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Effect of dual-cure activators on dentin bond strengths of universal adhesives

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Abstract
This study aims to examine the use of universal adhesives with dual-cure activators to evaluate their effect on the adhesion of light-cured and dual-cured composites to dentin. Ninety caries-free human third molar teeth were randomly allocated into three groups. The groups (N=30) were classified according to the adhesive agents used: Prime Bond Universal (PB), Clearfil Universal Bond Quick (CU), and G Premio Bond (GP).
On the dentin sample surfaces, PB, CU, and GP were utilized in light-curing mode (LC), dual-curing mode (DC), and self-curing mode (SC). Clearfil SE Bond (CSE) was used as the control (n=10). Shear bond strength was measured using a universal testing machine. The collected data were subjected to analysis of variance (ANOVA) and Tukey's HSD tests ($p<0.05$). Statistically significant variances were observed among the different bonding agents, composite materials, and polymerization modes. The utilization of universal adhesive systems in combination with dual-cure activators resulted in a significant decrease in the bond strength of light-cured composites to dentin ($p<0.05$).
Adhesive type failure was the most common both adhesives agents and curing modes. The dual-cure activators were found to be inadequately effective in mitigating the incompatibility issues between the dual-cure composite and the universal adhesives.

Keywords: Dual cure activator, shear bond strength, universal adhesive

Introduction
Advancements in dental material research have significantly improved the ability to restore the natural structure of damaged teeth, particularly in cases where endodontic treatment is required, making a substantial contribution to restorative dentistry.
Resin composites for core buildup, combined with adhesive systems, have become a prominent choice among available materials and are extensively used in clinical dental procedures. Nonetheless, it is noteworthy that post& core restorations continue to exhibit substantial clinical failure rate. In the case of core buildup resin composite materials, failures are mainly observed at the adhesive interface, especially when the core buildup resin composite is used in a dual-cured (DC) mode [1, 2].
Dual-cure resin composites have been introduced as a strategic solution to surmount the constraints associated with light-curing and self-curing composite materials. Dual-cure polymerizing materials comprise both an oxidation-reduction (redox) initiator system and photoinitiators. Polymerization is primarily initiated through exposure to light, which predominantly impacts the surface layers of the resin composite. Subsequently, chemical activation takes place in the deeper layers, particularly in areas with limited light penetration. [3, 4].
Acidic monomers in the self-etch adhesives are not compatible with dual-cured resin-based materials that incorporate tertiary amines. The presence of acidic monomers causes a decrease in the level of tertiary amine through their interaction. As a consequence of this reduction, the production of vital free radicals essential for polymerization is impeded, resulting in a slower polymerization rate. This slowdown in polymerization may have implications for the bond strength of self -etch adhesive systems. To resolve this lack of compatibility, dual-cure activators have been formulated with the inclusion of co-initiators such as cupric chloride, organo-boron compounds, and aryl sulfonic acid salts [5-7].

As universal adhesives exhibit resemblances to earlier self-etch adhesives, they might face analogous challenges, notably when it comes to compatibility issues with dual-cured core buildup resin composites.
In a recent study, the impact of self-curing activators and curing procedures on the adhesive characteristics of universal adhesives when applied to dual-cured composites was assessed. It was observed in the study that employing a self-curing activator had consequences on the bond strength and Nano leakage, this influence was material-dependent. Nevertheless, limited studies are using universal adhesives with dual curing activators [8].
The study was conducted with the goal of assessing how different curing methods influence the shear bond strengths of universal adhesive and resin composite. The study examined the following null hypotheses: (1) There is no significant difference in bond strengths when the adhesive is applied with varying curing protocols. (2) There is no significant difference in bond strengths when the adhesive is used with different types of resin composite.

Materials and Methods

The research received support from the Atatürk University Scientific Research Projects (BAP) Coordination Unit under project THD-2020-8620. It was also endorsed by the Dean's Office of the Faculty of Dentistry and obtained ethical approval from the Ethics Committee with the report dated 19/06/2020, bearing the reference number 03/2020.

