Two-year clinical evaluation of three adhesive systems in non-carious cervical lesions

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ABSTRACT

Objectives: Adhesive systems are continuously being introduced to Dentistry, unfortunately often without sufficient clinical validation. The aim of this study was to evaluate the clinical performance of cervical restorations done with three different adhesive systems. Material and Methods: 158 non-carious cervical lesions of 23 patients were restored with a nanofilled composite resin (Filtek Supreme, 3M/ESPE) combined with Single Bond (3M/ESPE, group SI), Clearfil SE (Kuraray Medical Inc., group CL) and Xeno III (De Trey Dentsply, group XE). In groups SI-B, CL-B and XE-B, the outer surface of the sclerotic dentin was removed by roughening with a diamond bur before application of the respective adhesive systems. In groups CL-BP and XE-BP, after removal of the outer surface of the sclerotic dentin with the bur, the remaining dentin was etched with 37% phosphoric acid and the self-etch adhesive systems Clearfil SE and Xeno III were applied, respectively. Lesions were evaluated at baseline, and restorations after 3 months, 1 year and 2 years using modified USPHS criteria. Results: After 2 years, no significant difference was found between the retention rates of the groups (p>0.05). Although groups CL and SI showed significantly better marginal adaptation than group XE (p<0.05) at 2 years, no significant difference was found between the marginal adaptation of the groups SI-B, CL-B and XE-B (p>0.05). After 2 years no significant difference was observed among the marginal staining results of all groups (p>0.05). Conclusion: Although all adhesive systems showed similar retention rates, Clearfil SE and Single Bond showed better marginal adaptation than Xeno III after 2 years of follow-up.

Key words: Adhesives. Dentin. Dental restoration. Composite resins.

INTRODUCTION

The fundamental principle of adhesion to tooth substrate is based upon an exchange process by which inorganic tooth material is replaced with synthetic resin[26]. Using adhesive systems, the exchange of substance between adhesive resin and tooth tissue is carried out in one, two, or three clinical application steps, depending on the bonding protocol used[21]. In addition to the number of steps, adhesive systems can further be classified based on the underlying adhesion strategy as etch-and-rinse and self-etch systems[1]. Self-etch adhesive systems use non-rinse acidic monomers that simultaneously etchs and prime enamel and dentin. Self-etch adhesive systems that can have one or two steps and are classified as mild (pH>2), intermediate (pH 1-2), and strong (pH<1) according to their acidity[26].

New adhesive systems are continuously being introduced to the dentistry, unfortunately often without sufficient clinical validation[26]. Although clinical trials have demostrated that reliable adhesive restorations can be achieved using three-step etch-and-rinse adhesive systems[2,15], more randomized clinical studies should be performed to evaluate the clinical performance of new adhesive systems[4].

Adhesive systems have mainly been clinically tested in non-carious cervical lesions. These lesions serve as ideal test cavities because they are relatively common and are located mainly in dentin in which it is more difficult to achieve bonding than enamel.

They present no macro-mechanical undercuts, and are usually found in anterior teeth or premolars[26] and offer good access. A drawback related to the use of non-carious cervical lesions might be the substantial differences in the composition of the bonding surface[15]. Non-carious cervical lesions have a high degree of sclerosis and hybrid layer formation on this hypermineaarlized dentin is more difficult[8,21]. Alternative strategies for adhesion to sclerotic dentin have been recommended by previous researchers who evaluated available techniques[21]. One recommended technique is the removal of the top layer of the sclerotic lesion using a bur[8]. Using phosphoric acid conditioning before self-etch primers is another possible adaptive strategy for improving retention of resins to sclerotic dentin[21]. Clinical trials of this approach however are limited in number.

The objective of this study was to evaluate the clinical perfomance of cervical restorations using a nanofilled composite resin and three different adhesive systems and to determine the effect of bur removal and phosphoric acid prior to self-etch primer of dentin for improving micromechanical retention of adhesive resins after 2 years of clinical service. The null hypothesis to be tested was that the clinical performance of cervical restorations does not vary with different adhesive systems or with different adhesive strategies like bur removal of the outer dentin layer and pre-etching.

