

Twenty-Four-Month Clinical Comparison of Two Bulk-Fill and a Microhybrid Composite Restorations in Class II Cavities

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ABSTRACT

Objectives: The aim of this study was to evaluate the clinical performance of two bulk-fill composite resins in Class II cavities for up to twenty-four months. *Materials and Methods:* In total 75 Class II restorations were made in 25 patients using two nanohybrid bulk-fill resin composites and a microhybrid composite. The restorations were evaluated at baseline and at 6, 12, and 24 months, using U.S. Public Health Service (USPHS) criteria. The restoration groups were compared using the Pearson chi-square test, and the Cochran Q-test was used to compare the changes across different time points within restorative materials ($p < 0.05$). *Results:* Two patients who did not attend the appointments were excluded from the study, so 23 patients were evaluated with a 92% recall rate; at the end of the two-year follow-up, 66 restorations were evaluated. Three restorations underwent endodontic treatment and were deemed failures. The overall success rate was 96%. There were statistically significant differences between the three restorative resins in terms of color match parameter ($p < 0.05$). No differences were observed between the restorative resins in terms of other criteria ($p > 0.05$). *Conclusions:* During the two-year follow-up period, the three composite resins showed similar clinical performance except for the color match parameter.

INTRODUCTION

The clinical use of resin composite materials is increasing day by day.¹ The use of adhesive restorative materials meets minimally invasive dentistry requirements and allows clinicians to maintain intact dental tissues.² The clinical evidence of the overall success of direct and light-polymerized resin composite restorations in posterior teeth is well documented.³

Although the mechanical and physical properties of resin composites have been improved, polymerization shrinkage remains a major problem.⁴ Although there are many ideas about the method of placing composite resin materials in cavities, it is recommended to place them with a layer technique of 2 mm or less.⁵ In order to avoid polymerization depth limitations and to overcome polymerization shrinkage stress, the layering technique is a frequently used method in clinical practice.^{5,6}

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The main problem with the application of thicker layers is that the resin composite cannot be effectively polymerized to obtain acceptable properties in deeper portions. The polymerization degree of resin composites is influenced by many factors, including the power density of the polymerization unit, exposure time, color of the resin, filler size, and layering level.⁷ As a result, manufacturers have tried to develop faster and easier procedures and improved resin-based materials.⁸ The introduction of bulk-fill resin composites is one of the most important developments in resin-based composite technology. The purpose of the development of the material is to make the process time shorter and more simple and to provide dentists with an easy-to-use procedure.⁹ In addition, bulk-fill composite resins eliminate many disadvantages, such as inter-layer contamination and voids between layers.⁵

Bulk-fill resin composites can be applied to cavities up to 4 mm thick, providing adequate polymerization and low polymerization shrinkage.¹⁰ Most studies have found that the performance of bulk-fill filler materials is similar to incrementally layered conventional resin composites in terms of marginal integrity.^{11,12} Although some properties of bulk-fill composite resins have been reported in previous studies *in vitro*,^{13,14} clinical follow-up studies are more important for the evaluation of dental restorative materials.

Recently, bulk-fill resin composite materials on the market have been reported to have lower polymerization shrinkage stresses than conventional resin-based composites¹⁵ and to consequently reduce the cuspal tension.¹⁶ Researchers use etch and rinse¹⁷ or self-etch^{18,19} techniques for adhesion. It is widely accepted in the literature that major differences in etch and rinse (ER), especially adhesive performance, have been reported when compared to one-step self-etch (SE) adhesives.²⁰ Only one study focused on adhesive strategies for layering and bulk-fill composite resins, and on sensitivity immediately after restoring.²¹ Previously published in randomized controlled studies with flowable bulk filling materials, they have shown enough clinical performances at 2-6 year recalls.^{17,19,22} However, as a recently published review revealed, there is not much information about the performance of more than two years of follow-up time on the performance of bulk viscosities with regular viscosity.²³ Therefore, this double-blind, randomized, and controlled follow-up study compared the clinical success of posterior restorative materials placed in bulk-fill or incremental layers, using different adhesive systems (self-etch or total-etch).