1. Tooth selection and sample preparation

One hundred human molar teeth, free of cavities, restorations, and fluorosis, were collected. Residues of soft and hard tissue on the tooth surfaces were eliminated using a periodontal curette, followed by a thorough cleaning of the teeth with a brush under a continuous stream of running water. The teeth were kept in distilled water at room temperature until the study began, and this storage period did not exceed 6 months.
Following the embedding in acrylic resin, the coronal enamel of the teeth was skillfully excised using a slow-speed diamond saw (Isomet Low Speed Saw 1000; Buehler Ltd., Illinois, USA) and cutting device (ISOMET, Buehler, Lake Buff, USA). A uniform smear layer was created by sanding the dentin surfaces for 1 minute using 600-grit silicon carbide sandpaper, with continuous water cooling. Subsequently, the teeth were allocated randomly into three groups based on the adhesive system to be applied (Fig 1).

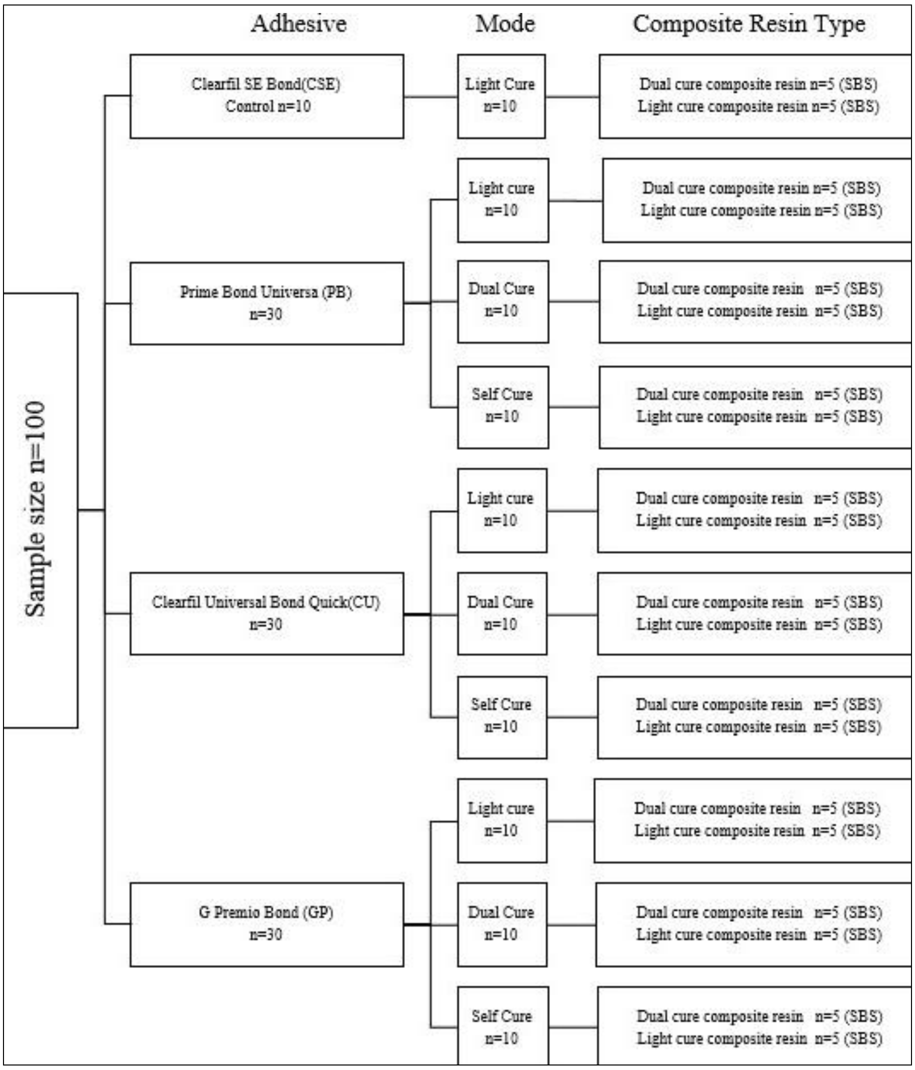


Fig 1: Flow chart describing sample size.

