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Research Article

Comparative Study of Universal Adhesives Applied in Self-Etch and Total-Etch Modes

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ABSTRACT
Background: Universal adhesives have been introduced to simplify bonding procedures by allowing clinicians to select either a self-etch or a total-etch mode with the same material.
Objective: To evaluate and compare the microtensile bond strength and microleakage of a universal adhesive in self-etch and total-etch modes to human dentin.
Materials and Methods: The present in vitro comparative experimental study was conducted in the Department of Operative Dentistry, Islamic International Dental Hospital Islamabad, Pakistan from November 2025 to April 2026 for a period of 6 months. Eighty caries-free human premolars were freshly extracted and randomly allocated into two groups (n=40 in each group). SPSS version 25 was used to analyze the data, and a p-value <0.05 was taken as significant.
Results: The mean microtensile bond strength for the total-etch group was significantly higher than that for the self-etch group (34.7 ± 6.1 MPa vs 28.4 ± 5.6 MPa, p<0.001). The total-etch group also had significantly lower microleakage scores than the self-etch group (p=0.004). The most frequent mode of bond failure in both groups was adhesive-type bond failure, with higher occurrence in the self-etch group.
Conclusion: Total-etch mode application of the universal adhesive produced significantly higher microtensile bond strength and lower microleakage than self-etch mode.

Keywords: Universal Adhesive, Self-Etch, Total-Etch, Microtensile Bond Strength, Microleakage.

INTRODUCTION

In the last 20 years, adhesive dentistry has made tremendous progress, and the development of universal adhesive systems has made the restorative process easier and more clinically successful. Since no different adhesive materials are needed for the self-etch or total-etch approach, universal adhesives are widely accepted. This versatility allows the clinician more flexibility when choosing an etching strategy based on the clinical scenario, tooth substrate and restorative procedure. Although these benefits have been demonstrated, there is still a debate about the optimal application of universal adhesives, with previous research showing varying results in terms of bonding strength, marginal integrity and long-term clinical performance.

There have been several in vitro investigations that have compared the performance of UAs with various etching protocols. They showed that there were significant differences in marginal sealing ability between the adhesive systems, as the etching process can be a significant factor in reducing microleakage and enhancing the longevity of the restoration (1). Likewise, Vahid compared the bonding performance of self-etch and total-etch adhesive systems, and found that the type of etching technique still has an effect on the bond, even though adhesive formulations have improved over the last few years (2). The study showed that the characteristics of the substrates and the etching method used were important factors to consider for bond quality, suggesting that the bond quality cannot be predicted for all dentin substrates (3).

Among the most important aspects of the resin-dentin contact quality remains a restoration's longevity. Despite the kind of adhesive system utilised, Kanniappan et al.'s study of the efficacy of universal and total-etch adhesive systems on sound and degraded dentin revealed that bonding effectiveness was proportional to the substrate state (4). They found that adequate surface preparation is still important in reducing marginal leakage and improving the success of restorations (5, 6). Bond strength is still one of the most reliable laboratory measures of adhesive performance. Ismail et al. performed a systematic review to assess the effect of etching procedures on the

bond strength of 10-MDP containing universal adhesives. The authors concluded that 10-MDP also increased the chemical bond with hydroxyapatite, but the mode of etching still significantly influenced bond strength, suggesting that universal adhesives were not able to completely overcome the differences between the self-etch and total-etch modes of use (7). Mirotti et al. also showed that the depth of dentin can affect bonding performance with various etching protocols when using a universal adhesive, which in turn indicates the significance of substrate morphology on the effectiveness of the adhesive (8). They concluded that phosphoric acid etching improves enamel bonding and promotes stability of the restorations (9).

