Short-Term Comparison of Clinical Performance of Universal Adhesives with Self-Etch Mode in NCCL Restorations

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ABSTRACT

Objectives: To evaluate the clinical performance of universal adhesives with self-etch mode regarding their functional monomer and HEMA contents. Methods: The study involved 27 patients (108 restorations) aged between 34 and 69 (mean age: 53.8). Each restoration contained one of four different universal adhesives applied in self-etch mode: G-Premio Bond (HEMA-free, MDP and 4-MET containing), Xeno Select (HEMA and MDP-free), Tetric-n-Bond Universal (HEMA and MDP-containing) and Clearfil Universal Bond Quick (HEMA, MDP and amide monomers containing). The restorations were evaluated according to the FDI criteria at baseline, 6, and 12 months. The data were statistically analyzed using Friedman's and Kruskal-Wallis tests for significance in each pair ($p<0.05$). Results: After 12 months, one restoration was lost in each of the G-Premio Bond and Clearfil Bond Quick groups. The success rate was 96.3% for both adhesives and 100% for Xeno Select and Tetric-n-Bond adhesives. There was no statistically significant difference between the four dentin adhesive groups among all the evaluation periods regarding any evaluation criteria. However, four universal adhesives showed clinically acceptable marginal discoloration and marginal deterioration in a few restorations. Conclusion: Monomer contents of universal adhesives with self-etch mode had no significant effect on the success of restorations.

INTRODUCTION

The aim of adhesive dentistry is the development of adhesives that form strong bonds between various dental tissues and restorative materials, are biologically compatible with the pulpo-dentinal complex, and provide adhesion that is clinically practical and stable.[1]

A couple of clinical application steps are required for the substance exchange between biomaterial and tooth tissue while using contemporary adhesives. Other than the number of application steps, adhesives can be classified as "etch&rinse" and "self-etch" systems based on the adhesion strategies.[2] The adhesion strategy most traditionally consists of three steps with the consecutive application of conditioner or acid etchant, followed by a primer or adhesion promoting agent, and finally, the actual bonding agent or adhesive resin. Simplified two-step adhesive systems combine the second and third steps, followed by a separate "etch and rinse" phase.[2] Self-etching adhesive systems, on the other hand, eliminate the need

for an "etching and rinsing" phase. This reduces the clinical application time and significantly reduces technical sensitivity and the risk of application and manipulation errors.[2]

Recently, adhesives that provide versatile application by applying different roughening methods have been developed in adhesive systems and have been introduced as the last-generation adhesive system. This adhesive system is called 'universal' or 'multi-mode' because it can be used with different adhesive strategies and different restoration types.[3] Universal adhesives combine all components in one bottle and can be applied with etch&rinse, self-etch, or selective-etch on the enamel surface.[4] These adhesives are used in direct restorations as well as indirect composite restorations.[5]

Despite the similarities between adhesives, the composition of universal adhesives differs from existing self-etch systems in that they include monomers capable of chemical and micromechanical bonding to dental tissues.[6,7] The functional monomers interact ionically with the calcium of hydroxyapatite through their functional groups, adding the potential for chemical bonding to the shallow micromechanical bonding achieved by limited surface decalcification and roughening effect caused by the acidic functional monomer.[8] Among the many functional monomers, methacryloxydecyl dihydrogen phosphate (10-MDP) is recognized as one of the most effective monomers.[9,10] 10-MDP chemically binds to the Ca of hydroxyapatite but also roughens, causing a significant release of Ca from the hydroxyapatite-based substrate. This Ca release continues with the formation of the stable 10-MDP-Ca salt of 10-MDP, which coalesces to form nanolayers of approximately 4 µm.[11,12] Aside from 10-MDP, functional monomers such as 2-(methacryloxyethyl) phenyl hydrogen phosphate (Phenyl-p), 4-methacryloxyethyl trimelitic acid (4-MET) are also used in universal adhesives. Phenyl-p gains acidic properties with its monohydrogen phosphate content and increases resin penetration into demineralized dentin. 4-MET is used as an adhesion promoter and demineralizing monomer. It forms calcium salts by ionic bonding with calcium of hydroxyapatite, but its chemical binding capacity is weaker compared with 10-MDP.[13,14]

Many universal adhesives contain 2-hydroxyethylmeth-acrylate (HEMA) as a mono-functional co-monomer, which acts as a wetting agent. HEMA, a low-molecular-weight small molecule, is a good diffusion agent and also acts as a co-solvent for other less water-soluble monomers. It helps prevent phase separation in one-step systems where hydrophobic and hydrophilic components are combined, such as universal adhesives.[8] Another feature of HEMA is its hydrophilicity. This increases the wettability of dentin, enables the diffusion of the resin into the collagens, and increases the bond strength. On the other hand, HEMA reduces the vapor pressure, making it difficult to remove water from the adhesive, and this residual water can interfere with the polymerization of the adhesive monomer and impair the quality of the hybrid layer.[15] This negative effect was overcome with the development of HEMA-free self-etch adhesive that isolates water.[16]

A study showed no significant differences in the clinical performance between HEMA-containing and HEMA-free all-in-one self-etch adhesive in Class I restorations after two years.[17] Further, it was found that the HEMA-free adhesives used in non-carious cervical lesions could last longer than 5 years.[18] So far, no study has evaluated the clinical performance of universal adhesives only self-etch mode. Thus, this study aimed to investigate the clinical performance of universal adhesives in self-etch mode regarding their functional monomer and HEMA contents. The null hypothesis was that there would be no significant differences between the clinical performances of universal adhesives applied in self-etch mode with respect to different functional monomers and with or without HEMA.

MATERIALS AND METHODS

STUDY DESIGN

Before starting this study, which was planned as a clinical follow-up study on volunteer participants, the relevant ethics committee approval was obtained from the Istanbul University Faculty of Dentistry Clinical Research Ethics Committee (Date 17.05.2018, Protocol number 2018/49) and was conducted in full accordance with the World Medical Association Declaration of Helsinki. Written informed consent form was obtained from each subject prior to participating in the study. Table 1 shows the brand, chemical composition, and manufacturer of the materials used. The restorations were performed in the Department of Restorative Dentistry, Faculty of Dentistry, Istanbul University.

SAMPLE SIZE CALCULATION

The sample size was calculated using the G*Power 1.2.9.2 software. Considering the 83% success rate based on previous studies, the sample size was calculated as 25 for each group, with 90% power and 5% type I error rate.[19] Considering that there might be losses during follow-up during the study period, 27 individuals were included.

PATIENT SELECTION

Among the patients who met the inclusion criteria, those who voluntarily agreed to participate were included in the study. A total of 27 patients (12 males, 15 females) aged between 34 and 69 (mean age: 53.8) years participated. A total of 108 restorations were performed, with four restorations per patient (*Figure 1*). The distribution of Class V restorations according to adhesives and tooth number is presented in Table 2.

