Biomedical & Pharmacology Journal, March 2025. Vol. **18**(1), p. 761-772

Strength of Bond Between Adhesives and Low-viscosity Bulk-fill Composites Utilizing 10-methacryloyloxydecyl Dihydrogen Phosphate (10-MDP)

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https://dx.doi.org/10.13005/bpj/3126

(Received: 30 September 2024; accepted: 27 January 2025)

To assess the adhesives' and low-viscosity bulk-fill composites' binding strength using 10-methacryloyloxydecyl dihydrogen phosphate (10-MDP). iBOND by Kulzer, Prime&Bond elect by DENTSPLY Caulk, TOKUYAMA UNIVERSAL BOND II, Tokuyama Dental Corporation, and Adper Easy Bond Self-Etch Adhesive, as well as one 10-MDP-free adhesive (Xeno IV DC, Dentsply Sirona) were put on the air-abraded, polished outer layers of arbitrarily allocated Filtek™ Bulk Fill Flowable Restorative blocks. 3M™ Filtek™ Universal Restorative was then applied in layers after the adhesives. Using a hard-tissue microtome, each multilayer composite block was cut into stick specimens. Microtensile bond strength was measured on half of the groups (immediate group), while the remaining groups were matured in a thermocyling machine for 5000 cycles before having their microtensile bond strength tested (aged group). Scanning electron microscopy was used to assess the adhesive contact (SEM). Light microscopy was used to observe failure modes. Levene's test, ANOVA, Welch's ANOVA, Tukey's test, and the Z-test were used to analyze the results as necessary (significance: p 0.05). The binding strength between the 10-MDP-containing adhesives and the 10-MDP-free glue varied significantly across all groups. In all glue groups, aging considerably reduced the binding strength. The binding strength and endurance of the 10-MDP-containing adhesives did not differ significantly from one another. Adhesives with 10-MDP outperform those without when applied to the air-abraded FiltekTM Bulk Fill Flowable Restorative composite surface. The chemical composition of the adhesives containing 10-MDP had no effect on the binding strength. As adhesives with 10-MDP age, their bond strength and durability declines.

Keywords: Aging, Bond strength; Low-viscosity bulk fill composite; Self-etch bonding agents; Universal bonding agents; 10-MDP.

In everyday clinical practice, photo-cured resin composites (RBCs) are the best bet of materials for restorative purposes since minimally invasive and cosmetic treatments are preferred in dentistry. [1] During the restorative method, conventional composites should be stacked incrementally, and the oxygen-inhibiting layer (OIL) on the uppermost composite surface is often enhanced by the copolymerization of successive composite layers. Bulk-fill resin composite (BFRC), which permits an increase in thickness of 4-5 mm, was created as a way

to simplify the time-consuming and technically delicate application process. BFRCs incorporate an alternate photoinitiator method and freshly synthesized monomers linked to stress-reduction technology.[1, 2]

There are two types of BFRCs: flowable (low viscosity) and full-body (high viscosity), each having a unique therapeutic application process. Yet, since universal resin composites must be employed for the finishing touch for the restoration because low-viscosity BFRCs are materials mostly used for the replacement of dentin. [1, 3]

Some clinical circumstances lead to the loss or contamination of the oil, and it may affect how a fresh composite layer is applied. To promote adhesion between both the composite layers in these specific situations, the damaged surface of the composite must be reactivated by making the surface rough or by making it wet. As a quick fix, this technique can be applied. [3,4]

The strength and longevity of adhesion are crucial for achieving interface stability. Programs emphasize the value of physical treatments of the surface and support the effectiveness of conditioning of the surface with chemical techniques [3,4], but they come to different findings on the best regimen. Although a fresh composite surface is much more activation-friendly than an old, crumbling one, there is little information on how to activate a flowable bulkfill composite surface using bonding agents that have 10-methacryloyloxydecyl dihydrogen phosphate (10-MDP), and the interface longevity is also in doubt. Due to their versatility in use and multimodality, universal adhesives are well-liked. Moreover, since they're self-etch adhesives, the application method is simpler. These adhesives' cutting-edge technology enables one-step bonding, priming, and etching with minimal technical sensitivity.[2] The precise composition and complexity of universal and self-etch adhesives are designed to create a firm and adequate strength in the bond, but their absorption of water and product-reliance effectiveness is a reason for worry. Several or more acidic functional molecules are present in universal and self-etch adhesives, which improve conditioning and chemical interaction. Of prime importance is the most adaptable operational monomer, 10-MDP, which processes a very great ability for adhesion to a wide range of substrates, including metals, lithium disilicate, zirconia ceramics, and dental hard tissues, and it appears to be essential for adhesives that are self-etch to reach a durable bond strength. [3, 5]

