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Clinical Research

Clinical Evaluation of Flowable Resins in Non-carious Cervical Lesions: Two-year Results

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Clinical Relevance

Different types of flowable resin materials placed in non-carious cervical lesions demonstrated acceptable clinical performance, except for the retention rates of Dyract Flow restorations, after two years.

SUMMARY

This study evaluated the two-year clinical performance of one microhybrid composite and three different types of flowable resin materials in non-carious cervical lesions. A total of 252 non-carious cervical lesions were restored in 37 patients (12 male, 25 female) with Admira Flow, Dyract Flow, Filtek Flow and Filtek Z250, according to manufacturers' instructions. All the restorations were placed by one operator, and two other examiners evaluated the restorations clinically within one week after placement and after 6, 12, 18 and 24 months, using modified USPHS criteria. At the end of 24 months, 172 restorations were evaluated in 26 patients, with a recall rate of 68%. Statistical analysis was completed using the Pearson Chi-square and Fisher-Freeman-Halton tests ($p<0.05$). Additionally, survival rates were analyzed with the Kaplan-Meier estimator and the Log-Rank test ($p<0.05$). The Log-Rank test indicated statistically significant differences between the survival rates of Dyract Flow/Admira Flow and Dyract Flow/Filtek Z250 ($p<0.05$). While there was a statistically significant difference between Dyract Flow and the other materials for color match at 12 and 18 months, no significant difference was observed among all of the materials tested at 24 months. Significant differences were revealed between Filtek Z250 and the other materials for marginal adaptation at 18 and 24 months ($p<0.05$). With respect to marginal discoloration, secondary caries, surface texture and anatomic form, no significant differences were found between the resin materials ($p>0.05$). It was concluded that

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different types of resin materials demonstrated acceptable clinical performance in non-carious cervical lesions, except for the retention rates of the Dyract Flow restorations.

INTRODUCTION

Non-carious cervical lesions, characterized by the loss of hard tissue at the cementoenamel junction in the absence of caries, are conditions commonly encountered in clinical practice, and not all of these lesions require dental management. The decision to treat a cervical lesion should be based on careful consideration of the etiology, the patient's complaints and the extension and depth of the defect.[1-9] Several preventive and restorative treatment modalities, such as occlusal adjustment, tooth brushing instructions, dietary advice, application of desensitization products and restorative procedures, have been proposed for non-carious cervical lesions.[10-16] Clinicians have tried many restorative materials and techniques to obtain the best performance for these lesions. Conventional glass-ionomers, resin-modified glass ionomers, compomers and several types of resin composites have been used for cervical restorations. Glass ionomers have been used due to their ease of use, adhesion to tooth substance and release of fluoride.[17-19] The disadvantages of these materials include sensitivity to moisture, low wear resistance and fracture toughness and poor esthetic properties.[20] In recent years, compomers and resin composites have become popular alternatives to conventional glass-ionomer cements for the restoration of cervical lesions, based on their satisfactory esthetic properties and high wear resistance.

It has been proposed that the filler content of resin composite also affects the clinical performance of cervical restorations. For example, compared to microhybrid composites, microfills have a lower elastic modulus, which, it is believed allows the material to flex with the tooth during function, reducing failure of the bonded interface and dislodgement of the restoration.[3,21] Based on this theory, flowable composites flex more than microhybrid composites during and after curing, allowing for greater relaxation of tensions imposed on the tooth-resin composite interface by shrinkage during polymerization, thermal expansion/contraction stresses and occlusal forces.[22] The use of flowable composites for Class V restorations has been suggested based on this hypothesis.

Flowable resin composites were developed in late 1996 in response to a request for special handling properties. These composites were created by retaining the same particle sizes as that of traditional hybrid composites, but by reducing the filler content and allowing the increased resin to reduce the viscosity of the mixture.[23-30] Recently, manufacturers have introduced different formulations of flowable resin composite materials, including flowable compomers and flowable ormocers. The performance of these materials has been tested in several *in vitro* studies, but few long-term clinical evaluation studies have been reported.

