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Research Article

EFFECT OF AIR-BLOWING PRESSURE ON DENTIN BOND STRENGTH OF UNIVERSAL ADHESIVES: AN IN VITRO STUDY

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ABSTRACT

Objective: This study investigated the shear bond strength of universal adhesive systems applied to dentin at different air-blowing pressures.

Materials and Methods: Flat dentin surfaces were prepared from 120 freshly extracted, caries-free human molar teeth. Three universal adhesives were used: G-Premio Bond, Clearfil S3 Bond Universal, and Scotchbond Universal. The samples were randomly divided into groups according to the adhesives and the air-blowing pressures (0.14 MPa, 0.28 MPa and 0.41 MPa) (n=10). In each adhesive system, an unpressurized group was designated as the control group (n = 10). The shear bond strength values were measured using a universal testing device (Instron 3344, Instron Corp, Wilmington, USA). The data were analyzed using ANOVA and Tukey's post hoc test at a significance level of 0.05.

Results: Both the adhesive system ($p<0.001$) and air-blowing pressure ($p<0.001$) significantly affected shear bond strength, with a significant interaction between the two factors ($p=0.002$). The highest mean value was obtained at a pressure of 0.41 MPa in the SU group (17.40±6.01), 0.14 MPa in the CU group (17.52±4.46), and 0.28 MPa in the GP group (10.05±3.89).

Conclusion: The influence of air-blowing pressure on bond strength depended on the adhesive, and each material showed a different optimal air-blowing pressure for achieving the best bonding performance.

Keywords: Air-blowing, Bond Strength, Dentin, Pressure, Universal adhesive

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INTRODUCTION

Solvents in bonding agents, such as acetone, ethanol, and water, enable hydrophilic and hydrophobic particles to combine in a single solution while also facilitating monomer infiltration due to the moist structure of the dentin (1-4) Water and organic solvents are fundamental components of single-step adhesive systems. Still, they should be eliminated during clinical applications. Any remaining water and solvents in the adhesive may negatively impact the polymerization process by diminishing the quality of the hybrid layer (4-7).

Studies have shown that differences in manufacturer's instructions may affect bond strength differently (8, 9). Evaporation caused by air blowing has been reported to affect the microtensile and shear bond strength of all-in-one systems (6, 8-10). Although the air-blowing pressure applied by the manufacturer's instructions is classified as gentle, mild, and strong, a clear numerical value regarding pressures has not been given. There is very limited information in the literature on this issue.

Air-blowing pressure depends on various factors that cannot be controlled entirely, which can significantly affect the output pressure in the air gun (1, 11, 12). Some factors that influence air-blowing pressure include the pressure of the compressor, the number of dental units connected to the compressor, the presence of leaks in the hoses, and how many devices are connected simultaneously (3, 13, 14). Output pressure could be determined by connecting the manometer directly to the equipment (8, 12, 13).

The study analyzed the dentin bond strength of universal adhesive systems under varying air-blowing pressure conditions. To provide a comprehensive evaluation, three universal adhesives with different chemical compositions were selected. These adhesives vary in their solvent systems—ethanol-, acetone-, or water-based—and whether they contain functional monomers like 10-MDP and HEMA, which are known to affect adhesive penetration, hybrid layer formation, and overall bonding performance. Including adhesives with different formulations enabled the assessment of whether compositional differences interact with air-blowing pressure to influence dentin bond strength. The null hypothesis stated that variations in air-blowing pressures would not influence shear bond strength.

MATERIALS AND METHODS

The sample size was calculated using G*Power 3.1.9.4. Based on the results of a pilot study conducted under similar experimental conditions, an effect size of 0.39 was determined and used for the calculation. When Power (1-β) = 0.80, the minimum required sample size was 116. In this study, 120 samples were evenly distributed among the subgroups.

