Sari et al. BMC Oral Health (2024) 24:1367
https://doi.org/10.1186/s12903-024-05138-0

BMC Oral Health

RESEARCH Open Access

Does different application modes of universal adhesives with universal resin composites affect the microleakage in class V cavities? An in vitro study

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Abstract

Aim Composite restorations often have gingival margins near the cemento-enamel junction (CEJ), where the microleakage of these margins can significantly contribute to the restoration failure, especially in the cervical lesions. It is important to determine the microleakage is crucial, as it typically occurs through the interfacial gap between the tooth and the restoration. Various resin composites and techniques have been developed to minimize this gap and reduce the risk of microleakage. The aim of this in vitro study was to evaluate the levels of microleakage of different modes of a universal adhesive and two novel resin composites in restoring class V cavities in the central incisors.

Methods Sixty-six freshly extracted sound human central incisors of the similar size were randomly assigned to 2 groups ($n = 33$ per group) according to the brand of resin composite. Each group was further divided into 3 subgroups based on the Scotch Bond Universal (3 M ESPE, Saint Paul, MN, USA) application protocol used: (a) total etch, (b) self-etch and (c) selective etch. After composite restoration completed with Omnichroma (Tokuyama Dental Corp., Tokyo, Japan) and Filtek Universal Restorative (3 M ESPE, Saint Paul, MN, USA), each tooth was immersed in a 0.5% basic fuchsin dye solution at $37C^0$ for 24 h. After dye penetration, teeth were sectioned and evaluated with conventional (scoring) and digital methods (ImageJ). The intra- and inter-examiner agreement was estimated according to the Kappa statistics and the results were analyzed with the one-way ANNOVA and the Kruskal–Wallis test ($p < 0.05$).

Results The rates of microleakage of the gingival and incisal margins are statistically similar, regardless of the composite brand and the method of application of the universal adhesive.

Conclusion The microleakage exhibited by current adhesives and resins is independent of the adhesive application mode and measurement method.

Keywords Class V, Composite, ImageJ, Microleakage, Universal adhesive

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Background

Modern dentistry aims to create biomimetic and biocompatible restorations while preserving a sound tooth tissue and maintaining the dental seal, which has been made possible with the development of adhesive techniques. One of the critical contributions has been the introduction of composites and adhesives with different properties to the market to ensure marginal tooth integrity and achieve sufficient aesthetics.

The most remarkable development in adhesives for this century is the introduction of 'universal-multimode' adhesives that can be used in any bonding strategy; such as etch-and-rinse, self-etch, or selective enamel-etch [1]. In order to provide adequate bonding, adhesive systems are developed with the aim of treated or removed smear layer, which is formed during the cavity preparation. Etch-and-rinse systems provide micromechanical bonding by applying acid to the dental hard tissues [2]. In contrast, self-etch systems offer surface conditioning with acid content in their structure, eliminating the need for an additional acid application, as bonding to dentin is more challenging due to its organic components the variation degree of mineralization and outward fluid movement [3]. In addition, self-etch adhesive systems reduce the risk of contamination and the chair time by reducing required procedure steps.

The primary concern in the literature related to these clinically simplified adhesive systems, which reduce the number of steps, is decreased bond durability after aging and indirectly occurring nano leakage, similar to self-etch adhesives [4]. Microleakage at the interface between the restoration site and the tooth poses a significant risk factor for various postoperative complications such as sensitivity, secondary caries, pulpal necrosis, and inflammation [5]. In addition, microleakage is a significant parameter when evaluating the success of composite restorations in the clinic**.** Microleakage has traditionally been assessed using scoring methods by experienced, previously calibrated researchers, but the results obtained through these methods tend to be quite subjective. Therefore, more quantitative approaches are now favored, where samples are digitized by photographing their cross-sections. These images are then analyzed using specific image processing software like ImageJ, allowing for measurements based on pixel data. Factors such as the physical–mechanical and viscoelastic properties of the composite resin, the type of adhesive bond, the restoration technique and cavity configurations should be carefully evaluated during restoration to avoid these negative effects of adhesive restorations caused by microleakage [6].

