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**Clinical Research**

# 24-Month Clinical Evaluation of Different Bulk-Fill Restorative Resins in Class II Restorations

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### Clinical Relevance

Regardless of the presence of a flowable bulk-fill resin or a short-fiber–reinforced resin under a conventional resin composite, restorations in class II cavities restored with bulk-fill resins showed satisfactory and similar clinical performance.


## SUMMARY

**The objective of this study was to evaluate the 24-month clinical performance of three different bulk-fill restorative resin materials in class II restorations. Forty patients with at least three approximal lesions in premolar and molar teeth participated in the study. A total of 120 class II cavities were restored using Tetric EvoCeram Bulk Fill (n=40), SureFil SDR flow + Ceram.X mono (n=40), and everX Posterior + G-aenial Posterior (n=40) with their respective adhesives according to the manufacturers' instructions. All restorations were placed by one operator. The restorations were evaluated at baseline and at six, 12, 18, and 24 months using modified US Public Health Service criteria by one examiner. The restoration groups for each category were compared using the Pearson chi-square test, while the Cochran Q-test was used to compare the changes across different time points within each restorative material ($p<0.05$). At the end of 24 months, 94 restorations were evaluated in 33 patients, with a recall rate of 82.5%. There were no statistically significant differences between the groups in terms of retention ($p>0.05$). At the 24-month recall, two restorations from the SureFil SDR flow + Ceram.X mono group and four from the everX Posterior + G-aenial Posterior group showed slight marginal discoloration and were rated as bravo. No marginal discoloration was observed in any of the Tetric EvoCeram Bulk Fill restorations. Six restorations from the Tetric EvoCeram Bulk Fill group, six from the SureFil SDR flow + Ceram.X mono group, and 12 from the everX Posterior + G-aenial Posterior group received bravo scores in terms of marginal adaptation. No difference was found among the three groups for any of the evaluation criteria tested ($p>0.05$). There were statistically significant differences between the baseline and 24-month recall in the everX Posterior + G-aenial Posterior group in terms of marginal discoloration**


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DOI: 10.2341/18-144-C

**($p<0.05$). For marginal adaptation, a significant difference was observed between baseline and 24 months for all the restorative resins ($p<0.05$). All the restorative resins tested performed similarly and showed acceptable clinical performance during the 24-month evaluation.**

## INTRODUCTION

Despite the developments in resin composites and their growing use in the posterior region, polymerization shrinkage stress, which is the main cause of adhesive failures, is still a challenge when resin-based restorative materials are used.[1,2] Therefore, numerous approaches have been advocated to decrease shrinkage stress by improving composite formulations, such as increasing filler content or the use of new less shrinking monomers, different curing methods, and manipulation of placement techniques.[3] Although incremental placement has been recommended for applying resin composites in order to reduce polymerization shrinkage, increase depth of cure, and avoid marginal disintegration,[4-7] this technique is time consuming and has a risk of contamination and entrapment of air voids between the layers. Moreover, the adaptation of multiple layers might be difficult, especially in small cavities.

The concept of using bulk placement has recently reemerged and is generating interest due to the introduction of bulk-fill resin restoratives. They are designed for placement in thick layers up to 4 mm, as clinicians wish to perform restorations using minimal chair time. Advancements in resin and filler technology and increased translucency have enhanced the depth of cure of bulk-fill resin composites.[8-11] Moreover, the inclusion of stress-reliever monomers, higher-molecular-weight resins, polymerization modulators, prepolymerized fillers, and more reactive photoinitiators in their composition resulted in reductions in polymerization shrinkage.[12] Bulk-fill resin composites are classified as high-viscosity bulk-fill flowable and low-viscosity bulk-fill nonflowable resins. Flowable bulk-fill resins require capping with a conventional resin composite for inferior mechanical properties, such as strength and wear resistance.[13] They have been generally advocated as dentin replacement materials.

Recent advances by manufacturers have resulted in the launch of a new type of short fiber-reinforced composite (everX Posterior) in order to overcome some of the concerns related to the restoration of large cavities with traditional resin composites.[14] This composite is composed of a resin matrix, short E-glass fibers, and inorganic particulate fillers. The resin matrix contains cross-linked bisphenol-A glycidyl methacrylate, triethylene glycol dimethacrylate, and linear polymethyl methacrylate, forming a polymer matrix called a semi-interpenetrating polymer network, which contributes to better bonding and flexural strength.[15-18] Glass fibers have been proposed to favor light transmission through the resin composite and to reduce or stop crack propagation.[16-18] Laboratory studies demonstrated good performance of fiber-reinforced materials with respect to fracture resistance, toughness, and polymerization shrinkage.[16,18-21]

To date, only limited data from clinical trials on these topics have been published.[22-27] Even though the *in vitro* data suggest that bulk-fill resins may outperform incrementally placed resins, the limited and thus far controversial clinical data do not fully support that claim. On the other hand, the information from laboratory tests does not always correlate with clinical performance. Therefore, the aim of the present study was to further investigate the clinical performance of bulk-fill flowable, bulk-fill, and fiber-reinforced restorative resins in class II cavities over 24 months. The null hypothesis tested was that the different types of bulk-fill restorative resins would not differ from each other in terms of clinical performance.