INCLUSION AND EXCLUSION CRITERIA

Patients who presented to our clinics for routine treatment were evaluated clinically and radiographically by two restorative dentistry specialists who were calibrated in terms of the inclusion and exclusion criteria (*Table 3*), and those with caries-free cervical lesions in their mouths that required

Table 1. The brand names, manufacturers, chemical compositions, and application of materials.

Materials	Manufacturer and LOT #	pH	Composition†	Application
G-Premio Bond	GC Corp., Tokyo, Japan #1901092	1,5	MDP, 4-MET, MDTP, MEPS, BHT, silica, acetone, water, photoinitiators	Apply adhesive. Leave for 10 s. Dry thoroughly for 5 s with oil-free air under max. Air pressure. Light cure for 10 s.
Xeno® Select	Dentsply Sirona, Konstanz, Germany #1807000817	<2,0	Bifunctional acrylate, acidic acrylate, functional phosphoric acid ester (ethyl 2-[5-dihydrogen phosphoryl-5,2-dioxapentyl] acrylate, tertbutyl alcohol, water, camphorquinone, DMABN (co-initiator), stabilizer	Apply the adhesive for 20 s with vigorous agitation, gently air thin for 5 s. Light-cure 10 s.
Tetric-n-Bond Universal	Ivoclar, Vivadent, Schann, Liechtenstein # X50984	2,5-3,0	10-MDP, Bis-GMA, HEMA, UDMA, MCAP, D3MA, silicon dioxide, camphorquinone, Ethanol, Water	Apply and then scrub for at least 20 s. Disperse with oil- and moisture-free compressed air until a glossy, immobile film layer. Light-cure 10 s.
Clearfil Universal Bond Quick	Kuraray Noritake, Tokyo, Japan # 7UD042	2,3	MDP, Bis-GMA, HEMA, Hydrophilic amide monomers, Colloidal silica, Silane coupling agent, Sodium fluoride, dl-Camphorquinone, Ethanol, Water	Apply with rubbing motion, then no waiting. Dry 5 s use a vacuum aspirator. Light-cure 10 s.
Clearfil Majesty ES-2	Kuraray Noritake, Tokyo, Japan #2Q0126 #1L0070		Silanated barium glass, prepolymerized organic filler, Bis-GMA, Hydrophobic aromatic dimethacrylate, di-camphorquinone	

†Bis-GMA: bis-phenol A diglycidylmethacrylate, BHT: butylated hydroxytoluene, HEMA: 2-hydroxyethyl methacrylate, MDTP: 10-methacryloyloxydecyl dihydrogen thiophosphate, D3MA: decandiol dimethadrylate, DMABN: 4-(dimethylamino) benzonitrile, MCAP: methacrylated carboxylic acid polymer, MDP: methacryloyloxydecyl dihydrogen phosphate, MEPS: methacryloyloxyalkyl thiophophate, UDMA: urethane dimethacrylate, 4-MET: 4- methacryloyloxyethy trimellitate.

treatment in four teeth were identified. These lesions had to be non-carious, non-retentive, and involve both the enamel and dentin of vital teeth without mobility.[20] Some features of these lesions were also evaluated. The degree of sclerotic dentin was measured according to the criteria defined by Swift *et al*., as shown in Table 4.[21] The cavity dimensions in millimeters (height and depth), percentage of margin in enamel, and cavity geometry (assessed by photographic profile and labeled <45, 45-90, 90-1350, and >135) were recorded. The presence of preoperative sensitivity and attrition facets were also observed and recorded *(Table 5*). These features were recorded to allow the comparison of the baseline cavity characteristics between the experimental groups.[22]

TREATMENT PROTOCOL

Each restoration contained one of four different universal adhesives: HEMA-free, MDP and 4-MET-containing adhesive (G-Premio BOND, GC Corp., Tokyo, Japan); HEMA and MDP-free adhesive (Xeno Select, Dentsply Sirona, Konstanz, Germany); HEMA and MDP-containing adhesive (Tetric-n-Bond Universal, Ivoclar, Vivadent, Schaan, Liechtenstein); and HEMA, MDP, and amide monomers containing adhesive materials (Clearfil Universal Bond Quick, Kuraray Noritake, Tokyo, Japan). All restorations were performed using a uniform composite resin (Clearfil Majesty ES-2, Kuraray Noritake, Tokyo, Japan). To determine which universal adhesive to apply to which lesion, a random decision was made by tossing a coin just before the restoration placement. Regardless of the region, among the premolar or anterior teeth with a caries-free cervical lesion, randomization was performed by first selecting the HEMA-free, MDP and 4-MET containing dentin adhesive and tooth number by flipping a coin, followed by the selection of HEMA and MDP-free, HEMA and MDP-containing, HEMA, MDP and amide monomers containing dentin adhesives, and tooth number, also accomplished by the flip of a coin.[23,24]

RESTORATIVE PROCEDURE

In the study, all restorative procedures such as preparation of cavities, isolation, and restorations were performed by a single practitioner (F.K.). Before starting the study, four different materials to be used in the study were applied in two patients with four non-carious cervical lesions in their mouths,