Table 1. Universal systems used in the study

Material	Chemical Formulation	Manufacturer	Manufacturer's Instructions
G-PREMIO BOND (GP) (Lot no:1611071)	4-MET, phosphate monomer, UDMA, water, acetone, silica filler, photoinitiators	GC Corp, Tokyo, Japan	-Apply for 10 s by rubbing. -Dry for 5 s with strong air-blowing pressure. -LC for 10 s.
SCOTCHBOND UNIVERSAL (SU) (Lot no: 3767361)	10-MDP phosphate monomer, Vitrebond copolymer, HEMA, Bis-GMA, silane, dimethacrylate resin, initiators, ethanol, water	3M ESPE, St. Paul, MN, USA	-Apply for 20 s by rubbing. -Dry for 5 s with gentle air-blowing pressure. -LC for 10 s.
CLEARFIL S³ BOND UNIVERSAL (CU) (Lot no: BD0070)	10-MDP, Bis-GMA, HEMA, hydrophilic amine monomers, colloidal silica, silane, sodium fluoride, di-camphoroquinone, ethanol, water	Kuraray Noritake Dental Inc, Okayama, Japan	-Apply for 20 s by rubbing. -Dry for 5 s with mild air-blowing pressure. -LC for 10 s.

Sample preparation

A total of 120 caries-free human molars, extracted within the last six months for periodontal and prosthetic purposes and stored frozen at -20°C, were used. After removing dental calculus with a periodontal curette, the teeth were embedded in acrylic resin with their crowns exposed. The coronal enamel of each tooth was sectioned using a low-speed diamond saw (Isomet Low-Speed Saw 1000; Buehler, Lake Buff, IL, USA). The dentin surfaces were then smoothed with 600- and 1000-grit silicon carbide (SiC) papers for 60 seconds under continuous water cooling to achieve a consistent smear layer.

Adhesive application procedure

Three universal adhesive systems were used in the study: G-Premio Bond (GP), Scotchbond Universal (SU) and

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Clearfil S3 Bond Universal (CU). Table 1 summarizes the chemical compositions and manufacturer-recommended application protocols of the adhesive systems. The groups were further divided into four subgroups according to the air-blowing pressures applied (n=10) In the randomly selected groups, the air-blowing pressure was adjusted to 0.14 MPa (20 psi), 0.28 MPa (40 psi), and 0.41 MPa (60 psi) using a manometer connected to the air-water spray of the unit (Figure 1). The manometer was calibrated before each measurement to verify the accuracy of the air-blowing pressure and ensure consistent pressure during adhesive application. A control group was designated for each adhesive system (n=10). The control groups were unpressurized and exposed to a soft, unmeasured breeze from a distance.

Figure 1. Setting the air-blowing pressure to 40 psi using a manometer connected to the unit

Each adhesive system was applied in a single layer, following its manufacturer's guidelines and instructions. The air-blowing duration was set to 5 seconds. The head of the air gun was adjusted to be perpendicular to the dentin surface from a distance of 2 cm (13). The air gun remained stationary in the center of the application area. The air was also filtered to remove oil and water contaminants.

Composite resins (Z250, 3M ESPE, St. Paul, MN, USA) were applied to the dentin using transparent molds with a 4 mm diameter and a 3 mm height. The composite resins were applied in two layers, and each layer was cured for 15 seconds using an LED device (Zenolite, President Dental GmbH, Germany). The LCU irradiance was measured at 1200 mW/cm2 using a radiometer. The LCU battery was wholly charged before irradiation. The same operator performed all steps.

Shear bond strength testing

The samples were kept in distilled water for 24 hours to complete polymerization. Shear bond strength (SBS) was then tested using a universal testing machine (Instron 3344, Instron Corp., Wilmington, USA) at a crosshead speed of 1 mm/min until bond failure occured. SBS values were calculated by dividing the maximum load at failure (N) by the 120 bonding area (mm^2) and expressed in megapascals (MPa) (MPa = N / mm^2).

Table 2. Mean shear bond strength (MPa) ± standard deviation of three universal adhesive systems at different air-blowing pressures

MATERIAL	Control	PRESSURE 20 Psi (0.14 MPa)	40 Psi (0.28 MPa)	60 Psi (0.41 MPa)	*p*
G-PREMIO BOND (GP)	5.52 ± 1.30 ^{C}	7.12 ± 2.29 ^{BC}	10.05 ± 3.89 ^{A}	8.53 ± 2.21 ^{AB}	0.006
SCOTCHBOND UNIVERSAL (SU)	6.37 ± 5.85 ^{C}	15.37 ± 4.95 ^{AB}	10.77 ± 4.00 ^{BC}	17.40 ± 6.01 ^{A}	<0.001
CLEARFIL S^{3} BOND UNIVERSAL (CU)	9.91 ± 1.71 ^{B}	17.52 ± 4.46 ^{A}	10.85 ± 5.93 ^{B}	12.91 ± 5.29 ^{B}	0.007

Different superscript letters in the duplicate rows are significantly different ($p<0.05$).