## METHODS AND MATERIALS

Approval for the clinical trial was obtained from the Human Ethics Committee of Hacettepe University (#71146310, KA-14043). Prior to the start of the study, the patients were informed about the nature and the objectives of the study, and then their written consent was obtained.

### Inclusion Criteria

Inclusion criteria for patients included 1) 18 years or older, 2) good general health and oral hygiene, 3) at least three similar-sized approximal primary caries lesions in premolar and molar teeth, and 4) available for follow-up visits. Inclusion criteria of the teeth were 1) normal occlusal relationship with natural dentition, 2) adjacent tooth contact, and 3) normal response to a vitality test with no periapical pathology.

### Exclusion Criteria

Exclusion criteria were 1) poor oral hygiene, 2) severe or chronic periodontitis, 3) heavy bruxism, 4) fewer than 20 teeth, 5) history of adverse reaction to

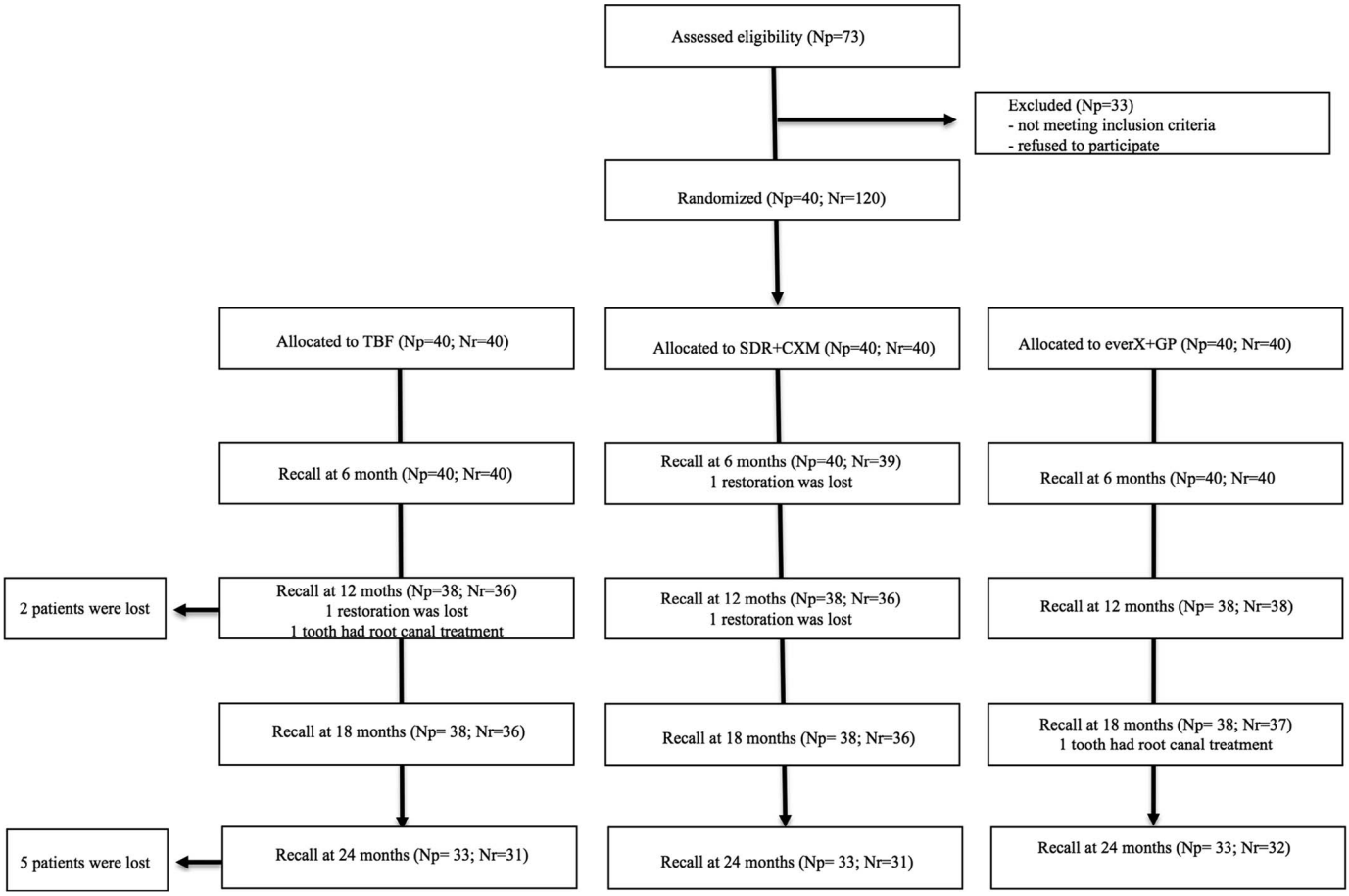


Figure 1. *Flowchart of the trial (Np=Number of patients; Nr=number of restorations).*

the test materials, 6) pregnancy or lactation period, and 7) potentially unable to attend recall visits.