It has been studied how well universal adhesives perform under various protocols [16]. In order to examine the performance of these four 10-MDP-containing bonding agents on the surface of bulk-fill composite of low-viscosity and also dependability about technique after aging, the microtensile bond strength (TBS) was measured. [5, 6]

We applied adhesives containing 10-MDP, aged the specimens using thermocycling, and employed abrasion with air as the industry-accepted surface treatment mechanically [4] (in accordance with ISO/TS 11405:2015). Three theories were investigated: The performance of adhesives containing 10-MDP is unaffected by aging, and there is an absence of discernible variation in the strength of the bond and its durability when contrasting 10-MDP-containing bonding agents and adhesives without 10-MDP. [1] Appreciable discrepancy was not there between the bond strengths of adhesives having 10-MDP with variable composition. [2]

Objective: How the dental substrate affects the self-curing and light-curing universal adhesives' performance

MATERIALS AND METHODS

Materials used in Study

Five dissimilar adhesives - Xeno IV DC (XEN, Dentsply Sirona), iBOND by Kulzer, Prime&Bond elect (DENTSPLY Caulk), TOKUYAMA UNIVERSAL BOND II, Tokuyama Dental Corporation and Adper Easy Bond Self-Etch Adhesive (3M ESPE) - were coated on the outside of Filtek™ Bulk Fill Flowable Restorative composite (Dentsply \Sirona; Konstanz, Germany) as the underlayer. 3M™ Filtek™ Universal Restorative composite was used to finish the layering process. Table 1 contains information about the materials' description, composition, and producers. Except for Xeno IV DC, which functioned as adhesive control that is hydrophobic and was devoid of monomers that were acidic and solvent, all adhesives contained 10-MDP or its derivatives.

Sample Preparation for µTBS Measurements

A specially constructed Teflon mold measuring 10 mm by 10 mm by 7 mm was used to create SDR blocks. The bulk-fill technique was used to apply layers that were four millimeters thick (Fig 1). In a Scheu LC-6 light oven (Iserlohn, Germany) fitted with various tube lights (three UVA and three blue-colored wavelengths with 370 nm and 450 nm maxima, individually.), each increment was polymerized for 180 s.

Surface treatment of Filtek™ Bulk Fill Flowable Restorative blocks

Using 400, 800, and abrasive papers of silicon-carbide, 1200 grit, and cooling with water, the adhesive surface of the Filtek™ Bulk Fill Flowable Restorative blocks was polished with the use of a polishing machine (Struers LaboPol35; Rdovre, Denmark) at 300 rotations per minute for half a minute. After polishing, the blocks underwent a 10-minute ultrasonic cleaning to remove any remaining abrasive materials. An intraoral sandblaster (Bio Art, Dentmark, Dental Equipment) was used to sandblast 50-m Al2O3 (BDSI, Dental Equipment & Consumables) onto the polished Filtek™ Bulk Fill Flowable Restorative blocks for 10 seconds at a range of 10 mm under 2.5 bar of pressure. This was followed by 90 seconds of washing and 90 seconds of drying with an air-water syringe. Before being adhesively attached to TEC, the blocks that were cured and polished were allowed to dry out at 37^0c for 24 hours.

Application of adhesives

A thin layer of every adhesive was placed, following the instructions given by the manufacturer, on a randomly selected sandblasted SDR surface after 24 hours. Table 2 provides a summary of adhesive application methods. With the use of an air-water syringe free from oil, the bonding agents were dried. With a dental plasma light-curing unit (Elipar™ DeepCure LED Curing Light) set to a high-mode curing program (1470 mW/cm^2), all adhesives were light-cured.

Application of universal composite

The Filtek™ Bulk Fill Flowable Restorative blocks were reinserted into the Teflon mold after adhesives had been used, and 3M™ Filtek™ Universal Restorative composite repair was made in accordance with the manufacturer's specifications. Each layer of the 3M™ Filtek™ Universal Restorative composite was polymerized for three minutes in a Scheu LC-6 illumination stove after being applied in 2-mm increments. In the following 24 hours, the restored cube was cut into two pieces with a microtome for hard-tissue cutting (Bluedent India), equipped with a diamond saw while being cooled by water. Stick-shaped specimens measuring 3 x 4 x 15 mm were the result. 90 non-trimmed sticks from each group were separated into two groups by drawing 30 at random. The first was subjected to group TBS measures, while the second was aged.