The progression of cervical lesions is attributed to multifactorial etiologies with a significant contribution from microorganisms that colonize the tooth surface and cause demineralization of the enamel and dentin, leading to the eventual destruction of teeth structure [7]. In addition, masticatory forces and lateral excursive movements place tensile and shear forces on the cervical area of the teeth, which contributes to the development of non-carious cervical lesions [8]. Class V cavity restorations have many challenging conditions that affect the longevity of the restoration related to controlling moisture, reaching caries, and working close to the gingival margin [9]. Additionally, the high configuration factor of class V restorations increases their susceptibility to polymerization stresses, which can cause shrinkage and deformation during the light-curing process, ultimately leading to microleakage of the restoration [10].

The primary requirement of esthetic resin composite restoration is to achieve excellent color matching and to maintain optical properties over time while obtaining morphological and biological results that mimic those of natural enamel and dentine [11]. Resin composites with blending effect have been developed to provide 16 VITA Classical shade color matches with just one shade. Composite's advanced color-matching capabilities and patented translucent filler technology makes the color matching achievable [12].

Determining the best adhesive protocol for universal adhesives, whether it should involve pre-etching or self-etch strategy, is still controversial despite numerous recently developed adhesives in Class V cavities [13]. Furthermore, limited literature is available to assess the behavior of microleakage exhibited by several novel resin composites that vary in color and structural characteristics. Therefore, the aim of this in vitro study was to evaluate the microleakage levels of different application modes of Scotchbond Universal performed with two novel universal composites. The null hypotheses tested were that: (1) no correlation exists between the digital and scoring microleakage measurement methods; and (2) there is no significant difference in microleakage levels among the three adhesive application protocols within each composite group in Class V cavity restorations.

Methods

This study was conducted according to the stipulations of the Helsinki Declaration (2000) and previously approved by the Research Ethics Committee the Gazi University under protocol number E-21071282–050.99–60064.

All teeth were extracted due to periodontal reasons and all patients and/or legal guardians gave their written informed consent for the use of their teeth for research purposes and all central incisors were irreversibly anonymized immediately after extraction.

Power analysis determined the number of test specimens by G*Power Ver. 3.1.9.4 (Franz Faul, Universität Kiel, Kiel, Germany) software; the level of significance (alfa) was set at 0.05 with 95% power, an effect size (d) 1.47. Sixty-six freshly extracted sound human central incisors of similar size were selected for this study. All teeth were extracted due to periodontal reasons and all patients and/or legal guardians gave their written

Table 1 Products used in this study

Product	Manufacturer	Lot Number	Composition	Filler Wt% / Vol%	Application method
Omnichroma	Tokuyama Dental Corp., Tokyo, Japan	205S2	UDMA, TEGDMA Spherical SiO2 -ZrO2 Particle size of 260 nm	79 wt% / 68 vol%	Dispensed from the syringe and plugged into the cavity using a composite instrument, with a thickness of 2 mm
Filtek Universal Restorative	3 M ESPE, Saint Paul, MN, USA	NA66211	AUDMA, AFM, diurethane-DMA, and 1,12-dodecane-DMA Composed of 20 nm silica, 4 to 11 nm zirconia, and 100 nm ytterbium trifluoride	76.5 wt% / 58.4 vol%	Dispensed from the syringe and plugged into the cavity using a composite instrument, with a thickness of 2 mm
Scotch Bond Universal	3 M ESPE, Saint Paul, MN, USA	8,934,765	10-MDP, HEMA, Dimethacrylate resins, Methacrylate-modified polyalkenoic acid copolymer, Filler, Ethanol, Water, Initiators, Silane		Adhesive was rubbed in with a saturated brush tip (20 s), lightly air-dried with a syringe (5 s) and light irradiated (10 s) with the LED light device

Abbreviations: AFM addition-fragmentation monomers, *AUDMA* aromatic urethane dimethacrylate, *HEMA* 2-Hydroxyethyl Methacrylate, bisphenol A glycidyl methacrylate, *TEGDMA* triethylene glycol dimethacrylate, *UDMA* diurethane dimethacrylate informed consent for the use of their teeth for research purposes and all central incisors were irreversibly anonymized immediately after extraction. Each tooth was examined microscopically (Leica DMS 1000®, Leica Microsystems, Wetzlar, Germany) under 20 × magnification to rule out the presence of any structural defects, caries, restorations, cracks or defects. A periodontal scaler was used to remove calculus deposits and remaining connective tissue. Teeth were disinfected with a 1% Chloramine-t solution for 24 h and then stored in distilled water at 4 °C prior to use in this study to preserve their optimum mechanical and physical properties.