The sample calculation indicated the need for approximately 35 patients for a confidence level of 85%. In total, 40 subjects (16 men and 24 women) ranging in age from 20 to 41 years were enrolled (Figure 1).

Bitewing radiographs of the teeth to be restored were taken preoperatively. The preparation was made using diamond straight (flat-end) burs (Edenta Ag Dental Products, Au, St.Gallen, Switzerland) in a high-speed hand piece with water cooling. The carious lesion was removed using round steel burs (Edenta). The preparation was limited to the removal of decay, preserving a maximum of sound tooth structure. The average bucco-lingual width of each preparation was equal to or greater than one-third of the distance between the cusp tips. The operative field was isolated using cotton rolls and suction after shade selection.

A total of 120 class II cavities were restored using Tetric EvoCeram Bulk Fill (TBF) (n=40), SureFil SDR flow + Ceram.X mono (SDR+CXM) (n=40), and everX Posterior + G-aenial Posterior (everX+GP) (n=40) with their respective adhesives according to the manufacturers' instructions. The composition and batch numbers are described in Table 1. The randomization process of subjects was performed using a table of random numbers, and the patient was unaware of which tooth received which restoration. All restorations were placed by one operator who was not blinded to group assignment.

For the Tetric EvoCeram Bulk Fill restorations, the preparation was etched with 37% phosphoric acid (Super Etch, SDI, Bayswater, VIC, Australia) applied initially to the enamel for 15 seconds and then to the dentin for 15 seconds. It was then rinsed with an air/water spray and blot dried, leaving the dentin slightly moist. An etch-and-rinse adhesive, ExciTE F (Ivoclar Vivadent, Schaan, Liechtenstein), was applied and agitated on the prepared surfaces

Table 1: *Materials Used in the Study*

| Product Name | Type | Manufacturer | Batch Number | Composition |
|---|---|---|---|---|
| Tetric EvoCeram Bulk Fill | Bulk-fill posterior restorative | Ivoclar Vivadent, Schaan, Liechtenstein | R77065 | Bis-GMA, UDMA, bis-EMA, barium alumina silicate glass filler, ytterbium fluoride, spherical mixed oxide |
| Excite F | Dental adhesive (two-step etch-and-rinse) | Ivoclar Vivadent | P56445 | Phosphonic acid acrylate, HEMA, dimethacrylate, highly dispersed silicone dixoide, initiators, stabilizers and potassium fluoride in an alcohol solution |
| SureFil SDR Flow | Bulk-fill flowable resin composite | Dentsply Caulk (Milford, DE, USA) | 1207205 | Barium and strontium alumino-fluoro-silicate glass, TEGDMA, modified UDMA, dimethacrylate, EBPADMA, pigment, photoinitiator |
| Ceram.X mono | Nanoceramic resin composite | Dentsply Caulk | 1203000406 | Methacrylate modified polysiloxane, dimethacrylate resin, barium-aluminum-borosilicate glass, methacrylate functionalized silicon dioxide nanofillers |
| Prime&Bond NT | Nanotechnology dental adhesive (two-step etch-and-rinse) | Dentsply Caulk | 1306000189 | Di- and trimethacrylate resins, functionalized amorphous silica, PENTA, stabilizers, cetylamine hydrofluoride, acetone |
| everX Posterior | Fiber-reinforced resin composite | GC Co (Milford, DE, USA) | 1309121 | Bis-GMA, TEGDMA, PMMA, triethylene glycol dimethacrylate, glass fillers and inorganic granular fillers |
| G-aenial Posterior | Posterior resin composite | GC Co | 1211192 | Methacrylate monomers, UDMA, dimethacrylate comonomers, prepolymerized fillers, camphorquinone and amine, fluoroaluminosilicate, fumed silica |
| G-aenial Bond | One-component self-etch adhesive | GC Co | 1401271 | Phosphoric ester monomers, 4-MET, a hydrophilic methacrylate monomer, water, acetone, photoinitiator, nanosilica |
| SDI Super Etch | Etching gel | SDI (Bayswater, VIC, Australia) | 140554 | 37% phosphoric acid, synthetic amorphous silica (fumed), polyethylene glycol, aluminum oxide, water |

*Abbreviations: bis-GMA, bisphenol-A glycidyl methacrylate; UDMA, urethane dimethacrylate; bis-EMA, bisphenol-A ethoxylated dimethacrylate; HEMA, hydroxyethyl methacrylate; TEGDMA, triethylene glycol dimethacrylate; EBPADMA, ethoxylated bisphenol-A dimethacrylate; PENTA, phosphonated penta-acrylate ester; PMMA, polymethyl methacrylate*

for at least 10 seconds. After the adhesive was dispersed into a thin layer with a weak stream of air, light curing was performed for 20 seconds with an LED curing unit (Starlight, Mectron, Carasco, Italy) with an intensity of 1400 mW/cm$^2$. The sectional matrix was placed and fixed with wooden wedges. Then the bulk-fill resin composite, TBF, was placed in bulk in about 4-mm thickness and then cured with the same curing unit for 20 seconds.