The null hypothesis investigated in this study tested whether there was no difference between the evaluation parameters of conventional resin composites and two different bulk-fill posterior composites resin restorations applied in a single layer.

MATERIALS AND METHODS

The Research Ethics Committee of Tokat Gaziosmanpasa University (Tokat, Turkey) approved the study (14-KAEK-232). A group of patients who came to the Department of Restorative Dentistry, Faculty of Dentistry, Tokat Gaziosmanpasa University were evaluated for suitability for the study. A total of 25 patients who required at least three similar Class II restorations were asked to be included in our research.

The inclusion criteria were as follows: Patient in need of restoration of caries lesion (diagnosed with bitewing radiograph and clinical examination); teeth in need of restoration to be molars or permanent premolars; at least three Class II restorations per patient; no history of hypersensitivity in the teeth to be restored; the presence of interproximal and antagonist teeth; vital pulp and free of painful symptoms; permanent dentition; good oral health and absence of periodontal disease; patients not to have suffered from systemic diseases or allergies; and absence of xerostomia, and bruxism; teeth involved not to have undergone direct pulp capping.

Specific exclusion criteria were as follows: Having less than 20 teeth; tooth sensitivity history; allergy to the materials used in the study; chronic use of anti-inflammatory drugs, analgesic and / or psychotropic drugs; non-vital teeth; being pregnant or breastfeeding; abutment teeth for fixed or removable prostheses. The average age of the patients participating in the study is 20 (18-22 years old). Detailed information about the treatment was given to all the participants by giving informed consent forms. Those who accepted as volunteers were included in the study. The participants were informed that they could leave the study at any stage of the examination process without having to give reasons.

The prepared cavities were at least 4-mm deep. The width, length and height of the cavities were measured by the operator with a probe (Hu-Friedy, Chicago, IL, USA). One experienced dentist placed all 75 restorations. Filling materials and adhesives (Table 1), bulk-fill materials [Sonic Fill (Kerr), X-tra Fil (VOCO)] and microhybrid composite (Filtek Z-250 3M ESPE) were used according to the manufacturer's instructions. In each patient, which composite resin would be used to fill the cavities was randomized using a table of random numbers. In addition, the vitality test of the teeth was done and the results were recorded.

RESTORATIVE PROCEDURE

All the restorations were done by the same operator for standardization (M.B.). Twenty-five patients received a total of 75 restorations. As such, each patient received three Class II restorations randomly: one with Sonic Fill (Kerr); a conventional viscosity composite, Filtek Z-250 (3M ESPE); and the other with X-tra Fil (VOCO), a high-viscosity bulk-fill composite. The cavity preparation was made by using a spherical diamond bur (Meisinger Dental Burs, Hager and Meisinger GmbH, Neuss, Germany) on a high-speed air turbine.

Table 1. Materials used in the study.