2. Bonding procedure

Three universal adhesive systems [Prime Bond Universal (PB) (Dentsply Sirona, Milford, DE, USA), Clearfil Universal Bond Quick (CU) (Kuraray Noritake Dental Inc., Okuyama, Japan), G Premio Bond (GP), (GC Corporation, Tokyo, Japan)] and the dual cure activators of these systems [(Self Cure Activator (Dentsply Sirona, Milford, DE, USA), Clearfil Dual Cure Activator (Kuraray Noritake Dental Inc., Okuyama, Japan), G Premio Dual Cure Activator (GC Corporation, Tokyo, Japan) were utilized. The manufacturers, contents and Lot numbers are shown in Table 1.

Ninety teeth were randomly allocated into three groups, with each group containing 30 teeth, based on both the adhesive materials and the polymerization mode (light cure, dual cure, self-cure). The application of adhesives to the exposed dentin surfaces followed the guidelines provided by the manufacturer, and polymerization was carried out in accordance with the selected polymerization mode. (Table 2). To ensure consistent polymerization of the samples, a mold made from silicone impression material (Elite HD, Zhermack SpA, Badia Polesine, Italy) with a 4 mm height and 4 mm diameter was employed to maintain a standardized distance from the light device. Subsequently, based on the type of composite resin intended for application [Clearfil Majesty Posterior, Clearfil DC Core Plus Automik (Kuraray Noritake Dental Inc., Okuyama, Japan)], the samples were randomly segregated into two groups (N=5).

Clearfil SE Bond (CSE) (Kuraray Noritake Dental Inc., Okuyama, Japan) was used as the control group in the light-cure mode. It was applied to the dentin surfaces following the manufacturer's instructions, and the samples were randomly divided into two subgroups based on the type of composite to be applied (N=5).

Table 1: Manufacturer, contents and pH values of used adhesive systems and dual cure activators

Materials	Manufacturer	pH	Content	Lot Number
Prime Bond Universal (PB)	Dentsply Sirona, Milford, DE, USA	2.5	Acetone, UDMA, PENTA, dimethacrylate resin, trimethacrylate resin	20030000979
Self-Cure Activator	Dentsply Sirona, Milford, DE, USA		Acetone, UDMA, HEMA, initiator	00056741
Clearfil Universal Bond Quick (CU)	Kuraray Noritake Dental Inc., Okuyama, Japan	2.3	Bis-GMA, ethanol, HEMA, 10-MDP, hydrophilic amine monomers, colloidal silica, silane bonding agent, sodium fluoride, dicomphoroquinone	000036
Clearfil Dual Cure Activator	Kuraray Noritake Dental Inc., Okuyama, Japan		Ethanol, catalysts, accelerators	260009
G Premio Bond Universal (GP)	GC Corporation, Tokyo, Japan	1.5	Acetone, water, 4-MET, MDP, methacrylate monomer, silicon dioxide	1910251
G Premio Dual Cure Activator	GC Corporation, Tokyo, Japan		Initiators, distilled water, ethanol	1910081
Clearfil SE Bond (CSE)	Kuraray Noritake Dental Inc., Okuyama, Japan	1.9	PRIMER: MDP, HEMA, Hydrophilic aliphatic dimethacrylate, dl-camphorquinone, N,N-diethanol-p-tolidine, Water BOND: MDP, Bis-GMA, HEMA, Hydrophobic aliphatic dimethacrylate, dl-camphorquinone, N,N-diethanol-p-tolidine, colloidal silica	000347

Table 2: Application forms of the adhesives used according to the polymerization type