For SDR + Ceram.X mono restorations, the cavities were etched as described above. A two-step etch-and-rinse adhesive, Prime&Bond NT (Dentsply DeTrey, Konstanz, Germany), was applied to all enamel/dentin surfaces, air-dried for five seconds, and light cured for 10 seconds. After the sectional matrix was placed, the flowable bulk-fill resin composite, SureFil SDR flow (Dentsply Caulk, Milford, DE, USA), was placed in a 4-mm bulk increment in the dentinal part cured for 20 seconds and followed by a covering layer of the nanohybrid resin composite, Ceram.X Mono (Dentsply DeTrey), that was cured for 20 seconds.

For everX + G-aenial Posterior restorations, the enamel was etched with 37% phosphoric acid for 10 seconds, then rinsed and dried with an air/water syringe for at least five seconds. A self-etch adhesive, G-aenial Bond (GC Co, Tokyo, Japan), was applied to all enamel/dentin surfaces and gently air thinned and then light cured for 10 seconds. After the matrix was placed and wedged, mesial or distal walls were built with 1- to 2-mm layers of G-aenial Posterior resin composite (GC Co). The fiber-reinforced composite, everX Posterior (GC Co), was placed into the cavity in approximately 4-mm thickness. The last 2 mm of the cavity were restored using the G-aenial Posterior composite as an overlay layer. Each increment was light cured for 20 seconds using the same LED unit.

The occlusion was checked and adjusted. Finishing was done using diamond finishing burs (Diatech, Coltène/Whaledent AG, Altstätten, Switzerland). Polishing was accomplished with aluminum oxide disks (OptiDisc, Kerr, Bioggio, Switzerland) and rubber cups and points (Kerr).

An experienced dentist, not involved in the placement of the restorations and therefore blinded to the group assignment, performed the evaluation. As an intraexaminer agreement of at least 85% was

Table 2: *Distribution of Materials According to Tooth and Arch*

| Groups | Mandibular | | Maxillar | | Total |
|---|---|---|---|---|---|
| | Premolar | Molar | Premolar | Molar | |
| TetricEvoCeram Bulk Fill | 24 | 5 | 5 | 6 | 40 |
| SureFil SDR flow + Ceram.X mono | 12 | 4 | 18 | 6 | 40 |
| everX Posterior + G-aenial Posterior | 11 | 14 | 4 | 11 | 40 |
| Total | 47 | 23 | 27 | 23 | 120 |

necessary before the beginning of the evaluation, intraexaminer training was conducted on 40 restorations from approximately 20 patients who were not participating in the present study. Examination was repeated after two weeks to record intraexaminer reproducibility. The examiner was calibrated to 100% intraexaminer agreement for all the evaluated criteria.

The restorations were evaluated at baseline and at six, 12, 18, and 24 months using modified United States Public Health Service criteria.[28] The postoperative sensitivity was evaluated by applying air for 10 seconds from a dental syringe at a distance of 1 cm from the tooth surface and by questioning the patients. During this evaluation, adjacent teeth were isolated with cotton rolls. Clinical photographs were taken pre- and postoperatively at baseline and at each recall. At the end of 24 months, bitewing radiographs were also taken. Table 2 shows the distribution of restorations to teeth, with the majority of restored teeth being premolars. Forty-six restorations (38.3%) were inserted in molars, whereas 74 (61.7%) were inserted in premolars.

The results were analyzed using IBM SPSS 22.0 (SPSS, Chicago, IL, USA). The restoration groups for each category were compared using the Pearson chi-square test, while the Cochran Q test was used to compare the changes across different time points within each restorative material. The level of significance was set at 5%.

## RESULTS

Table 3 presents the results of the clinical evaluation of the restorations.

### Recall and Retention Rate

At the six-month recall, the recall rate was 100%. Two patients did not attend the 12-month recall. At the 12- and 18-month recalls, the recall rates were 95%. At the 24-month recall, five more patients were lost, and the recall rate declined to 82.5%. The reasons were moving to another city for two patients and failed attempts to contact the other three.

The retention rate was 100% for Tetric EvoCeram Bulkfill and everX + G-aenial posterior restorations at six months. For the Surefil SDR Flow + Ceram.X mono group, the retention rate was 97.5% due to the loss of one restoration. At 12 months, one restoration from the TBF group and one from the Surefil SDR Flow + Ceram.X mono group were lost, and one restoration received root canal treatment from the Tetric Bulk Fill group with a retention rate of 97.3%. Within the everX group, one restoration was replaced due to root canal treatment at 18 months. Twenty-four-month retention rates were 100% for all groups, and the number of evaluated restorations was 31 for TB and SDR and 32 for everX. There were no statistically significant differences between the groups after six, 12, 18, or 24 months ($p>0.05$).