Statistical Analysis

Statistical analysis was performed using IBM SPSS Statistics for Windows, Version 27.0 (IBM Corp., Armonk, NY, USA). The Shapiro–Wilk test was used to assess the normality of data distribution, and the Levene's test was applied to evaluate the homogeneity of variances. Two-way analysis of variance (ANOVA) was used to evaluate the effects of the adhesive system and air-blowing pressure on SBS. Since a significant interaction was found, additional one-way ANOVA tests were performed within each adhesive system and within each air-blowing pressure level, followed by Tukey's post-hoc test for multiple comparisons (α=0.05).

Field-Emission Scanning Electron Microscopy (FESEM)

Twelve human molar teeth, one per group, were used for FESEM imaging. After applying the bonding agent and composite resin, the samples were cut in half from the middle, aligning with the long axis of the tooth and perpendicular to the adhesive inner surface. The cut surfaces were polished with 600-grit silicon carbide sandpaper, using a constant water-cooling stream. After applying the diamond gloss polish (TDV Dental Ltd, Pomerode/SC, Brazil, LOT: 1501327501), the samples were cleaned in an ultrasonic bath for 10 minutes. Next, the samples were immersed in 1 M hydrochloric acid for 30 minutes, then in 5% sodium hypochlorite for 5 minutes, and finally rinsed with water. The samples were dehydrated with 99% ethanol and then gold-coated. The thickness of the adhesive layers was quantitatively measured using the built-in scale bar of an FESEM (Zeiss

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Sigma 300, Hamburg, Germany) at a magnification of ×1000.

Evaluation of failure modes

Failure modes were assessed using a stereomicroscope (×40 magnification; Olympus SZ61, Tokyo, Japan) after debonding. Each specimen was examined to identify the location and type of fracture. The failure modes were categorized into three types: adhesive failure (at the adhesive–dentin interface), cohesive failure (within the dentin or composite resin), and mixed failure (a combination of adhesive and cohesive failures).

RESULTS

Table 2 presents the mean and standard deviation (SBS) values for all experimental groups. The two-way ANOVA revealed that both the adhesive system and air-blowing pressure had statistically significant effects on SBS ($p<0.001$), with a significant interaction also observed between the two factors ($p=0.002$). GP showed significantly lower SBS than CU and SU ($p<0.001$). Overall, each adhesive exhibited a specific air-blowing pressure at which SBS values generally peaked. The highest SBS values were recorded at 0.41 MPa for SU, 0.14 MPa for CU, and 0.28 MPa for GP. Because the interaction was significant, the impact of air-blowing pressure was further examined within each adhesive system using one-way ANOVA followed by Tukey post-hoc tests.

For GP, a significant difference was observed among the air-blowing pressure groups ($p=0.006$). Post-hoc analysis revealed that statistically significant differences were present between the control and 0.28 MPa groups ($p=0.005$), as well as between the control and 0.41 MPa groups ($p=0.011$). The highest mean SBS value was obtained at 0.28 MPa.

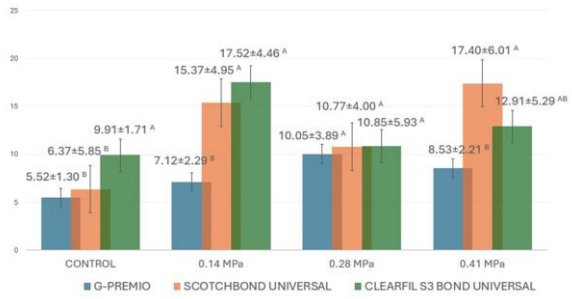

Figure 2. Mean SBS values of universal adhesive systems at each air-blowing pressures. Within each pressure level, different uppercase letters indicate significant differences among adhesives (Control: $p=0.038$; 0.14 MPa: $p<0.001$; 0.28 MPa: $p=0.924$; 0.41 MPa: $p=0.030$)

For SU, air-blowing pressure had a highly significant effect ($p<0.001$). Tukey post-hoc comparisons revealed significant differences between the control and 0.14 MPa ($p=0.006$), and control and 0.41 MPa ($p=0.001$). The maximum SBS was achieved at 0.41 MPa. SBS values indicate that increasing the air-blowing pressure from the control condition to 0.14 MPa, then to 0.41 MPa, significantly enhanced bond strength. In contrast, intermediate air-blowing pressure levels produced outcomes comparable to the control condition.