	Light Cure	Dual Cure (with Activator)	Self-Cure (with Activator)
Prime Bond Universal (PB)	Bonding agent was applied actively for 20 seconds at a large amount with a bond brush. It was air-dried for 5 seconds and then light cured for 10 seconds.	One drop of bonding agent and one drop of self-cure activator of the same brand were mixed in a clean plastic container. Light cure polymerization was applied in the same way as indicated in the application.	One drop of bonding agent and one drop of self-cure activator of the same brand were mixed in a clean plastic container. The mixture was left for 20 seconds to activate. It was air dried for 5 seconds and not light-cured afterwards.
Clearfil Universal Bond Quick (CU)	Bonding agent was applied with the help of a brush. It was air-dried for 5 seconds without waiting. It was light cured for 10 seconds.	One drop of bonding agent and one drop of dual cure activator of the same brand were mixed in a clean plastic container, air-dried for more than 5 seconds and light-cured for 10 seconds.	One drop of bonding agent and one drop of dual cure activator of the same brand were mixed in a clean plastic container, air dried for more than 5 seconds and not light-cured afterwards.
G Premio Bond Universal (GP)	After bonding agent was applied with the help of a brush, it was left for 10 seconds. It was air dried for 5 seconds and then light-cured for 10 seconds.	One drop of bonding agent and one drop of dual cure activator of the same brand were mixed in a clean plastic container. Light cure polymerization was applied in the same way as indicated in the application.	One drop of bonding agent and one drop of dual cure activator of the same brand were mixed in a clean plastic container. The mixture was left for 10 seconds, air-dried for 5 seconds and not light-cured afterwards.
Clearfil SE Bond (CSE) (Control)	Primer was applied to the cavity for 20 seconds and then lightly air-dried. Bonding agent was then applied. It dried slowly. Finally, it was light-cured for 10 seconds.		

3. Applying Composite resins

After applying adhesive to the exposed dentin surface, composite resins (Clearfil Majesty Posterior light cure composite, Shade A2- Clearfil DC Core Plus Automik, Shade Dentin; Kuraray Noritake Dental Inc, Japan) was applied in two layers using a silicone mold with a height of 4 mm and a diameter of 4 mm (Elite HD+, Zhermack SpA, Badia Polesine, Italy). Each layer was polymerized using an LED device (D-Light Duo 1200-1300 mW/cm², GC, Tokyo, Japan) for 20 seconds. The completed restorations were kept in an incubator in distilled water at 37 °C for 24 hours.

4. Shear bond strength tests

To measure shear bond strength, a universal testing machine (AGS-X, Shimadzu, Japan) was employed, and a stainless-steel rod with a blade-shaped tip was secured to the upper movable arm of the testing apparatus. The platform to which the samples were affixed was positioned at the lower part of the testing apparatus. A force was exerted parallel to the acrylic surface, employing the thin blade of the device, with a speed of 1 mm per minute, originating from the point where the dentin surface met the composite cylinder. Application of shear force continued until the joint surface fractured, and the measured force values were noted in MPa.

5. Failure Analysis

The fracture surfaces of each shear bond strength-tested sample were analyzed under a stereomicroscope (Olympus SZ4045 TRPT, Osaka, Japan) at a magnification of x20. The fracture patterns were classified based on the failure characteristics of the bonding surfaces, including adhesive fractures (within the resin composite), cohesive fractures (within the dentin), and mixed fractures (involving both the interface and the dentin or composite)

7. Statistical Analysis

Mean shear bond strength values are obtained and subjected to statistical analysis using SPSS software (version 20.0; SPSS Inc., Chicago, IL, USA). One-way ANOVA test was used for evaluation of overall significance ($p<0.05$). The relationship between the application mode and the type of composite was examined for each adhesive using the Tukey HSD Test. Additionally, the failure analysis included the assessment of both quantitative and percentage-based data.

Results

Shear Bond Strength (SBS): In our study, the data on the dentin bond strength of the light cure and dual cure composite material with three universal bonding agents in different polymerization modes were analyzed by ANOVA, and the results are shown in Table 3.

Table 3: Analysis of variance (ANOVA) results and interactions between groups

Source	DF	Mean of squares	F	P Value
Adhesive	2	35.887	9.757	.000*
Composite resin	1	87.802	23.872	.000*
Adhesive Curing mode	3	141.579	38.492	.000*
Adhesive*Composite resin	2	4.466	1.214	0.301
Adhesive*Curing mode	6	3.448	.938	0.472
Composite Resin* Curing mode	2	40.717	11.070	.000*
Adhesive* Composite resin* Curing mode	6	4.266	1.160	0.334
Error	104	3.678		
Total	130			

Significant statistical variations were noted among the adhesives, composite resins, and curing modes ($p<0.05$). An interaction was detected between composite and adhesive curing mode. Table 4 displays the shear bond strength test results, represented as mean ± standard deviation values (MPa).