MATERIAL AND METHODS

A total of 252 restorations were placed in 29 subjects (16 males and 13 females; age range 30-70 years) being treated for non-carious cervical lesions. Patients with a medically compromised history, periodontitis, extreme caries risk and heavy bruxism were excluded from the study. Extreme caries risk was evaluated according to a large number of decayed and filled tooth surfaces and missing teeth (not those removed for orthodontic reasons), infrequent use of toothpaste and toothbrush, frequent consumption of fermentable carbohydrates and low socio-economic status[3]. Heavy bruxism was evaluated according to presence of multiple wear facets on the occlusal surfaces of the teeth[12]. Additionally, all restored teeth made contact with the opposing teeth in Class I cusp fossa or cusp marginal ridge occlusion relationships, and the participants had normal periodontal health (no gingival inflammation or pocket formation around the teeth)[18]. Prior to participating in the study, all patients signed a written informed consent form. The clinical trial protocol was approved by the Gazi University Commission for Medical Ethics. One operator who was familiar with adhesive dentistry, placed all restorations to the non-carious cervical lesions. The occlusal cavosurface margins of the lesion involved enamel, and all axial surfaces and gingival cavosurface margin of the non-carious cervical lesion involved dentin. Plaque-covered lesions were cleaned preoperatively with a flour of pumice. Operative procedures were performed without local anesthetic. The teeth were isolated with cotton rolls and a gingival retraction cord. No bevel was placed to the adjacent enamel. Patients who had at least 6 and no more than 20 non-carious cervical lesions were had the teeth restored with treated groups randomly in order.

The groups are summarized in Figure 1. The adhesive systems, their manufacturers and compositions are shown in Figure 2.

Group SI: Lesion surfaces were etched for 15 s with 35% phosphoric acid gel (Vococid, Voco, Cuxhaven, Germany), rinsed with water and gently air dried. Single Bond total-etch adhesive system was applied to the etched surfaces, gently air dried and light-cured for 20 s.

Group SI-B: The outer surface of the sclerotic dentin was removed by roughening with a diamond bur (Diatech, Coltene, Whaledent AG, Switzerland) at a highspeed handpiece with water spray and Single Bond was applied in the same manner as described for Group SI.

Group CL: Clearfil SE Primer self-etch primer was applied to the lesion surfaces for 20 s and gently air dried. Clearfil SE Bond was applied, air thinned

Groups	Bur	Adhesive materials
Group SI	-	Single Bond
Group SI-B	+	Single Bond
Group CL	-	Clearfil SE
Group CL-B	+	Clearfil SE
Group XE	-	Xeno III
Group XE-B	+	Xeno III
Group CL-BP	+	37% Phosphoric acid+Clearfil SE
Group XE-BP	+	37% Phosphoric acid+Xeno III

SI: Single Bond, CL: Clearfil SE, XE: Xeno III, B: Bur; P: 37% phosphoric acid

Figure 1- Summary of treated groups

and light-cured for 10 s.

Group CL-B: The outer surface of the sclerotic dentin was removed by roughening with a water-cooled high-speed diamond bur and Clearfil SE Bond system was applied in the same manner as described for Group CL.

Group XE: Xeno III Single Step Self Etching Dental Adhesive was applied to the lesion surfaces for 10 s, air-thinned and light-cured for 10 s.

Group XE-B: The outer surface of the sclerotic dentin was removed by roughening with a water-cooled high-speed diamond bur and Xeno III was applied to the roughened surfaces in the same as

explained for Group XE.

Group CL-BP: After removing the outer surface of the sclerotic dentin with a water-cooled high-speed diamond bur, the remaining dentin was etched with a 37% phosphoric acid gel for 15 s, rinsed with water and gently air dried, and Clearfil SE Bond system was applied in the same manner as described for Group CL.

