94 (8):1070-7.

11.**Beltrán-Aguilar ED.** Silver Diamine Fluoride (SDF) may be Better than Fluoride Varnish and no Treatment in Arresting and Preventing Cavitated Carious Lesions.Journal of Evidence Based Dental Practice.2010;10(2):122-4.

12. **Yee R, Holmgren C, Mulder J,Lama D,Walker D, van Palenstein Hel dermman** W. Efficacy of Silver Diamine Fluoride for Arresting Caries Trea tment.Journal of Dental Research. 2009;88 (7): 644-7.

13.**Hamama HH,Yiu CK,Burrow** MF.Effect of silver diamnine fluoride and potassium iodide on residual bacteria in dentinal tubules.Australian Denta l Journal. 2015;60(1):80-7.

14.**Knight GM,Mclntyre JM,Craig GG,Mulyani, Zilm PS,Gully** NJ.Differences between normal and demineralized dentine pretreated with silver fluori de and potassium iodide after aan<i>EVitro</i>challenge by <i>Streptococ cus mutann</i.Australian Dental Journal. 2007;52(1):16-21.

15. **Houpt** M. Topical Application of Silver Diamine Fluoride may Arrest Dental Caries.Journal of Evidence Based Dental Practice. 2011; 11(1):54-
5.

16.Thanatvarakorn O, Islam MDS, Nakashima S, Sadr A, Nikaido T,Taga mi J. Effects of zinc fluoride on inhibiting dentin demineralization and c ollagen degradation in vitro : A comparison of various topical fluoride a gents.Dental Materials Journal. 2016;35 (5):769-75.

17. Göstemeyer G, Schwendicke F, Blunck U. Restoring the Carious Lesi on. Monographs in Oral Science: S. Karger AG;2018.p.42-55.

18.Isolan CP, Sarkis-Onofre R, Moraes RR. Bonding to sound and cariesaffected dentin: Systematic review and meta-analysis. Dental Materials.20 15;31:e55.

19. **Mazzoni A, Tjäderhane L, Checchi V, Di Lenarda R,Salo T,Tay FR,et al.**Role of dentin MMPs in caries progression and bond stability. J Dent Res.2015; 94 (2): 241-51.

20. **Karched M,Ali** D, **Ngo** H. In vivo antimicrobial activity of silver diam mine fluoride on carious lesions in dentin. Journal of Oral Science.2019; 61(1):19-24.

21.Seifo N,Robertson M, MacLean J, Blain K, Grosse S, Milne R,et al.Th e use of silver diamine fluoride (SDF) in dental practice. Br Dent J.2020 ;228(2):75-81.

22. **Perdigão J, Swift** EJ. Universal Adhesives. Journal of Esthetic and Re storative Dentistry. 2015;27 (6):331-4.

23. Soliman N, Bakry N, Mohy ElDin M, Talat D. Effect of silver diamine fluoride pretre atment on microleakage and shear bond strength of resin modified glass ionomer cemen t to primay dentin (in-vitro study).Alexandria Dental Journal. 2021;0 (0):0-.

24. Siriporananon C, Senawongse P, Sattabanasuk V, Srimaneekarn N,Sano H, Saikaew P. Effects of dentin surface preparations on bonding of self-etching adhesives under simula ted pulpal pressure.Restorative Dentistry &Endodontics.2022;47(1).

25.Roberts A, Bradley J,Merkley S, Pachal T, Gopal JV, Sharma D.Does potassium iodide application following silver diamine fuoride reduce staining of tooth? A systematic review. Australian Dental Journal.2020;65(2):109-17.

26. **Valizadeh S, Moradi A, Mirazei M, Amiri H, Kharazifard** MJ.Microshear Bond Strengt h of Different Adhesive Systems to Dentin.Frontiers in Dentistry. 2019.

27.Loomans BAC, Mesko ME, Moraes RR, Ruben J,Bronkhorst EM,Pereira-Cenci T,et al.Eff ect of different surface treatment techniques on the repair strength of indirect composit es. Journal of Dentistry.2017;59:18-25.