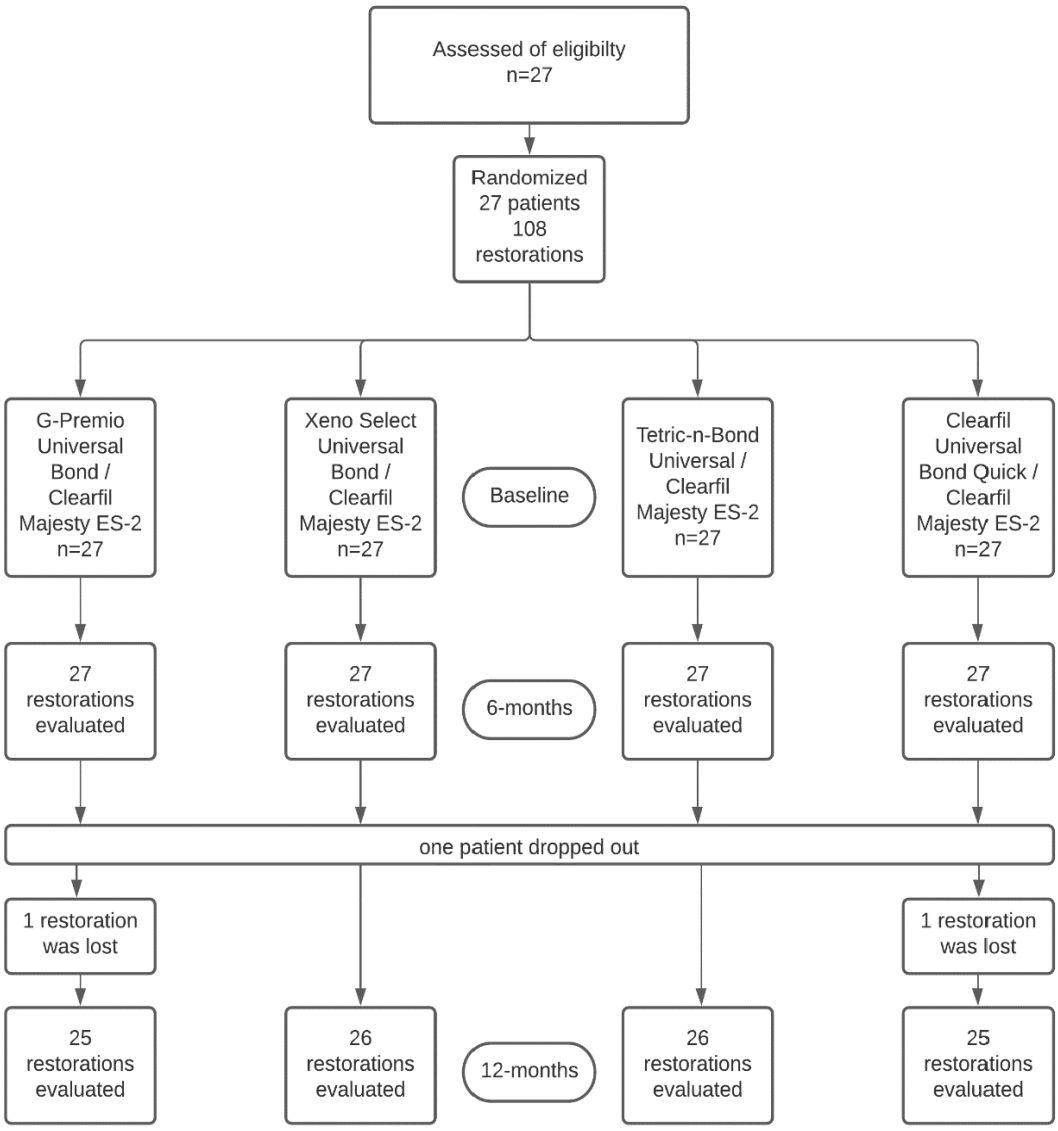

Figure 1: Flow diagram for history of restorations.

Table 2. Distribution of adhesives group by maxillary and mandibular tooth numbers.

Adhesives	Tooth No.																			
	15	14	13	12	11	21	22	23	24	25	45	44	43	42	41	31	32	33	34	35
G-Premio	1	4	2	-	1	2	-	2	3	2	2	2	1	-	-	-	1	1	3	-
Xeno Select	4	1	3	-	-	-	-	1	4	1	1	5	-	-	-	-	-	-	1	6
Tetric-n-Bond	2	3	1	-	1	-	-	2	2	2	1	2	1	-	-	-	-	4	5	1
Clearfil Bond Quick	1	2	1	1	-	-	1	1	5	2	2	1	3	1	-	-	-	1	3	2
Sum of restoration	8	10	7	1	2	2	1	6	14	7	6	10	5	1	-	-	1	6	12	9

and restorations were made. In this way, it is ensured that the practitioner was calibrated and familiar with the application of the materials and restorations.

Before restorative treatment was performed, all patients received oral hygiene instructions, with a demonstration of brushing techniques and the use of dental floss. The restorations started with a preliminary cleaning of the tooth

Table 3. Inclusion/exclusion criteria of volunteers.

Inclusion Criteria	Exclusion Criteria
Over the age of 18 years	Under the age of 18
Good oral hygiene	Poor oral hygiene
Normal occlusal relationship with natural dentition	Poor general health condition
At least 20 teeth in occlusion	Bruxism or uncontrolled parafunction
The tooth with the lesion must be vital, non-mobile and non-carious	Premature contacts in teeth to be restored
At least 4 non-carious cervical lesions that require treatment	Patients with periodontal or gingival diseases
The tooth with the lesion should have antagonist and contact teeth	Endodontically treated teeth

Table 4. Dentin Sclerosis Scale. †

Category	Criteria
1	Sclerosis is not present. Dentin is light yellow or whitish in color. Dentin is opaque and shows little translucency. (These lesions are more typical for younger individuals.)
2	More sclerosis than in category 1, but less than 50% between categories 1 and 4.
3	Less sclerosis than in category 4, but more than 50% between categories 1 and 4.
4	Significant sclerosis present. Dentin dark yellow or brownish. Dentin appears vitreous with marked translucency. (These lesions are more typical for older individuals.)

†Adapted from Swift and others[21]

surface with a polishing paste and water to remove the salivary pellicle and dental plaque residues, followed by washing and drying. The color of the composite was then determined by comparison with an appropriate color guide (Vita Lumin, Vita Zahnfabrik, Bad Säckingen, Germany). Local anesthesia was used as needed to avoid the discomfort of the participant during the intervention. During the restorative procedures, the isolation of the working area was provided with a cotton roll, saliva ejectors, and a gingival retraction cord (Ultrapak™, Ultradent, USA). No additional retention or beveling was performed on the enamel and dentin walls of the lesions. The four non-carious cervical lesions in the patients were divided into four material groups and the adhesives were applied to the lesion in each group in a self-etch mode according to the manufacturer's instructions for use (*Table 1*). After the adhesive application was completed, all groups were restored using Clearfil Majesty ES-2, a nanohybrid composite resin, in accordance with the layering technique. Polymerization was performed for 20 seconds using an LED light device (Elipar™ S10, 3M Espe, St. Paul, MN, USA) at no less than 1200 mW/cm². For the finishing and polishing processes, fine-grained diamond burs with 25-micron grains were used as the finishing bur and the finishing process was performed. Then, polishing respectively using medium (purple/40-µm silicon oxide), fine (green/20-µm aluminum oxide), superfine (pink/7-µm aluminum oxide) flexible discs (Super-Snap Rainbow Technique Kit, Shofu, USA) were completed under water cooling.

CLINICAL EVALUATION

Restorations were evaluated by a dental explorer and mirror, at baseline (1 week after completion), and 6 and 12 months. The evaluation was performed by two experienced calibrated examiners from the Department of Restorative Dentistry, Faculty of Dentistry, Istanbul University, who were unaware of the objectives of the research, were not involved in the placement of restorations and were blind to the experimental groups. For training purposes, reference photographs are provided to show the scoring for each criterion for the calibration of the evaluators who were informed of the clinical evaluation criteria used in the evaluation of restorations. The evaluators clinically evaluated 20 Class V restorations with a two-day interval. These restorations were not included in the study. The study's evaluation phase began after at least 85% intra-examiner and inter-examiner agreement was established in the calibration phase.[25]

Restorations were evaluated according to FDI World Dental Federation criteria at baseline and after 6 and 12 months, based on esthetic (surface gloss, surface coloration, marginal discoloration, color match and translucency, esthetic anatomic form), functional (fracture and retention, marginal adaptation), and biologic criteria (postoperative sensitivity and vitality, caries recurrence).[26,27]

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Table 5. Distribution of Class V lesions according to cavity variables and restoration success and failure rate for all of universal adhesives (%(n)) (According to FDI criteria, success: score 1, 2, 3; failure: score 4, 5).