Material	Type	Chemical composition	Application steps
Vococid Acid	Etching Gel	35% phosphoric acid, water soluble polymers	It is applied to the enamel for 30 s and dentine for 15 s.
Scotchbond Acid	Etching Gel	32% phosphoric acid, water soluble polymers, fumed silica	It is applied to the enamel for 30 s and dentine for 15 s.
OptiBond™ XTR	Self-etch adhesive	GPDM phosphate monomer, HEMA, dimethacrylate monomers, acetone, ethyl alcohol, water, initiator (2.4), Adhesive: dimethacrylate monomers, barium aluminoborosilicate glass, fumed silica, sodium hexafluorosilicate, ethyl alcohol	Primer applied to air-dried tooth surface with rubbing action for 20 s. Medium air pressure applied to surface for 5 s. Adhesive applied to primed tooth surface with rubbing action for 15 s and then air thinned for 5 s. Primer/adhesive photocured for 10 s
Solobond M	Total-etch adhesive	Bis-GMA, HEMA, BHT, acetone, organic acids.	Etched with phosphoric acid for 15 s, rinsed and air-dried, applied adhesive with a brush, let act for 30 s, dispersed adhesive with a faint air jet, light cured for 20 s.
Adper Single Bond 2	Total-etch adhesive	BIS-GMA, HEMA, dimethacrylate, amines, methacrylic copolymer of polyacrylic and polyitaconic acids, ethanol, water, photoinitiator	Apply etchant for 15 s, Rinse for 15 s, Air dry to remove excess of water, Apply 2 consecutive coats of adhesive for 15 s with gentle agitation, Gently air for 5s to evaporate the solvent, Light-cure for 10 s
Sonic Fill	Bulk-fill resin composite	Glass, oxide, chemicals 3-trimethoxysilylpropyl methacrylate Silicon dioxide EBPADMA Bisphenol-A-bis-(2-hydroxy-3-methacryloxypropyl) ether TEGDMA (83.5/unreported)	5 mm bulk-filling without capping lightcured 40s
X-tra Fill	Bulk-fill resin composite	Inorganic fillers in a methacrylate matrix, Bis-GMA, UDMA, TEGDMA (W/V: 86%/70.1%)	4 mm bulk-filling without capping lightcured 10s
Filtek Z 250	Microhybrid resin composite	Bis-GMA, UDMA, Bis-EMA, canforoquinone, inorganic filler zirconia/silica 60% by volume (0.01-3.5 µm) and wt:%75-85	2 mm layers, lightcured 20s

GPDM: Glycerol phosphate dimethacrylate. Bis-GMA: Bisphenol A diglycidyl dimethacrylate. UDMA: Urethane dimethacrylate; Basic composition based on manufacturers' technical profiles; HEMA: Hydroxyethyl methacrylate. EBPADMA: Ethoxylated bisphenol A dimethacrylate. TEGDMA: triethylene glycol dimethacrylate

Anesthesia was performed in the patients with pain complaints or sensitivity during the procedures. The infected dentin in the cavity was removed by carbide round burs used with a low-speed handpiece, and no bevel was prepared. The discolored but hard dentine was left in place at the cavity floor. The cavities were prepared in accordance with minimally invasive dentistry rules. None of the cavities prepared in the study are wide enough to cover the tubercular cusps. All the margins of the cavities end with solid enamel. The operative field was cleaned with an air/water spray, gently air-dried, and then carefully isolated with cotton rolls and suction. The borders of the prepared cavities were determined according to the areas formed after the removal of the carious tissue. Additional retention areas and bevel were not prepared for the cavities.

What kind of cavities were prepared for the treated teeth and which restorative materials were used were recorded. Oral hygiene training was given to the patients before restorative procedures and a professional dental cleaning was performed. No liner or base was used.

An ivory type matrix system (Hahnenkratt, Königsbach-Stein, Germany) and wooden wedges were used. To remove water, the cavities were rinsed for 10 s and air-dried for 5 s. Three adhesive systems were used: OptiBond™ XTR (Kerr), Solobond M (VOCO), Adper Single Bond 2 (3M ESPE). The adhesives were applied following the manufacturer's instructions (Table 1). Light polymerization procedures were carried out according to the polymerization times in accordance with the manufacturer's

instructions. It was applied with the same LED polymerization light unit (Model BUILT-IN C, Guilin Woodpecker Medical Instrument Co., Ltd., Guilin, Guangxi, China) with a light intensity of 1200 mW/cm² and allowed to operate in a continuous mode. The light was directed perpendicular to the occlusal surface.

In the study in which a total of 75 restorations were applied, three different restorative composite resins were applied to each patient; 25 of the preparations were restored using the bulk-fill resin composite Sonic Fill (Kerr, Orange, CA, USA) (n = 25), 25 of them were restored with Filtek Z-250 (3M ESPE, St Paul, MN, USA) (n = 25), and 25 of them were restored with X-tra Fil (VOCO, Cuxhaven, Germany), according to the manufacturers' instructions (Table 1). The Filtek Z-250 restorative material was applied by using an incremental filling technique with a thickness not exceeding 2 mm to complete the appropriate morphology, and each layer was light-cured for 20 seconds. The X-tra Fil restorative material was placed in bulk up to 4 mm in thickness and cured for 10 seconds with the same light-curing unit. The other bulk-fill resin composite material, Sonic Fill, was applied to the bonded cavities with sonication (SonicFill Handpiece, Kerr) and photo-polymerized for 40 s according to the manufacturer's instructions. Random selection of the material was provided using the random numbers table.