This study evaluated the two-year clinical performance of one microhybrid and three different types of flowable resins (flowable ormocer, flowable compomer and flowable composite) in non-carious cervical lesions.

METHODS AND MATERIALS

Subjects

Thirty-seven patients (12 male, 25 female), with at least four non-carious cervical lesions each, participated in this study. Patients with poor oral hygiene, a severe or chronic periodontitis or heavy bruxism were excluded from the study. The cervical lesions were typical wedge- or saucer-shaped lesions with an approximal axial depth of 1-2 mm and were non-hypersensitive. The median age of these patients was 50 years, while the patients ranged in age from 29 to 67 years. The patients included in this study were selected from the dental clinics of Hacettepe University School of Dentistry, Department of Conservative Dentistry. The protocol of this study was approved by the Hacettepe University Ethics Committee on Investigations Involving Human Subjects. Written informed consent was also obtained from all participants prior to treatment.

Operative Procedures

All of the lesions were cleaned with plain pumice in a rubber prophylaxis cup and rinsed with water. After shade selection, isolation was accomplished using cotton rolls and a saliva ejector, with no mechanical preparation or beveling being done. A total of 252 non-carious cervical lesions were restored with Admira Flow, Dyract Flow, Filtek Flow and Filtek Z250 (Table 1) according to manufacturers' instructions. The assignment of materials was made randomly and all restorations were placed by one operator. The distribution of materials and tooth location were randomized (Table 2).

Admira Flow Restorations (Flowable Ormocer)

Vococid (Voco, Cuxhaven, Germany) was applied to enamel margins for 30 seconds and to dentin for 15 seconds, respectively. After etching, the lesion was rinsed for 10 seconds and dried to remove any excess water, leaving a moist surface. Admira Bond (Voco) was applied with a brush and left for 30 seconds. The solvent was removed with a gentle stream of air, and the adhesive was polymerized for 20 seconds with a halogen light-curing unit (Hilux Expert, Benlioglu Dental, Ankara, Turkey). Flowable ormocer, Admira Flow (Voco) was incrementally applied to the lesion and each layer was cured for 40 seconds. The first

Table 1: *Products, Lot Numbers and Manufacturers of Restorative Materials and Adhesive Resins Tested*

Material	Lot #	Manufacturer	Composition	Filler Content (by volume%)
Admira Flow	02481E1	Voco, Cuxhaven, Germany	Anorganic-organic co-polymers(ormocers), aliphatic, aromatic dimethacrylates	50.5%
Admira Bond	019884	Voco, Cuxhaven, Germany	Ormocers, methacrylates, BHT, acetone, organic acids	-
Dyract Flow	0011001425	Dentsply, Konstanz, Germany	Strontium-alimino-fluoro-silicate glass, ammonium salt of PENTA, N, N-dimethyl aminoethyl methacrylate, carboxylic acid modified macromonomers, iron pigments, titanium dioxide	38%
Prime&Bond NT	0202000837	Dentsply, Konstanz, Germany	Di and trimethacrylate resins, functional amorphous silica, PENTA, cetylamine hydrofluoride, acetone, photoinitiators	-
Filtek Flow	3700A3	3M/ESPE, St Paul, MN, USA	BisGMA, TEGDMA, zirconia/silica	47%
Filtek Z250	20020219	3M/ESPE, St Paul, MN, USA	Bis-GMA, UDMA, Bis- EMA, zirconia/silica	60%
Single Bond	2GM	3M/ESPE, St Paul, MN, USA	Bis-GMA, HEMA, polyalkenoic acid copolymer, water, ethanol, dimethacrylates	-

Table 2: *Distribution of Materials and Tooth Locations*

	Maxillary Arch		Mandibular Arch		Total
	Anteriors	Posteriors	Anteriors	Posteriors	
Admira Flow	18	12	18	15	63
Dyract Flow	12	17	16	18	63
Filtek Flow	16	16	12	19	63
Filtek Z250	15	16	13	19	63
Total	61	61	59	71	252
	122		130		

increment of resin material was placed from the midpoint of the gingival margin to the incisal or occlusal margin and the second increment filled the remainder of the lesion. The thickness of each increment was approximately 1 mm.