Aging of the interface

The thermocycling machine (Scalibra Calibration Lab., Skjetten, Norway) was used to age the next group of slices (3 mm x 4 mm x 15 mm) for 4000 cycles at 5-56^{o}C with a half-minute stay time. The blocks' TBS was then determined after age. The 2nd figure displays the groups for experimental purposes according to the adhesives used and the aging procedure.

µTBS Measurements

A digital caliper was used to measure the width and thickness of each sample at three distinct locations. The average width and thickness were determined using these measurements.

The aged and unaged sticks were fastened to a metallic cuvette with an active grip notch. The cuvette was put inside a mechanical analyzer with a 2-kN load cell (Instron 5566; Norwood, MA, USA). A one mm per minute crosshead speed was chosen. By splitting the measured load (N) by the area of cross section, the TBS was computed (mm^2).

Detection of the Failure Mode

To identify the type of failure, all fragmented surfaces were examined with a stereo light microscope (Leica 7.5 Mz, Microsystems Ltd. Business Unit SM, Heerbrugg, Switzerland) at a 45X magnification. The failures were separated into two categories: cohesive failures that happened within the bulk fill flowable Restorative or universal restorative composite and adhesive failures that occurred at the contact between the bulk fill flowable Restorative and Universal Restorative composite.

Statistical Analysis

Using Levene's test, the homogeneity of variability was examined. The means of all groups were evaluated using a one-way ANOVA

for evidence with uniform difference. Welch's was employed to compare the groups' means for data with homogeneous variance. For pairwise comparisons, we next applied the proper post-hoc test, such as the Tukey's honestly significant masked (HSD) test or the Tamhane test. To identify adhesive or cohesiveness percentages that were distinct from 50%, binomial testing was used. In order to contrast the rates of adhesive cracks, a two-sample Z-test for proportions was used for immediate and aged cases. All tests were done using IBM's SPSS Statistics 27 software, excluding the Z-test of proportions, which is a two-sample test were computed in R. 20.

RESULTS

Microtensile bond strength (μTBS) Results

In Fig. 3, the TBS data are displayed. The tested treatments had a mean TBS that ranged from 36.4 MPa to 46.6 MPa. In all groups, the difference that was statistically significant was there in TBS between the bonding agents that had 10-MDP and 10-MDP-free bonding agents ($p < 0.05$). In all adhesive groups, aging significantly decreased TBS ($p < 0.05$). The older groups of adhesives containing 10-MDP had significantly higher variations in TBS ($p < 0.05$), which were related to wider ranges and lower minima (Fig. 3). TBS did not significantly differ between the old

Table 1. Content and producers of resin composite and bonding agents

	Material	Producer	Components
1	3M™ Filtek™ Universal Restorative	3M™ ESPE	1,12-dodecane-DMA, diurethane-DMA, AUDMA, and AFM. The filler is composed of combined zirconia/silica clusters (consisting of 20 nm silica and 4 to 11 nm zirconia particles), non-sintered particles that are loosely attached silica fillers (20 nm), zirconia fillers (4 to 11 nm), and a ytterbium trifluoride filler composed of clustered particles of 100 nm.
2	Filtek™ Bulk Fill Flowable Restorative	3M™ ESPE	Zirconia/silica 0.01 to 3.5 μ, bisGMA, UDMA, bisEMA, and Procrylat resins, and ytterbium trifluoride filler with a 0.1–5.0 μ particle dimension range.
3	Xeno IV DC		Xeno® IV bonding agent: PENTA (dipentaerythritol penta acrylate monophosphate); mono-, di-, and trimethacrylate resins; photoinitiators; stabilizers; cetylamine hydrofluoride; acetone; waterSelf-curing activators include acetone, water, catalysts, photoinitiators, mono- and di-methacrylate resins, and stabilizers.
4	iBOND Universal	Kulzer	4-META, MDP, Methacrylates, Acetone, Water
5	Prime&Bond elect	Dentsply Sirona	Prime&Bond elect bonding agent include acetone, water, cetylamine hydrofluoride, PENTA (dipentaerythritol penta acrylate monophosphate), diketone, organic phosphine oxide, and mono-, di-, and trimethacrylate resins. Self-curing activators include acetone, water, catalysts, photoinitiators, mono- and di-methacrylate resins, and stabilizers.
6	Tokuyama Universal Bond II	Tokuyama Dental Corporation	MTU-6 (thiouracil monomer), 3-hydroxyethyl methacrylate (HEMA), phosphoric acid monomer, bisphenol A di(2-hydroxy propoxy) dimethacrylate (Bis-GMA), triglycerol dimethacrylate (TEGDMA), silane coupling agent, peroxide, borate catalyst, acetone, ethanol, and purified water.
7	Adper Easy Bond Self-Etch Adhesive	3M™ ESPE™	Functionalized polyalkenoic acid (Vitrebond™ Copolymer), bis-GMA, 1,6 hexanediol dimethacrylate, 2-hydroxyethyl methacryate (HEMA), water, ethanol, sintered silica filler that is finely distributed and has a main particle dimension of 7 nm, and camphorquinone stabilizers-based initiators