The use of universal adhesives is also now moving beyond direct restorative dentistry into several specialty fields of clinical dentistry. Researchers found that the type of adhesive used could affect the retention of the brackets and the failure rate during orthodontic treatment (10). Both application methods showed good clinical retention, but there was no significant difference between the two methods in the follow-up period, suggesting that the clinical results might differ depending on the type of restoration (11). Furthermore, Yin et al. examined the performance of universal adhesives in composite resin repair procedures, and found that the selected etching strategy still had an impact on the repair bond strength, again emphasizing the significance of proper surface conditioning in secondary restorative procedures (12).

Additionally, a number of additional therapeutic applications utilising different dental substrates were investigated employing universal adhesive methods. Researchers compared the push-out bond strength of fibre posts bonded with universal adhesives used in the etch-and-rinse and self-etch modes and discovered that the latter had a noticeably stronger bond (13,14). Their results showed a slight, but statistically significant, improvement in adhesive performance after acid etching, suggesting that the positive effect of phosphoric acid conditioning might be dependent on clinical conditions and material properties (15). In addition to the actual etching protocol itself, other technical factors have been demonstrated to affect bonding performance, such as adhesive application. A study results indicated that the extended application leads to better adhesive infiltration and partially offsets the reduced bond strength that is typically found with self-etch methods (16). In recent years, Razumova et al. reviewed the literature comprehensively in a narrative review on the use of universal adhesive systems. The authors stressed that while universal adhesives have made restorative procedures easier, further standardized laboratory investigations and well-designed clinical trials are still required to provide evidence-based recommendations for various substrates and restorative situations (17).

While there has been significant research on the use of universal adhesive systems, there is still a lot of variation in the results reported between the self-etch and total-etch application modes. The discrepancies could be caused by variations in the composition of the adhesives, the properties of the substrates, the way the tests are conducted, and the criteria used for evaluation from study to study. Thus, more standardized studies are needed to yield more uniform evidence of the comparative effectiveness of such application strategies. Thus, the purpose of the present study was to evaluate the microtensile bond strength and microleakage of a universal adhesive under standardized in vitro conditions, applied in self-etch and total-etch modes, on human dentin, while focusing on the clinical relevance of the two methods.

Objective: To assess the difference in microtensile bond strength and microleakage of a universal adhesive used in self-etch and total-etch protocols on human dentin.

MATERIALS AND METHODS

Study Design: Vitro comparative experimental study.

Setting: Department of Operative Dentistry, Islamic International Dental Hospital Islamabad, Pakistan.

Study Duration: Six months, from November 2025 to April 2026.

Sample Size: The estimated total sample size was determined by OpenEpi software based on the difference in mean microtensile bond strength between universal and total-etch adhesive systems reported by Kanniappan et al., with a power of 80% and a level of significance of 5%.

Inclusion Criteria: Caries-free non-carious, non-restored human premolars extracted for orthodontic treatment and showing no crack or

structural defect, as observed under visual and stereomicroscopic examination, were included.

Exclusion Criteria: Teeth with pre-existing restorations, caries, cracks, hypoplasia, or fluorosis, and teeth stored for more than three months prior to use, were excluded from the study.

Methods: Premolars were extracted and stored in normal saline until use, and then cleaned and disinfected. A computer-generated random number sequence was used to divide the 40 specimens into two sets of 40. The dentin surface in the middle of the tooth was exposed by sectioning, and standard smear layers were prepared with 600-grit silicon carbide paper. Group A: Universal adhesive was used in self-etch mode, as per the manufacturer's instructions, without a separate phosphoric acid etch. The adhesive in both groups was light-cured, and a standardized composite resin build-up was incrementally placed. Specimens designated for bond strength testing were stored for 24 hours at 37°C in distilled water, then sectioned into resin-dentin beams (about 1 mm2 cross-sectional area) and tested for bond strength with the microtensile test (1 mm/min crosshead speed, universal testing machine). Specimens for microleakage testing were thermocycled, submerged in 2% methylene blue dye, sliced, and evaluated under a stereomicroscope, and the amount of dye penetration was rated on a 0–3 ordinal scale. SPSS version 25 was used for data analysis.

