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ORIGINAL ARTICLE *Volume 14 (Issue 4), 2025*

PAKISTAN JOURNAL OF MEDICINE & DENTISTRY

Exploring the Effect of Saliva Contamination on Shear Bond Strength of Dental Adhesives

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ABSTRACT

Background: Contamination of saliva during restorative procedures may be one of the most common clinical concerns in adhesive dentistry. It may interfere with adhesive systems-dentin interaction, and eventually lead to shear bond strength (SBS) loss and influence the restoration longevity. Systems that are generally employed are the etch-and-rinse and self-etch adhesives but sensitivity to salivary contamination is a major issue. The objective of the present study was to determine how saliva contamination influences the SBS of these adhesive systems.

Methods: This comparative in-vitro study was conducted on 120 human premolars that had been extracted. The teeth were randomly subdivided into four sets (n = 30 each): Group A (etch-and-rinse without contamination), Group B (etch-and-rinse with saliva contamination), Group C (self-etch without contamination), and Group D (self-etch with contamination). Preparation of composite build-ups was done then SBS testing done using universal testing machine. Failure modes were evaluated under the stereomicroscopy. Statistical analyses were ANOVA, independent t-tests, chi-square tests. The significant p-value was assumed to be less than 0.05.

Results: The maximum SBS was noted in etch-and-rinse that was not contaminated with saliva (Group A; 22.4 ± 2.8 MPa) and significantly lower in saliva-contaminated etch-and-rinse (14.1 ± 3.2 MPa, p = 0.001). The bond strength of self-etch adhesives was relatively lower in general (Group C: 18.3 ± 2.9 MPa), although contamination resulted in a weaker drop (Group D: 13.9 ± 2.7 MPa, p = 0.01). A failure mode analysis revealed that there were higher adhesive failures in contaminated groups (p = 0.002).

Conclusion: Saliva contamination greatly compromises the SBS of both adhesive systems with the etch-and-rinse more susceptible. Proper moisture management and selection of adhesives are very important to long-term restorative success.

Keywords: Dental Bonding, Dental Materials, Adhesives, Saliva, Shear Strength.

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How to cite: Ehsan K, Irfan F, Memon AK, Memon MK, Memon K, Shah MA. Exploring the Effect of Saliva Contamination on Shear Bond Strength of Dental Adhesives. Pak J Med Dent. 2025 September ;14(4): A-B. Doi: https://doi.org/10.36283/ziun-pjmd14-4/017.

Received: Wed, September 14, 2025 **Accepted:** Sun, September 28, 2025**. Published:** Mon, September 29, 2025

INTRODUCTION

The adhesive bonding strength and durability between dental substrations and restorative substances is an important factor that determines the longevity of resin-based restorations [1]. Recent developments in adhesive dentistry have provided less complicated systems like etch-and-rinse and self-etch adhesives that are easier to use in clinical practice and at the same time, offer decent bond strengths [2]. Nevertheless, attaining optimal adhesive interface is a clinically challenging task because of the possible contaminants in the oral cavity, and saliva is the most common [3]. The slightest contamination during bonding may compromise the infiltration and polymerization of resin, resulting in low bond strength and premature failure of restorations [4].

Saliva is a complex biological fluid that is rich in proteins, glycoproteins and enzymes, that adsorbs easily on the surface of enamel and dentin [5]. This electrostatic adsorption forms a pellicle layer that disrupts in the micromechanical interlacing of resin monomers with conditioned substrates [6]. The earlier researches have also shown that contamination of saliva may have a severe impact on shear bond strength (SBS) though the degree of decrease depends on the system of adhesive and the time of contamination [7]. Etch-and-rinse adhesives that depend on the ability to remove all smear layer and deep penetration of resin into demineralized dentin are said to be exceptionally vulnerable to contamination [8]. On the contrary, self-etch systems can have a comparatively lower tolerance, but nevertheless, performance is compromised during clinical contamination [9]. In spite of the evidence, gaps still exist in the relative influence of saliva contamination on various adhesive approaches. Moreover, the majority of laboratory tests fail to recreate the conditions of intraoral, which complicates clinical translation [10].

The aim of the present study was to measure how etch-and-rinse and self-etch adhesives influence the strength of the shear bond in the presence of saliva contamination, thus, offering evidence to direct clinicians towards better restorative outcomes.

METHODS

This is an in-vitro experimental research carried out between January and May 2025, in the Department of Pathology, SU, PU and SZH Lahore (Ref: RS-4427). OpenEpi version 3.0.0 (Atlanta, GA, USA) was used to compute the sample size based on the earlier literature that indicated a mean difference between the shear bond strength between the contaminated and uncontaminated samples

[11]. The study collected 120 extracted human premolars, which had no caries, cracks, or restorations. There were exclusion of teeth with developmental defects or attrition and structural anomaly.