Table 4: Mean, standard deviation values (MPa) and Tukey HSD test results of bond strength

			Light Cure Composite	Dual Cure Composite
Adhesives	Adhesive Curing mode	N	Mean ± STD	Mean ± STD
Prime Bond Universal(PB)	Light Cure	10	11.47 ± 3.01 [A, a]	6.68 ± 0.93 [B, ab]
	Dual Cure	10	7.59 ± 1.57 [A, ab]	9.63 ± 2.28 [A, a]
	Self-Cure	10	6.18 ± 2.76 [A, b]	6.01 ± 2.35 [A, b]
Clearfil Universal Quick Bond(CU)	Light Cure	10	11.57 ± 3.95 [A, a]	6.46 ± 1.41 [B, a]
	Dual Cure	10	7.40 ± 2.61 [A, a]	7.82 ± 1.26 [A, ab]
	Self-Cure	10	4.74 ± 0.57 [A, ab]	5.41 ± 1.64 [A, a]
G-Premio Bond(GP)	Light Cure	10	7.46 ± 1.08 [A, a]	5.87 ± 1.61 [A, a]
	Dual Cure	10	5.64 ± 1.78 [A, b]	5.69 ± 0.73 [A, a]
	Self-Cure	10	3.20 ± 0.64[A, c]	6.17 ± 2.19 [B, a]
Clearfil SE Bond(CSE) (Control)	Light Cure	10	14.51 ± 2.99 [A, a]	7.46 ± 1.26 [B, a]

*Different capital letters within the same row represent statistically significant differences between adhesive curing methods and composite resins Light &Dual cure) (HSD test: $p<0.05$). Different lowercase letters within each adhesive column indicate statistically significant differences among curing methods (HSD test: $p<0.05$).

The samples restored with the light-cure composite using CSE as the control group exhibited the highest shear bond strength, measuring 14.51 MPa. In specimens where the adhesive was applied in self-cure mode, all universal bonding agents demonstrated the lowest bonding values. The GP samples yielded the lowest value at 3.20 MPa.

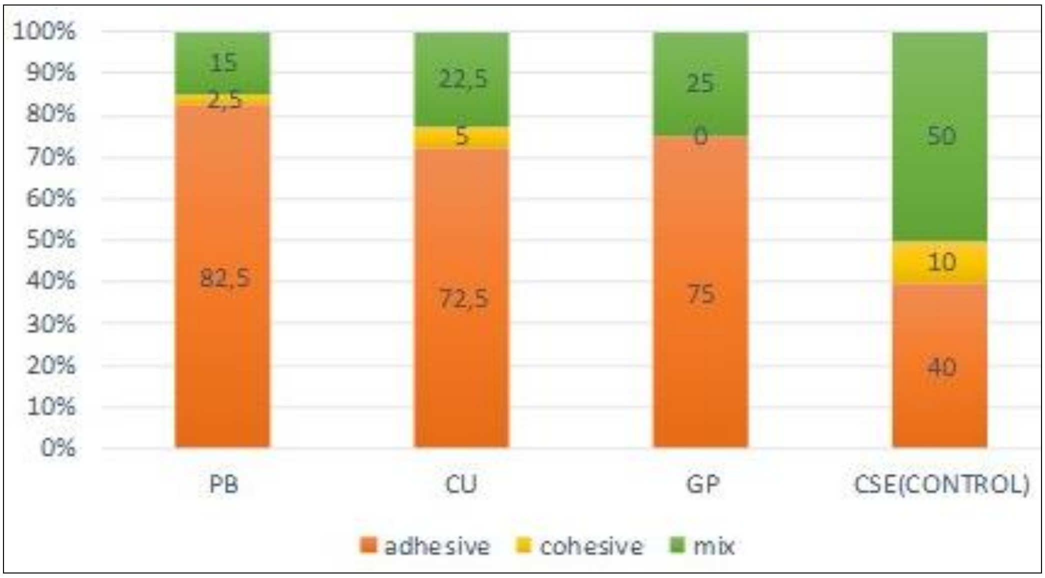
Based on the results of the bond strength analysis for PB and CU in the light-cure mode, specimens restored with the light-cure composite (PB: 11.47 MPa, CU: 11.57 MPa) demonstrated significantly higher strength values ($p<0.05$) in comparison to those restored with the dual-cure composite (PB: 6.68 MPa, CU: 6.46 MPa). Nonetheless, a notable significant disparity was observed between the strength values of the dual-cure composite (6.17 MPa) and the light-cure composite (3.20 MPa) in cases where GP was applied in the self-cure mode ($p<0.05$).