Dyract Flow Restorations (Flowable Compomer)

DeTrey conditioner (Dentsply, Konstanz, Germany) was applied for 30 seconds for enamel margins and 15 seconds to dentin surfaces. After etching, the lesion was rinsed for 10 seconds and dried to remove excess water, leaving a moist surface. Prime&Bond NT (Dentsply) was applied to the whole surface with a brush and left undisturbed for 15 seconds. The solvent was removed for five seconds with a gentle stream of air and the adhesive was light-cured for 10 seconds (Hilux Expert). Dyract Flow (Dentsply) was applied to the lesion incrementally, as mentioned above, and each layer was light cured for 40 seconds.

Filtek Flow Restorations (Flowable Composite)

Scotchbond etchant (3M/ESPE, St Paul, MN, USA) was applied for 30 seconds to the enamel margins and for 15 seconds to the dentin surfaces. After etching, the lesion was rinsed for 10 seconds and dried to remove any excess water, leaving a moist surface. Two consecutive coats of Single Bond (3M/ESPE) were applied with a brush. The solvent was removed with a gentle stream of air for two-to-five seconds and the adhesive was light-cured for 10 seconds (Hilux Expert). Filtek Flow (3M/ESPE) was applied to the lesion incrementally, as mentioned above, and each layer was light cured for 40 seconds.

Filtek Z250 Restorations (Microhybrid Composite)

Scotchbond etchant (3M/ESPE) was applied to the enamel margins for 30 seconds and to the dentin surfaces for 15 seconds. After etching, the lesion was rinsed for 10 seconds and dried to remove excess water, leaving a moist surface. Two consecutive coats of Single Bond (3M/ESPE) were applied with a brush. The solvent was removed with a gentle stream of air for two-to-five seconds and the adhesive was light-cured for 10 seconds (Hilux Expert). Filtek Z250 (3M/ESPE) was applied incrementally, and each layer was light-cured for 40 seconds.

After placement of the restorations, gross contouring was completed using ultrafine-grain diamond burs (Diatech, Switzerland). Finally, the restorations were polished using Sof-Lex Pop-on discs (3M/ESPE).

Clinical Evaluation

The restorations were clinically evaluated within one week after placement, then after 6, 12, 18 and 24

months. Two other calibrated examiners, using a mirror and probe, followed the Modified United States Public Health Service (USPHS) criteria (Table 3).[31] A forced-consensus model was used to determine a final rating when there was disagreement between examiners.[32-37] The criteria evaluated in this study were retention, color match, marginal discoloration, marginal adaptation, secondary caries, surface texture and anatomic form.

Statistical Evaluation

The survival rates were analyzed with a Kaplan-Meier estimator and the Log-Rank test, and statistical analysis was completed using the Pearson Chi-square and Fisher-Freeman-Halton tests ($p<0.05$).

RESULTS

At the end of two years, due to patient drop-out, a total of 172 restorations were available for clinical evaluation in 26 patients (recall rate = 68%).

Figure 1 shows the survival rates of the restorations over two years. At the end of six months, the probability of survival rates of the restorations were 100% for Admira Flow, 97% for Dyract Flow, 95% for Filtek Flow and 98% for Filtek Z250. After 12 months, the probability of survival rates were 96% for Admira Flow, 93% for Dyract Flow, 95% for Filtek Flow and 95% for Filtek Z250. At 18 months, the survival rates were 94% for Admira Flow, 81% for Dyract Flow, 89% for Filtek Flow and 92% for Filtek Z250. There was no statistically significant difference