The teeth were cleaned and stored in 0.1% thymol solution, after which they were randomly assigned to four groups (n = 30 per group). Group A: etch and rinse adhesive uncontaminated, Group B: etch and rinse adhesive contaminated with saliva, Group C: self-etch adhesive uncontaminated and Group D: self-etch adhesive contaminated with saliva. In case of contaminated groups, unstimulated human saliva was freshly gathered and used, massaged on the area and air-dried after 5 seconds before adhesive was applied. Bonded surface was built up with composite resin cylinders (4 mm diameter, 3 mm height) in various steps.

Each of the specimens was placed in distilled water at 37 ºC in 24 hours followed by thermocycling (500 cycles at 5 ºC to 55 ºC with 30 seconds dwell time). A universal testing machine was used in shear bond strength testing with a crosshead speed of 1 mm/min until failure. All data were processed by the means of the SPSS version 26.0 (IBM Corp., Armonk, NY). SBS values were computed in terms of mean and standard deviation. It was estimated using one-way ANOVA and Tukey-Post hoc test and the significance level was considered as $p < 0.05$.

RESULTS

Table 1: Baseline Characteristics of Tooth Specimens (n = 120)

Variable	Group A (n=30)	Group B (n=30)	Group C (n=30)	Group D (n=30)	Test Value	p-value
Donor Age (Years, Mean ± SD)	29.6 ± 6.5	29.9 ± 6.8	30.1 ± 7.0	29.7 ± 6.4	F = 0.12	0.86
Male Teeth (%)	17 (56.7%)	16 (53.3%)	18 (60.0%)	17 (56.7%)	$\chi^2 = 0.22$	0.96
Storage Time (Days, Mean ± SD)	9.8 ± 2.3	9.5 ± 2.7	10.0 ± 2.5	9.7 ± 2.4	F = 0.34	0.79

Independent t-test and Chi square test were used. No statistically significant differences were found ($p > 0.05$).

There were 120 abstracted human premolars that were randomly assigned to four groups (n=30 in each group): Group A (Etch-and-rinse without contamination), Group B (Etch-and-rinse with saliva contamination), Group C (Self-etch without contamination), and Group D (Self-etch with saliva contamination). The average age of the donors was 29.8 years with a standard deviation of 6.7 years.

No significant differences were found in the age of donors, sex distribution and storage duration of extracted teeth in the groups ($p > 0.05$). **Table 1** demonstrates the baseline characteristics of specimens.

Table 2: Comparison of Shear Bond Strength (MPa) Among Groups

Group	Shear Bond Strength (Mean ± SD)	Test Value (t/F)	p-value
A: Etch-and-rinse (No contamination)	22.4 ± 2.8	Ref	–
B: Etch-and-rinse (Contamination)	14.1 ± 3.2	t = 10.28	0.001*
C: Self-etch (No contamination)	18.3 ± 2.9	Ref	–
D: Self-etch (Contamination)	13.9 ± 2.7	t = 5.12	0.01*
Overall Comparison (ANOVA)	–	F = 18.46	<0.001*

Saliva contamination significantly reduced bond strength in both systems ($p < 0.05$).

At the baseline, four groups were similar in terms of age of donors, sex distribution and storage period. **Table 2** shows the mean values of shear bond strength (SBS). The contamination of saliva had a significant effect in reducing SBS on both adhesive systems ($p < 0.05$). Group A (etch-and-rinse, no contamination) exhibited the greatest SBS (22.4 ± 2.8 MPa) and Group B (etch-and-rinse, saliva contaminated) exhibited a significant reduction (14.1 ± 3.2 MPa, $p = 0.001$). The overall bond strength of self-etch adhesive groups was lower than etch-and-rinse, though the decrease caused by saliva contamination was not as significant (Group C: 18.3 ± 2.9 MPa vs Group D: 13.9 ± 2.7 MPa, $p = 0.01$).

