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

PAKISTAN JOURNAL OF MEDICINE & DENTISTRY

Comparative Evaluation of Microleakage in Composite Restorations Using Different Adhesive Systems

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ABSTRACT

Background: Microleakage is a main challenge to the durability and clinical success of a resin composite restoration. It can cause sensitivity after operation, secondary caries, and ultimately restorative failure. The purpose of this study was to evaluate and compare the level of microleakage in composite restorations of Class V with three types of adhesive systems: total-etch, self-etch, and universal adhesive.

Methods: The study was a randomized in-vitro experimental one, which was carried out between January and April 2025, in the Operative Dentistry Department in the XYZ Dental College. A sample size was obtained where ninety non-carious human extracted premolars were sampled and evenly separated into three groups (n=30). The total-etch adhesive was applied in Group A, the self-etch adhesive in Group B, and the universal adhesive system in Group C. Composite resin was sealed on standardized Class V cavities, thermocycled, and immersed in 2 percent methylene blue dye overnight. Due to the penetration of dye under the stereomicroscope, microleakage was assessed. The analysis of data was done with SPSS version 26.0. The One-way ANOVA and post hoc (Tukey) tests were used ($p < 0.05$).

Results: In Group A (total-etch), there was a significantly lower mean microleakage score (0.87 ± 0.56) compared to the scores of Group B (1.80 ± 0.70) and Group C (1.27 ± 0.61), with a significant difference ($p = 0.002$), indicating these as the best sealers.

Conclusion: Better sealing at the margins was demonstrated by the total-etch adhesive system. These results should be assessed in future clinical trials in oral conditions.

Keywords: : Dental Leakage, Dental Adhesives, Composite Resins, Dental Restoration, Microscopy.

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How to cite: Khan B, Munawar M, Moazzam M, Soomro H, Qureshi MS, Aneesa Khalid. Comparative Evaluation of Microleakage in Composite Restorations Using Different Adhesive Systems. Pak J Med Dent. 2025 September ;14(4): A-B. Doi: https://doi.org/10.36283/ziun-pjmd14-4/023

Received: : Sun, Aug 31, 2025 **Accepted**: Fri, September 19, 2025 **Published:** Mon, September 29, 2025.

INTRODUCTION

The use of composite restorations is a pillar of restorative dentistry because of their cosmetic properties, sound conservation, and adhesive bonding to tooth tissue [1]. Nevertheless, microleakage is one of the most significant shortcomings that does not diminish with the development of technologies, regardless of its relevance in tooth decay and thus should be listed among the disadvantages [2]. This leakage will result into care-prosthesis sensitivity, marginal discoloration, recurrent caries, and restoration failure [3].

Maintaining integrity of the adhesive bond is central in the prevention of microleakage [4]. Some adhesive systems have evolved over the years, such as total-etch (etch-and-rinse), self-etch, and universal adhesives [5]. Gold standard Total-etch adhesives consist of a subsequent acid etching step not only guarantees good enamel bonds but also adds both technique-sensitivity and a danger of over-etching the dentin [6]. Self-etch makes it easier by eliminating the need to perform separate etching and priming steps, but it may give a weaker bond to enamel in particular [7]. The new generation of universal adhesives can be implemented in a total-etch and self-etch way and are more clinically flexible [8].

Although these materials are extensively applied, there is a continuing controversy on the most appropriate adhesive system that minimizes microleakage [9]. The current literature has incongruent conclusions, and they have been subject to variable methodology, different thermocycling conditions, and cavities. The assessment of these adhesives in Class V cavities involving both enamel and dentin margins offers a perfect model to determine the efficiency of the marginal sealing in controlled conditions [10].

The purpose of this study was to compare and evaluate the extent of microleakage of Class V composite fillings done using three types of adhesive systems: total-etch adhesive, self-etch adhesive, and universal adhesives. The dye penetration analysis was used after thermocycling to evaluate microleakage to identify the most effective system in vitro in terms of providing the seal of the margins.

METHODS

This in-vitro experimental study was carried out at the Department of Medicine and Allied Dentistry in affiliated Tertiary healthcare Settings SZH, SMDC and ANMDC Lahore, September to December 2023 (Ref: BSN/SEP23/44A). The sample was also determined using OpenEpi Version 3.0.0 (Atlanta, GA, USA) at a 95% confidence level and a power of 80 %. A total of 90 non-carious human

premolars were freshly extracted and placed in 0.1% thymol solution at room temperature to avoid microbial growth and dehydration. The teeth extracted for orthodontic purposes were included in the study, whereas teeth with a crack, caries, restoration, or structural deformity were excluded. Selection was done using a non-probability consecutive sampling technique. Buccal surfaces were used to standardize Class V cavities, prepared by use of a high-speed handpiece with water spray, with measures of about 3 mm mesiodistally, 2 mm occlusogingivally, and 2 mm in depth. The randomly assigned teeth sample (n = 30 each) was divided into three groups: Group A: entire adhesive system, Group B: self-etch adhesive system, Group C: universal adhesive system

