Original Article

Clinical Evaluation of Bulk-Fill Resins and Glass Ionomer Restorative Materials: A 1-Year Follow-Up Randomized Clinical Trial in Children

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Abstract

Objective: This prospective study aimed to evaluate the clinical performance of different restorative materials in primary molars with class II carious lesions. **Materials and Methods:** A total of 160 class II carious lesions (with radiographic involvement of the outer half of dentin) in 30 patients were randomly divided into four groups and restored with a glass ionomer restorative system (Equia™), two different bulk-fill composites (Sonicfill™ and X-tra fil™), and a nanohybrid composite (Filtek Z550™). The restorations were clinically and radiographically evaluated at the baseline, and 3, 6, and 12 months according to the modified United States Public Health Service criteria. Statistical analyses were performed using Pearson's Chi-square and McNemar tests. **Results:** After 1 year, 134 restorations were evaluated in 26 patients. Equia was statistically less successful than the other restorative materials in marginal adaptation and retention criteria ($P < 0.05$). However, no material was found to be superior to the others over the study period in marginal discoloration, color matching, secondary caries, anatomical form, and postoperative sensitivity ($P > 0.05$). **Conclusion:** The bulk-fill and conventional composites exhibited good clinical performance, and Equia exhibited minor changes over the 1-year trial period.

Keywords: *Bulk-fill materials, clinical performance, primary molars*

Introduction

In pediatric dentistry, restorative materials that require fewer application steps facilitate the continuous delivery of quality treatment by reducing chair time and decreasing the contamination risk of restoration preparation during placement which is advantageous for working on children with limited attention spans.[1,2] Such simplified multistep restorative procedures have fostered an interest in the use of bulk-fill restorative materials, including high-viscosity glass ionomer cement (HVGIC), resin-modified GICs, and bulk-fill composite (BC) resins.[3]

HVGIC has been developed to enhance the inadequate mechanical properties of materials used in restorative procedures, including increased resistance to abrasion against high occlusal forces of GICs.[4] These materials have highly cross-linked matrices resulting from optimized polyacid and particle size distribution and have improved physical properties especially compressive, flexural, and tensile strength. They also have better wear resistance than GICs do.[5] A new generation of bulk-fill posterior restorative glass ionomers, namely Equia™, has been introduced. The Equia system consists of two parts: an HVGIC called Equia Fil, formerly known as Fuji IX GP Extra, and a nano-filled coating material called Equia Coat, which provides an improved seal for the material surface.[6]

Previous reports on Equia as a permanent filling material are mainly related to the primary molars and atraumatic restorative treatment. Ersin *et al.*[7] applied HVGIC Fuji IX GP to class I and II cavities using atraumatic restorative treatment and monitored the

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restorations over 24 months. This trial revealed a 96.7 and 76.1% success rate for retention criteria in class I and II restorations, respectively. Class I restorations were statistically more successful. Diem *et al*.[8] carried out a study using atraumatic restorative treatment in the field and compared the clinical performance of Fuji IX GP Extra with and without a low-viscosity nano-filled resin coating in the restoration of the permanent molars of pediatric patients. After 3 years, moderate marginal staining was noted along with the marginal adaptation losses (7%) for all restorations. These authors concluded that the performance of the Equia system was clinically acceptable.

In an effort to decrease the time required to perform a conventional restorative procedure, a new concept in composite resins (CRs) has been developed in the form of BCs.[9] BCs are classified as new generation nano-hybrid resin composites produced by chemical changes to the monomer structure of CRs.[10,11] The polymerization reaction of BCs offer better control and enable restoration in thick layers (up to 4 mm) without degradation of their mechanical properties or conversion degree.[10,12] The material can be polymerized to a maximum depth of 4 mm due to the action of photoactive groups added to the methacrylate resin structure. Generally, the particles of barium glass, mixed oxide, proacrylate, ytterbium trifluoride, and zirconium/silica are incorporated into the material, as these particles enhance the light-curing performance by reducing the material's opacity.[11,13]

To the best of our knowledge, few clinical studies have examined the use of BCs on permanent teeth, making this one of the first studies to use these materials for the restoration of primary teeth. The aim of this study was to compare the clinical success of BCs, HVGICs, and CRs when applied to pediatric patients. The null hypothesis was that under the study conditions there would be no differences in the clinical performance of these restorative materials in terms of the assessed criteria.

Materials and Methods

This prospective, single-center, and a controlled clinical trial was conducted in the university's pediatric dental clinic using a parallel-group design with a balanced randomized block design. The approval for this study was obtained from the research ethics committee of the university, (2015/05). All the subjects participated voluntarily, and the procedure, possible discomfort, and benefits were explained to the parents, with their informed consent being obtained prior to the study.

Study design and sample size

The study used four different restorative materials, that is, one CR, two BCs, and one glass ionomer restorative system [Table 1]. G*Power version 3.0.10 software (Franz Faul Universitat, Kiel, Germany) was used to determine the sample size of this study. A total of 120 restorations was required to detect significant differences with a 0.35 effect size at the $\alpha = 0.05$ significance level, considering a power of 90% between the study materials. The total number of restorations in the study was increased to 160 to compensate for the number of participating patients of the study. A flow diagram summarizing the progress of the subjects through the clinical trial is presented in Figure 1.