Standardized rectangular class V conventional cavities were prepared on each tooth's buccal surface. Cavities prepared with a high-speed handpiece under water cooling using cylindrical diamond bur. Cervical margins were prepared above the cemento-enamel junction (CEJ), and all cavosurface angles were 90^0 without bevel design. The diamond bur was changed after every five cavity preparations. The overall dimensions of the cavities were standardized as follows: 3 mm width, 2 mm depth, and 2 mm height incisal direction, with the gingival margin extending at least 1 mm above the enamel-cementum junction on the root surface. Then, all cavities were checked by a single operator with a periodontal explorer to ensure that they conformed to the dimensions. The specimens were randomly assigned to two groups ($n = 33$ per group) according to the resin composite: group 1. Omnichroma (Tokuyama Dental, Tokyo, Japan), group 2. 3 M Filtek Universal (3 M, Saint Paul, MN). Each group was further divided into three subgroups based on the universal adhesive application protocol used: (a) total etch, (b) self-etch, and (c) selective etch ($n = 11$ per group).

Material compositions used in the restorations and their full descriptions are listed in Table 1.

For total etch mode, 37% phosphoric acid (FineEtch, Spident Co., Ltd., Korea) was applied for 30 s (s) to enamel and 15 s to dentine. For the selective etch mode, acid was applied only to the enamel for 15 s, rinsed for 15 s and air dried for 5 s. The Scotchbond Universal adhesive system was applied to the cavity according to the manufacturers' instructions and all the specimens were light cured with Elipar (Elipar FreeLight S10, 3 M ESPE, USA) for 20 s. All cavities were restored with Omnichroma or 3 M Filtek Restorative according to their group and then light cured for 20 s. The restorations were finished with fine needle-shaped diamond burs to obtain accurate marginal adaptation. A series of aluminum oxide-coated flexible discs (Sof-Lex Contouring and Polishing Disks, 3 M ESPE) were used to polish the restorations (with medium grit at 10,000 rpm and with fine and super-fine grits at 30,000 rpm for 30 s) by the same operator. All specimens were subjected to 500 cycles at 5–55 C^0 with a dwell time of 15 s for thermal aging (MTE-101, MOD Dental, Turkey). These temperatures, intervals, and the number of cycles were chosen according to the ISO/TS 11405: 2015 recommendations. Then, two layers of nail varnish were applied on the remaining exposed area except for 1 mm away from the restoration margins, and the apical foramina were sealed with cyanoacrylate (BOSS 8.07, Boss Industrial, Turkey). The teeth were immersed in a 0.5% basic fuchsin dye solution at $37C^0$ for 24 h. Then the solution was removed, and the samples were rinsed for 30 s with distilled water. The samples were sectioned mid-sagitally in the mesiodistal plane with a double-face diamond saw (Horico, Diamond Instruments, Germany) under water. The surface of each restored section was examined under a stereomicroscope at 40 × magnification. Then, the sections were photographed at 4 × magnification with a digital camera (Canon Eos 600D, Canon, Taiwan) to evaluate the degree of dye penetration in the gingival/cervical and incisal plane of restorations. Images were saved as TIFF images and transferred to Image Analysis software (ImageJ, National Institute of Health, Maryland, USA) at a resolution of 1280 × 1024. To calculate the percentage of microleakage, dye penetration measured as mm was recorded and calculated as follows: Stained surface / Total surface of the restorative material (Fig. 1).

The extension of dye penetration was also measured by following the ISO score system (ISO/TS 11405: 2003):

Score 0 = No dye penetration
Score 1 = Dye penetration into ½ of the cervical floor
Score 2 = Dye penetration of more than ½ of the gingival floor
Score 3 = Dye penetration into cervical and axial wall

To compare the inter-examiner perceptibility of digital measurement and scoring, digital measurement values were converted into scores as follows:

0% penetration = Score 0
1–50% penetration = Score 1
51–99% penetration = Score 2
> 100% penetration = Score 3