For CU, one-way ANOVA also revealed a significant difference among the air-blowing pressure groups ($p=0.007$). Post-hoc comparisons showed significant differences between the control group and 0.14 MPa ($p=0.009$), between 0.14 and 0.28 MPa ($p=0.028$), and between 0.14 and 0.41 MPa ($p=0.03$). The highest SBS value was obtained at 0.14 MPa, indicating that the lowest pressure level yielded the greatest bond strength for this adhesive system.

The mean SBS values of the three universal adhesives at each air-blowing pressure level are shown in Figure 2. At 0.14 MPa, SBS values differed significantly among the adhesives ($p<0.001$), and both SU and CU exhibited significantly higher SBS than GP. No significant differences among adhesives were observed at 0.28 MPa ($p=0.924$). At 0.41 MPa, the adhesive systems again showed significant variation ($p=0.030$), with SU demonstrating the highest SBS value, followed by CU, and GP showing the lowest. Under control conditions, CU presented significantly higher SBS than both GP and SU ($p=0.038$), indicating a superior baseline performance for this adhesive.

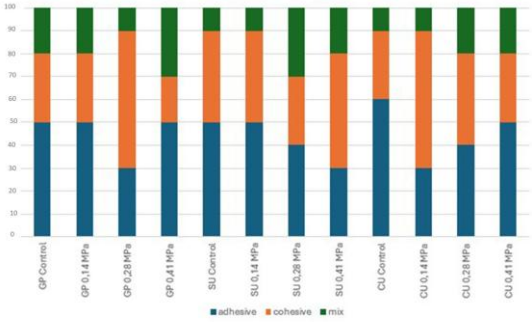

Figure 3. Failure modes of adhesive systems

Failure modes

Figure 3 illustrates the distribution of failure modes. Across all adhesive systems, failure mode distribution varied notably with the applied air-blowing pressure, and

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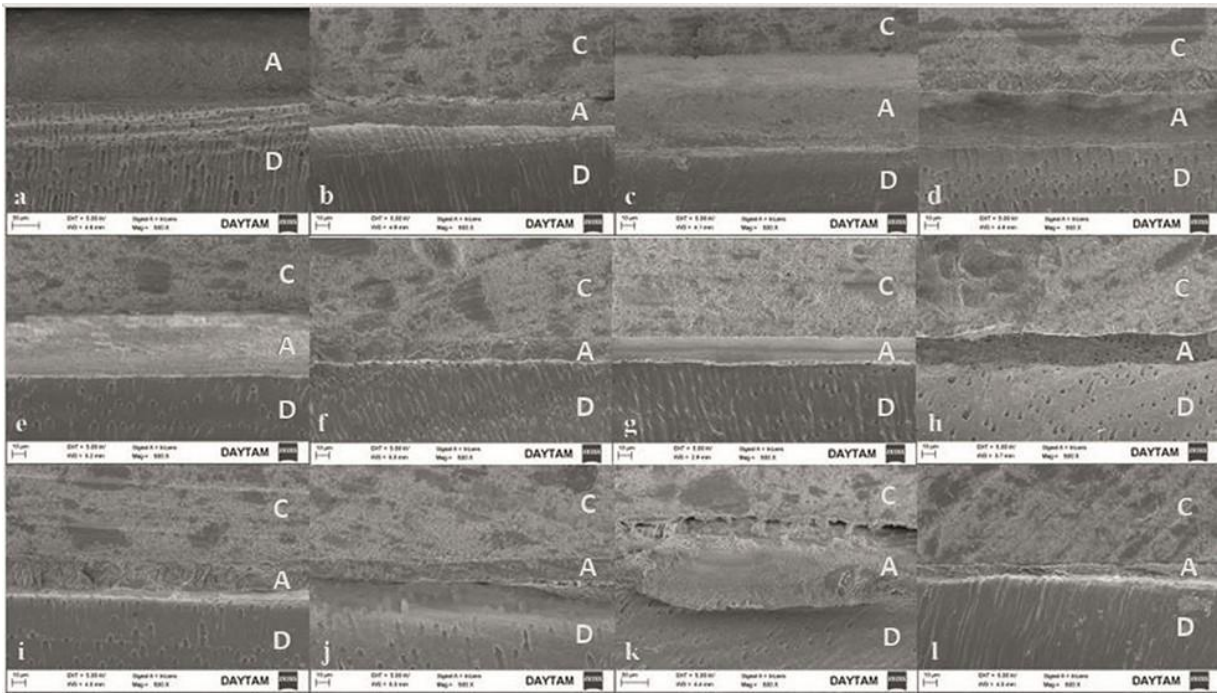