Cavity variables	GP	XS	TnB	CBQ	Success	Failure	p
Shape, Cavity angle							0.677
<45°	-	3.7 (1)	3.7 (1)	3.7 (1)	2.9 (3)	-	
45°-90°	22.2 (6)	7.4 (2)	22.2 (6)	18.5 (5)	18.3 (19)	-	
90°-135°	51.9 (14)	59.3 (16)	48.1 (13)	51.9 (14)	46.2 (48)	5.8 (6)	
>135°	25.9 (7)	29.6 (8)	25.9 (7)	25.9 (7)	26.0 (27)	1.0 (1)	
Cervicoinsizal Height							0.471
<1,5 mm	-	11.1 (3)	3.7 (1)	11.1 (3)	6.7 (7)	-	
1,5 mm- 2,5 mm	48.1 (13)	37.0(10)	25.9 (7)	29.6 (8)	35.6 (37)	1.0 (1)	
> 2,5 mm	51.9 (14)	51.9 (14)	70.4 (19)	59.3 (16)	51.0 (53)	5.8 (6)	
Lesion Depth							0.872
< 1 mm	63.0 (17)	55.6 (15)	63.0 (17)	48.1 (13)	54.8 (57)	2.9 (3)	
> 1 mm	37.0 (10)	44.4 (12)	37.0 (10)	51.9 (14)	38.5 (40)	3.8 (4)	
Percent of margin in enamel							0.977
<25%	33.3 (9)	33.3 (9)	37.0 (10)	29.6 (8)	34.6 (36)	-	
25- 50 %	66.7 (18)	59.3 (16)	59.3 (16)	66.7 (18)	54.8 (57)	6.7 (7)	
50- 75%	-	7.4 (2)	3.7 (1)	3.7 (1)	3.8 (4)	-	
Dentin Sclerosis Scale							0.556
1	22.2 (6)	33.3 (9)	18.5 (5)	14.8 (4)	23.1 (24)	-	
2	48.1 (13)	29.6 (8)	37.0 (10)	40.7 (11)	37.5 (39)	1.9 (2)	
3	25.9 (7)	33.3 (9)	44.4 (12)	44.4 (12)	30.8 (32)	4.8 (5)	
4	3.7 (1)	3.7 (1)	-	-	1.9 (2)	-	
Attrition facet							0.804
yes	77.8 (21)	70.4 (19)	81.5 (22)	77.8 (21)	71.2 (74)	4.8 (5)	
no	22.2 (6)	29.6 (8)	18.5 (5)	22.2 (6)	22.1 (23)	1.9 (2)	
Preoperative sensitivity							0.733
yes	25.9 (7)	14.8 (4)	25.9 (7)	22.2 (6)	23.1 (24)	-	
no	74.1 (20)	85.2 (23)	74.1 (20)	77.8 (21)	70.2 (73)	6.7 (7)	

Abbreviations: GP: G-premio; XS: Xeno Select; TnB: Tetric-n-Bond; CBQ: Clearfil Bond Quick.

The restorations were scored using a scale of 1 to 5: 1=clinically very good; 2=clinically good and possibly very good after polishing; 3=clinically adequate, minor imperfections not enough to damage the tooth; 4=clinically inadequate but requiring prophylactic repair; 5=clinically unacceptable and requiring restoration replacement. Conflicts in scoring were resolved through consensus.[26,27]

Cumulative failure rates were calculated according to the formulation in the ADA guidelines. ([(PF+ NF) / (PF+RR)] X 100%; PF is the number of current failures before evaluation, NF is the current new failures during evaluation, and RR is the number of restorations available during evaluation.)

STATISTICAL ANALYSIS

The data obtained in the research were analyzed using the IBM SPSS 20.0 (IBM Corp., Armonk, NY, USA) package program.

Descriptive statistics of the lesions were made, and the effect of each cavity variable used in the cavity classification on the success of restorations was analyzed using the Kruskal-Wallis test.

The data collected from evaluating each dentin adhesive were statistically analyzed for changes over the one-year evaluation period using the Friedman test. The comparison between dentin adhesives was performed using the Mann-Whitney U test and Kruskal-Wallis one-way analysis of variance (ANOVA). When a statistically significant difference was found for the assessed criterion, multiple comparisons between each recall time interval for each dentin adhesive were performed using Dunn's *post hoc* test. To determine the clinical survival probability of restorations for a given period, Kaplan-Meier survival analysis was used.

The statistical significance value of all tests was accepted as $p<0.05$. Cohen's Kappa test was used to test the level of inter-examiner and intra-examiner agreement for evaluation criteria.

RESULTS

After 6 months, the recall rate was 100%. After one year, one patient with four restorations did not return. A total of four restorations, one from each dentin adhesive group found in this patient, were excluded from the study *(Figure 1)*. Therefore, the cumulative recall rate after 12 months was 96.3%.

The Cohen Kappa test revealed a strong agreement between the examiners without a statistical difference (Cohen Kappa coefficient 0.87, $p>0.05$). Figure 2 shows the survival rate according to Kaplan-Meier survival analysis. The survival rate at the end of 6 months was 100% for the all-dentin adhesive group. At the end of 12 months, one restoration each was lost in the G-Premio BOND and Clearfil Bond Quick dentin adhesive groups, and the survival rate was 96.3% for both adhesive material groups. The survival rate was 100% for the Xeno Select and Tetric-n-Bond dentin adhesive groups. When the survival rates for the dentin adhesives were compared, no statistically significant difference was found between them after 12 months.

The baseline, 6-month, and 12- month scores of the restorations according to the FDI criteria are shown in Table 6. There was no statistically significant difference between the dentin adhesive groups among all evaluation periods regarding any evaluation criteria. Also, statistical analyses detected no significant differences between ($p>0.05$) all the evaluation periods for each dentin adhesive group in respect