Table 2. Application mode of adhesives

	Xeno IV DC	iBOND Universal	Prime & Bond elect	Tokuyama Universal Bond II	Adper Easy Bond Self-Etch Adhesive
Duration of application (s)		20 seconds	Enamel was Conditioned for a minimum of 15 seconds and dentin for not more than 15 seconds.	25-seconds	20 seconds
Motion		To ensure that consumed monomers are eliminated and that new monomers come into contact with the tooth surface, the liquid in the cavity must be shaken.	Wet every tooth surface completely. For 20 seconds, agitate the placed adhesive. To completely cover the preparation for the entire 20 seconds, the microbrush might need to be rewetted.	Place A and B into the same disposable concave vessel, mix thoroughly, and combine. Apply the mixed bond.	Apply using a rubbing motion
Drying time		These products include a lot of water along with alcohol or ethanol since self-etch adhesives require water activation of their acidic groups. This water must be eliminated from the layer of adhesive by adequate air-drying before polymerization.	Spend at least 15 seconds thoroughly rinsing the conditioned regions. Use an air syringe to gently blow off the rinsing water, or use a cotton pellet to blot dry.	no need towait	5 seconds
Polymerization time		Short curing time of only 10 seconds.	Use a curing lamp with a spectral output of 470 nm and a minimum light output of 550 mW/cm^2 to cure for 10 seconds.	no need tolight cure	10 seconds

and immediate groups for the adhesives containing 10-MDP ($p < 0.05$).

Analysis of failure Mode

Outcome for failure modes are shown in Figures 4 and 5. The immediate groups with adhesive containing 10-MDP experienced a much greater rate of adhesive failure: 98% for Adper Easy Bond Self-Etch Adhesive, 92.1% for Tokuyama Universal Bond II, 87.3% for PBE, and 64.9% for iBOND. Nonetheless, cohesive failure (56.8%) was the most prevalent failure category for XEN. The percentages of cohesive failure were often much higher in the older groups: 84.6% for the Adper Easy Bond, 81% for the PBE, 82% for the TBF II, and 72.9% for the XEN. In contrast, the elderly TUB group (81%) was mostly affected by adhesive failures.

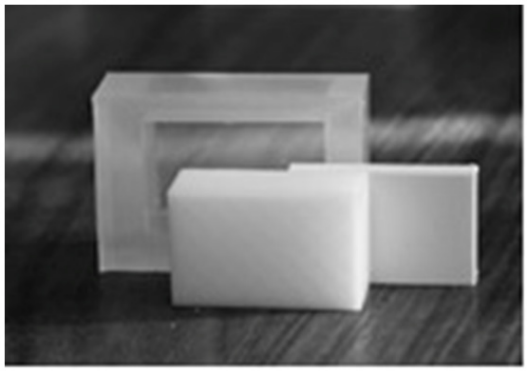

Fig. 1. Custom made Teflon mould

DISCUSSION

In this research, we assessed TBS of the four 10-MDP-containing bonding agents to a flowable resin composite that can be bulk-filled and looked at the bonding strength both pre- and post- thermocycling regimen Ibond, Prime&Bond elect [PBE], TOKUYAMA UNIVERSAL BOND II (TUB), and Adper Easy Bond (AEB). In order to address the shortcomings of multiple-step etch-and-rinse bonding agents employed during final restorations and to achieve adherence chemically in specific clinical circumstances, self-etch and universal adhesives were developed.[7,8] The chemical processes significantly alter the chemical makeup of self-etch adhesives and greatly enhance adhesion quality. Consequently, interactions between the various adhesive components, application procedures, and substrate surface quality affect the performance clinically and the effectiveness of self-etch bonding agents. [9, 10, 11]

Hydrophilic and hydrophobic molecules are combined in simplified adhesives, but the sterility and strength of the monomers vary