Figure 5. FESEM images of resin-dentine interfaces under x1000 magnification. The scale bar represents 20 μm. a: GP Control, b: GP 0.14 MPa, c: GP 0.28 MPa, d: GP 0.41 MPa, e: SU Control, f: SU 0.14 MPa; g: SU 0.28 MPa, h: SU 0.41 MPa, i: CU Control, j: CU 0.14 MPa, k: CU 0.28 MPa, l: CU 0.41 MPa. In all photos, C: composite, A: adhesive layer, and D: dentin

each adhesive exhibited pressure-dependent increases in cohesive failures at its characteristic pressure level.

GP exhibited adhesive-dominant failures at lower pressures, with a substantial rise in cohesive failures at 0.28 MPa (60%). SU showed similar behavior, with adhesive- and cohesive-dominant patterns alternating across pressures; at 0.28 MPa, failures were balanced (40% adhesive, 30% cohesive, 30% mixed), whereas cohesive failures became predominant at 0.41 MPa (50%). CU demonstrated adhesive dominance in the control group but showed a sharp increase in cohesive failures at 0.14 MPa (60%). Representative stereomicroscopic images of 222 adhesive, cohesive, and mixed failures are provided in Figure 4.

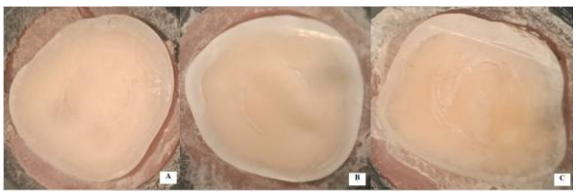

Figure 4. Images obtained under x20 magnification of stereomicroscope showed (A) adhesive failure, (B) cohesive failure, and (C) mixed failure

FESEM observations of the resin-dentin interface

FESEM analysis revealed that all universal adhesive systems exhibited effective bonding to the dentin surface. The thicknesses of the hybrid layers were assessed in the micrograph of the pressure-applied groups (Figure 5). Thicker hybrid layer formation was observed with GP at 0.28 MPa, SU at 0.41 MPa, and CU at 0.14 MPa air-blowing pressure applications.

DISCUSSION

The results of this study revealed that the applied air-blowing pressures significantly affect the bond strength of universal adhesives, leading to the rejection of the null hypothesis that bonding performance would not be influenced by air-blowing pressure. Since universal systems have different chemical compositions, they also vary based on their application procedures, such as coating form, waiting time, and air-blowing pressure (1, 13) Studies have indicated that bond strength can be influenced by both air-blowing pressure and the duration of its application (8, 11, 15, 16). In particular, variations in pressure intensity have been shown to differently affect the dentin bond strength of all-in-one adhesive systems (8, 12, 17, 18).

Although the manufacturer recommends air-blowing pressure as gentle, mild, or strong, no specific numerical values are provided for these categories. The available literature on this topic offers minimal information. De Munck et al. (18) reported a gentle air-blowing pressure of

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0.1 MPa and a high pressure of 0.4 MPa. Spreafico et al. (17) reported a gentle pressure of 0.12 MPa and a high pressure of 0.68 MPa. Based on these studies, a mild air-blowing pressure was later defined as 0.25 MPa (11, 12). The head of the air gun was positioned 2 cm from the dentin surface, which was considered the closest value reported in the literature (12, 13, 17).

The functional monomer 10-MDP found in universal adhesives contributes to their strong bonding capabilities (19, 20). 10-MDP creates a stable nanolayer at the adhesive interface. MDP-Ca salts precipitate along this layer, providing high and stable bond strength (21). The high bonding values for SU and CU may be attributed to the 10-MDP functional monomer in their composition. SU also contains the polyalkenoic acid copolymer, known as Vitrebond copolymer (VCP). More than 50% of the carboxylic groups in the copolymer can replace phosphate ions and form chemical bonds with hydroxyapatite (22). Studies have shown that self-etch systems are very effective in adhesion through these two chemical bonding processes (21).