Following the removal of the isolation equipment and matrix systems, the restorations were light-cured again in buccal lingual and occlusal directions for 20 seconds. The cotton rolls were then removed, and the occlusion and articulation were checked and adjusted. The surface of the teeth was finished with fine-grit diamond instruments (Diatech, Coltene, Switzerland), polishing disks (Sof-Lex, 3M-ESPE, MN, USA), and rubber polishing instruments (One Gloss, Shofu, Kyoto, Japan). Water-cooling was used throughout the finishing procedures. Abrasive bands (3M ESPE, St. Paul, MN, USA) were used for proximal surfaces. The interproximal contacts and cervical adaptation of the restorations were checked with dental flossing and bitewing radiographs. All the operative procedures, including the preparation of the cavities and the placement of the restorations, were performed by the same specialist dentist.

PERIODS AND EVALUATION CRITERIA

The patients whose fillings were made were called again after one week, and the restorations were examined clinically. The direct clinical evaluation of the restorations was performed using the USPHS criteria (Table 2) by two independent investigators (E.S.K. and H.A.) using bitewing radiographs and scored as Alpha, Bravo, or Charlie. The Charlie score is not clinically accepted, the Bravo score is clinically acceptable, and the Alpha score represents a successful condition. (Table 2). The patients were recalled for the evaluation of the restorations at 6, 12 and 24 months to be evaluated according to our criteria. Before the evaluations, the specialist dentists observed 10 photographs for each criteria that were representative of each score. Measurements of percentage agreement between the observers were over 85%. For disagreement on decisions, the observers reached a consensus.

During the evaluation, to ensure a double-blind study, the observers were not informed about which filling material had been used on which teeth. When different results were given after the evaluation, the observers made a joint decision and scores were determined. All the evaluations were performed under a dental operating light. Postoperative sensitivities were evaluated by applying a stream of compressed air for three seconds at a distance of 2 to 3 cm from the restoration under isolation from the adjacent teeth and by moving the probe over the restored tooth surface. Then participants were questioned regarding sensitivity. The statistical analyses were carried out with the IBM SPSS version 22.0 software package (SPSS, Chicago, IL, USA). The restoration groups for each category were compared using the Pearson chi-square test, and the Cochran Q-test was used to compare the changes across different time points within each restorative material (p <0.05).

RESULTS

In the study, a total of 75 restorations were performed in 25 patients. Forty-nine of these restorations (71%) were placed in premolars, and 26 (29%) were placed in molars. Two patients did not come to any appointments. At the end of 2 years, twenty-three patients followed their appointments and came for examinations, and at the end of the two-year follow-up, 66 restorations were evaluated. There were no changes in the number of restorations performed at the sixth month. (Table 3).

At the baseline evaluation, all the Sonic Fill, X-tra Fil, and Filtek Z-250 restorations were scored Alpha except for 'color match'. In the X-tra Fil group, 11 restorations were scored Bravo for the color match.

At all the recalls, there was no significant difference in the color change score of the Filtek Z-250 group (p > 0.05). In the Sonic Fill and X-tra Fil groups, no color change was observed at the six-month evaluation when compared with baseline, whereas at the one-year and two-year recalls, a difference in a color match of the Sonic Fill and X-tra Fil group restorations was observed (p <0.05). Also, the difference between the materials was statistically significant at all the recall periods (p <0.05) (Table 4). There was a statistically significant difference between the X-tra Fil group and the Sonic Fill and Filtek Z-250 groups for the color match (p <0.05), although there was no statistically significant difference between the Sonic Fill and Filtek Z-250 groups in any evaluation period except for the last evaluation (p <0.05).