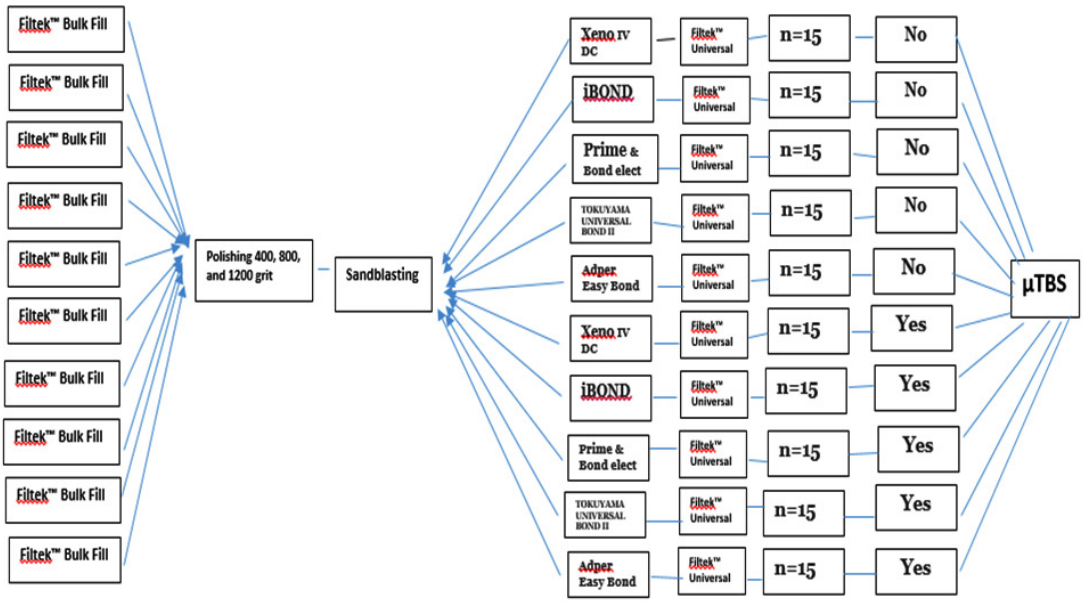

Fig. 2. Flowchart test groups: Filtek™ bulk fill flowable restorative, 3M™ filtek™ universal restorative, XENO IV DC, Ibond universal, Prime&Bond elect, Tokuyama Universal Bond II, Adper Easy Bond Self-Etch Adhesive

depending on the product, which significantly impacts the binding strength and longevity. [12] It is understood that HEMA's hydrophilicity improves dentin wetting and permits adequate resin monomer infiltration into the dental surface [13].

Despite the fact that the long-range efficacy of universal adhesives on dentin and dentin has been previously studied [9,2, 14] there is a dearth of information about the bonding strength of adhesives that contain 10-MDP on low-viscosity bulk-fill composite surfaces. The 10-MDP-containing self-etch and universal bonding agents examined in this study may adhere to a wide range of substrates, including silica, metal oxides, zirconia, and monomers of resin. [35] The linking functional groups may provide an

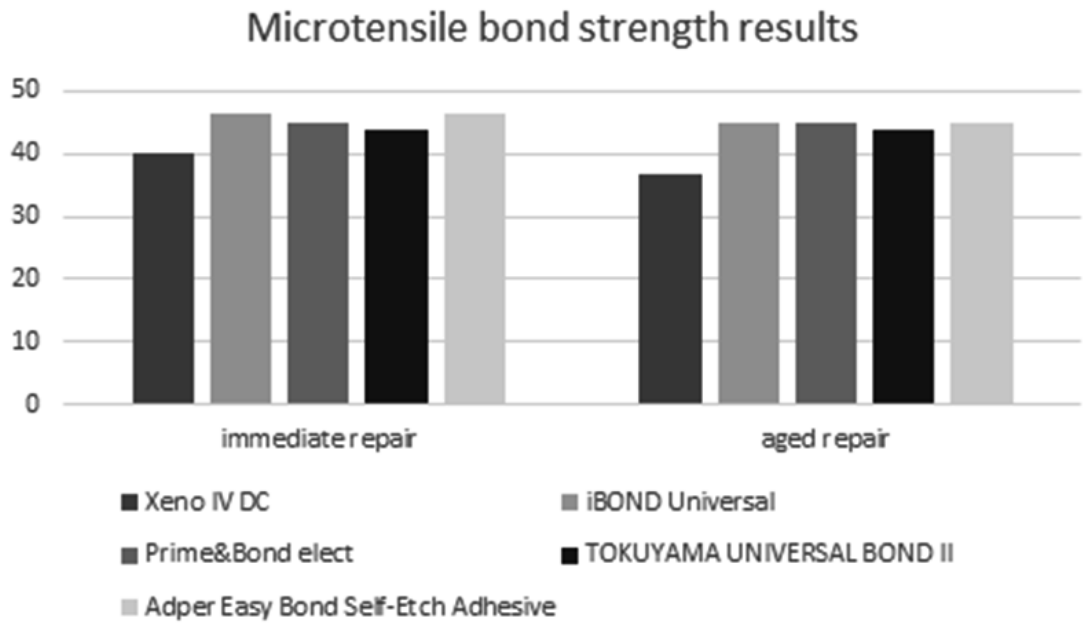

Fig. 3. Findings of microtensile bond strength based on the adhesives that were evaluated for immediate and aged protocols.