Table 3: *Modified USPHS Evaluation Criteria*

Retention	**Alpha:** No loss of restorative material **Charlie:** Any loss of restorative material
Color Match	**Alpha:** Matches tooth **Bravo:** Acceptable mismatch **Charlie:** Unacceptable mismatch
Marginal Discoloration	**Alpha:** No discoloration **Bravo:** Discoloration without axial penetration **Charlie:** Discoloration with axial penetration
Marginal Adaptation	**Alpha:** Closely adapted, no visible crevice **Bravo:** Visible crevice, explorer will penetrate **Charlie:** Crevice in which dentin is exposed
Secondary Caries	**Alpha:** No caries present **Charlie:** Caries present
Surface Texture	**Alpha:** Enamel-like surface **Bravo:** Surface rougher than enamel, clinically acceptable **Charlie:** Surface unacceptably rough
Anatomic Form	**Alpha:** Continuous **Bravo:** Slight discontinuity, clinically acceptable **Charlie:** Discontinuous, failure

Table 4: *The Distribution of Lost Restorations with Regard to Maxillary and Mandibular Arches*

	Maxillary Arch		Mandibular Arch		Total
	Anteriors	Posteriors	Anteriors	Posteriors	
Admira Flow	0	2	1	1	4
Dyract Flow	3	5	2	4	14
Filtek Flow	1	2	1	3	7
Filtek Z250	0	2	2	0	4
Total	4	11	6	8	29
	15		14		

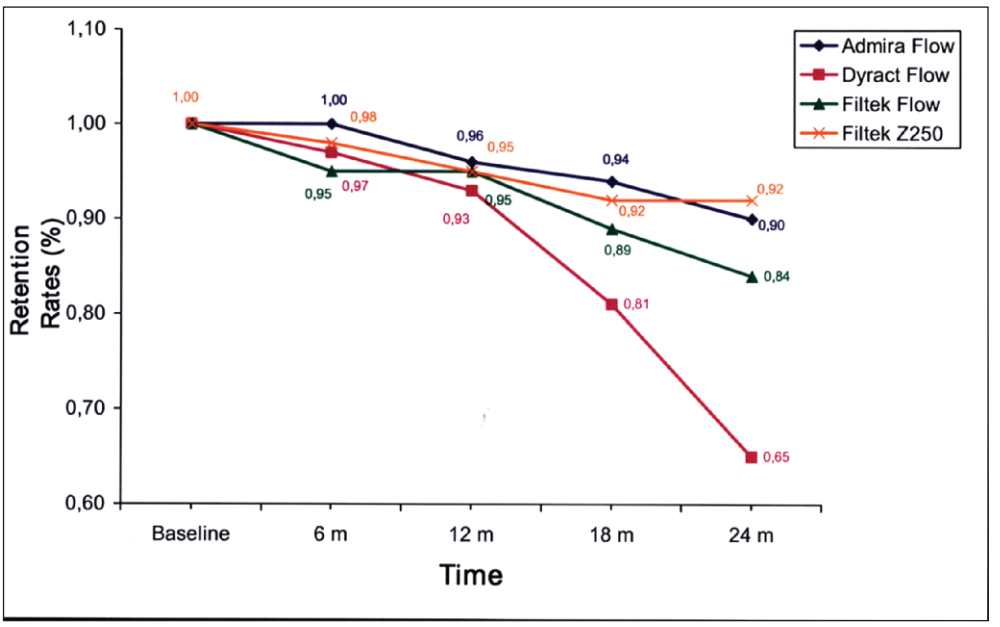

Figure 1. *Cumulative survival rates of restorations.*

Table 5: *Color Match*

	Admira Flow				Dyract Flow				Filtek Flow				Filtek Z250			
	n	A	B	C	n	A	B	C	n	A	B	C	n	A	B	C
Baseline	63	58(92%)	5(8%)	0(0%)	63	57(90%)	6(10%)	0(0%)	63	60(95%)	3(5%)	0(0%)	63	63(100%)	0(0%)	0(0%)
6 m	59	53(90%)	6(10%)	0(0%)	57	48(84%)	9(16%)	0(0%)	56	52(93%)	4(7%)	0(0%)	58	55(95%)	3(5%)	0(0%)
12 m	52	45(87%)	7(13%)	0(0%)	50	34*(68%)	16(32%)	0(0%)	51	45(88%)	6(12%)	0(0%)	51	46(90%)	5(10%)	0(0%)
18 m	50	38(77%)	12(23%)	0(0%)	43	25*(58%)	18(42%)	0(0%)	47	39(83%)	8(17%)	0(0%)	49	41(84%)	8(16%)	0(0%)
24 m	39	31(79%)	8(21%)	0(0%)	33	22(67%)	11(33%)	0(0%)	37	32(86%)	5(14%)	0(0%)	40	34(85%)	6(15%)	0(0%)