Materials in marginal discoloration, marginal adaptation, secondary caries, and postoperative sensitivity parameters gave statistically similar results both in their measurements at different times and in comparison with each other at different times (p >0.05). At the end of the two-year follow-up, the marginal discoloration was determined with an alpha score of 90% in Filtek Z-250, 86% in X-tra Fil, and 81% in Sonic Fill. In addition, in marginal adaptation, Filtek Z-250 was 86%, Sonic Fill was 81%, and X-tra Fil was 72% alpha (Table 4).

Table 2. USPHS Criterias

USPHS Parameters	Score	Criterion	Methods of Evaluation
Anatomic Form	Alfa	Continuous.	Visual and Probe
	Bravo	Slight discontinuity, clinically acceptable.	
	Charlie	Discontinuous, failure.	
Color Match	Alfa	Restoration matches adjacent tooth structure in color and translucency.	Visual
	Bravo	Mismatch is within an acceptable range of tooth color and translucency.	
	Charlie	Mismatch is outside the acceptable range.	
Marginal Discoloration	Alfa	Absence of marginal discoloration.	Visual
	Bravo	Presence of marginal discoloration limited and not extended.	
	Charlie	Evident marginal discoloration penetrated toward the pulp chamber.	
Marginal Adaptation	Alfa	Closely adapted, no visible crevice	Visual and Probe
	Bravo	Visible crevice, explorer will penetrate	
	Charlie	Crevice in which dentin is exposed	
Secondary Caries	Alfa	No evidence of caries	Radiographic
	Charlie	Caries is evident	
Postoperative Sensitivity	Alfa	Absence of the dentinal hypersensitivity	Thermal Testing and Interviewing the patient
	Bravo	Presence of mild and transient hypersensitivity	
	Charlie	Presence of strong and intolerable hypersensitivity	
Retention	Alfa	Complete retention of the restoration	Visual and Probe
	Bravo	Partially retained	
	Charlie	Loss of the restoration	

In the postoperative sensitivity parameter, the alpha score was determined at 86% of the X-tra Fil and Sonic Fill groups at the end of the two-year recalls. In the Z-250 group, the alpha score was determined at 95% (Table 4).

At the first year of the recalls, secondary caries were determined as 3 in the X-tra Fil group, 1 in the Sonic Fill group, and 2 in the Filtek Z-250 group. These numbers remained the same at the end of the second year. In the first year, Sonic Fill and Filtek Z-250 experienced retention problems in one tooth in each group. In the X-tra Fil group, there was no loss of retention in the restorations (Table 4).

DISCUSSION

Recently, bulk-fill adhesive composite restorative materials have become a widely used material in operative dentistry as it provides easy and fast application to dentists. Applying restorative materials incrementally can cause some difficulties, such as the gap between the layers, the risk of contamination and the difficulty of placing the layers in narrow areas. The bulk application of restorative materials prevents such situations. In this clinical follow-up study, we aimed to evaluate the clinical performance of a micro hybrid composite resin and two different bulk-fill composite resin in Class II cavities. Our null hypothesis was rejected because composite resin materials showed a significantly different clinical performance in the color matching parameter.

Table 3. Number of restorations evaluated by location(tooth) for each material from baseline to 2 years.

	Baseline			6. Month			One Year			Two Years		
	P	M	T	P	M	T	P	M	T	P	M	T
Sonic Fill (OptiBond™ XTR)	7	16	23	7	16	23	7	15 (%94)	22 (%96)	7	15 (%94)	22 (%96)
X-tra Fil (Solobond M)	16	7	23	16	7	23	16	7	23	15 (%94)	7	22 (%96)
Filtek Z-250 (Adper Single Bond 2)	20	3	23	20	3	23	19 (%95)	3	22 (%96)	19 (%95)	3	22 (%96)
Total	43	26	69	43	26	69	42 (%98)	2 (%96)	67 (%97)	41 (%95)	25 (%96)	66 (%96)

P; premolar, M; molar. T; Total (%: Survival rate)

Restorations are subject to temperature changes during chewing. More importantly, factors related to chewing pressures cause load accumulation, leading to chemical and mechanical deterioration.²⁴ It is therefore not correct to compare the results of *in vitro* studies and clinical follow-up studies. *In vitro* studies make an important contribution to the initial evaluation of restorative materials. Since we cannot fully simulate the variable factors in the mouth with *in vitro* methods, we cannot learn the performance of the materials correctly. It is important to evaluate the clinical performance of newly produced restorative materials. Randomized controlled clinical trials are required to compare different restorative materials.²⁵