The kappa statistical test was used to assess to analyze both the intra-examiner agreement and the agreement between the score-based and the digital measurements. The resulting data recorded by ImageJ was statistically analyzed with one-way ANOVA followed by the Tamhane test at $p = 0.05$. Mann–Whitney U and Chi-square tests were used to compare the differences in microleakage scores among different groups, comparisons between independent groups, respectively. Kruskal–Wallis test

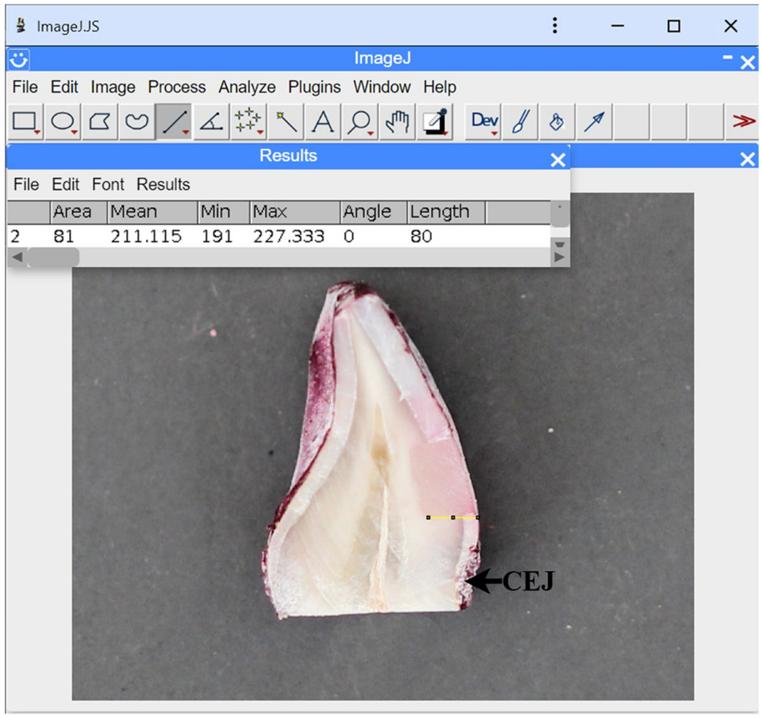

Fig. 1 Measurements of the microleakage with ImageJ program

was used to assess differences within the groups as the conventional methods data were on an ordinal scale. A p-value < 0.05 was considered significant.

Results

The intra- and inter-examiner agreement by visual scoring and image analysis was examined with Kappa. The intraclass correlation coefficient (ICC) test showed an excellent inter-examiner correlation (incisal 0.92, gingival 0.86).

In the Kappa analysis, where digital measurements and scores were compared, the agreement between the measurement methods was determined as substantial correlation κ = 0.70 based on the gingival scores, while the agreement between the incisal measurements was determined as κ = 0.64.

Penetration percentage

The mean percentage microleakage values of the test groups are presented in Tables 2 and 3. All test materials exhibited dye penetration along the tooth-restoration interface. The highest amount of microleakage was observed on the gingival site enamel of the Omnichroma group, where universal adhesive was used in self-etch mode. A comparison between materials at each site (incisal and gingival) showed that, although Omnichroma generally exhibited higher microleakage values at the gingival margins, the difference between Omnichroma and Filtek Universal Restorative was not statistically significant at either site (p > 0.05). The statistical analysis showed no significant difference between the incisal site and gingival site enamel margins for all of the tested materials and the adhesive modes.

Table 2 Microleakage Penetration Percentages (%)

	Omnichroma	Filtek Universal Restorative
Self-Etch		
İncisal	36.07 ± 22.7	27.75 ± 24.8
Gingival	41.52 ± 30.4	34.93 ± 31.8
Total Etch		
İncisal	28.84 ± 15.8	24.41 ± 24.0
Gingival	32.09 ± 28.1	26.05 ± 23.5
Selective Etch		
İncisal	26.73 ± 15.5	25.36 ± 19.0
Gingival	40.77 ± 35.0	30.183 ± 25.1

ANOVA, Mann Whitney U, p < 0.05

Scoring

The Kruskal Wallis test showed no statistical difference between the microleakage scores regardless of