Group XE-BP: After removing the outer surface of the sclerotic dentin with a water-cooled high-speed diamond bur, the remaining dentin was etched with a 37% phosphoric acid gel for 15 s, rinsed with water and gently air dried, and Xeno III

Material	Manufacturer	Composition
Single Bond (Two-step total-etch adhesive) pH: 5.	3M ESPE, St. Paul, Minn, USA	Acid: 37% phosphoric acid Adhesive: Bis-GMA, HEMA, poly-alcenoic copolymer, water, ethanol
Clearfil SE Bond (Two-step self- etch adhesive) pH: 2.7	Kuraray Medical, Tokyo, JAPAN	Primer: MDP, HEMA, water, hydrophilic dimethacrylate, camphoroquinone, p-toluidine Adhesive: Bis-GMA, MDP, HEMA, hydrophilic dimethacrylate, camphoroquinone, p-toluidine, silanated colloidal silica
XENO III (One-step self-etch adhesive) pH: 1.5	Dentsply/ DeTrey, Konstanz, GERMANY	Primer: HEMA, water, ethanol, BHT, stabilizer, nanofiller Adhesive: PEM-F, UDMA, camphoroquinone, EPD
Filtek Supreme (Nano-fill composite)	3M ESPE, St. Paul, Minn, USA	Bis-GMA, Bis-EMA, UDMA, TEGDMA, nanosilica filler, zirconi-silica nano cluster

Figure 2- Composition of materials used

		Maxilla			Mandibula			Sclerosis		WS	SS
	N	An	Prm	Mo	An	Prm	Mo	Yes	No		
Group SI	30	7	8	4	4	5	2	29	1	20	10
Group SI-B	30	8	6	3	4	6	3	29	1	17	13
Group CL	41	8	6	3	7	13	4	40	1	30	11
Group CL-B	31	10	5	3	5	5	3	30	1	24	7
Group XE	30	6	5	3	6	6	4	29	1	14	16
Group XE-B	30	8	5	3	6	4	4	29	1	12	18
Group CL-BP	30	7	6	4	4	6	3	29	1	16	14
Group XE-BP	30	6	6	4	6	5	3	29	1	22	8

SI: Single Bond, CL: Clearfil SE, XE: Xeno III, B: Bur , P: 37% phosphoric acid

An: Anterior, Prm: Premolar, Mo: Molar, WS: Wedge-shaped. SS: Saucer-shaped

Figure 3- Distribution of restorations by treatment, tooth type, sclerosis and configuration

Category	Acceptable	Unacceptable	Criteria
Retention	Alfa		Retained
		Charlie	Missing
Marginal Staining	Alfa		None
	Bravo		Superficial staining (removable, localized)
		Charlie	Deep staining (not removable, generalized)
Marginal Adaptation	Alfa		Undetectable margin or slight detectable step
			Detectable crevice
	Bravo		
		Charlie	Obvious crevice or fracture
Other failures (post operative sensitivity, recurrent caries, gingival response, tooth vitality, wear)	Alpha		None
		Charlie	Present

Figure 4- Modified U.S. Public Health Service (USPHS) criteria for clinical evaluation

was then applied as explained for Group XE.

Eight non-sclerotic cervical lesions were observed in only one patient. Other sclerotic lesions were randomly chosen to be roughened with a diamond bur at a high speed handpiece with water spray before phosphoric acid etching (Figure 3).

In all groups, lesions were restored with the nanofilled composite resin Filtek Supreme. The resin was placed in at least two 2-mm-thick increments, which were light-cured for 40 s each using a halogen lamp (Hilux, Benlioğlu Dental Inc., Turkey) at 620 mW/cm^2 maintaining the light-guide tip at a distance of 1 mm from the composite surface. Restorations were then finished with Po-Go disks (De Trey Dentsply, Konstanz, Germany).