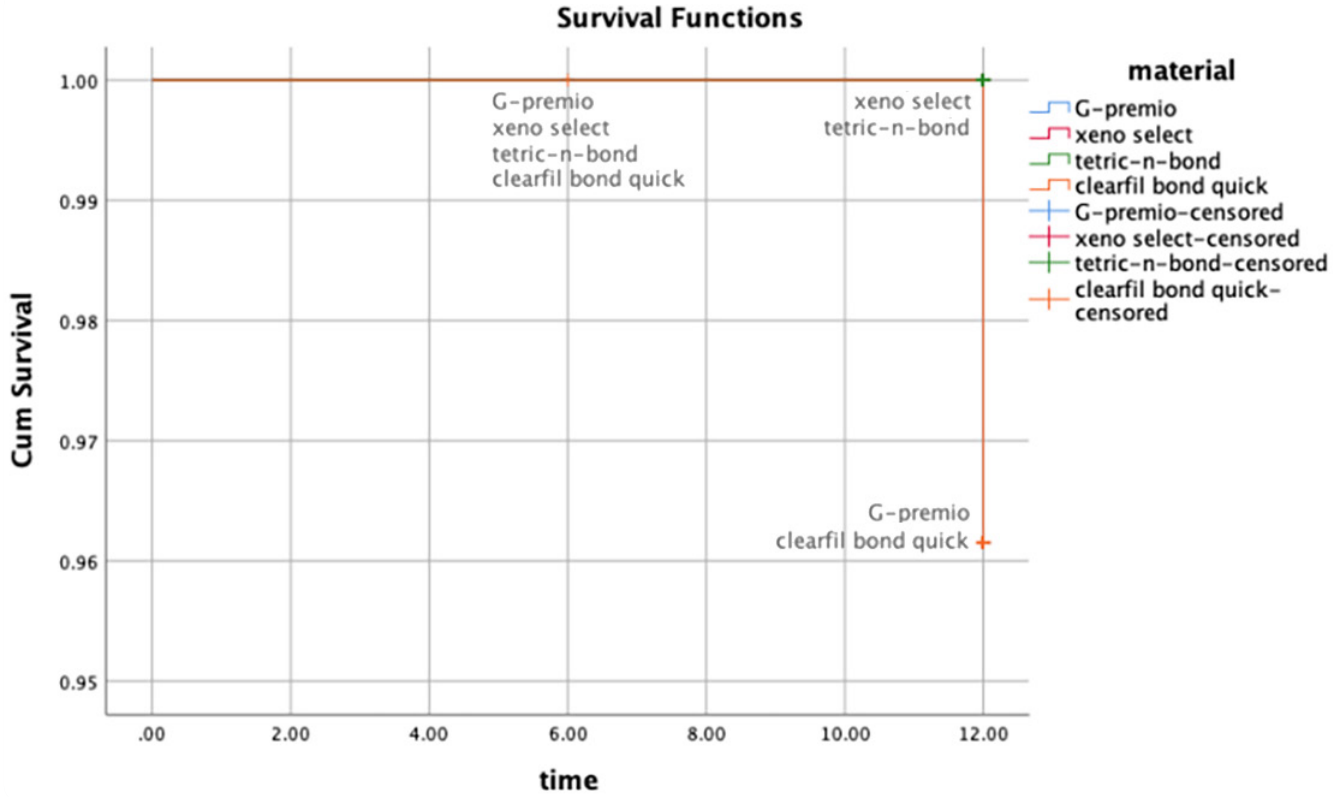

Figure 2: Kaplan-Meier survival analysis.

Table 6. Distribution of all restorations according to evaluation periods and FDI criteria (%(n)).

FDI Criteria & Scores*	Baseline				6-months				12-months				p*
	GP	XS	TnB	CBQ	GP	XS	TnB	CBQ	GP	XS	TnB	CBQ	
Retention and Fractures													0.788
1	100 (27)	100 (27)	100 (27)	100 (27)	100 (27)	100 (27)	100 (27)	100 (27)	96.2 (25)	92.3 (24)	92.3 (24)	88.5 (23)	
2	-	-	-	-	-	-	-	-	-	-	-	-	
3	-	-	-	-	-	-	-	-	-	-	3.8 (1)	-	
4	-	-	-	-	-	-	-	-	-	7.7 (2)	3.8 (1)	-	
5	-	-	-	-	-	-	-	-	3.8 (1)	-	7.7 (2)	3.8 (1)	
Marginal Adaptation													0.743
1	100 (27)	100 (27)	100 (27)	100 (27)	100 (27)	100 (27)	100 (27)	100 (27)	88.5 (23)	80.8 (21)	80.8 (21)	76.9 (20)	
2	-	-	-	-	-	-	-	-	3.8 (1)	11.5 (3)	19.2 (5)	7.7 (2)	
3	-	-	-	-	-	-	-	-	3.8 (1)	3.8 (1)	-	7.7 (2)	
4	-	-	-	-	-	-	-	-	-	3.8 (1)	-	3.8 (1)	
5	-	-	-	-	-	-	-	-	3.8 (1)	-	-	3.8 (1)	
Marginal Discoloration													0.253
1	100 (27)	100 (27)	100 (27)	100 (27)	100 (27)	100 (27)	100 (27)	100 (27)	92.0 (23)	80.8 (21)	88.5 (23)	72.0 (18)	
2	-	-	-	-	-	-	-	-	4.0 (1)	15.4 (4)	7.7 (2)	20.0 (5)	
3	-	-	-	-	-	-	-	-	4.0 (1)	-	-	4.0 (1)	
4	-	-	-	-	-	-	-	-	-	3.8 (1)	3.8 (1)	4.0 (1)	
5	-	-	-	-	-	-	-	-	-	-	-	-	
Postoperative Sensitivity													0.404
1	100 (27)	100 (27)	100 (27)	100 (27)	100 (27)	100 (27)	100 (27)	100 (27)	100 (25)	96.2 (25)	100 (26)	100 (25)	
2	-	-	-	-	-	-	-	-	-	3.8 (1)	-	-	
3	-	-	-	-	-	-	-	-	-	-	-	-	
4	-	-	-	-	-	-	-	-	-	-	-	-	
5	-	-	-	-	-	-	-	-	-	-	-	-	
Secondary Caries													-
1	100 (27)	100 (27)	100 (27)	100 (27)	100 (27)	100 (27)	100 (27)	100 (27)	100 (25)	100 (26)	100 (26)	100 (25)	
2	-	-	-	-	-	-	-	-	-	-	-	-	
3	-	-	-	-	-	-	-	-	-	-	-	-	
4	-	-	-	-	-	-	-	-	-	-	-	-	
5	-	-	-	-	-	-	-	-	-	-	-	-	

***Comparison among the universal adhesives at the 12 months-follow up.**

to the clinical evaluation criteria. Except for the color match and esthetic anatomic form criteria, all restorations were clinically evaluated at a very good level (score 1) at the baseline and 6-month evaluation.

ESTHETIC PROPERTIES

At the end of 12 months, 92% of the G-Premio, 80.8% of the Xeno Select, 88.5% of the Tetric-n-Bond, and 72% of the Clearfil Bond Quick were evaluated as clinically very good level (score 1) for marginal discoloration *(Figure 3*). For the Xeno Select, Tetric-n-Bond, and Clearfil Bond Quick material groups, 3.8%, 3.8%, and 4%, respectively, had noticeable discoloration of the restoration margins and were evaluated as clinically inadequate level (score 4) *(Figure 4*). In terms of surface gloss, 3.8% of the restorations of the Xeno Select and 7.7% of the Tetric-n-Bond were clinically good (score 2) with an opaque surface gloss that could not be noticed from speaking distance, and 3.8% of the Xeno Select material group had esthetically unacceptable moderate surface coloration and was evaluated as clinically sufficient (score 3). In the 6 and 12-month evaluations of the restorations, the baseline scores continued in all material groups; no changes were observed in color match/translucency and esthetic anatomic form.

FUNCTIONAL PROPERTIES

After 12 months, restoration loss (score 5) was detected in 3.8% of the G-Premio and Clearfil Bond Quick material groups, and 3.8% of the restorations with Tetric-n-Bond had fractures that did not affect the marginal integrity and clinically adequate level (score 3) *(Figure 5*). In terms of marginal adaptation, 3.8% of G-Premio, 11.5% of Xeno Select, 19.2% of Tetric-n-Bond, and 7.7% of Clearfil Bond Quick had mild irregularities and were evaluated as clinically good level (score 2). Dentin was exposed in 3.8% of the Xeno Select and Clearfil Bond Quick adhesive groups, as assessed according to the clinically inadequate but repairable marginal adaptation level (score 4) *(Figure 6*).