RESULTS

Eighty specimens were tested, with 40 specimens assigned to each of the two groups: self-etch and total-etch. The two groups were comparable at baseline in terms of tooth characteristics.

Table 1: Distribution of Specimens and Baseline Characteristics (N = 80)

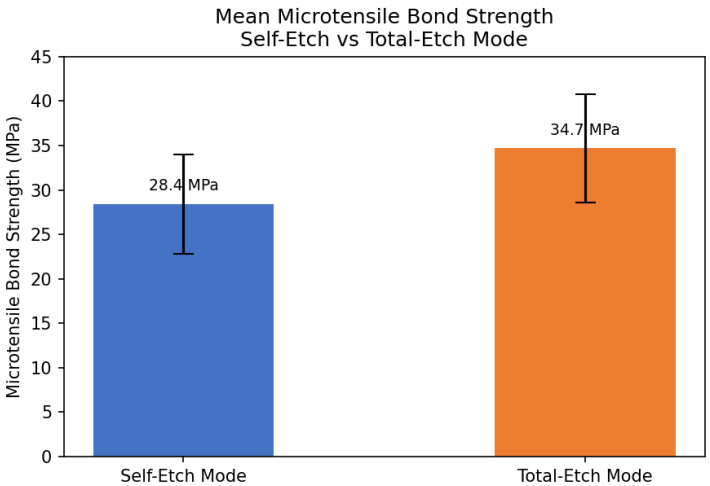
Variable	Self-Etch (N=40)	Total-Etch (N=40)
Tooth Type: Premolar	40 (100%)	40 (100%)
Mean Specimen Storage Time (Weeks)	5.2 ± 1.4	5.4 ± 1.6
Beams Tested For µtbs	20 Teeth (60 Beams)	20 Teeth (60 Beams)
Specimens For Microleakage	20	20

The mean microtensile bond strength was significantly higher in the total-etch group than in the self-etch group.

Table 2: Comparison of Microtensile Bond Strength between Groups

Variable	Self-Etch (N=40)	Total-Etch (N=40)
Mean µtbs (Mpa)	28.4 ± 5.6	34.7 ± 6.1
Range (Mpa)	18.2 – 39.5	22.6 – 47.3

$p<0.001$ (independent t-test).



Graph (Bar Chart): Mean Microtensile Bond Strength by Etching Mode

The graphic representation clearly shows that the total-etch mode produced a higher mean microtensile bond strength than the self-etch mode. Microleakage scores were also significantly lower, indicating better marginal sealing, in the total-etch group.

Table 3: Distribution of Microleakage Scores between Groups

Microleakage Score	Self-Etch (N=20)	Total-Etch (N=20)	P-Value
Score 0 (No Leakage)	6 (30.0%)	13 (65.0%)	0.004
Score 1 (Enamel Only)	7 (35.0%)	5 (25.0%)	-
Score 2 (Dentin, <1/2)	5 (25.0%)	2 (10.0%)	-
Score 3 (Dentin, ≥1/2)	2 (10.0%)	0 (0.0%)	-

Table 4: Mode of Bond Failure Following Microtensile Testing

Failure Mode	Self-Etch (N=60 Beams)	Total-Etch (N=60 Beams)
Adhesive Failure	38 (63.3%)	27 (45.0%)
Cohesive (Dentin) Failure	9 (15.0%)	13 (21.7%)
Mixed Failure	13 (21.7%)	20 (33.3%)

p=0.041 (chi-square test).

Overall, the total-etch mode of the universal adhesive exhibited significantly higher microtensile bond strengths, lower microleakage scores, and a lower percentage of pure adhesive failure than the self-etch mode, indicating that the total-etch mode of the universal adhesive resulted in a more stable and durable resin-dentin bond under the tested in vitro conditions.

DISCUSSION

The aim of the present study was to compare and assess the microtensile bond strength and microleakage of a universal adhesive used in self-etch and total-etch modes on human dentin under standard in vitro conditions. The total-etch group had significantly lower microleakage scores and a lower number of adhesive failures, suggesting a more stable and strong resin-dentin interface. The results indicate that the phosphoric acid pretreatment increases the penetration of the adhesive into dentin substrate, which increases mechanical retention and decreases marginal leakage.