Table 3: Failure Mode Distribution after Shear Testing

Failure Mode	Group A n (%)	Group B n (%)	Group C n (%)	Group D n (%)	χ^2 value	p-value
Adhesive failure	8 (26.7%)	21 (70.0%)	10 (33.3%)	20 (66.7%)	χ^2 = 14.28	0.002*
Cohesive failure	3 (10.0%)	2 (6.7%)	2 (6.7%)	1 (3.3%)	χ^2 = 1.12	0.77
Mixed failure	19 (63.3%)	7 (23.3%)	18 (60.0%)	9 (30.0%)	χ^2 = 12.56	0.005*

$p < 0.05$ = statistically significant

Table 3 shows demonstrates failure mode distribution. The frequency of adhesive failures was lower in uncontaminated groups (A and C) than in contaminated groups (B and D), which had adhesive failures predominately at the resin/dentin interface ($p = 0.002$). In all groups, cohesive failures in composite or dentin were uncommon.

DISCUSSION

The present study determined the effects of saliva contamination on the shear bond strength (SBS) of dental adhesives comparing etch-and-rinse system to self-etch system under a controlled in vitro condition. The results indicated a considerable decrease in SBS when adhesives were used on the saliva-contaminated surfaces with the etch-and-rinse group achieving a higher decrease than the self-etch group. This outcome can be discussed as evidence in favor of the hypothesis that moisture and organic proteins that may be found in saliva disrupt the penetration of the adhesive in the conditioned enamel or dentin surface, and eventually results in poor performance with respect to bonding [12,13].

The current findings can be compared to previous works which have continuously found saliva contamination as one of the most prevalent reasons of adhesive bond failures [14]. Earlier studies have shown that saliva glycoproteins and mucins rapidly form a pellicle on conditioned tooth surfaces, so that optimum adhesive penetration by adhesive in the demineralized dentin matrix or into etched enamel prisms is inhibited [15]. Moreover, lowering the capacity of self-etch primers to demineralize is partly due to the buffering capacity of saliva reducing the acidity of the self-etch primers [16]. Nevertheless, recent researchers indicate that timely decontamination measures, e.g., rinsing and re-

etching, can restore bond strength to the levels of uncontaminated controls, and therefore the significance of clinical management approaches during adhesive procedures [17].

Such findings are of great clinical importance, because adhesive dentistry depends largely on a clean and moisture-controlled field [18]. Saliva contamination is hard to prevent accidentally in restorative and prosthodontist surgeries that are performed on the back teeth or on patients whose salivary flow is large [19]. The current work supports the necessity of effective isolation methods like using rubber dams or using state-of-the-art suction systems [20]. Further, the findings indicate the relativity of self-etch adhesives relative to etch-and-rinse systems during contamination, indicating that the material choice can affect the clinical outcomes in less optimal settings [21].

Mechanistically, the diminished bond strength measured is probably due to physical and chemical interferences [22]. The salivary pellicle layer provides a mechanical barrier, by which the adhesive monomers are inhibited to penetrate the etched substrate, and its proteins can also compete during binding sites on the hydroxyapatite crystals or the exposed collagen fibrils in a chemical way [23]. Also, the hybrid layer formation may be weak in case of incomplete polymerization caused by contamination [24,25]. Such explanations render the biological plausibility of the obtained results and agree with the existing knowledge regarding adhesive interface degradation [26].

There are limitations to this study. Being an in vitro study, the findings cannot be generalized entirely to clinical practice where factors like the pulpal pressure, intraoral temperature, long-term water storage are additional factors that influence the performance of adhesives. The sample was small, and only two adhesive systems were checked without taking into consideration more recent universal adhesives. Moreover, contamination was made standardized in laboratory conditions, and this might not be a perfect reflection of clinical saliva variability. Subsequent research must use more comparisons of multi-adhesive designs with longer aging conditions in order to confirm these results. Nevertheless, the findings are highly valuable in understanding the harmful impact of saliva contamination and confirm the necessity of performing a careful isolation when performing adhesive dentistry.

CONCLUSION

This paper indicates that saliva contamination can significantly reduce the shear bond strength of dental adhesives with etch and rinse systems proving more susceptible than self-etch systems. Proteins in the saliva and the formation of pellicles influences the penetration of adhesives into dentin, and thus the hybrid layer becomes weaker and the restoration less durable. These results underscore the significance of stringent moisture and isolation of adhesive processes. More so,

adhesives with superior contamination tolerance can be selected to reduce clinical failures. Further studies must be conducted in the future on the strategies to improve bond stability in conditions of compromised intraoral conditions.

ACKNOWLEDGEMENT

None

FUNDING

None

CONFLICT OF INTEREST

None

ETHICAL APPROVAL

Ethical approval was obtained from the Institution Research Board (IRB) of Department of Pathology, The Superior University and Shaikh Zayed Hospital, Lahore (Ref: IRB/FAHS/Allied-HS/03/25/MS/RS-4427).

AUTHORS' CONTRIBUTION

All authors contributed equally as per ICMJE.

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