Table 3 Microleakage Penetration Scores

	Omnichroma				Filtek Universal Restorative			
	Score 0	Score 1	Score 2	Score 3	Score 0	Score 1	Score 2	Score 3
Self-Etch								
İncisal	3(13.6%)	17(77.2%)	2(9.0%)	0	8(36.3%)	10(45.4%)	4(18.1%)	0
Gingival	7(31.8%)	8(36.3%)	7(31.8%)	0	9(40.9%)	6(27.2%)	3 (13.6%)	3(13.6%)
Total Etch								
İncisal	5(22.7%)	15(68.1%)	2(9.0%)	0	12(54.5%)	6(27.2%)	2(9.0%)	2(9.0%)
Gingival	8(36.3%)	8(36.3%)	6(27.2%)	0	11(50.0%)	7(31.8%)	2(9.0%)	1(4.54%)
Selective Etch								
İncisal	7(31.8%)	13(59.0%)	3(13.6%)	0	8(36.3%)	12(54.5%)	2(9.09%)	0
Gingival	9(40.9%)	8(36.3%)	3(13.6%)	3(13.6%)	7(31.8%)	13(59.0%)	2(9.09%)	0
		P value = 0.172				*P* value = 0.160		

Kruskal Wallis test

application mode or composite brand on both side enamel margins. Examination of the adhesive application modes using both scoring and penetration techniques revealed that the total etch method exhibited the least microleakage, even though the difference between the application modes was not statistically significant ($p > 0.05$).

Discussion

Today's resin composite restorations are widely utilized in various applications ranging from anterior aesthetic restorations to wider posterior restorations, and are predominantly limited by microleakage, which is attributed to material shrinkage during polymerization reactions [14].

Consistent adhesion between the tooth-restoration interface is crucial for protecting restorations from the negative effects of polymerization reactions and the oral cavity's mechanical and thermal stresses [15]. Accordingly, one of the most critical considerations in the evolution of a novel resin restorative material is to extensively examine and minimize the potential for microleakage.

Different methodologies are available in the literature to evaluate microleakage in vitro and in vivo [16]. Different in vitro techniques for assessing microleakage have been developed and used, such as the use of dyes, radioactive isotopes, bacterial activity, air pressure, scanning electron microscopy, dye penetration, and microcomputed tomography between the restoration-tooth interface [17]. Traditionally and as a most widely accepted method, evaluation of microleakage with a conventional scoring system is used to rate the degree of dye penetration where particle size of the dyes that is larger than the diameter (1–4 µm) of the dentinal tubules is preferred [18, 19]. In the dye penetration method, dyes such as methylene blue (2%), basic fuchsin (0.5%), silver nitrate (50%), and Rhodamine B (0.2%) are commonly used [16]. In the literature, no systematic evaluation of the test methods themselves were found in comparing the dye types among microleakage studies., no statistically significant difference was detected between the dyes in the study by Heintze et al., in which they compared the microleakage values of samples stained with silver nitrate, basic fuchsin and methylene blue [20]. Therefore, in our study, 2% basic fuchsin was used in the conventional method as it is highly feasible and easily reproducible.

However, the examination with dye penetration alone is a conventional method that does not yield quantitative results, and the intermediate intervals can be attributed to the same score [20, 21]. In microleakage assessment studies, reliable results can be achieved by utilizing technological developments that facilitate easier digital manipulation and zooming, allowing for more objective results through the use of advanced software. In this study, ImageJ software, which is easy to operate and allows for quick image analysis, was used. Digital imaging is suggested as a suitable method for identifying minor endodontic filling abnormalities, early stages of caries lesions, periodontal bone defects, and the marginal microleakage [22]. As seen from the Kappa analysis used in our study, microleakage scores evaluated with dye penetration by more than one person have different results than 10–20% of the other scores. In line with this approach, in the current study, image analysis was performed with ImageJ software in addition to the dye penetration scoring method, and the two methods were compared just perform Kappa analysis for reliability.

In our study, we aimed to compare two different methods using kappa analysis, and therefore, the percentage values obtained from Image J were converted into microleakage scores. In this context, based on the ISO/TS 11405: 2003 standards, scores were assigned as follows: scores below 50% penetration, which correspond to dye penetration into less than half of the cervical floor, were assigned as score 1; scores encompassing penetration into the entire cervical floor (50–100%) were assigned as score 2; and scores indicating penetration beyond the entire cervical floor, including into the axial wall (more than 100%), were assigned as score. A comparison of the results showed that the two different microleakage measurement methods used were 'substantially' correlated. Contrary to our expectations, although 'no agreement' was detected between the microleakage values evaluated by digital and scoring in our study, 'perfect agreement' was not detected either. Based on the results of the present study, the first null hypothesis cannot be rejected since no differences were found in microleakage between the digital and scoring microleakage measurement methods. Similarly, the study by Mesa et al. also found comparable results between visual and scoring methods; however, this was not consistent with our expectations.