The restorations were evaluated by a single investigator (not the operator) at baseline, 3 months, 1 year and 2 years after placement using the modified USPHS criteria (Figure 4). Marginal adaptation, gingival tissue response and wear were evaluated using a mirror and a probe. Gingival tissue response was evaluated according to presence of red, hypertrophic gingiva and gingival bleeding on probing around the cervical restoration[5]. Postoperative sensitivity was evaluated before and after the restorative procedures with a 3-s air blast applied directly at the restoration site from a distance of 1 inch. Tooth vitality was evaluated with an electronic digital pulp tester (Parkell, Parkell Electronics Division, Farmingdale, NY, USA). Kruskal Wallis and Mann-Whitney U test were used to determine the statistical differences in clinical marginal adaptation and marginal staining data between the groups. Differences between the time intervals were analyzed using the Wilcoxon Signed Rank test. The significance level was set at 5% for all analyses.

RESULTS

Four patients with 20 lesions each, one patient with 6 lesions and one patient with 8 lesions could not be evaluated at the 3-month recall due to nonattendance (63% recall rate). All of the remaining restorations were evaluated at 3 months, 1 year and 2 years.

Retention

Number of retained restorations and retention rates of the groups are shown in Table 1. At 2 years, retention rates of the groups SI, SI-B, CL, CL-B, XE, XE-B, CL-BP, XE-BP were 70.6%, 86.7%, 78.1%, 95.5%, 70%, 85.7%, 93.3%, 93.8%, respectively. At all time intervals no significant difference was found among the groups (p>0.05).

Marginal staining

Number of restorations that had no marginal staining (Alpha) and comparisons of the groups are shown in Table 2. No group presented discoloration at 3 months. At 1 year, significant difference was found between group XE and other groups (p<0.05). In addition, only group XE showed significant difference according to time (between 3 months and 1 year, between 3 months and 2 years) (p<0.05). Marginal staining was always seen at the gingival margin of the restorations.

Marginal adaptation

Number of restorations that had undetectable margins (Alpha) and comparisons of the groups are shown in Table 3. At all time intervals (3 months, 1 year, 2 years) when groups SI, CL and XE were compared, no significant difference was found between the groups CL and SI (p>0.05),

Table 1- Number, and percentages of retained restorations and comparisons between the groups at 3 months, 1 year and 2 years (p<0.05) (Total no. of restorations/no. of restorations)

Groups	Baseline	3 months	1 year	2 years
Group SI	30/30 (100%)	17/15 (88.2%)aA	17/14 (82.4%)aAB	17/12 (70.9%)aB
Group SI-B	30/30(100%)	15/14 (93.3%)aA	15/13 (86.7%)aA	15/13 (86.7%)aA
Group CL	41/41(100%)	32/31 (96.9%)aA	32/31 (96.9%)aA	32/27 (78.1%)aA
Group CL-B	31/31 (100%)	22/21 (95.5%)aA	22/21 (95.5%)aA	22/21 (95.5%)aA
Group XE	30/30 (100%)	20/17 (85%)aA	20/15 (75%)aA	20/14 (70%)aA
Group XE-B	30/30 (100%)	21/19 (90.5%)aA	21/19 (90.5%)aA	21/18 (85.7%)aA
Group CL-BP	30/30 (100%)	15/15 (100%)aA	15/15 (100%)aA	15/14 (93.3%)aA
Group XE-BP	30/30 (100%)	16/16 (100%)aA	16/15 (93.8%)aA	16/15 (93.8%)aA

Lower cases represent the significant differences between the groups (p<0.05) the same lower cases showed non-significant difference between the groups. Capitals stated at the bottom, represent the significant differences between the time (3 month, 1 year, 2 years) (p<0.05), the same capitals showed non-significant difference between the time.

Table 2- Number and percentages of restorations that have no marginal staining (Alpha) and comparisons of the groups at 3 months, 1 year and 2 years (p<0.05). (Total no. of restorations/no. of restorations)