The PB and CU samples exhibited the highest bond strength values when restored with the light-cure composite in the light-cure mode (PB: 11.47 MPa, CU: 11.57 MPa) It's noteworthy that there were no significant differences observed among the various curing methods (p>0.05). In contrast, for the GP samples, the highest bond strength values were found in samples restored with the light-cure composite using the light-cure mode of the adhesive (7.46 MPa). Importantly, a notable difference was observed when compared to the dual-cure mode ($p<0.05$)

In the case of the PB and CU samples restored with the dual-cure composite, the highest bond strength was observed when the dual-cure mode of the adhesives was used (PB: 9.63 MPa, CU: 7.82 MPa). Importantly, no significant differences were detected among the curing modes (p>0.05).

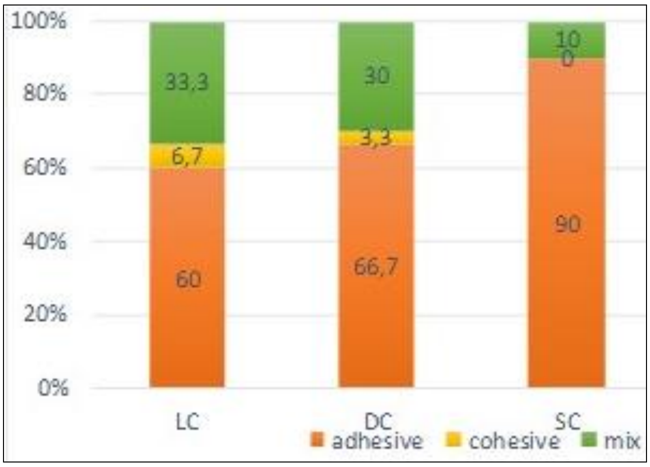
As for the GP samples, in the specimens restored with the dual-cure composite, the highest bond strength was achieved in the adhesive's self-cure mode (6.17 MPa). However, it's worth noting that there were also no significant differences found among the curing modes (p>0.05).

Failure Analysis
After the shear bond strength test was applied, failure types were categorized as adhesive, cohesive and mixed type under a stereomicroscope. The failure rates were evaluated as percentages (Figures 2, 3).



* PB: Prime Bond Universal, CU: Clearfil Universal Bond Quick, GP: G-Premio Bond, CSE: Clearfil SE Bond

Fig 2: Types of bond failure according to the adhesive agent applied



*LC: Light Cure, DC: Dual Cure, SC: Self-Cure

Fig 3: Types of bond failure according to polymerization modes

Adhesive failure (73.8%) was the most common in all samples, followed respectively by mixed failure (23.1%) and cohesive failure (3.1%).
Figure 1. Displays the percentages of failure types based on the adhesive agent. The control group had the highest mixed-type failure rate (50%). In the universal bonding agents, the percentage of adhesive-type failures was found to be the highest.
Figure 2 shows the percentages of the bond failure types according to the polymerization modes. Although adhesive type failure was the most common in all polymerization modes, the percentage of adhesive failure was higher in the self-cure than in the other modes.