The safest way to control humidity during processing is to use a rubber dam. However, this is impractical as it can cause minor damage to tissues around the tooth and cause discomfort in the patient. During the treatments, cotton rolls and suction were used to protect the operation area from saliva and moisture. In addition, studies in the literature revealed that, when compared with the use of rubber dam and insulation with cotton rolls, the evaluation results of the materials were similar.²⁶

Commonly used USPHS criteria²⁷ were used in our study to evaluate clinical trials. It is a reliable method widely used to evaluate the important features of restorations such as retention, color matching, marginal discoloration, anatomical form, marginal adaptation, secondary caries and postoperative sensitivity. In this clinical study, two experienced dentists evaluated the patients using the modified USPHS criteria. The researchers periodically recorded the scores of the clinical results of the resin composites at each recall.

Retention scores are known as the most important criteria for determining the success of composite resins. In order to ensure the full acceptance of the filling material, the American Dental Association demands the retention rate of restorations to be at least 90% in evaluations made 18 months later.²⁸ In this study, the two-year survival rate of the Sonic Fill, X-tra Fil, and

Filtek Z-250 restorations was 96%. Based on this information, the composite resins were found to be clinically acceptable. The reasons for the high survival rates in this study are related to the fact that the restorations were performed by a qualified clinician in optimal conditions and that the teeth with exclusion criteria were excluded from the study. Similar findings to our study have been reported in previous clinical trials.^{29,30}

The adhesion ability of the resin composite material; application and polymerization technique; volumetric size of the restorative material used and the shape of the cavity; physicians' skills; and patient-related differences (chewing forces, heat changes in the mouth and pH changes) directly affect the clinical longevity of dental restorations.³¹ The one-year clinical performance of Class II restorations performed using bulk-fill composite resins and layered composite resins were evaluated.^{18,32} In these studies, the composite resins used were reported to show an acceptable clinical performance. In the literature, there is a study reporting that the clinical performance of a hybrid composite resin material and a bulk-fill composite resin in Class II cavities performed quite well for 10 years.³³ Similarly, in the examination performed in the 12th month of another study, filling materials were reported to show a similar clinical performance in all criteria. At the 36-month recall, there was no difference between the materials except for marginal discoloration and marginal adaptation parameters. The bulk-fill composite resin showed better clinical performance in terms of marginal discoloration and marginal adaptation.¹⁷

The results of the color match evaluation in our study were different from previous studies.^{17,33,34} In a study that was similar to our findings, the material different from the baseline is a high-viscosity glass ionomer.³⁵ In our study, the physicians who performed the evaluations stated that the color of one of the restorations was more translucent than the color of the tooth and showed a high inconsistency in color harmony. In another study evaluating the color changes of composite resins,

Table 4. Baseline, six-month, one-year and two-year clinical evaluation of restorations according to USPHS criteria..