Groups	Baseline	3 months	1 year	2 years
Group SI	30/30 (100%)	17/15 (88.2%)aA	17/14 (82.4%)aA	17/9 (52.9%)aA
Group SI-B	30/30 (100%)	15/14 (93.3%)aA	15/13 (86.7%)aA	15/11 (73.3%)aA
Group CL	41/41(100%)	32/31 (96.9%)aA	32/28 (82.5%)aA	32/25 (78.1%)aA
Group CL-B	31/31 (100%)	22/21 (95.5%)aA	22/20 (90.90%)aA	22/20 (90.90%)aA
Group XE	30/30 (100%)	20/17 (85%)aA	20/11 (55%)bB	20/9 (45%)aB
Group XE-B	30/30 (100%)	21/19 (90.5)aA	21/18 (85.7%)aA	21/16 (76.2)aA
Group CL-BP	30/30 (100%)	15/15 (100%)aA	15/15 (100%)aA	15/13 (86.6%)aA
Group XE-BP	30/30 (100%)	16/16 (100%)aA	16/15 (93.7%)aA	16/14 (87.5%)aA

Lower cases represent the significant differences between the groups (p<0.05) the same lower cases showed non-significant difference between the groups. Capitals stated at the bottom, represent the significant differences between the time (3 month, 1 year, 2 years) (p<0.05), the same capitals showed non-significant difference between the time.

Table 3- Number and percentages of restorations that have undetectable margin (Alpha) and comparison of the groups at 3 months, 1 year and 2 years (p< 0.05).(Total no. of restorations/no. of restorations)

Groups	Baseline	3 months	1 year	2 years
Group SI	30/30 (100%)	17/13 (76.5%)aA	17/11 (64.7%)aB	17/8 (47.1%)aB
Group SI-B	30/30(100%)	15/13 (86.7%)aA	15/10 (66.7%)aA	15/10 (66.7)acA
Group CL	41/41(100%)	32/20 (62.5%)abA	32/15 (46.9%)abB	32/14 (43.8%)aB
Group CL-B	31/31 (100%)	22/18 (81.8%)aA	22/17 (77.3%)aB	22/14 (63.6%)aB
Group XE	30/30 (100%)	20/9 (45%)bA	20/7 (35%)bB	20/5 (25%)bB
Group XE-B	30/30 (100%)	21/16 (76.2%)abcA	21/11 (52.3%)abB	21/10 (47.6%)aB
Group CL-BP	30/30 (100%)	15/15 (100%)acA	15/15 (100%)cA	15/13 (86.7%)cA
Group XE-BP	30/30 (100%)	16/16 (100%)acA	16/15 (93.7%)cA	16/15 (93.7%)cA

Lower cases represent the significant differences between the groups (p<0.05) the same lower cases showed non-significant difference between the groups. Capitals stated at the bottom, represent the significant differences between the time (3 month, 1 year, 2 years) (p<0.05), the same capitals showed non-significant difference between the time.

but significant differerence was found between groups SI and XE (p<0.05). Although no significant difference was found between the groups CL and XE at 3 months and 1 year (p>0.05), significant difference was detected at 2 years (p<0.05). At all time intervals, there was no significant difference among the groups SI-B, CL-B and XE-B (p>0.05). No significant difference on marginal adaptation was observed by bur removal of dentin at 3 months and 1 year (p>0.05) between groups SI and SI-B, groups CL and CL-B, and groups XE and XE-B. At 2 years, significant difference was found between group XE and group XE-B (p<0.05). Bur removal of dentin and pre-etching with phosphoric acid in the groups with self-etch adhesive systems (groups CL and CL-BP, and groups XE and XE-BP) showed a significant difference at all time intervals (p<0.05).

When the groups were evaluated according to time, marginal adaptation did not decreased over time in groups SI-B, CL-BP and XE-BP (p>0.05). Other groups showed significant difference between 3 months and 1 year and between 3 months and 2 years (p<0.05). While group XE-BP showed the best marginal adaptation, group XE showed the worst marginal adaptation at 2 years. Marginal deteriorations were seen especially at the gingival margin.

Remaining clinical variables

None of the restorations showed postoperative sensitivity, gingival tissue response or secondary caries and all of the retained restorations were clinically and aesthetically acceptable.

Failure analysis

When failed restorations were evaluated, 54% of totally lost restorations were in premolars, 58% in wedge-shaped lesions and 42% in saucer-shaped lesions. Failed restorations occurred almost equally in both arches, so no correlation was determined between arch and restoration failure.