The current study's findings are consistent with earlier research examining how different etching techniques affect binding strength. In Class V composite restorations, Singh et al. demonstrated that the etching process significantly affected microleakage, including total-etch having superior marginal sealing qualities over self-etch (1). Similarly, Vahid demonstrated that despite advancements in adhesive technology, the bonding effectiveness of contemporary adhesive systems still depends on the type of etching employed, underscoring the clinical significance of appropriate surface preparation (2). Other studies showed that bonding performance depends on the dentin substrate as well as the etching procedure used, suggesting that substrate properties are important in the success of universal adhesive systems (3). The results of these observations are very significant and indicate good bonding performance of the total-etch technique used in the present investigation.

This interaction between substrate condition and etching mode, as described by Kanniappan et al., on sound versus eroded dentin (4), may account for some of the intra-group variability, as dentin quality was not further subdivided in the present study. The results of Yollar et al. were similar to our findings, in which total-etch procedures demonstrated significantly better microleakage results in class II composite restorations (5). From a clinical point of view, Javed et al.'s randomized trial (6) that compared postoperative hypersensitivity between total-etch and universal adhesive systems provides an important complementary perspective, since, from a clinical perspective, higher bond strength and lower microleakage in the total-etch group of our study would likely be associated with lower postoperative sensitivity, which was not directly evaluated in the present in vitro design (7).

The range of the bond strength values within each of our groups may be due to the interaction between dentin depth and bonding protocol, as demonstrated by Mirotti et al. in deep dentin (8). Menon et al. (9) have confirmed this general rule, which is also shown by our results, that a total-etch step provides a measurable bonding benefit when using universal and two-step self-etch adhesives, with the pre-etch step being phosphoric acid. The findings of our study are also applicable to primary restorative bonding, as evidenced by

the work of Yin et al. (12) on universal adhesives in composite resin repair, where etching mode also had an impact on the repair bond strength. Such etching mode effects have been reported in other, more specialized applications. The total-etch advantage seen in our study was not limited to permanent tooth coronal dentin (13).

Rezvani et al. reported similar etching-mode effects on microshear bond strength to primary dentin (14). Consistent with the results of our study, Assis et al. in their systematic review and meta-analysis reported that the total-etch group had an improved bonding and sealing ability in non-carious cervical lesions, and that the effect size was measurable but variable in both clinical and laboratory studies (15). Lastly, technique-related factors can influence some of the self-etch disadvantage seen in our study. Valian et al. (16) systematically reviewed and meta-analyzed the effects of various self-etch adhesive application times on bond strength compared to total-etch adhesives, and they reported that higher application times of self-etch adhesives may partially compensate for the bond strength disadvantages. This suggests that a longer application protocol for the self-etch adhesives, which was not specifically tested in our study, may have reduced the bond strength difference between the groups.

The present study also addresses the question raised by Razumova et al., which was to assess the advantages and disadvantages of various universal adhesive systems in both the self-etch and total-etch mode, and to continue comparative testing of these adhesive systems on different substrates (17). Our study has certain limitations. It was performed in one institution with standardized in vitro conditions and with extracted premolars that may not completely mimic the complex clinical oral environment, such as the masticatory load, salivary contamination, and patient-specific dentin variability.

CONCLUSION

Based on the limitations of this in vitro study, total-etch application of the universal adhesive yielded higher microtensile bond strength and lower microleakage than self-etch application to human dentin, and a lower percentage of pure adhesive failure. Based on these results, the application of universal adhesives for total-etch might provide a more predictable and stable resin-dentin bond when clinical conditions allow another etching step. The choice between self-etch and total-etch modes of application of the universal adhesive should be made by clinicians based on substrate characteristics, restoration type, and clinical workflow considerations, and additional clinical research is recommended to validate these in vitro findings.

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