Lucena et al. reported that standard error values in microleakage studies tend to be higher compared to other types of studies [23]. Similarly, one limitation of our study is the relatively high standard deviations, which are consistent with findings in the literature [5, 21].This can be explained by the use of teeth, a biological material, in our in vitro study, where the performance of the materials could be influenced by the permeability and mineral structure of enamel and dentin.

While in vivo studies are considered the best method for evaluating dental materials, in vitro simulations help to predict the longevity of the mechanical and structural behaviors of the composites despite some limitations [24]. In the present study, thermocycling at a range of 5–55 °C and a dwell time of 15 s, totaling 500 cycles, was used to evaluate microleakage. This approach was chosen according to the ISO/TS 11405: 2015 recommendations, as it closely mimicked the clinical conditions, although there is no standard methodology for thermal cycling in such studies, as observed in most related research [25–27].

Restoration of Class V lesions is challenging, and the optimal restoration technique is still controversial among the clinicians due to the presence of oblique dentin tubule morphology at the marginal edges and the difficulty of isolation, adhesion, finishing, and polymerization pattern of the resin composites [28, 29]. The preparation of Class V cavities with incisal margins produces stronger coherence bonds and poses unique challenges in the cervical surface bond due to the structure of the cement substrate [30].

Additionally, the high configuration factor (C-factor: 5) in Class V cavities influences the polymerization stress that occurs within the restoration during the photopolymerization of the resin and may result in microleakage. Due to the morphological differences observed in the incisal and gingival margins, these two margins were compared separately in the current study. Although more microleakage is expected to be observed due to the more significant number and diameter of the dentinal tubules in the cervical region, no statistically significant difference was detected as the current materials enable successful restorations.

In order to manage the polymerization kinetics under clinical conditions, the chemical components of the restorative materials, primarily the filler distribution and shape, have been improved [31]. Filtek Universal and Omnichroma resin composites contain nanofillers to increase the filler ratio and improve the aesthetic properties of the material [32]. These fillers are in the form of homogeneous nano-fillers in the structure of Omnichroma composites and a patented TRUE nanofiller technology is used in the structure of Filtek Universal composites, in accordance with the manufacturer's claim. These newly developed TRUE-type fillers comprise sub-100 nm particles and clusters, that provides an increased filler ratio and improved mechanical properties. The increased filler ratio reduces the polymerization shrinkage of the material and may explain the reduced microleakage values of the composites in the current study [33].

New resin composite materials, Filtek Universal and Omnichroma, were released to the market to overcome aesthetic issues on the anterior regions with the color adjustment potential ability and the new chemical composition [34]. Microleakage comparison of the two new composites yielded that both groups exhibited a low level of microleakage. However, the group where Omnichroma resin composites were applied to the cavity using the self-etch method showed a slightly higher incidence of microleakage, however it was not statistically significant. Filtek Universal composites contain newly released Aromatic urethane dimethacrylate (AUDMA) and addition-fragmentation monomers (AFM), which reduce polymerization shrinkage during the photopolymerization and may minimize the gaps between tooth-restoration interfaces [35].

Filtek Universal and Omnichroma, have blending effects and provide color adjustment by reflecting light from the neighboring hard tissues with increased translucency by manufacturers [36]. Omnichroma manufacturers claim that sufficient polymerization can be achieved even in deeper cavities due to increased translucency. These materials may also have reduced microleakage by increasing the degree of the conversion with increased translucency [37].

Although it is known that etch and rinse systems achieved higher bond strength than self-etch systems, the formulation of adhesives and application methods are constantly changing [38]. It is necessary to identify the optimal etching mode to reduce the microleakage in current composite resins.

Etching the dental hard tissue aims to increase the surface roughness by dissolving the hydroxyapatite minerals in the structure to eliminate the smear plugs in the dentinal tubules and achieve adequate adhesion. Moreover, phosphoric acid etching dissolves enamel rods, creating a porous surface where the adhesive can diffuse [39]. Aside from its benefits, dentin etching could result in reduced interfibrillar space, inducing a collapse in the collagen fibril structure and consequently restricting the extent of monomer penetration and low quality hybrid layer [40].