A= Alpha , B= Bravo, C= Charlie
**: Denotes statistically significant (p<0.05)*

Table 6: *Marginal Discoloration*

	Admira Flow				Dyract Flow				Filtek Flow				Filtek Z250			
	n	A	B	C	n	A	B	C	n	A	B	C	n	A	B	C
Baseline	63	63(100%)	0(0%)	0(0%)	63	63(100%)	0(0%)	0(0%)	63	63(100%)	0(0%)	0(0%)	63	63(100%)	0(0%)	0(0%)
6 m	59	58(98%)	1(2%)	0(0%)	57	56(98%)	1(2%)	0(0%)	56	55(98%)	1(2%)	0(0%)	58	55(95%)	3(5%)	0(0%)
12 m	52	49(94%)	3(6%)	0(0%)	50	44(88%)	6(12%)	0(0%)	51	45(88%)	6(12%)	0(0%)	51	46(90%)	5(10%)	0(0%)
18 m	50	41(82%)	9(18%)	0(0%)	43	30(70%)	13(30%)	0(0%)	47	36(77%)	11(23%)	0(0%)	49	39(80%)	10(20%)	0(0%)
24 m	39	28(72%)	11(28%)	0(0%)	33	20(61%)	13(39%)	0(0%)	37	27(73%)	10(27%)	0(0%)	40	26(65%)	14(35%)	0(0%)

A= Alpha , B= Bravo, C= Charlie

Table 7: *Marginal Adapatation*

	Admira Flow				Dyract Flow				Filtek Flow				Filtek Z250			
	n	A	B	C	n	A	B	C	n	A	B	C	n	A	B	C
Baseline	63	63(100%)	0(0%)	0(0%)	63	63(100%)	0(0%)	0(0%)	63	63(100%)	0(0%)	0(0%)	63	63(100%)	0(0%)	0(0%)
6 m	59	59(100%)	0(0%)	0(0%)	57	57(100%)	0(0%)	0(0%)	56	56(100%)	0(0%)	0(0%)	58	58(100%)	0(0%)	0(0%)
12 m	52	52(100%)	0(0%)	0(0%)	50	50(100%)	0(0%)	0(0%)	51	50(98%)	1(2%)	0(0%)	51	51(100%)	0(0%)	0(0%)
18 m	50	43(86%)	7(14%)	0(0%)	43	38(88%)	5(12%)	0(0%)	47	43(91%)	4(9%)	0(0%)	49	49*(100%)	0(0%)	0(0%)
24 m	39	26(67%)	13(33%)	0(0%)	33	25(76%)	8(24%)	0(0%)	37	32(86%)	5(14%)	0(0%)	40	40*(100%)	0(0%)	0(0%)

A= Alpha , B= Bravo, C= Charlie
**: Denotes statistically significant (p<0.05)*

between the survival rates of restorations at the end of the 18-month evaluation period ($p>0.05$). After 24 months, the probability of survival rates of the restorations was 90% for Admira Flow, 65% for Dyract Flow, 84% for Filtek Flow and 92% for Filtek Z250. The Log-Rank test indicated statistically significant differences among the survival rates of Dyract Flow/Admira Flow and Dyract Flow/Filtek Z250 ($p=0.01$) (Figure 1). In this study, 29 restorations had been lost at the end of the evaluation period (Table 4).

At baseline and six months, there was no significant difference between restorative materials for color match. Significant differences were demonstrated between Dyract Flow and the other restoratives for color match at the end of 12 and 18 months ($p=0.009$) ($p=0.017$). At the end of two years, the percentages of alpha ratings for color match were 79% for Admira Flow, 67% for Dyract Flow, 86% for Filtek Flow and 85% for Filtek Z250. Therefore, no significant difference was observed between Dyract Flow/Filtek Flow and Dyract Flow/Filtek Z250 at 24 months ($p>0.05$) (Table 5).