Criterion	Baseline (%)			6. Month (%)			One Year (%)			Two Years (%)		
	A	B	C	A	B	C	A	B	C	A	B	C
Anatomic Form												
Sonic Fill-(OB)	23	0	0	23	0	0	22	0	1	22	0	0
X-tra Fil-(SB)	23	0	0	23	0	0	23	0	0	22	0	0
Filtek Z-250-(ASB)	23	0	0	22	1	0	23	0	0	22	0	0
Color Match												
Sonic Fill-(OB)	22 ^b (96)	1	0	15 ^b (65)	8	0	8 ^{b,x} (35)	15	0	7 ^{a,x} (32)	14	1
X-tra Fil-(SB)	12 ^a (52)	11	0	7 ^a (30)	16	0	2 ^{a,x} (9)	21	0	2 ^{a,x} (9)	19	1
Filtek Z-250-(ASB)	22 ^b (96)	1	0	16 ^b (70)	7	0	15 ^b (65)	8	0	15 ^b (68)	7	0
Marginal Discoloration												
Sonic Fill-(OB)	23	0	0	20	3	0	20 (87)	3	0	18 (81)	4	0
X-tra Fil-(SB)	23	0	0	22	1	0	20 (87)	3	0	19 (86)	3	0
Filtek Z-250-(ASB)	23	0	0	21	2	0	20 (87)	3	0	20 (87)	2	0
Marginal Adaptation												
Sonic Fill-(OB)	23	0	0	22	1	0	17 (73)	6	0	18 (82)	4	0
X-tra Fil-(SB)	23	0	0	20	3	0	17 (73)	6	0	16 (73)	6	0
Filtek Z-250-(ASB)	23	0	0	21	2	0	19 (83)	4	0	19 (86)	3	0
Secondary Caries												
Sonic Fill-(OB)	23	-	0	23	-	0	22 (96)	-	1	21 (95)	-	1
X-tra Fil-(SB)	23	-	0	22	-	1	20 (87)	-	3	19 (86)	-	3
Filtek Z-250-(ASB)	23	-	0	21	-	2	21 (91)	-	2	20 (91)	-	2
Postoperative Sensitivity												
Sonic Fill-(OB)	21	2	0	20	3	0	21 (91)	2	0	19 (86)	3	0
X-tra Fil-(SB)	21	1	1	20	3	0	19 (83)	4	0	19 (86)	3	0
Filtek Z-250-(ASB)	21	2	0	23	0	0	22 (96)	0	1	21 (95)	1	0
Retention												
Sonic Fill-(OB)	23	0	0	23	0	0	21 (91)	1	1	22 (100)	0	0
X-tra Fil-(SB)	23	0	0	23	0	0	23 (100)	0	0	22 (100)	0	0
Filtek Z-250-(ASB)	23	0	0	23	0	0	22 (96)	0	1	22 (100)	0	0

Abbreviations: A: Alpha, B: Bravo, C: Charlie, OB: OptiBond™ XTR, SB: Solobond M, ASB: Adper Single Bond 2
a, b: Significant difference between the restorative materials (p<0.05)
x: Significant difference in comparison with baseline for each restorative material (p<0.05)
The comparison of the three restorative materials for each category was performed with the chi-square test.
p <0.05 was used for the level of significance.

the nanohybrid resin composite material in red wine and coffee were stable within one week, and the color changes of the bulk resin composite materials gave high scores.³⁶ This result is in line with our study. In our study, the color match scores of the microhybrid resin composite material used were higher than those of bulk-fill composites after two years.

It has been reported in some *in vitro* studies that stress caused by polymerization shrinkage adversely affects the marginal integrity of the restoration.^{37,38} Resin-based composite filling materials create stress on cavity walls as they shrink during polymerization. Polymerization stresses occur when resin composites cannot balance the volume loss due to polymerization with the plastic flowability of the material.³⁹ The viscoelastic properties of filling materials greatly affect the size of polymerization stresses.³⁹ These tensions may adversely affect the survival of the restoration.⁴⁰ The stability of the connection at the cavity-composite resin interface is an important criterion for the longevity of restorations. Low polymerization stress caused by bulk-fill resin composite materials may be associated with better marginal adaptation. It is known that tensions formed in the polymerization processes of resin composite materials are affected by the composition of the material.⁴¹

Bulk-fill resin composite and conventional resin composite materials have been reported to yield similar results in a recent *in vitro* study evaluating gap formations in restorations.⁴² Campos *et al.*³⁷ investigated the marginal adaptation of new generation bulk fill restorations. They reported that bulk-fill composite materials exhibited acceptable adaptation similar to standard composites. In another study, the cervical marginal integrity of Class II resin composite filling materials, which were incrementally placed and restored by the bulk fill technique, was analyzed and the results were reported to be similar.⁴³ In our study, it was shown that all the materials evaluated at the 24-month recall gave satisfactory marginal adaptation scores.