### Marginal Discoloration

One restoration from the SDR group showed slight marginal discoloration at six, 12, and 18 months. At 24 months, two restorations showed discoloration. Two restorations from the everX group showed superficial discoloration at 12 and 18 months. At 24 months, discoloration was observed in four restorations. Figure 2 through 5 show approximal lesions and class II restorations in a patient before the procedure, at baseline, and at the 12- and 24-month recall visits. None of the restorations from the TBF group showed discoloration anywhere along the margin during the evaluation periods.

### Marginal Adaptation

In terms of marginal adaptation, four restorations from both the TBF and the SureFil SDR flow + Ceram.X mono group and seven everX Posterior + G-aenial Posterior restorations were rated as bravo at six months. At 12 months, two more restorations from the everX group showed slight discoloration. At 18 months, five restorations from both the Tetric EvoCeram Bulk Fill and the SureFil SDR flow + Ceram.X mono group and 11 everX Posterior + G-aenial Posterior restorations were rated as bravo. At 24 months, one more restoration from each group was rated as bravo in terms of marginal adaptation.

Table 3: *Results of the Clinical Evaluation of the Restorations*

| | Baseline | | | 6 Months | | |
|---|---|---|---|---|---|---|
| | TBF | SDR + CXM | everX + GP | TBF | SDR + CXM | everX + GP |
| Retention | | | | | | |
| A | 40/40 (100) | 40/40 (100) | 40/40 (100) | 40/40 (100) | 40/39 (97.5) | 40/40 (100) |
| C | 40/0 (0) | 40/0 (0) | 40/0 (0) | 40/0 (0) | 40/1 (2.5) | 40/0 (0) |
| Marginal discoloratiom | | | | | | |
| A | 40/40 (100) | 40/40 (100) | 40/40 (100) | 40/40 (100) | 39/38 (97.4) | 40/40 (100) |
| B | 40/0 (0) | 40/0 (0) | 40/0 (0) | 40/0 (0) | 39/1 (2.6) | 40/0 (0) |
| Marginal adaptation | | | | | | |
| A | 40/40 (100) | 40/40 (100) | 40/40 (100) | 40/36 (90) | 39/35 (89.7) | 40/33 (82.5) |
| B | 40/0 (0) | 40/0 (0) | 40/0 (0) | 40/4 (10) | 39/4 (10.3) | 40/7 (17.5) |
| Color match | | | | | | |
| A | 40/40 (100) | 40/40 (100) | 40/39 (97.5) | 40/40 (100) | 39/39 (100) | 40/39 (97.5) |
| B | 40/0 (0) | 40/0 (0) | 40/1 (2.5) | 40/0 (0) | 39/0 (0) | 40/1 (2.5) |
| Surface texture | | | | | | |
| A | 40/40 (100) | 40/40 (100) | 40/40 (100) | 40/40 (100) | 39/38 (97.4) | 40/39 (97.5) |
| B | 40/0 (0) | 40/0 (0) | 40/0 (0) | 40/0 (0) | 39/1 (2.6) | 40/1 (2.5) |
| Anatomic form | | | | | | |
| A | 40/40 (100) | 40/40 (100) | 40/40 (100) | 40/40 (100) | 39/39 (100) | 40/40 (100) |
| B | 40/0 (0) | 40/0 (0) | 40/0 (0) | 40/0 (0) | 39/0 (0) | 40/0 (0) |
| Postoperative sensitivity | | | | | | |
| A | 40/40 (100) | 40/38 (95.0) | 40/39 (97.5) | 40/37 (92.5) | 39/38 (97.4) | 40/37 (92.5) |
| B | 40/0 (0) | 40/2 (5.0) | 40/1 (2.5) | 40/3 (7.5) | 39/1 (2.6) | 40/3 (7.5) |
| Secondary caries | | | | | | |
| A | 40/40 (100) | 40/40 (100) | 40/40 (100) | 40/40 (100) | 39/39 (100) | 40/40 (100) |

*Abbreviations: TBF, Tetric EvoCeram Bulk Fill; SRD + CXM, SureFil SDR flow + Ceram X Mono; everX + GP, everX Posterior + G-aenial Posterior; A, alpha; B, bravo; C, charlie.*