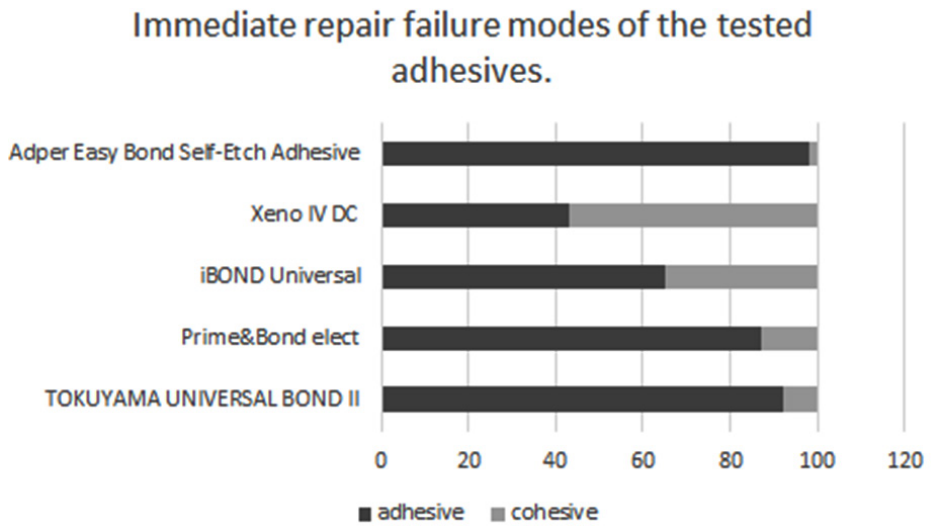

Fig. 4. The tested adhesives' immediate repair mechanisms of failure

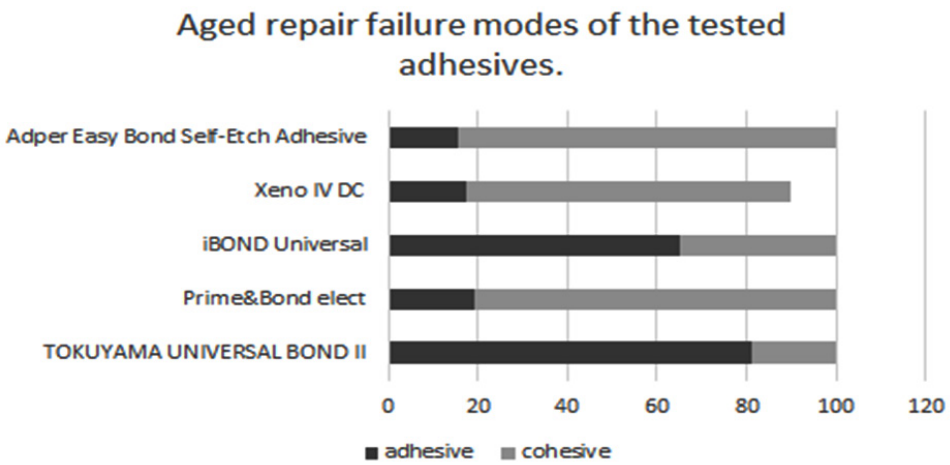

Fig. 5. The tested adhesives' aging repair mechanisms of failure

effective protective zone against biodegradation at the adhesive contact in the form of a stable nanolayered structure. [14, 15] MDP, because of its strong adhesive qualities and surfactant capability, is a preferable replacement monomer that is included in several dental adhesive system compositions. MDP concentrations in marketed dental adhesives range from 5 weight percent to 15 weight percent. It has been shown that MDP can connect with hydrophilic substrates to form numerous dual layers and organize themselves. It can be found in universal single bonds. This ingredient also contributes to the flowable bulk fill composite's improved adhesion capabilities. Because of its resistance to hydrolysis and capacity to establish potent ionic connections with calcium, it is said to be the strongest possible monomer for chemically binding to the hydroxyapatite of enamel and dentin. Because methacryloyloxydecyl dihydrogen phosphate (10-MDP) is hydrophobic, its phosphate ester group adheres to the latent hydroxyl groups, improving chemical longevity and shielding the adhesive surface from hydrolytic degradation [16].