DISCUSSION

Clinical trials are the ultimate test for assessment of bonding effectiveness of adhesive materials. Peumans, et al.[15] (2005) reviewed clinical studies published between 1998 and 2004 and concluded that three-step etch-and-rinse and two-step self-etch adhesive systems showed a clinically reliable and sufficiently predictable clinical performance. The clinical performance of two-step etch-and-rinse adhesive systems was less favorable, while one-step self-etch adhesive systems had an unacceptable clinical performance. In the present study, three adhesive systems were compared and two-step self-etch adhesive (Clearfil SE) showed more reliable marginal adaptation than the one-step

self-etch adhesive (Xeno III) in the groups without bur removal of dentin at 2 years. There was no difference between the two-step self-etch adhesive (Clearfil SE) and the two-step etch-rinse adhesive (Single Bond) with respect to marginal adaptation.

Clearfil SE is a two-step self-etch adhesive whose self-etching primer contains 10-methacryloxydecyl dihydrogen phosphate (10-MDP) as a functional monomer, which is dissolved in water resulting in a pH of approximately 3. In previous studies, 10-MDP has been shown to chemically react with hydroxyapatite[7,26]. The resulting two-fold micromechanical and chemical bonding mechanism might have led to the better marginal adaptation of Clearfil SE over Xeno III at 2 years. In fact, at 2 years, Xeno III showed the worst marginal adaptation of all three systems. This may be due to the weak bond between dentin and Xeno III adhesive resin, which may be more affected than the other adhesive systems used in this study by occlusal stresses and intraoral temperature changes in the oral cavity. Water trees in the hybrid layer may be another explanation of the lower marginal adaptation of Xeno III to dentin surfaces. Water trees represent an area where a certain volume of water is retained causing incomplete polymerization of the adhesive[21]. It has been speculated that this volume of water may cause degradation of the bonded surface due to hydrolysis[9]. Tay, et al.[22] (2003) suggested that water treeing in the hybrid layer may explain the initial problems associated with the bonding of simplified adhesive systems and the underlying causes of their relative lack of durability. Tay, et al.[20] (2001) noted that one-step self-etch adhesive systems are permeable membranes that permit diffusion of water, and this residual water within the adhesive layer may lead to areas of incomplete polymerization of the adhesive. In previous nanoleakage studies, it was reported that the lowest occurrence of nanoleakage within the hybrid layer occurred with Clearfil SE[5].

In the present study, however, the retention results were different from those of marginal adaptation, as no significant difference was found among the groups. Peumans, et al.[14] (2005) evaluated the clinical performance of the mild two-step self-etch adhesive Clearfil SE in non-carious cervical lesions. They reported 100% retention rate after 3 years and 98% retention rate after 5 years. Burrow and Tyas[4](2007) compared Clearfil SE, Single Bond and a resin-modified glass ionomer cement in cervical non-carious cervical lesions, and found that RMGIC performed the best clinical success (97%), followed by Clearfil SE (90%) and Single Bond (77%). In the present study, Clearfil SE showed 77.12% retention rate with no bur removal of dentin, and 95.45% retention rate with bur removal of dentin after two years. The difference

between previous studies and this current study may be due to factors associated with individual patients (such as occlusal loading, dentin sclerosis).

Sugizaki, et al.[19] (2007) restored class V cavities with Xeno III and composite resin, and evaluated the outcomes at recall intervals up to 18 months. They reported that all restorations were clinically satisfactory. Similar to these results, Türkün[23] (2003) reported a 96% retention rate for Xeno III and no significant difference was found between Xeno III and a two-step self-etch adhesive (Clearfil Protect Bond). In the present study, retention rates for Xeno III (70%) were not significantly different from those for the other groups.