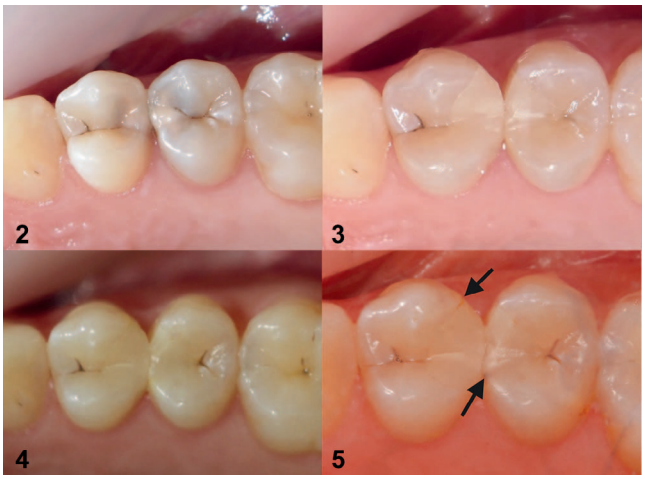


Figure 2. *Preoperative approximal lesions on teeth #4 and #5.*

Figure 3. *Class II restorations on teeth #4 (everX Posterior+G-aneial Posterior) and #5 (SureFil SDR flow+Ceram.X mono).*

Figure 4. *Restorations at the 12-month follow-up on teeth #4 and #5.*

Figure 5. *Restorations at the 24-month follow-up on teeth #4 and #5 (arrows show marginal discoloration).*

### Color Match

One restoration from the everX Posterior + G-aenial Posterior group received a bravo score from the baseline. At 12, 18, and 24 months, two restorations were rated as bravo in the everX group. The rest of the restorations showed no mismatch in color during the study.

### Surface Texture

At six months, one restoration from the SureFil SDR flow + Ceram.X mono group and one from the everX Posterior + G-aenial Posterior group were rated as bravo in terms of surface texture, while at 12, 18, and 24 months, two restorations from the same groups received this rating.

### Anatomic Form

Only one restoration from the everX Posterior + G-aenial Posterior group received a bravo score at the 12- and 18-month evaluations. However, this restoration could not be evaluated at the 24-month follow-up because this patient did not attend the recall. The

Table 3: *Results of the Clinical Evaluation of the Restorations (ext.)*

| | 12 Months | | | 18 Months | | | 24 Months | | |
|---|---|---|---|---|---|---|---|---|---|
| | **TBF** | **SDR + CXM** | **everX + GP** | **TBF** | **SDR + CXM** | **everX + GP** | **TBF** | **SDR + CXM** | **everX + GP** |
| Retention | | | | | | | | | |
| A | 37/36 (97.3) | 37/36 (97.3) | 38/38 (100) | 36/36 (100) | 36/36 (100) | 37/37 (100) | 31/31 (100) | 31/31 (100) | 32/32 (100) |
| C | 37/1 (2.7) | 37/1 (2.7) | 38/0 (0) | 36/0 (0) | 36/0 (0) | 37/0 (0) | 31/0 (0) | 31/0 (0) | 32/0 (0) |
| Marginal discoloratiom | | | | | | | | | |
| A | 36/36 (100) | 36/35 (97.2) | 38/36 (94.7) | 36/36 (100) | 36/35 (97.2) | 37/35 (94.6) | 31/31 (100) | 31/29 (93.5) | 32/28 (87.5) |
| B | 36/0 (0) | 36/1 (2.8) | 38/2 (5.3) | 36/0 (0) | 36/1 (2.8) | 37/2 (5.4) | 31/0 (0) | 31/2 (6.5) | 32/4 (12.5) |
| Marginal adaptation | | | | | | | | | |
| A | 36/32 (88.9) | 36/33 (91.7) | 38/29 (76.3) | 36/31 (86.1) | 36/31 (86.1) | 37/26 (70.3) | 31/25 (80.6) | 31/25 (80.6) | 32/20 (62.5) |
| B | 36/4 (11.1) | 36/3 (8.3) | 38/9 (23.7) | 36/5 (13.9) | 36/5 (13.9) | 37/11 (29.7) | 31/6 (19.4) | 31/6 (19.4) | 32/12 (37.5) |
| Color match | | | | | | | | | |
| A | 36/36 (100) | 36/36 (100) | 38/36 (94.7) | 36/36 (100) | 36/36 (100) | 37/35 (94.6) | 31/31 (100) | 31/31 (100) | 32/30 (93.7) |
| B | 36/0 (0) | 36/0 (0) | 38/2 (5.3) | 36/0 (0) | 36/0 (0) | 37/2 (5.4) | 31/0 (0) | 31/0 (0) | 32/2 (6.3) |
| Surface texture | | | | | | | | | |
| A | 36/36 (100) | 36/34 (94.4) | 38/36 (94.7) | 36/36 (100) | 36/34 (94.4) | 37/35 (94.6) | 31/31 (100) | 31/29 (93.5) | 32/30 (93.7) |
| B | 36/0 (0) | 36/2 (5.6) | 38/2 (5.3) | 36/0 (0) | 36/2 (5.6) | 37/2 (5.4) | 31/0 (0) | 31/2 (6.5) | 32/2 (6.3) |
| Anatomic form | | | | | | | | | |
| A | 36/36 (100) | 36/36 (100) | 38/37 (97.4) | 36/36 (100) | 36/36 (100) | 37/36 (97.3) | 31/31 (100) | 31/31 (100) | 32/32 (100) |
| B | 36/0 (0) | 36/0 (0) | 38/1 (2.6) | 36/0 (0) | 36/0 (0) | 37/1 (2.7) | 31/0 (0) | 31/0 (0) | 32/0 (0) |
| Postoperative sensitivity | | | | | | | | | |
| A | 36/34 (94.4) | 36/35 (97.2) | 38/35 (92.1) | 36/36 (100) | 36/35 (97.2) | 37/36 (97.3) | 31/31 (100) | 31/31 (100) | 32/32 (100) |
| B | 36/2 (5.6) | 36/1 (2.8) | 38/3 (7.9) | 36/0 (0) | 36/1 (2.8) | 37/1 (2.7) | 31/0 (0) | 31/0 (0) | 32/0 (0) |
| Secondary caries | | | | | | | | | |
| A | 36/36 (100) | 36/36 (100) | 38/38 (100) | 36/36 (100) | 36/36 (100) | 37/37 (100) | 31/31 (100) | 31/31 (100) | 32/32 (100) |