SU and CU are adhesive systems containing HEMA. HEMA is a hydrophilic monomer that promotes better wetting and penetration into moist dentin, improves monomer miscibility in water-containing environments, and stabilizes the hybrid layer, preventing phase separation. This greatly improves the bond strength between the adhesive and dentin (2, 16, 21). Ethanol, which enhances the infiltration of resin monomers into the collagen matrix and reduces nanophase separation of the adhesive component, evaporates more slowly than acetone, resulting in a more controlled drying process (3, 4, 13). Combining HEMA with water and ethanol enhances wettability in SU and CU, potentially contributing to the improved bonding performance of these adhesives.

The absence of HEMA in G-Premio Bond (GP), combined with its acetone–water-based solvent system, renders it more sensitive to air-drying pressure compared to systems like SU or CU. Without HEMA, GP lacks this buffering capacity, making the adhesive layer more vulnerable to the effects of rapid solvent evaporation (9). If air-blowing pressure is too high or prolonged, the acetone–water solvent may evaporate too quickly, leading to incomplete resin infiltration or collapse of the exposed collagen network. This can ultimately compromise the formation of a stable hybrid layer and reduce bond strength (15, 16).
The lower bond strength of GP compared to SU and CU may largely result from formulation differences, such as the absence of HEMA, the quick evaporation of acetone, and the lack of stabilizers like Vitrebond copolymer. Additionally, during the air-blowing process, these component differences are crucial for monomer penetration into dentin, effective solvent removal, and hybrid layer formation. This directly influences clinical success and the long-term bond strength. Mild air-blowing pressure in the GP might have permitted these procedures to be carried out safely and efficiently.

Solvent evaporation, viscosity, and inorganic fillers influence film thickness and uniformity. These factors ultimately impact SBS by affecting resin penetration, hybrid layer formation, and the quality of the mechanical bond (3, 10). Applying high air-blowing pressure to low-viscosity adhesives, like CU, creates an extremely slim adhesive film layer, resulting in a weak hybrid layer. The filler content is minimal, leading to decreased mechanical strength. Medium-viscosity adhesives, like SU, are more resistant to air-blowing pressure. Since they contain some filler, they create a more uniform film thickness. Under strong air-blowing pressure, SU performed well, maintaining proper film thickness and hybrid layer quality. Because CU is a low-viscosity, water-rich solvent, it might have performed better at gentle air-blowing pressure.

Among the three adhesive groups, the lowest bond strength was observed in the unpressurized control groups. This occurs because the solvent was not fully removed, staying on the surface and reducing the monomer concentration. As a result, polymerization was insufficient, leading to low bond strength.

The incorporation of an elastic intermediate layer in composite restorations is believed to reduce the stress caused by polymerization shrinkage. This layer can absorb some of the stresses generated during the curing process, thereby improving the longevity of the restoration (23). The hybrid layer created during the bonding process has a lower modulus of elasticity compared to both composite resin and dentin (4, 7). This characteristic is important because it provides greater flexibility and more even stress distribution, minimizing the risk of debonding or failure at the interface. The optimal thickness of this hybrid layer is crucial for adequate bonding (15). Studies have shown that variations in air-blowing pressure during the adhesive application can influence the thickness and quality of the hybrid layer, thereby affecting the bond strength to dentin (15, 23). A thicker, well-formed hybrid layer tends to enhance bond strength due to better adhesive infiltration into dentin tubules (23). Considering the results of the study, the highest mean values were obtained at SU 0.41 MPa, CU 0.14 MPa, and GP 0.28 MPa

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air-blowing pressures. The FESEM images confirmed these findings, as evidenced by the qualitative observations in the micrographs.

A certain relationship was found between the bond strengths and failure types. It was observed that cohesive failure in dentin was higher in the groups with high bond strength, while adhesive failure was higher in the groups with lower bond strength. The results were in line with previous findings (24, 25).