Discussion
In this study, the bond strength of light cure and dual cure composites to the dentin with different polymerization modes of 3 different universal adhesives was evaluated using the shear bond test.
Residual acidic monomers in self-etch systems with pH < 3 inhibit the polymerization reaction initiated by peroxide-amine redox catalysts in self- and dual-polymerized composites, thereby deactivating the initiator component. Hence, a weak bond forms between self-curing and dual-curing composites and acidic adhesive systems [7, 9-11]. Tay *et al.* [7], in their study aimed at determining whether the chemical interaction between self-etch adhesives and self-cure and dual-cure composites is responsible for incompatibility, demonstrated that the reaction between the tertiary amine of the composite and the acidic monomer of the adhesive led to the failure of the bond. Furthermore, they reported that the use of a co-initiator could potentially enhance the bond strength.
The pH levels of universal adhesives typically fall within the range of 1.5 to 3.2 [12]. Previous studies [9, 13] have noted the incompatibility of these adhesives with self-cure and dual-cure resin composites. In response to this issue, some manufacturers have introduced universal adhesives with higher pH (> 3) [14]. Furthermore, some manufacturers have recommended using dual-cure activators in conjunction with the adhesive to resolve this issue. Michaud *et al.* [15]. investigated the compatibility of 3-stage total etch, 2-stage total etch and universal adhesive agents with dual cure composite material using the shear bond test. The 3-stage total etch adhesive system showed the most successful bonding result. The reason for this was the lower pH value of the other 2 adhesive systems. The authors also reported that the dual cure composite was also significantly effective on this incompatibility. There are other studies showing that different brands of dual cure composite materials have different sensitivity to the pH values of adhesive systems [16, 17].
In our study, the correlation of the strength results with the dual cure composite type was found to be significantly lower for PB and CU compared to the light-cured composite ($p<0.05$). Although the difference was not significant for GP, the connection strength with the dual cure composite was found to be lower.
Activators are derived from aryl sulfinate salts, and their interaction with acidic monomers results in the generation of phenyl or benzene sulfonyl free radicals. These free radicals play a pivotal role as initiators for the chemical

polymerization process within the adhesive system [6]. Activators are recognized for their potential contribution to the enduring success of bonding by elevating the level of polymerization conversion in adhesive systems [18]. Notably, certain universal adhesives do not necessitate the incorporation of an additional activator. For instance, All-Bond Universal exhibits a notably lower acidity level at a pH of 3.2 in contrast to other universal adhesives. On the other hand, adhesives like OptiBond XTR and Futurabond Universal include an activator as part of their formulation [19]. Consequently, it has been reported that when employing self- or dual-cure resin-based materials for polymerization, the need for a separate dual-cure activator is obviated [20].

Rathke *et al.* [21] undertook a study to explore the consequences of employing total etch and self-etch adhesive systems along with different polymerization modes on the bond strength between dentin and a dual-cure composite. Their research revealed that the utilization of activators did not lead to a significant enhancement in dentin bond strength. Additionally, Elsayed *et al.* [22] conducted research to evaluate the impacts of varying application and polymerization modes of universal adhesives on the shear bond strength of a dual-cure composite when applied to dentin surfaces. Activator use was found to negatively affect connection strength. In both studies cited above, it was thought that the amount of solvent in the activator diluting the bonding agent affected the bond strength negatively [21]. Elsayed *et al.* [22] stated that manufacturers should adjust the solvent content at a rate that does not dilute the monomer content when a universal adhesive and a dual cure activator are used together.

It has been shown in other studies that the use of activators cannot reverse incompatibility with dual cure materials [17, 23-25]. In many studies, it has been stated that the reason for this situation may be the dilution of the adhesive resin by the activator [10, 25, 26].

The pH values of the PB, CU and GP universal adhesives specified by the manufacturers are respectively 2.5, 2.3 and 1.5. Due to the incompatibility that may occur during their use with a dual cure composite, we evaluated their use with dual cure activators in our study. Although the addition of the adhesive dual cure activator showed a slight increase in the shear bond strength values in the PB and CU samples, this increase was not statistically significant. In the GP samples, the bond strength decreased in the dual cure mode and increased slightly in the self-cure mode. We think that this situation was caused by the fact that the adhesive shows an increase in the solvent ratio when mixed with the activator due to the presence of the solvent in the activator. Universal adhesives need to strike a delicate balance in terms of acidity. They should possess sufficient acidity to function effectively in the self-etch mode, yet not be overly acidic to the extent that they compromise the integrity of initiators necessary for the polymerization of both self-cure and dual-cure materials [20].