rest of the evaluated restorations showed no loss of anatomic form and were continuous with existing anatomic form.

### Postoperative Sensitivity

Postoperative sensitivity was observed in three restorations from the TBF group at six months. At 12 months, one of them received root canal treatment; the other two patients were still suffering from mild sensitivity. After 18 months, sensitivity totally disappeared in these two patients. In the SureFil SDR flow + Ceram.X mono group, two patients had postoperative sensitivity at the baseline. In one of them, pain had disappeared by the six-month recall, while the other one still had sensitivity at the 18-month recall. One patient suffered from postoperative sensitivity from baseline up to 24 months in the everX Posterior + G-aenial Posterior group. Two more patients had postoperative sensitivity at the six- and 12-month recalls. At 18 months, one of them received root canal treatment, and pain disappeared in the other one. At 24 months, none of the patients from any groups suffered from postoperative sensitivity.

Overall, no statistically significant differences were noted among these three groups for marginal discoloration, marginal adaptation, color match, surface texture, or anatomic form ($p<0.05$). No secondary caries was detected.

When comparing each group at different recall times, a significant difference was observed in all groups for marginal adaptation between baseline and 24 months ($p<0.05$). In terms of marginal discoloration, there was a statistically significant difference between baseline and 24 months only in the everX Posterior + G-aenial Posterior group ($p<0.05$).

## DISCUSSION

A recent innovation in posterior resin restoratives is the introduction of bulk-fill restoratives. Although many *in vitro* studies have been conducted to evaluate the performance of these newly introduced restorative materials, their findings do not always

reflect the behavior of these materials, and so the best way to predict their performance is to conduct clinical studies. In previous clinical studies,[23-27,29,30] bulk-fill resins were compared mostly with incrementally placed conventional resins. To the best of the authors' knowledge, no study has so far compared the performance of bulk-fill, bulk-fill flowable, and fiber-reinforced restorative resins in class II cavities over 24 months. In the present study, the tested resin restoratives performed similarly in every aspect over the 24-month evaluation period, leading to acceptance of the hypothesis.

It is important to find out whether application of a flowable bulk-fill resin or a short-fiber–reinforced resin could improve the internal marginal adaptation of restorations. In an *in vitro* study, the marginal adaptation of two flowable bulk-fill and two bulk-fill resin-based composites and one incrementally placed composite was compared, and it was concluded that the bulk-fill resin composites showed better adaptation than the flowable bulk resins.[31] Contrary to this finding, in another study, the marginal and internal integrity of posterior resin composites with or without a 4-mm SDR base was compared, and no influence was reported with the presence of a 4-mm layer of SDR.[32] Patnana and others[33] compared the marginal integrity of short-fiber–reinforced restorations with or without a composite superficial layer and with conventional resin composite. They concluded that fiber-reinforced restorations showed improved marginal integrity compared to traditional ones. In a short-term 12-month clinical follow-up, restorations combining a base of short-fiber–reinforced composite resin with hybrid composite resins showed promising performance.[22] However, the study did not compare their results with those of another type of resin composite. A more recent publication compared the clinical durability of a flowable bulk-fill resin composite, SDR, capped with a layer of nanohybrid composite and an incrementally placed conventional resin composite.[29] At the end of six years, the annual failure rate was 1.0% for both groups. It was concluded that the restorations made with a flowable bulk-fill base demonstrated good results that were not significantly different from those of incrementally placed composites.