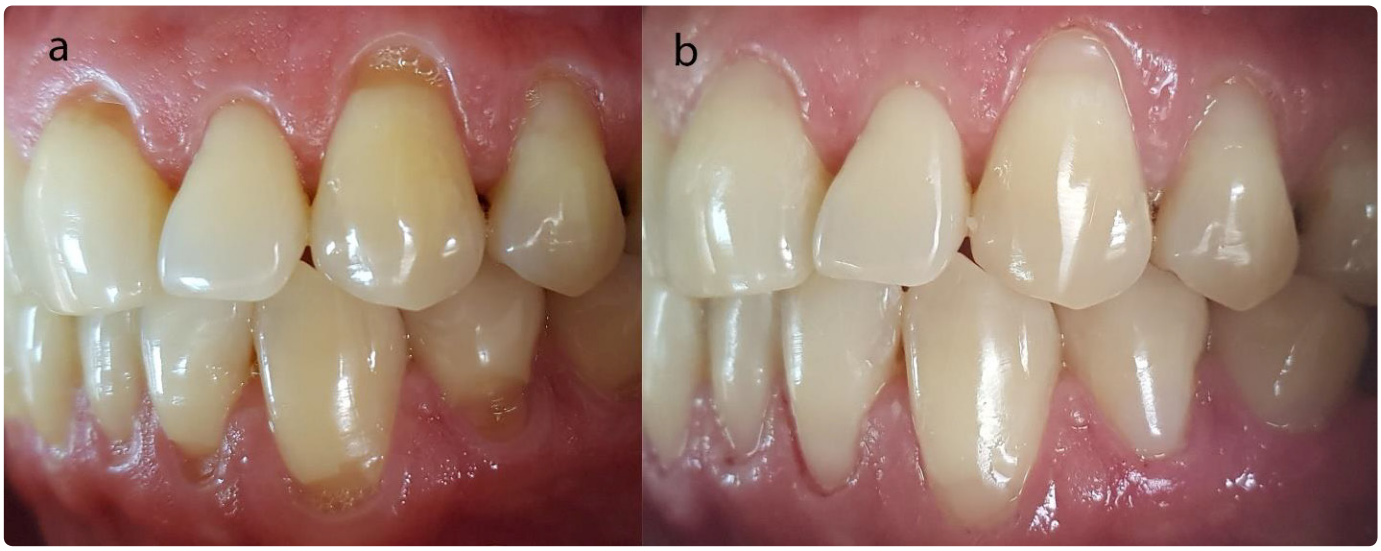

Figure 3: a) before the treatment; b) after 1 year. The restorations were clinically rated as score 1 (clinically very good) with regard to retention, marginal adaptation, marginal discoloration, and formation of caries.

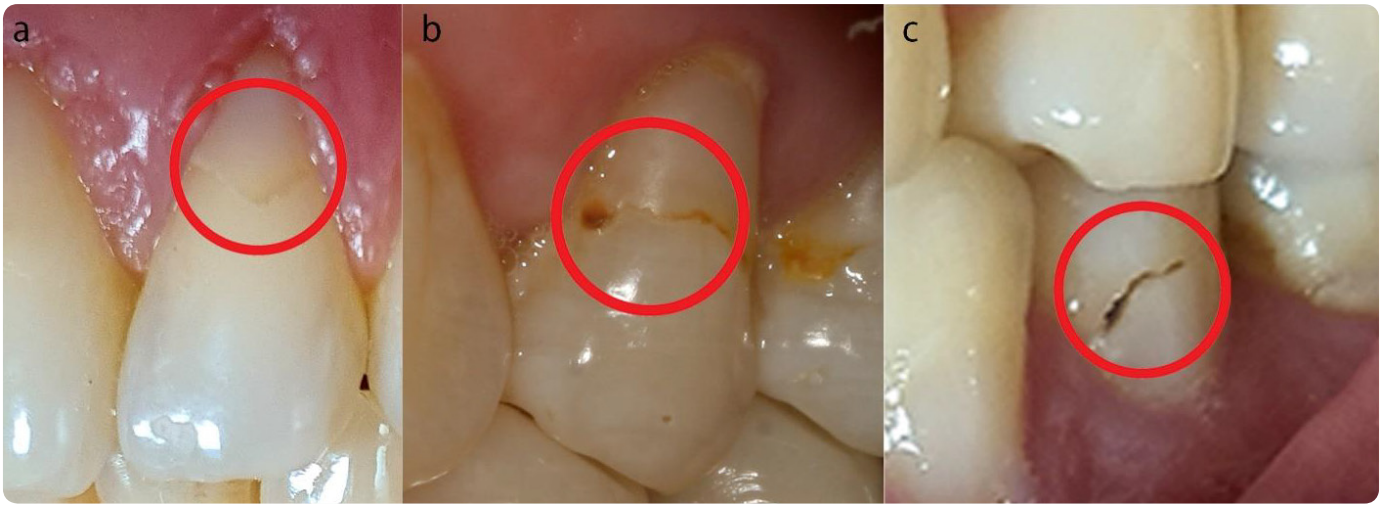

Figure 4: In terms of marginal discoloration, the restorations were clinically rated as a) score 2; b) score 3; c) score 4 according to FDI criteria after 1 year.