According to the instructions for the systems selected in this study, CU requires mild air blowing for 5 seconds, and SU requires gentle blowing for 5 seconds.GB is the only system that requires strong air-blowing pressure for 5 seconds throughout. Since manufacturers typically recommend as 'blow gently with oil-free air for 5 seconds until the bond does not move', the air-blowing duration was standardized to 5 seconds. Some newer adhesive formulations claim to achieve adequate bond strength with reduced application times (approximately 5 seconds). However, there is limited evidence supporting the effectiveness of such short durations, particularly concerning long-term performance. As a result, the influence of air-blowing duration on the resin–dentin bond remains unclear and warrants further investigation. In the present study, the air-blowing time may have been insufficient for complete solvent evaporation, potentially compromising the mechanical properties and bond strength of the adhesive systems.

Another limitation of this study is that it was conducted in vitro. Three universal adhesive systems, applied in self-etching mode, were used in the study. It should be noted that the etch-and-rinse mode was not evaluated, which may limit the applicability of the findings to other bonding methods strategies. In different situations and clinical conditions, the optimal air-blowing pressure may be affected by several factors, including the compressor's pressure, the intensity and duration of the air-blowing pressure, cavity depth, shape, and temperature. Within our study's limitations, further investigations are necessary to assess the use of universal adhesives in self-etch and etch-and-rinse modes, and to evaluate long-term, real-time bonding durability.

CONCLUSION

Within the scope of this in vitro investigation, and based on the relationship between air-blowing pressure and SBS of universal adhesive systems, the study concludes that:

1. Air-blowing pressure greatly affects bond strength, and the impact differs depending on the adhesive system used.
2. Higher bond strength can be achieved by using mild air-blowing pressure on GP, gentle air-blowing pressure on CU, and strong air-blowing pressure on SU.

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Authorship contributions
BK; Methodology, Investigation, Resources, Data Curation, Writing - Original Draft, Visualization, Project administration. NÖ; Methodology, Software, Formal analysis Validation, Review & Editing, Supervision. YZB.; Conceptualization, Methodology, Validation, Writing - Review & Editing, Supervision.

Data availibity statement
The data supporting this study's findings are available from the corresponding author upon reasonable request.

Declaration of competing interest
There is no conflict of interest in this study.

Ethics
The study was approved by the Ethics Committee of Atatürk University Faculty of Dentistry (No:9/2018-76).

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REFERENCES

1. Fu J, Saikaew P, Kawano S, Carvalho RM, Hannig M, Sano H, et al. Effect of air-blowing duration on the bond strength of current one-step adhesives to dentin. Dent Mater 2017; 33(8): 895-903.
2. Jang JH, Jeon BK, Mo SY, Park M, Choi D, Choi KK, et al. Effect of various agitation methods on adhesive layer formation of HEMA-free universal dentin adhesive. Dent Mater J 2019; 38(1): 101-106.
3. Bourgi R, Hardan L, Cuevas-Suárez CE, Scavello F, Mancino D, Kharouf N, et al. The use of warm air for solvent evaporation in adhesive dentistry: A meta-analysis of in vitro studies. J Funct Biomater 2023; 14(5): 285.
4. Betancourt D, Baldion P, Castellanos J. Resin - dentin bonding interface: mechanisms of degradation and strategies for stabilization of the hybrid layer. Int J Biomater 2019(1); 5268342.

MMDJ
MEANDROS MEDICAL AND DENTAL JOURNAL
March 2026 27(1):41-48
Meandros Medical and Dental Journal
doi: 10.69601/meandrosmdj.1748086