In our study, although no significant difference was detected, six restorations each from the TBF and SDR + CXM groups and 12 restorations from the everX + GP group showed poor marginal adaptation. In other words, restorations with the combination of a conventional resin composite over flowable bulk-fill or a short-fiber–reinforced resin showed similar performance in terms of marginal adaptation. Jung and Park[31] stated that polymerization shrinkage and stress are the major factors for imperfect marginal adaptation. Filler content is also an important material property that affects marginal adaptation. When the polymerization shrinkage is similar, the material with the lower viscosity has better marginal adaptation. Although the polymerization shrinkage of SDR (3.5%) was higher than that of the other tested restorative resins, their marginal adaptation was similar. With a lower modulus of elasticity,[34] SDR might act as a stress buffer. On the other hand, the features of the resin composite material that caps the flowable bulk fills are also important. In the present study, Ceram.X mono, with a polymerization shrinkage rate of 2.3, was used to cap SDR flowable bulk-fill composite. Its polymerization shrinkage value was quite similar to that of the other restorative resins tested. This might be another reason for the similarity in marginal adaptation ratings. However, the marginal adaptation scores of all tested restorative resins varied with respect to baseline measurements. The increase in the amount of inorganic fillers and the decrease in monomer content might also contribute to lower polymerization shrinkage. In the present study, the inorganic filler volume was 60% for Tetric EvoCeram Bulk Fill, 57% for Ceram.X mono, and 62% for G-aenial Posterior. Besides the filler load, polymerization shrinkage might also be affected by the size and shape of fillers, monomer composition, and initiators.

The reason that no differences were observed between the restorative materials might be related to the specific properties of the resins. Tetric EvoCeram Bulk Fill has a germanium-based photoinitiator, the initiator booster Ivocerin.[35] Due to its higher absorption in the region between 400 and 450 nm, it has a higher photo-curing activity than camphorquinone (CQ) does.[9,36] This material contains some prepolymerized fillers that cause low modulus of elasticity.[35,37] In addition, the material includes a shrinkage stress reliever.[35] On the other hand, with the high translucency of SDR, the transmission of light through the material is much easier. Moreover, a special group boosting polymerization that interacts with CQ was incorporated in its monomer composition;[8,9] everX Posterior has CQ and N,N-dimethylaminoethyl methacrylate as a photoinitiator and contains E-glass fibers that conduct and scatter the light, enabling adequate polymerization depth. In an *in vitro* study, suffi-

cient polymerization properties in terms of degree of conversion, hardness, polymerization volume shrinkage, and shrinkage stress were obtained at 4-mm depth for bulk-fill resin composites.[38] As poorly polymerized resin can cause gap formation, leading to marginal leakage, discoloration, and recurrent caries; their adequate depth of cure might have caused the lack of difference between the tested resins' marginal discoloration scores. On the other hand, it might have been expected that restorations with everX base, having short-fiber fillers that may absorb polymerization stress and increase stress-relieving capacity, might improve adaptation and thereby reduce marginal discoloration. In an *in vitro* study, the use of a base material, short-fiber–reinforced composite, everX Posterior, and a surface layer of conventional resin showed less leakage than SDR + conventional composite and bulk-fill resin composite.[39] The results contradict the predictions that could be made for everX based on *in vitro* data. Contrary to these expectations, although not significantly different, Tetric EvoCeram Bulk Fill restorations showed a trend toward superior performance in terms of marginal discoloration. None of the restorations in this group showed any discoloration. In a three-year clinical study that compared the clinical performance of Tetric EvoCeram Bulk Fill and an incrementally placed resin composite, no marginal discoloration was detected in any of the bulk-fill restorations at 24-month recall. However, two restorations showed slight discoloration at three-year recall.[27] It is better to conduct long-term clinical studies in order to obtain clear evidence about their performance.

In the present study, one restoration from the TBF group at 12 months and one restoration from the everX + GP group at 18 months had to be endodontically treated. The reason for the root canal treatment was postoperative sensitivity. As these two restorations were in the same patient, this could be related to low pain perception in that patient.

Anatomic form and surface texture could be related to either the patient's habits and eating or the restorative materials' specifications, such as the filler type and content. Most of the restorations received 100% alpha scores throughout the study. These favorable results could be attributed to the mechanical properties of the resin composites tested and the patients' good oral hygiene as well as their frequent dental visits.

## CONCLUSIONS

Within the limitations of the present study, all investigated bulk-fill restorations, regardless of the presence of a flowable bulk-fill resin or a short-fiber–reinforced resin under a conventional resin composite, were found to be clinically acceptable and similar after 24 months of clinical use. However, this is only a short-term clinical study, and the durability of the tested restorative materials might change over time. Observation of a significant deterioration in marginal adaptation for all the restorations is another important outcome of the present study. Therefore, further recall evaluations have already been planned.

#### Acknowledgements

The authors thank for Ivoclar/Vivadent, Dentsply Caulk, and GC Co for providing materials for this study.

#### Regulatory Statement

This study was conducted in accordance with all the provisions of the local human subjects oversight committee guidelines and policies of the Hacettepe University. The approval code for this study is #71146310, KA-14043.

#### Conflict of Interest

The authors of this article certify that they have no proprietary, financial, or other personal interest of any nature or kind in any product, service, and/or company that is presented in this article.

*(Accepted 1 November 2018)*

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