Since XEN is a bonding agent with no acidic operative monomer, it was used as the control. Bonding agents using acidic operational monomers include crude solvents (such as acetone or alcohol) that lessen the mixture's viscosity and aid the monomers in penetrating surface imperfections. Due to the solvent and the monomers' excellent miscibility, retain the solvent in the layer at the interface after the adhesive layer has dried. The solvent that is still present may have an impact on how well SDR and TEC adhere.

With the solvent-free XEN glue, this phenomenon is not seen. Based on their molecular mobility, the faults of the sandblasted surface of the composite are filled with a slightly viscous monomer mixture.

The substrate for the tested adhesives was Filtek™ Bulk Fill Flowable Restorative composite. Filtek™ Bulk Fill Flowable Restorative has a conversion of high degree and with a modest filler load of particles made up of barium, aluminum, and silica that were different sizes (0.01 to 3.5µ) [17, 18] .These big particles may be useful to resin bonding agents as a retentive region. Chemical and mechanical components both have an impact on adhesion at the composite-composite interface. [19, 20] Thus, the surfaces of the composite resin were prepared with disks of silicon carbide (up to 1200 grit), subsequently air abrasion done using 50-m Al_2O_3 particles, before adhesive was applied. This approach is applicable to clinical scenarios in which an immediate correction is necessary owing to failure after completing an RBC restoration. A brand-new composite surface is an idealized surface devoid of hydrolysis or degradation traces. Unreacted monomers give the intermediate agent the C=C needed to generate C-C covalent bonds. Furthermore, functional monomers join with the fillers to raise the composite substrate cohesion strength by strengthening the bonds between them. [3, 19]

The 10-MDP-containing adhesives under investigation here have TBS that are consistent with those provided by research done in the past. [20, 21]

These researchers discovered strong adhesion to the low viscosity bulk-fill composite, and this is in sync with the STEM findings. Also, in the immediate groups, the TBS of all tested adhesives containing 10-MDP was much more than with those in the adhesive in control group, which is similar to the findings of an earlier investigation. 10 Similar to the conclusions of studies done earlier.[22, 6] Although in contrast to results from a previous investigation, the composition of the 10-MDP-containing adhesives varied in this research but has not produced notably variable TBS. [23] We therefore agreed with our initial theory.

The relatively thin Adper Easy Bond layer of adhesive seen in scanning transition electron micrographs is consistent with the application of Adper Easy Bond, which required a brief burst of maximum air pressure. The application protocol's air-thinning step may have an impact on the bond layer thickness, but the filler's presence doesn't seem to have much of an impact. Before applying adhesive, silanization has been recommended as a separate priming process to enhance wetting and bonding.

According to a research hypothesis, silane inclusion in adhesives enhances wetting and sticking ability [24], much like a separate silanization phase. [10] The process may be made simpler by including silane in the adhesive agent, but other factors, such as the bonding agent's composition and pH, may also have an impact on how well it affects TBS. [25] The crystalline filler fragments of the old composite are chemically bonded to the new resin using silane. Bonding agents containing silane (PBE and TUB) or not having silane (iBOND and AEB) demonstrated comparable TBS in the young and old groups regardless of the silane level. These results concur with those of research done in the past. [16, 26, 18] The stability of silane may be harmed by the acidic pH of PBE and TUB, leading to a changed chemical formula with a decreased priming capability.

The probable solvent function of 2-hydroxyethyl methacrylate (HEMA) is, in part, to prevent separation of different phases, and it may enhance wetting of the surface when used as an ingredient of dental adhesives. Phase separation may also be the cause of the creation of pores in the cured adhesive surface and hybrid phase by preventing adhesive resin from diffusing into the bottom portion of the etched surface (typical nanoleakage). [26] The formation of the 10-MDP interfacial nanolayer and high water uptake [27] have both been linked to it, as well as an inhibitory effect on polymerization. [28]. Only one of the bonding agents that was tested, GP-Premio Bond, does not contain HEMA; however, it did not have a considerably higher TBS than the other adhesives that contained 10-MDP. This discovery differs from those made by earlier studies. [1]