Self-etch adhesives dissolve the smear layer and the underlying dentin structure with acidic monomers in their structure, of which eliminates the need for a separate acid application [9]. Although they are user-friendly with these features, their adhesion success is controversial because they cause superficial demineralization of the dentin, and the dentinal tubules are partially occluded by the smear [41]. Furthermore, having low acidity may cause low bond strength at the tooth restoration interface, which may be responsible for the higher rates of marginal discoloration of cervical lesions [42].

In addition to the advantages of roughening the surfaces by etching the inorganic structures in the enamel, the disadvantages of the organic structure were evaluated, and the concept of separate etching of the enamel (selective etching) was developed to be applied with multipurpose (universal) or self-etch adhesives [43]. Although there are few results in the literature regarding the clinical outcomes of the selective etching techniques, studies pointed out that the selective etching of the enamel achieves results in a more durable marginal integrity [42, 44].

In the present study, the difference between the adhesive methods applied in different modes was not statistically significant. Similar to our results, Perdiago et al. evaluated the application of Scotchbond Universal adhesive with multi-modes in vivo and did not detect a significant difference between the application methods during the 18-month follow-up period [42]. Since the lack of statistical significance, the second null hypothesis also can be accepted. This can be explained by the fact that Scotchbond Universal adhesive, unlike conventional self-etch adhesives, causes deeper demineralization with reduced acidity ($pH > 2.5$) with acidic monomers [45]. In addition to these innovations, the adhesives used in this study contain hydroxyethyl methacrylate (HEMA) and Methacryloyloxydecyl dihydrogen phosphate (MDP) monomers. 10-MDP monomers interact with calcium without deep demineralization on the dentin and enamel surface, and by providing the formation of MDP-Ca salts, it aims to increase the bond strength [46]. At the same time, the HEMA molecule in the adhesive interacts chemically with hydroxyapatite and increases the adhesion to the dental tissues by increasing the wettability of dentin with due to the hydrophilic character [47].

Furthermore, the consistent performance of the Scotchbond Universal adhesive across different groups suggests its versatility and reliability. These findings highlight the potential of this adhesive for various applications within the field of dentistry.

Conclusions

According to the results, it can be concluded that:

1. There was no statistically significant difference between the microleakage values of Omnichroma and Filtek Universal resin composites.
2. The microleakage of the gingival and incisal margins was statistically similar, regardless of the composite brand and the universal adhesive's application method.
3. Resin composites with color adjustment potential are suitable for use in class V cavities while being easy to handle, providing aesthetics and reduced microleakage.
4. Evaluation of microleakage in vitro can be done by conventional or quantitative methods.

Abbreviations

List of acronymes

AFM	Addition-fragmentation monomers
ANOVA	Analysis of variance
AUDMA	Aromatic urethane dimethacrylate
CEJ	Cemento enamel junction
HEMA	2-Hydroxyethyl Methacrylate
ISO	The International Organization for Standardization
MDP	Methacryloyloxydecyl dihydrogen phosphate
pH	Potential hydrogen
Rpm	Root per minute
TEGDMA	Triethylene glycol dimethacrylate
TIFF	Tag Image File Format
UDMA	Diurethane dimethacrylate

List of symbols

C^0	Celcius
Mm	Milimeter
s	Second

Acknowledgements

None declared.

Authors' contributions
CS: Formal analysis, investigation, resources, writing, visualization, project administration, funding; SA: Writing, conceptualization, methodology, investigation, resources, supervision; OB: Conceptualization, methodology, validation, resources, funding All authors read and approved the final manuscript.

Funding
No funding was obtained for this study.

Data availability
No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate
This study was conducted according to the stipulations of the Helsinki Declaration (2000) and previously approved by the Research Ethics Committee the Gazi University under protocol number E-21071282–050.99–60064. All teeth were extracted due to periodontal reasons and all patients and/or legal guardians gave their written informed consent for the use of their teeth for research purposes and all central incisors were irreversibly anonymized immediately after extraction.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

Received: 30 May 2024 Accepted: 30 October 2024
Published online: 13 November 2024

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