All of the restorations received alpha ratings at baseline evaluation for marginal discoloration; however, regardless of the restorative material, each group showed some marginal discoloration at the end of 6, 12 and 18 months. At the two-year recall, 72% of Admira Flow, 61% of Dyract Flow, 73% of Filtek Flow and 65% of Filtek Z250 restorations received alpha ratings for marginal discoloration. Differences among the restorative materials were not statistically significant ($p>0.05$) (Table 6).

For marginal adaptation, at six months, all of the restorations scored alpha. At the end of 12 months, Admira Flow, Dyract Flow and Filtek Z250 restorations had scored as alpha; there was only one Filtek Flow restoration that received a bravo rating. After 18 months, these results completely changed, and there was an increase in bravo ratings, except for the Filtek Z250 restorations. Statistical analysis demonstrated a significant difference between the Filtek Z250 restorations and others ($p=0.03$). At the end of this study, the alpha ratings for marginal adaptation were shown to be 67% for Admira Flow, 76% for Dyract Flow, 86% for

Table 8: *Secondary Caries*

	Admira Flow				Dyract Flow				Filtek Flow				Filtek Z250			
	n	A	B	C	n	A	B	C	n	A	B	C	n	A	B	C
Baseline	63	63(100%)	0(0%)	0(0%)	63	63(100%)	0(0%)	0(0%)	63	63(100%)	0(0%)	0(0%)	63	63(100%)	0(0%)	0(0%)
6 m	59	59(100%)	0(0%)	0(0%)	57	57(100%)	0(0%)	0(0%)	56	56(100%)	0(0%)	0(0%)	58	58(100%)	0(0%)	0(0%)
12 m	52	52(100%)	0(0%)	0(0%)	50	50(100%)	0(0%)	0(0%)	51	51(100%)	0(0%)	0(0%)	51	51(100%)	0(0%)	0(0%)
18 m	50	50(100%)	0(0%)	0(0%)	43	43(100%)	0(0%)	0(0%)	47	47(100%)	0(0%)	0(0%)	49	49(100%)	0(0%)	0(0%)
24 m	39	39(100%)	0(0%)	0(0%)	33	33(100%)	0(0%)	0(0%)	37	37(100%)	0(0%)	0(0%)	40	40(100%)	0(0%)	0(0%)

A= Alpha , B= Bravo, C= Charlie

Table 9: *Surface Texture*

	Admira Flow				Dyract Flow				Filtek Flow				Filtek Z250			
	n	A	B	C	n	A	B	C	n	A	B	C	n	A	B	C
Baseline	63	63(100%)	0(0%)	0(0%)	63	63(100%)	0(0%)	0(0%)	63	63(100%)	0(0%)	0(0%)	63	63(100%)	0(0%)	0(0%)
6 m	59	57(97%)	2(3%)	0(0%)	57	57(100%)	0(0%)	0(0%)	56	56(100%)	0(0%)	0(0%)	58	58(100%)	0(0%)	0(0%)
12 m	52	49(94%)	3(6%)	0(0%)	50	49(98%)	1(2%)	0(0%)	51	51(98%)	1(2%)	0(0%)	51	51(100%)	0(0%)	0(0%)
18 m	50	46(92%)	4(8%)	0(0%)	43	43(93%)	3(7%)	0(0%)	47	46(98%)	1(2%)	0(0%)	49	48(98%)	1(2%)	0(0%)
24 m	39	35(90%)	4(10%)	0(0%)	33	30(91%)	3(9%)	0(0%)	37	33(89%)	4(11%)	0(0%)	40	38(95%)	2(5%)	0(0%)