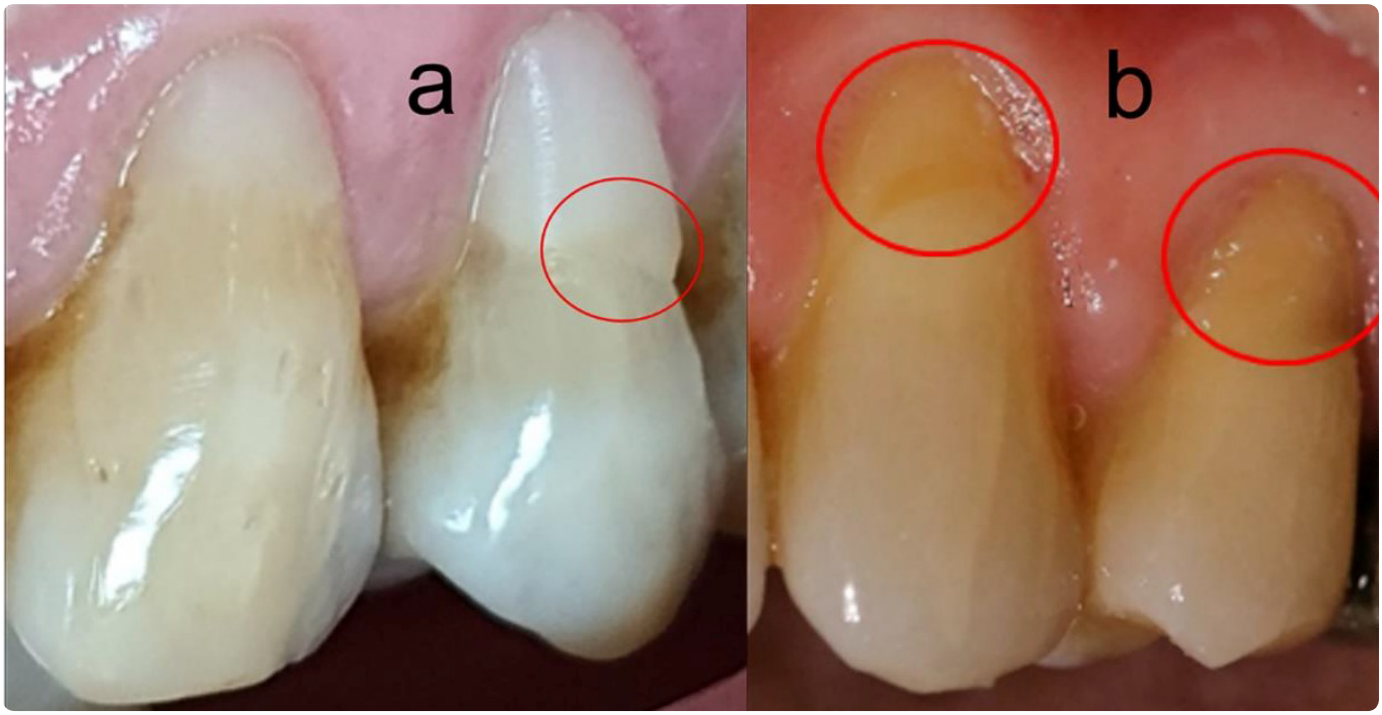

Figure 5: Clinical appearance after 1 year with fracture and failure. a) Tetric-n-Bond restoration; b) G-premio .

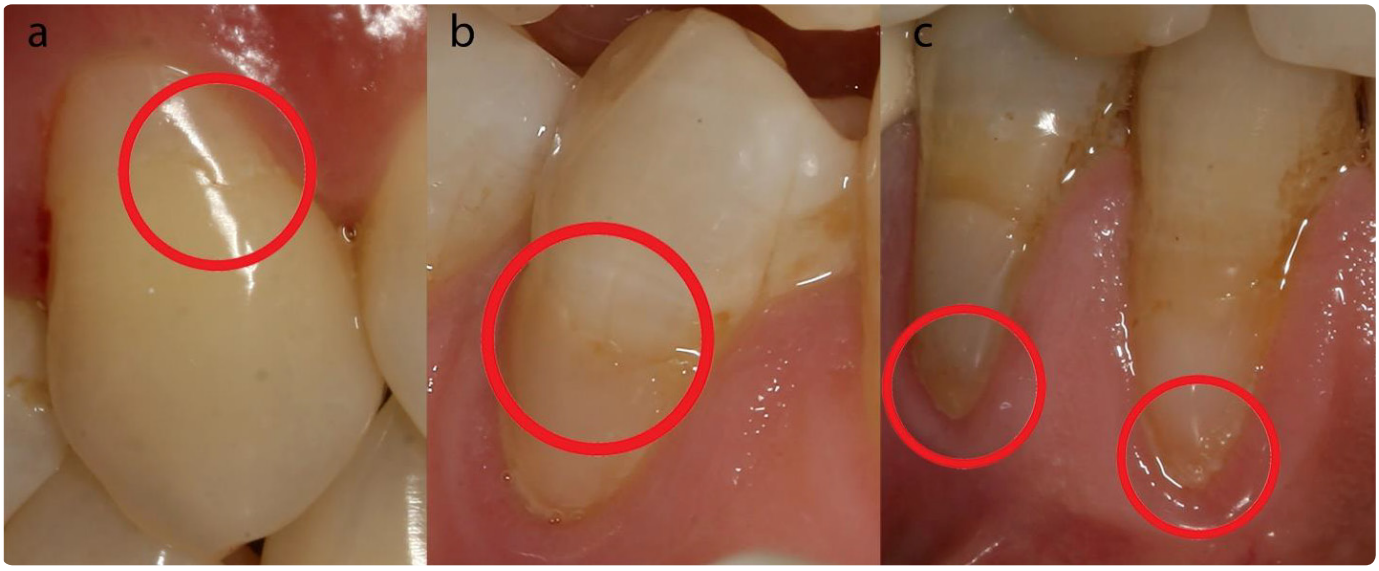

Figure 6: In terms of marginal adaptation, the restorations were clinically rated as a) score 2; b) score 3; c) score 4 according to FDI criteria after 1 year.

BIOLOGIC PROPERTIES

The restorations in all dentin adhesive groups showed no recurrence of caries/lesions after 6 and 12 months. All restorations were clinically scored very good in baseline and 6-month evaluations in terms of postoperative sensitivity. At the end of the 12th month, short-term sensitivity (score 2) was detected in 3.8% of the Xeno Select restorations. All restorations with G-Premio BOND were clinically very good level (score 1) in respect to postoperative sensitivity.

DISCUSSION

It has been reported that selective enamel roughening improves the long-term clinical performance of restorations in terms of edge discoloration and adaptation criteria.[28] However, clinical studies have shown that the application of self-etch adhesives with chemical binding capacity with selective enamel etching does not increase the retention rate in non-carious cervical lesions.[28,29] Although adhesive systems are similar to each other in terms of the monomers they contain, universal adhesive systems differ from other adhesive systems with monomers that can form chemical

and micro-mechanical bonds.[7] The chemical bonding of these monomers between enamel and dentin is thought to play an important role in creating a long-lasting interfacial connection.[30] Our study aimed to investigate the effect of the monomer contents on clinical performance by using G-Premio, Xeno Select, Tetric-n-Bond, and Clearfil Bond Quick universal adhesives in self-etch mode regarding different monomer contents.

According to the ADA guidelines, high success (retention) rates were obtained at the end of 12 months for the four universal adhesives used in our study (G-Premio, 96.2%; Xeno Select, 100%; Tetric-N-Bond, 96.2%; Clearfil Bond Quick, 100%).[31] G-Premio, Tetric-n-Bond, and Clearfil Bond Quick universal adhesives contain 10-MDP as an acidic functional monomer. *In vitro*[32,33] and clinical studies[34-38] have suggested that 10-MDP has a significant effect on the success of dentin adhesives. In addition, it is stated that there are differences in the bonding efficiency of different adhesives containing 10-MDP, which is due to the differences in the concentration of the 10-MDP functional monomer.[10] In this study, universal adhesives containing 10-MDP contain more than one component with chemical bonding potential. G-Premio contains the acidic monomer 4-MET with two carboxylic groups in addition to 10-MDP, and Tetric-n-Bond contains an additional methacrylate carboxylic acid polymer (MCAP). By contrast, Xeno Select universal adhesive contains phosphoric acid ester and acrylaminoalkyl sulfonic acid, which are responsible for chemical interaction with the dentin surface. All these ingredients in the structure of the universal adhesives used in our study can be considered as factors that may have contributed to the high success rates achieved. Adhesives containing MDP showed 6-month retention rates ranging from 94% to 98%,[34,35] whereas universal adhesives without MDP showed a retention rate of approximately 80% after 6 months.[39] In a study comparing different application modes of Tetric-n-Bond universal adhesive material, the authors showed similar retention rates regardless of tooth surface preparation, and no statistically significant difference was found between them. The high retention rates of Tetric-n-Bond universal adhesive were attributed to its two monomers content (MDP, MCAP), which have chemical binding potential.[40] However, in our study, the retention rates of the universal adhesives that did and did not contain MDP and contained different acidic functional monomers together with MDP were found to be very similar to each other. This result shows that the different functional monomer contents in terms of HEMA, MDP, 4-MET, MCAP and amide monomer of universal adhesives used do not have a significant effect on retention (success) rates and do not make a difference between universal adhesives.