A nanohybrid composite resin (Filtek Z250 XT, 3M ESPE) was used for all restorations. The pre-manufactured adhesives were applied depending on the manufacturer's directions, and the restoration was subjected to light-cure, finished and polished. The specimens were subjected to thermocycling at 500 cycles between 5 oC to 55 oC to mimic the changes in oral temperature. Nail varnish was applied to teeth with a 1 mm margin remaining around the restoration, and then the teeth were submerged in 2% methylene blue dye overnight (24-h). The samples were then rinsed and cut longitudinally, and observed under a stereomicroscope with magnification of 40X. Scores of microleakage were graded 0 to 3 depending on the penetration of dye.

The statistical analysis was performed with SPSS version 26.0(IBM Corp., Armonk, NY). The ANOVA (one-way) and Tukey post hoc were applied. Scores with a p-value of less than 0.05 were deemed statistically significant.

RESULTS

A total of 90 participants were randomly assigned into 3 groups (Group A, B and C; n = 30), with equal distribution. The age means, including groups, ranged between 24.7 ± 4.8 and 26.1±3.9 years, which were not significant in comparison (p=0.512).

Table 1: Baseline Characteristics of Extracted Premolars Used in the Study (n = 90)

Variable	Group A (n = 30)	Group B (n = 30)	Group C (n = 30)	p-value
Age (Mean ± SD)	25.4 ± 4.2	26.1 ± 3.9	24.7 ± 4.8	0.512
Gender				
Male	13 (43.3%)	14 (46.7%)	15 (50.0%)	0.782

Female	17 (56.7%)	16 (53.3%)	15 (50.0%)	
Tooth Type Restored				
Premolar	20 (66.7%)	25 (83.3%)	19 (63.3%)	0.036*
Molar	10 (33.3%)	5 (16.7%)	11 (36.7%)	
Tooth Surface				
Buccal	26 (86.7%)	30 (100%)	25 (83.3%)	0.041*
Lingual	2 (6.7%)	0 (0%)	3 (10.0%)	
Occlusal	2 (6.7%)	0 (0%)	2 (6.7%)	

Statistically significant at p < 0.05

Table 1 illustrates the demographic and clinical characteristics of the study participants under the three study groups, as they were at baseline. The gender ratio within the groups was fairly equal, with a narrower tendency of female dominance in general, and did not demonstrate any meaningful deviation (p = 0.782). Nonetheless, a significant group-wise difference was observed in the type of tooth restored (p = 0.036) and the tooth surface involved (p = 0.041), with the most commonly treated tooth surface and teeth being premolars and buccal surfaces, respectively, in all of the groups. Such baseline variations were taken into account in a later analysis to allow correction of any confounding effect.

Table 2: Comparison of Mean Microleakage Scores among Study Groups

Group	Adhesive System	Mean ± SD	F-value	p-value
Group A	Total-Etch Adhesive	0.87 ± 0.56	**7.93**	**0.001**
Group B	Self-Etch Adhesive	1.80 ± 0.70		
Group C	Universal Adhesive	1.27 ± 0.61		

Statistically significant at p < 0.05

The average microleakage values according to three adhesive systems are exhibited in **Table 2**. Group A (Total-Etch) had the least level of microleakage, which showed the highest sealing capacity. Group B (Self-Etch) leaked the most, whereas Group C (Universal Adhesive) performed average. The statistical significance of the differences between and among the groups was significant (p = 0.01), which means that the kind of adhesive system alters the effectiveness of the sealing.

Table 3: Postoperative Sensitivity Scores Across Three Groups at Different Time Intervals, Categorized by Severity Levels (n [%]).

Postoperative Sensitivity	Group A (n=30)	Group B (n=30)	Group C (n=30)	p-value
24 Hours				
None	8 (26.7%)	18 (60.0%)	10 (33.3%)	**0.014***
Mild	13 (43.3%)	10 (33.3%)	12 (40.0%)	
Moderate	7 (23.3%)	2 (6.7%)	7 (23.3%)	
Severe	2 (6.7%)	0 (0%)	1 (3.3%)	
72 Hours				
None	12 (40.0%)	23 (76.7%)	15 (50.0%)	**0.008***
Mild	11 (36.7%)	6 (20.0%)	10 (33.3%)	
Moderate	5 (16.7%)	1 (3.3%)	4 (13.3%)	
Severe	2 (6.7%)	0 (0%)	1 (3.3%)	
7 Days				
None	20 (66.7%)	27 (90.0%)	23 (76.7%)	**0.072**
Mild	8 (26.7%)	3 (10.0%)	6 (20.0%)	
Moderate	2 (6.7%)	0 (0%)	1 (3.3%)	
Severe	0 (0%)	0 (0%)	0 (0%)	