A= Alpha , B= Bravo, C= Charlie

Table 10: *Anatomic Form*

	Admira Flow				Dyract Flow				Filtek Flow				Filtek Z250			
	n	A	B	C	n	A	B	C	n	A	B	C	n	A	B	C
Baseline	63	63(100%)	0(0%)	0(0%)	63	63(100%)	0(0%)	0(0%)	63	63(100%)	0(0%)	0(0%)	63	63(100%)	0(0%)	0(0%)
6 m	59	59(100%)	0(0%)	0(0%)	57	57(100%)	0(0%)	0(0%)	56	56(100%)	0(0%)	0(0%)	58	58(100%)	0(0%)	0(0%)
12 m	52	52(100%)	0(0%)	0(0%)	50	50(100%)	0(0%)	0(0%)	51	51(100%)	0(0%)	0(0%)	51	51(100%)	0(0%)	0(0%)
18 m	50	50(100%)	0(0%)	0(0%)	43	43(100%)	0(0%)	0(0%)	47	46(98%)	1(2%)	0(0%)	49	49(100%)	0(0%)	0(0%)
24 m	39	39(100%)	0(0%)	0(0%)	33	32(97%)	0(0%)	0(0%)	37	36(97%)	1(3%)	0(0%)	40	40(100%)	0(0%)	0(0%)

A= Alpha , B= Bravo, C= Charlie

Filtek Flow and 100% for Filtek Z250. There was a statistically significant difference between Filtek Z250 and the other materials for marginal adaptation at the end of 24 months (p=0.001). Filtek Z250 restorations showed no changes in marginal adaptation at the end of this evaluation period (Table 7).

No restorations in any group exhibited secondary caries at any evaluation period within this study (Table 8).

With regards to surface texture, only two Admira Flow restorations received bravo ratings at six months; the other restorations had alpha-rated surface texture. At the end of 12, 18 and 24 months, the percentage of alpha ratings for surface texture decreased. With respect to this criteria, no significant differences were found between resin materials (p>0.05) (Table 9).

None of the restorations had any anatomic form loss until the end of 12 months. At the end of 18 months, only one Filtek Flow restoration had demonstrated a bravo rating in this criteria. All of the Admira Flow and Filtek Z250 restorations had excellent anatomic form after two years. One Dyract Flow and one Filtek Flow restoration was rated Bravo at the 24-month recall (Table 10).

DISCUSSION

In clinical studies, the success of a material is indicated by its longevity in the oral cavity, which makes retention rates the most important evaluation criteria. American Dental Association (ADA) guidelines for submitted dentin and enamel adhesive materials require provisional acceptance, meaning that no more than 5% of the restorations have been lost at the six-month recall and, in order to obtain full acceptance, the cumulative incidence of clinical failures in each of two independent clinical studies has to be lower than 10% of lost restorations after 18 months.[38] In this study, according to the ADA, the retention rates of Dyract Flow restorations were found to be lower than expected, and the decrease in retention rates of all materials may depend on the absence of mechanical preparation.

It has been shown that localization of the cervical lesion may affect the retention rates of restorations. In the current study, similar results have been determined in both arches, but some authors observed a higher failure rate in the mandibular arch relative to the maxillary arch.[34,39] Heymann and others suggested that this finding may be the result of greater flexure of mandibu-

lar teeth or greater difficulty with moisture control.[21] The other reason is that mandibular teeth may be more sclerotic and may have less dentin tubules than maxillary teeth.[34]

It has been recommended that beveling of the enamel margins of non-carious cervical lesions may provide higher retention rates of restorations.[28] While routine mechanical preparation may not be currently required, it was considered a necessity before the development of new adhesive resins.[32,35] In this study, no beveling procedure was done.