PBE comprises Vitrebond copolymer (VCP), a self-adhesive glass-ionomer-based polyalkenoic acid copolymer that has demonstrated outstanding bonding performance. [24] In line with prior research, PBE did not improve the bond strength following repair in contrast to the other self-etch or universal bonding agents. [29]. The reactions between PBE constituents, such as the higher-molecular-weight polyalkenoic copolymer, can make it difficult for 10-MDP to adhere to the same substrate, which is one argument that might be put up [30]. The polyalkenoate reaction may also be hampered by the components of the resin.[25] Thermocycling is an effective technique for mimicking the effects of stress due to hydrolysis, water absorption, and heat; as a result, that will be excellent for evaluating how long a bonded interface will last. The cross-linked matrix deterioration, monomer leaching, resin polymer hydrolysis, and interface of resin-filler, microcrack development, and degradation of the interface of the bonded resin weaken the repair bond. [3, 26, 31] According to other studies [15, 32, 33], the bonding strength was considerably weaker in the case of the elderly compared to the proximate groups in our study. We therefore disproved another hypothesis. The limited hydrolytic stability of self-etch adhesives is consistent with this result. HEMA, silane, or hydrophilic substances with hydroxyl or phosphate groups may hasten the degradation of the bonded interface.[34] Notwithstanding this fact, the adhesive groups comprising 10-MDP had a much greater TBS than those made with XEN. While it was also proposed that the hydrophobic layer of resin play the role of a barrier of protection to lessen the hydrophilic deterioration of bonding agents [35], the decrease in TBS of XEN also was notable.

The TBS decrease for TBF II was 9%, PBE was 9%, TUB was 10%, GP was 8%, and XEN was 13%. Independent of composition or application method on the bulk-fill resin composite surface, these alterations show a comparable deterioration trend in all adhesive groups.[36]

With the exception of Xeno IV DC, there was a bigger proportion of adhesive fractures in the proximate groups, demonstrating the similarity of the 10-MDP-containing adhesives. With the exception of TUB, studies have [3, 15] reported that the cohesive fracture kind was the primary kind found after age. The existence of the hydrophilic amide methacrylate component may be the cause of this variation. Although scanning transition electron micrographs showed no gap, cohesive, close interfaces in all categories, the degradation hydrolytically and softening of the matrix of resin, as well as the filler particles loosening, is similar to disintegration at the interface and may be the cause of the majority of cohesive fractures. [37, 38] Furthermore, even with a higher light source power output (3000 mW/cm2), bulk-fill composites combined with universal bonding agents exhibit less adherence when the polymerization period is shortened. A reduction in bond strength is linked to inadequate hardening of the substrates at the contact [39, 40].

Research indicates that self-adhesive flowable resin composite (SAR) has lower chemical bonding ability when compared with traditional adhesive systems[41]. Using phosphoric acid etching on enamel can improve moisture absorption, surface free energy, imperfection, and coverage.

Our use of TBS to assess binding strength is in line with earlier research [42, 43]. Nonetheless, there are well-known drawbacks of in-vitro research. Therefore, additional research should be done to assess the impact of prolonged aging or the durability of the binding strength of multiple-layered adhesives.

CONCLUSIONS

The following conclusions can be drawn within the limitations of this study: The effectiveness of flowable bulk-fill resin composite inserted in individuals with parafunctional habits and high caries risk, as well as in other forms of cavities, should be examined in additional clinical research. Furthermore, longer-term clinical research is required to confirm flowable bulk-fill resin composite therapeutic efficacy.

The TBBS to a flowable bulk-fill resin composite is unaffected by the makeup of bonding agents containing 10-MDP. The strength of the bond of agents used for bonding with and without 10-MDP decreases with time. In the Filtek™ Bulk Fill Flowable Restorative - Universal Restorative interface, bonding agents with 10-MDP appear to be more efficient and long-lasting than solvent-free, bonding agents without 10-MDP.

ACKNOWLEDGEMENT

I thank the Deanship of Scientific Research, King Faisal University, college of dentistry, kingdom of Saudi arabia, for supporting this project electronic supplementary material.

Funding source

This work was supported by the Deanship of Scientific Research, Vice Presidency for Graduate Studies and Scientific Research, King Faisal University, Saudi Arabia [GRANT3,638].

Conflict of Interest

The author(s) do not have any conflict of interest.

Data Availability Statement

This statement does not apply to this article.

Ethics Statement

This research did not involve human participants, animal subjects, or any material that requires ethical approval.

Informed Consent Statement

This study did not involve human participants, and therefore, informed consent was not required.

Clinical Trial Registration

This research does not involve any clinical trials**.**

Author's contribution

The sole author was responsible for the conceptualization, methodology, data collection, analysis, writing, and final approval of the manuscript

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