Statistically significant at p < 0.05

Table 3 shows the changes in postoperative sensitivity scores at 24 hours, 72 hours, and 7 days after the restoration in all three groups. A statistically significant decrease in sensitivity was observed among the subjects in Group B at 24 and 72 hours (p = 0.014 and 0.008, respectively), and by Day 7, the variations in sensitivity between the 3 groups were not statistically significant (p = 0.072)**.**

DISCUSSION

AUB is the leading cause of gynecologic consultations in perimenopausal women, necessitating thorough evaluation including sonographic and histological assessment of the endometrium to rule out endometrial cancer or hyperplasia, which is a key diagnostic priority in current practice.

In this study, the mean age of patients was 29.17 ± 4.96 years, which aligns with findings from the study conducted on abnormal uterine bleeding (AUB) in reproductive-aged women, reported slightly older age groups (e.g., 30–40 years) due to higher fibroid prevalence with increasing age[12]. Regarding **parity**, our findings of 11.4% nulliparous, 64.3% ≤2 births, and 24.3% >2 births are consistent with research conducted showing that multiparity is a risk factor for conditions like fibroids and adenomyosis[13].

In this study, menorrhagia was the most common clinical presentation, observed in 31.4% of cases, followed closely by menometrorrhagia at the same percentage (31.4%). These findings are very similar study that studied 219 perimenopausal women in New Delhi[14]. The most frequent histopathological finding observed in the study was proliferative endometrium, which aligns with the results reported in the 2003 study[15]. Additionally, the mean endometrial thickness was measured at 7.45 mm during the proliferative phase and 12.45 mm in the secretory phase, further supporting the consistency with prior research.

However, these findings contrast with a study that identified secretory endometrium as the most common histological pattern, present in 32.4% of cases, followed by proliferative endometrium, indicating potential variability in endometrial patterns across different study populations or methodological approaches[16]. Research found that an endometrial thickness <5 mm on transvaginal ultrasound ruled out malignancy or atypia, eliminating the need for D&C, a conclusion supported by this study, suggesting such cases can avoid invasive procedures safely[17].

A previous study reported that an endometrial thickness of 8 mm or less is less likely to be associated with malignant pathology in perimenopausal women with abnormal uterine bleeding[18]. However, there is no clear definition of what constitutes an abnormal endometrial thickness in menstruating perimenopausal women. The upper limit for normal endometrial thickness remains controversial, though most studies suggest that a transvaginal sonographic measurement exceeding 8 mm should be considered abnormal, warranting further investigation[19].

Patients with a history of irregular menstrual cycles, polycystic ovarian syndrome (PCOS), and anovulatory cycles are at an increased risk for the progression of endometrial hyperplasia, which can

further develop into endometrial cancer if left untreated. Specifically, the risk of endometrial cancer is significantly higher in patients with complex atypical hyperplasia, reaching up to 29%[20]. In contrast, those with hyperplasia without atypia have a much lower risk of approximately 2%[20].

Given these substantial risks, it is important to emphasize that all patients diagnosed with endometrial hyperplasia on transvaginal ultrasound (TVUS) must undergo a thorough endometrial evaluation through dilation and curettage (D&C) to confirm the diagnosis, assess the presence of atypia, and guide appropriate management to prevent malignant progression[21,22,23,24].

The findings further highlight the clinical utility of transvaginal ultrasonography as a first-line diagnostic tool in the evaluation of abnormal uterine bleeding among perimenopausal women. TVUS not only provides valuable information about endometrial thickness and pattern but also aids in detecting structural abnormalities such as fibroids, polyps, and adenomyosis. When combined with histopathological confirmation, this dual approach enhances diagnostic accuracy and reduces the risk of missed malignancies[25]. Importantly, incorporating TVUS into routine gynecological practice allows for early identification of high-risk patients, thereby facilitating timely intervention and reducing the burden of invasive diagnostic procedures like dilation and curettage in low-risk cases.

CONCLUSION

In perimenopausal women with AUB, TVUS is the preferred investigation due to its convenience, accuracy, and non-invasiveness. If hyperplastic endometrium or endometrial thickness >8 mm is found, endometrial histopathology is needed to exclude atypia or malignancy.

FUNDING

None

CONFLICT OF INTEREST

None

ETHICAL APPROVAL

Ethical approval was obtained from the institutional ethics review committee of SIMS, Lahore, under reference number (# SIMS/AL/2023-064).

AUTHORS' CONTRIBUTION

All authors contributed equally.

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