5. Lawson NC, Robles A, Fu CC, Lin CP, Sawlani K, Burgess JO. Two-year clinical trial of a universal adhesive in total-etch and self-etch mode in non-carious cervical lesions. J Dent 2015; 43(10): 1229-1234.
6. Silva E, Penelas AG, Simmer FS, Paiva R, Moreira E, Poskus LT. Can the use of a warm-air stream for solvent evaporation lead to a dangerous temperature increase during dentin hybridization. J Adhes Dent 2018; 20: 335-340.
7. Stape THS, Tjäderhane L, Abuna G, Sinhoreti MAC, Martins LRM, Tezvergil-Mutluay A. Optimization of the etch-and-rinse technique: New perspectives to improve resin–dentin bonding and hybrid layer integrity by reducing residual water using dimethyl sulfoxide pretreatments. Dent Mater 2018; 34(7): 967-977.
8. Karalar B, Bayındır YZ. Effects of adhesive application time and air blowing pressure on
dentin bond strength of self-etch mode universal adhesives. J Adhes Sci Technol 2022; 36(3): 287-301.
9. Saikaew P, Matsumoto M, Chowdhury A, Carvalho R, Sano H. Does shortened application time affect long-term bond strength of universal adhesives to dentin? Oper Dent 2018; 43(5): 549-558.
10. Hardan L, Bourgi R, Kharouf N, Mancino D, Zarow M, Jakubowicz N, et al. Bond strength of universal adhesives to dentin: A systematic review and meta-analysis. Polymers 2021; 13(5): 814.
11. Fu J, Pan F, Kakuda S, Sidhu SK, Ikeda T, Nakaoki Y, et al. The effect of air-blowing duration on all-in-one systems. Dent Mater J 2012; 31(6): 1075-1081.
12. Daneshmehr L, Ozer F, Mante FK, Blatz MB. Relationship between air-blowing duration and bond strengths of three adhesive systems to dentin after thermal aging. Dent Mater J 2013; 32(5): 767-774.
13. Carvalho CN, Lanza MDS, Dourado LG, Carvalho EM, Bauer J. Impact of solvent evaporation and curing protocol on degree of conversion of etch - and - rinse and multimode adhesives systems. Int J Dent 2019; 2019(1): 5496784.
14. Chen Y, Yan X, Li K, Zheng S, Sano H, Zhan D,et al. Effect of air-blowing temperature and water storage time on the bond strength of five universal adhesive systems to dentin. Dent Mater J 2021; 40(1): 116-122.
15. Saikaew P, Fu J, Chowdhury AA, Carvalho RM, Sano H. Effect of air-blowing time and long-term storage on bond strength of universal adhesives to dentin. Clin Oral Investig 2019; 23(6): 2629-2635.
16. Saikaew P, Chowdhury AA, Fukuyama M, Kakuda S, Carvalho RM, Sano H. The effect of dentine surface preparation and reduced application time of adhesive on bonding strength. J Dent 2016; 47: 63-70.
17. Spreafico D, Semeraro S, Mezzanzanica D, Re D, Gagliani M, Tanaka T, et al. The effect of the air-blowing step on the technique sensitivity of four different adhesive systems. J Dent 2006; 34(3): 237-244.
18. De Munck J, Arita A, Shirai K, Van Landuyt KL, Coutinho E, Poitevin A, et al. Microrotary fatigue resistance of a HEMA-free all-in-one adhesive bonded to dentin. J Adhes Dent 2007; 9(4).
19. Carrilho E, Cardoso M, Marques Ferreira M, Marto CM, Paula A, Coelho AS. 10-MDP based dental adhesives: Adhesive interface characterization and adhesive stability—A systematic review. Mater 2019; 12(5): 790.
20. Fehrenbach J, Isolan CP, Münchow EA. Is the presence of 10-MDP associated to higher bonding performance for self-etching adhesive systems? A meta-analysis of in vitro studies. Dent Mater 2021; 37(10): 1463-1485.
21. Van Meerbeek B, Yoshihara K, Van Landuyt K, Yoshida Y, Peumans M. From Buonocore's pioneering acid-etch technique to self-adhering restoratives. A status perspective of rapidly advancing dental adhesive technology. J Adhes Dent 2020; 22(1): 7-34.
22. Mohenski D, Vrebac M, Sever EK, Grego T, Goršeta K, Ivanišević A. Effects of Ionizing Radiation on the Shear Bond Strength of Composite Materials to Dentin. J Compos Sci 2024; 8(7): 261.
23. Yingchao Z, Haihuan G, Dan F, Tengjiaozi F, Danfeng C, Zuosen S, et al. New strategy for overcoming microleakage: an elastic layer for dental caries restoration. J Mater Chem B 2015; 3(21): 4401-4405.
24. Ahmed MH, Yoshihara K, Mercelis B, Van Landuyt K, Peumans M, Van Meerbeek B. Quick bonding using a universal adhesive. Clin Oral Investig 2020; 24: 2837-2851.
25. Kitahara S, Shimizu S, Takagaki T, Inokoshi M, Abdou A, Burrow MF, et al. Dentin Bonding Durability of Four Different Recently Introduced Self-Etch Adhesives. Mater 2024; 17(17): 4296.