The removal of the outer surface of the sclerotic dentin by roughening with a diamond bur has been recommended in the literature in order to create a better hybrid layer[8]. Van Dijken[24] (2004) determined that roughening of sclerotic dentin surfaces with a diamond bur did not increase the retention of restorations. In the present study, although the group of XE-B, tended to show better marginal adaptation, marginal staining and retention than the group of Xe, it is found that no significant differences were determined between them. A significantly better marginal adaptation was determined as a result of the study after 2 years. On the other hand, no significant differences were observed between groups SI and SI-B, and groups CL and CL-B, in which the adhesive systems were applied with or without bur removal of dentin. The different results between these adhesive systems may depend on their different bonding ability to sclerotic dentin. Sclerotic dentin has diffusion barriers (obliteration of dentin tubules with sclerotic casts and presence of acid-resistant hypermineralized layer), which can inhibit the acid demineralization and compromise bonding[21]. Unlike Single Bond and Clearfil SE, Xeno III was completely ineffective in overcoming the diffusion barriers in sclerotic dentin and could not bond sufficiently to the intact substrate. However, roughening the sclerotic dentin with a diamond bur increased the bonding ability of Xeno III.

Different strategies were used in previous studies to increase the bond strength of adhesive systems to sclerotic dentin, such as bur removal of the most superficial sclerotic dentin layer or pre-etching with phosphoric acid[11,21]. However, none of these earlier studies investigated these two mechanisms together. In the present study, bur removal of dentin and additional phosphoric acid etching before self-etch primer application increased marginal adaptation of both self-etch adhesive systems, but did not change their retention rates. Although Van Landuyt, et al.[25] (2006) reported that prior acid-etching significantly decreased the bond strength of self-etch adhesive systems to sound dentin, in the current study sclerotic dentin surfaces were used as a bonding substrate. The different dentin substrates (sclerotic versus sound dentin) may be the explanation for the different results obtained in the studies.

Several clinical co-variables that are unique to the oral environment have been described to affect the clinical performance of adhesive systems[1]. With regard to location, researchers determined that the retention of cervical restorations was significantly higher in the maxillary arch than in the mandibular arch[16]. Differently from previous studies, in the current study, failed restorations occurred almost equally in both arches. However, most of the failed restorations occurred in premolars (54%). Using finite element method (FEM) analysis, researchers compared tooth groups and reported that the magnitude of cervical stress was highest for premolars, followed by incisors and lowest for canines[13]. Powell, et al.[16] (1995) reported that the shapes of the lesions do not affect the retention of restorations. On the other hand, Eliguzeloglu, et al.[6] (2011) compared the effect of cavity shape on the stress distribution of cervical lesions which were restored with a composite using FEM analysis, and it is determined that the stress distribution of saucer-shaped non-carious cervical lesions have more advantages than wedge-shaped lesions. In the present study, 58% of the lost restorations had been placed in wedge-shaped lesions, and 42% of them in saucer-shaped lesions. These results are in good aggrement with the authors' previous FEM study.

To be considered clinically effective, adhesive systems should keep the restoration in place and completely seal the restoration margins against the ingress of oral fluids and microorganisms. Incomplete marginal seal will result in post-placement sensitivity, marginal staining and, eventually, recurrent caries, which are still the most common symptoms associated with clinical failure of adhesive restorations[17]. Marginal staining is probably caused by microleakage or an accumulation of stains at a marginal defect, such as the chip fracture of a slight excess of material covering unground and/or non-treated tooth surface[10]. In the present study, the sealing capacity of adhesive systems was assessed with the marginal staining index. In the present study, no staining was determined along the margins of any restorations after 3 months. Marginal staining increased over time in all groups, but only in group XE significant difference was found between the time intervals. In addition, all groups showed similar marginal staining at two years.

CONCLUSIONS

In conclusion, the null hpothesis could not be accepted because;

The two-step self-etch adhesive system Clearfil SE showed better marginal adaptation than the one-step self-etch adhesive system Xeno III after 2 years;

Clearfil SE showed similar marginal adaptation, retention and marginal staining to those of the etch-and-rinse adhesive system Single Bond after 2 years;

The removal of the outer surface layer of sclerotic dentin did not increase the retention and marginal staining of the adhesive systems evaluated in this study;

The removal of the outer surface layer of dentin and additional phosphoric acid etching, increased the marginal adaptation of Xeno III and Clearfil SE after 2 years.

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