Attaining optimal monomer infiltration and achieving a high degree of polymerization conversion are critical factors for ensuring long-term and high adhesive bond strength. Research has demonstrated that protocols designed to enhance the polymerization conversion of adhesives, especially in deep cavities, can have a positive impact on the enduring bond strength of restorations [18, 27]. The utilization of dual-cure adhesive systems can also have a beneficial influence on the bond strength of light-cure composites to dentin by elevating the degree of polymerization conversion. In a study by Borges *et al.* [18], they investigated the bond strength of a light-cure composite applied to the dentin surface of bovine teeth using both 3-stage and 2-stage total-etch adhesive systems in both light-cure and dual-cure modes. Their findings indicated that the inclusion of a dual-cure activator enhanced the bond strength in total-etch adhesive systems.

In our study, the highest bond strength values for all three universal adhesives were achieved in the light-cure mode without the use of an activator. The bonding efficiency of the light-cure composite to dentin was negatively affected in all adhesive groups by the use of the dual-cure activator. As in the groups we restored with the dual cure composite, the decrease in the success of the bond may have occurred due to the dilution of the bonding agent by the solvents in the activator. Our first hypothesis was not rejected as the use of universal adhesives with dual-cure activators did not have a significant effect on the adhesion of light-cured and dual-cured composites to dentin.

Gutiérrez *et al.* [8] investigated the bond strength of dual cure composite materials by polymerizing universal adhesives that they applied in the self-etch mode, by light cure, dual cure and self-cure. In the PB used in their study, lower bond strength values were found in the light cure mode compared to the dual cure and self-cure modes. The adhesives were not significantly affected by the polymerization modes. Adding the dual cure activator to the universal adhesives and using different polymerization protocols affected shear bond strength, but this effect was found to be material dependent.

In our study, we observed that the bond strength values in groups where we applied the dual-cure composite were generally lower in the light-cure mode compared to the dual-cure mode, specifically for the PB and CU samples. This finding indicates that the utilization of the dual-cure activator partially mitigated the incompatibility between the dual-cure composite and the adhesive agent. However, in the case of GP samples restored with the dual-cure composite, we noticed a lower bond strength in the dual-cure mode compared to the light-cure mode, suggesting that the impact of activator use could vary depending on the specific adhesive material employed.

Additionally, when examining the self-cure polymerization mode, we observed a decrease in bond strength across all groups, with the exception of the GP group where the dual-cure composite was used. This discrepancy in the effect of polymerization modes and activator usage among the different universal bonding agents utilized in our study may be attributed to variations in the compositions of these adhesive materials.

Ultimately, the application of universal adhesives in distinct polymerization modes had discernible effects on the bonding of similar composite types to dentin. As a result, our third hypothesis, which posited no significant differences, had to be rejected.

The fracture types frequently seen in adhesive system failures are adhesive fractures. The increase in the bond strength of adhesive systems increases the incidence of cohesive and mixed fracture types [28]. In the universal adhesive systems and in all polymerization modes in our study, the adhesive type of failure was observed most frequently. The adhesive failure rate was higher in the self-cure mode in comparison to the other polymerization modes.

Conclusion

The results obtained within the scope of this study were as follows:

1. The highest bond strength values among all universal

bonding agents were observed in the light cure mode of the adhesive in the specimens restored with the light cure composite.
2. The use of the universal adhesive systems with the dual cure activators caused a decrease in the bond strength of the light cure composite to the dentin.
3. The universal adhesive exhibited incompatibility with the dual-cure composite, and the inclusion of dual-cure activators did not effectively resolve this issue.

Regarding the use of universal adhesive systems with dual cure activator, there is limited literature on the effect of both light-cured and dual-cured composite resins on dentin bond strength. Therefore, more *in vitro* and *in vivo* studies are needed to evaluate the effect of activator use on bond strength.

Clinical significance
Within the limitations of this study, the incorporation of a dual-cure activator alongside the universal adhesive did not yield the anticipated enhancement in the bond strength values of both light-cured and dual-cured composites to dentin.

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Conflict of Interest
Not available

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Not available

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