Different applications in bonding systems can affect marginal adaptation and marginal discoloration scores. Generally, marginal discoloration occurs due to the mismatch between the restoration and cavity margins. Inadequate placement of restorations in cavities or improper finishing and inadequate adhesion and / or stress fatigue afterwards can cause marginal discolorations.⁴⁴ Minor problems or superficial color changes in marginal adaptation can be considered negligible and treatment is not required. Therefore, restorations with bravo scores are considered to be clinically acceptable. However, the deterioration between the restoration and the dental interface may continue, which may cause loss of restoration or change of restoration over time. Therefore, long-term follow-up clinical studies are needed to determine the detailed information of the successes of bulk-fill resin composites.¹⁷

In a study conducted in a group with a high risk of caries, Stefanski and van Dijken observed no secondary caries to Class II nano-restorations in the participants evaluated.⁴⁵ This is an

indication of a good marginal integrity. Some studies have shown secondary caries as the main cause of restoration replacing.^{46,47} In our study, a total of six secondary caries were detected. This may be related to local errors such as marginal adaptation deficiencies and saliva contamination when placing the restoration. In our study, secondary caries and post-operative sensitivities were observed during the 24-month follow-up period. Chlorhexidine, an antimicrobial agent, is commonly used for cavity disinfection, but no cavity disinfection was performed in this study. In addition, in our study, two of the teeth that were removed from the study due to the need for root canal treatment were in the same patient. The patient's lack of oral hygiene may have caused this.

Postoperative pain is expected to be higher in patients undergoing bulk-fill adhesive composite restoration than in patients undergoing restoration by incremental technique. However, none of the participants in this study complained of postoperative sensitivity at Charlie grade and there was no significant difference between the groups. In our study, a low postoperative sensitivity score was reported. These results are not in line with current studies in this field.^{35,44} In the study, postoperative sensitivities may have occurred due to the lack of cavity liners in deep cavities. The use of cavity liners protects the pulpal-dentin complex and eliminates or reduces the possibility of thermal / electrical stimuli. It also promotes the formation of tertiary dentin in deep cavities and minimizes hydrodynamic movements.

The distance of the prepared cavities to the pulp tissue is an important factor in the formation of postoperative complications. The postoperative sensitivity rate after restoration and the increase of the depth of the cavity are directly proportional. In addition, another factor that can cause postoperative sensitivity is operative trauma.⁴⁸ In our study, the preparation of the cavities and the placement of the restorations were carefully conducted by an experienced operator. The depth of the cavities in our study is generally moderate. In addition, Ca (OH)₂ cavity lining material was not applied in deeper cavities. All these factors may have had an impact on postoperative sensitivity. Another limitation of this study is that it is not designed as a split mouth. The design of a split-mouth study can reduce the effects of inter-patient variations on studies, such as dietary and brushing habits, differences in oral hygiene.

Long-term follow-up studies provide more information than short-term studies in determining the clinical properties of materials. The follow-up periods observed in the present study were 6, 12 and 24 months. Most of the restorative materials used today has the ability to perform satisfactorily for 2 to 3 years in clinically. Therefore, studies planned for less than 2-3 years observation time have limited clinical relevance.⁴⁹ Failure behavior of materials can change and differences in treatment success can only be measured after a few years. Some materials may be more susceptible to tooth fractures and some to secondary caries in long periods. Therefore, long observation periods are required to observe all effects

and differences. However, maintaining a population of participants for an extended period is also extremely difficult.⁵⁰ The short evaluation period of our study is one of the limitations. However, we can also learn some useful information about the clinical performance of materials from short-term clinical trials. The follow-ups of the restorations continue for additional evaluations. In addition, more research is needed to support our findings in patients with different cavity sizes, cavity types and harmful or parafunctional habits.

CONCLUSION

At the end of the two-year follow-up period, a conventional micro hybrid composite resin and bulk-fill composite resins showed similar clinical performance except for the color matching parameter. The overall survival rate of this two-year study indicates that posterior bulk fill materials, X-tra Fil (96%), Sonic Fill (96%), and the microhybrid composite Filtek Z-250 (96%), performed with no significant difference quite well. All the materials clinically performed acceptably over two years. Longer studies should be conducted to determine the long-term results of bulk-fill resin composite materials with future studies.

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