Non-carious cervical lesions are used as a clinical model to evaluate the efficacy of dentin bonding agents in non-retentive tooth preparations. This model is recommended by the ADA in its Acceptance Program for Adhesive Restorative Materials.[38] When applied to non-retentive cervical lesions, the clinical performance of restorations relies on the bond strength values of adhesive resins. The forces created by compression of the restoration are localized at the bulk of the resin composite as compressive stress and less as shear stress at the adhesive interface. Therefore, the adhesive bond is preserved, while marginal adaptation is adversely affected, which is only valid when the adhesive bond is sufficiently strong.[40]

In this study, prior to placement of Dyract Flow restorations, acid etching was applied to the cavity surface. It has been shown that the additional use of acid etching improves the clinical success of compomer materials in some studies.[41-42]

In an attempt to maximize the retention rates of Class V restorations, low elastic-modulus materials are recommended. According to Heymann and others, the reason for this choice is that these materials are supposed to flex with the tooth rather than debond during cervical flexure.[21] In this study, the mean elastic modulus value of flowables was about 5.1 GPa, but for Filtek Z250, this value is shown to be 11.6 GPa.[43] There were no statistically significant differences between the retention rates of Filtek Z250 restorations and Admira and Filtek Flow restorations, while Dyract Flow restorations obtained the worst result of all the materials tested. Therefore, elastic modulus is not the only factor that affects retention rates, other factors also play a role.

It is generally accepted that a higher filler content and lower monomer concentration of a material could lead to less polymerization shrinkage.[24] In this study, the filler content of the restorative materials from highest to lowest were: Filtek Z250 (60%), Admira Flow (50.5%), Filtek Flow (47%) and Dyract Flow (38%) (Table 1). According to low filler content, flowable composites shrink more upon polymerization when compared with conventional composites.[24] It has been suggested that the materials with the most polymerization shrinkage obtain the lowest bond strength values.[44] This may be another reason for the low retention rate of Dyract Flow.

The high organic content of flowable resin materials allows for higher water sorption and discoloration over time, as demonstrated in microfilled composites whose organic content is higher than that of microhybrid composites.[45-48] In several clinical studies, the color stability of hybrid restorative materials has been found to be perfect.[20,33,49] In this study, the prevalence of discoloration was significantly higher for the flowable compomer Dyract Flow. Many restorations did not match well with tooth color. This was evident from the beginning of the study, which indicated the lower aesthetic properties of compomers compared to resin composites.[41,50] Maneenut and Tyas mentioned incomplete polymerization, residual HEMA molecules after light activation, susceptibility to water sorption and desiccation as factors that may effect color stability of compomer materials.[51]

Some authors postulate that the combination of excess restorative material and the deformation to which cervical restorations are subjected may be responsible for the breakdown of the bond and fracturing of the material at the margins, leading to marginal discoloration and discrepancies.[3,52] In the current study, marginal discoloration was noted around some restorations, but there were no statistically significant differences for this criteria between the materials at the end of the evaluation period.

The loss of marginal adaptation is one of the most important factors that shows the failure of a restoration and the reason for replacement.[53]

In this study, Filtek Z250 restorations demonstrated good marginal adaptation when compared to the other materials; all of the restorations received an alpha rating after two years. Similarly, Van Meerbeek and others found that the marginal adaptation of microhybrid resin restorations was more successful than microfilled restorations.[40] Some authors indicated that this could be explained with the high modulus of elasticity, which might support resistance to deformation.[54-55] Lambrechts and others reported cohesive and adhesive chip fractures three or four times more often at enamel cavosurfaces with microfilled resin composites than with conventional resin composites.[56]

Two-year results could provide some information about the clinical performance of resin materials, but this period is also too short for the development of any secondary caries. In this study, at the end of two years, no caries was found adjacent to the restorations, which is similar to several other clinical studies.[32-33,37,57-58]

The size and composition of the filler particles of the resin composite primarily determine the surface texture

of a restoration and the material's ability to be finished and polished.[28] In this study, despite the differences in filler percentage and the dimensions of the particles, the microhybrid resin composite and flowable resin materials demonstrated good results after two years.

The consistent alpha ratings for anatomic form reflect the relative resistance to wear of the test materials.[48] In the current study, only two restorations were rated bravo after two years. This result was related to the good physical and mechanical properties of resin materials.

CONCLUSIONS

It was concluded that different types of resin materials demonstrated acceptable clinical performance in non-carious cervical lesions, except for the retention rates of Dyract Flow restorations. None of the restorations received a charlie rating for the evaluation criteria and required replacement therapy during the study. However, further evaluation is necessary for the long-term clinical performance of these materials.

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