Many universal adhesives contain HEMA, an effective hydrophilic methacrylate monomer. Unlike Tetric-n-Bond and Clearfil Bond Quick, G-Premio and Xeno Select do not contain HEMA. HEMA improves the bond strength by increasing the wettability of the hydrophilic dentin surface and expanding the demineralized collagen, promoting the diffusion of co-monomers. HEMA in universal adhesives acts as a co-solvent for other monomers. HEMA keeps the hydrophilic and hydrophobic components of the adhesive in a single solution and prevents phase separation between them.[41] However, the high hydrophilicity of HEMA increases water absorption after polymerization; increased water uptake accelerates the reduction of the mechanical properties of adhesives and makes the adhesive interface prone to hydrolytic degradation.[42] In our study, the clinical performances of the universal adhesives with and without HEMA were found to be very similar. In addition, universal adhesives with and without HEMA showed high retention rates. Consistent with our study findings, in a study comparing self-etch adhesives with and without HEMA, at the end of 2 years, the retention rates of HEMA-containing and HEMA-free adhesives were 100%.[17] This suggests that HEMA content does not affect the clinical performance of restorations regarding retention rates.

Although there was no significant difference between the groups in our study in respect to marginal discoloration and marginal adaptation, the Clearfil Bond Quick material group showed the greatest changes in marginal adaptation and discoloration. Clearfil Bond Quick contains a newly developed hydrophilic monomer. This hydrophilic amide monomer has a higher curing ability; as a result, the polymer formed will be resistant to hydrolysis. It has also been reported to have good wettability of tooth structure because it has a greater hydrophilic potential than HEMA.[43] Consistent with our study findings, in an *in vitro* study comparing Clearfil Bond Quick material with two different adhesives containing only HEMA, Clearfil Bond Quick showed a higher rate of marginal adaptation and discoloration.[44] This result may be because Clearfil Bond Quick contains an amide monomer with strong hydrophilic properties, unlike other material groups. Water absorption associated with strong hydrophilicity may reduce the mechanical resistance of polymer chains and weaken the bonds between dentin and resin, leading to deterioration in the adhesive interface and thus deterioration in the marginal region.[42] On the other hand, van Landuyt *et al*. found that a self-etch adhesive without HEMA exhibited significantly more marginal defects and discoloration than those containing HEMA, although there was no statistical difference between them.[45] In addition to, the early marginal changes can also be explained by not applying acid etching to the enamel margins. In previous studies comparing the applications of universal adhesives in the etch&rinse, self-etch, and selective etch mode, they found that the application of etch&rinse and selective etch gave better clinical results in terms of marginal adaptation and coloration compared with the self-etch mode.[46,47] Another 18- month follow up study comparing different application modes of a universal adhesive, it was found that self-etch application showed 30% more marginal discrepancy compared with other groups where the enamel was etched.[35] It can be mentioned with the studies that selective phosphoric acid etching creates a stable adhesive-enamel interface.[48] All these findings are similar to the early

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changes in marginal discoloration and adaptation in the 12-month evaluation of our study, in which we used universal adhesives in the self-etch mode.

In our study, a clinically acceptable level of postoperative sensitivity was detected in one (3.8%) restoration with Xeno Select, but no postoperative sensitivity was observed for the other adhesives. Consistent with the findings of our study, Perdigao *et al*. detected no postoperative sensitivity at the end of 18 months in any restorations in which they applied a universal dentin adhesive in the self-etch mode.[49] Lopes *et al*. found sensitivity in restorations where a universal dentin adhesive was applied as etch-rinse to dry dentin.[39] Zanatta *et al*. evaluated three different types of adhesives and they observed that the postoperative sensitivity rates were very close to each other.[50] However, the sensitivity rates were higher than the rates in our study. This difference may be due to differences in the adhesives used and the evaluation period.

In our study, secondary caries formation was not detected, in agreement with other studies.[34,35,39,50-53] Perdigao *et al*. found secondary caries in only one restoration in which universal adhesive was applied in a two-stage etch&rinse mode at the end of 18 months.[49] Lawson *et al*. detected secondary caries in two restorations performed with universal adhesive in the self-etch mode at 24 months.[36] It can be considered that the adhesives used, the differences in the evaluation times and factors related to the patients may be effective in the differences in the secondary caries rates found between the studies.

All lesions included in the study were classified preoperatively according to NCCL cavity characteristics. In our study, according to the FDI criteria, a score of 1, 2, and 3 for cervical lesion restorations was considered clinically successful, and scores of 4 and 5 were considered as a failure for restorations. After that, the differences between success and failure rates and lesion characteristics were analyzed statistically and no significant differences were found between them. Consistent with the findings of our study, previous studies reported that there were no significant differences between the success rates and cavity variables.[35,50,54,55] On the other hand, Ritter *et al*. found a difference in terms of retention in their clinical studies in which they applied one-step self-etch adhesives and three-step etch&rinse adhesives to NCCL with different degrees of sclerosis (1-2, 3-4). It has been reported that the alpha scores for marginal discoloration and marginal adaptation of self-etch adhesive restorations applied to lesions with a sclerosis score of 3-4 are significantly lower.[53] In a 3-year clinical performance evaluation study in which a one-step HEMA-free self-etch adhesive was applied to NCCLs, the authors found that 75% of lost restorations belonged to lesions with a high degree of sclerosis.[45] Although restorations applied to lesions with sclerotic dentin show good performance in short-term clinical performance evaluations, it can be considered that there is a risk factor for loss of retention in the long term.[45,53,56]

In our study, in order not to affect the success of different universal adhesives in caries-free cervical lesions, a single type of composite material was used to eliminate the effects that might arise from the difference of composite materials. Apart from factors related to physician and technical sensitivity, the use of a single type of composite material in restorations may also be a factor in the absence of a statistical difference between the material groups in terms of color and transparency, esthetic anatomic form and surface gloss.

CONCLUSION

High success (retention) rates were obtained at the end of 12 months for the four universal adhesives. Monomer contents of universal adhesives did not have a significant effect on the success of restorations. The four universal adhesives applied in self-etch mode showed similar retention rates at the end of 12 months; however, a long-term evaluation is needed to confirm these results.

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CONFLICT OF INTEREST

The authors declare no potential conflicts of interest with respect to the authorship and/or publication of this article

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