Sample selection and randomization

The subjects were recruited from patients seeking routine dental care at the pediatric dental unit. A total of 75 healthy children aged 6–10 years attending the dental unit were examined to determine their eligibility for the study. The collection of informed consent, and pretreatment and randomization steps were performed by an experienced operator. The following inclusion criteria were used: the teeth to be restored had to be symptomless and vital, have code 4 or 5 proximal carious lesions according to the International Caries Detection and Assessment System II, and be first or second primary molars requiring restoration. At least four class II restorations were to be performed on each patient and each jaw needed to contain at least two proximal carious lesions in contact with adjacent teeth and exhibit occlusion with the antagonist's teeth. The inclusion criteria for radiography were having radiolucency in the outer half of the dentin. Patients also had to have a good likelihood of recall availability. Patients with poor oral hygiene, extensive carious lesions, known or suspected allergies to any drug or restorative material, serious health problems, or potential behavioral disorders were not included.

As a result, the study included a total of 160 proximal lesions in the primary molars of 30 patients, which were assigned to one of the four groups according to the randomized block design. For the restorative procedure, primary molars on both sides of the lower and upper jaws of the patients were selected. The patients' teeth were randomly classified into four restorative material groups (Filtek Z550™ (CR), Equia Fil (HVGIC), SonicFill™, and X-tra fil™ (BCs)) using a table of random numbers prepared in a Microsoft Excel spreadsheet. The carious teeth in each patient were subjected to this randomization, beginning from the upper right quadrant, followed by the upper left quadrant, and the lower left quadrant, and finally the lower right quadrant.

Restoration placement

Periapical radiographs (size 2 phosphor plate, Digora® Optime, Soredex, Helsinki, Finland) were taken to evaluate the carious lesions levels in the teeth prior to the treatment. Restorative materials were applied according to the manufacturer's directions by a single operator (H.A.). Local anesthesia was applied to the patients who complained about pain or sensitivity to prevent discomfort during the restorative procedures.[14] The cavities were prepared using diamond fissure burs (Micro Diamond Technologies, Afula, Israel) at high speed with water-cooling. Handheld instruments and slow-speed tungsten carbide burs were used to remove caries. Isolation of the cavities was achieved using cotton rolls and a saliva ejector. A universal dental matrix tensioning system (Supermat, Kerr, Switzerland) and interdental wedge were used for the treatment.

Composite resin restorations

The Clearfil SE Bond (Kuraray, Tokyo Japan) bonding system was used for restorations using materials containing CRs. After applying primer and performing the bonding procedure for each composite system, Filtek Z550 was applied incrementally (in 2 mm layers) and then light-cured ValoLED curing light (Ultradent, South Jordan, UT, USA) for 20 s. Sonicfill and X-tra fil were placed in the gingival step with 4-mm mass-interfacial cavities and were condensed with a round-tipped cement spatula. The Sonicfill was light-cured for 20 s and the X-tra fil for 10 s in line with the manufacturers' instructions. Finally, the restoration was shaped with composite finishing burs and aluminum oxide discs (OptiDisc, Kerr, Switzerland).

Glass ionomer restorations

Before the Equia Fil was applied, the dentin and enamel of the cavities were conditioned with 20% polyacrylic acid for 20 s (Cavity Conditioner, GC Corp., Japan), washed, and briefly dried. The Equia Fil was then injected into the cavity. After the manufacturer's recommended setting time of 2.5 min, the restoration was finished using polishing diamond burs with an air/water coolant. After the restoration had been briefly dried, Equia Coat (cavity varnish, GC Corp, Japan) was applied and light-cured for 20 s.

Evaluation intervals and criteria

All the restorations were evaluated at 3 months, 6 months, and 1-year post-restoration by the authors (two experienced investigators), who were unaware of the restoratives used for any of the cavities. Before starting the evaluations, two experienced investigators were trained for both intra-examiner and inter-examiner reliability. For this purpose, they observed 10 photographs that were representative of each score for each criterion. A modification of the United States Public Health Service (USPHS) criteria by Cvar and Ryge was used to evaluate the following parameters: retention, color matching, marginal discoloration, secondary caries, anatomical form, marginal adaptation, and postoperative sensitivity.[15] Restorations were scored as "Alpha" (ideal clinical outcome), "Bravo" (clinically acceptable), or "Charlie" (clinically unacceptable). Restorations were scored for radiographic evaluations as "Alpha" (no evidence of secondary caries, no detectable radiolucencies, no periradicular, or furcal radiolucency), "Charlie" (evidence of caries along the margin of the restoration, radiolucencies adjacent to the restoration, and presence of periradicular or furcal radiolucency). Intraoral color photographs (300 dpi) were taken at the baseline and control appointments to aid the evaluation, as were radiographic images of the restorations for radiographic evaluation. In the event of any disagreement during the evaluation, the final decision was made by the consensus of both investigators (inter-examiner Kappa value = 0.91).

Statistical analyses

Statistical analyses were performed using SPSS 15.0 software. Pearson's Chi-square test was used to compare the performances of the restorative materials according to the USPHS criteria over the study period. The McNemar test was used to observe temporal changes after 3, 6, and 12 months for each group. Coherence between the evaluations of the two investigators according to the USPHS criteria was determined by applying Cohen's Kappa score. The level of significance was set to $P = 0.05$ for all tests.

Results

After 1 year, 134 restorations in 26 patients were evaluated and scored according to the modified USPHS criteria. Four patients were excluded from the study because their data had not been recorded in the control study for personal reasons. A root canal treatment was performed after 3 months in one of the restorations (Filtek Z550) because of swelling; this restoration was excluded from the study. The distribution of the number of tooth types according to the randomized groups is listed in Figure 2.

The results of the evaluations are shown in Table 2. After 1 year, there were no significant differences between the restoration groups in terms of color matching, secondary caries, anatomical form, or postoperative sensitivity. In the radiographic evaluations, 100% success rates were found for all experimental groups at 3-, 6- and 12-month follow-up period. Pathological root resorption, periradicular or furcal radiolucency, and radiolucencies

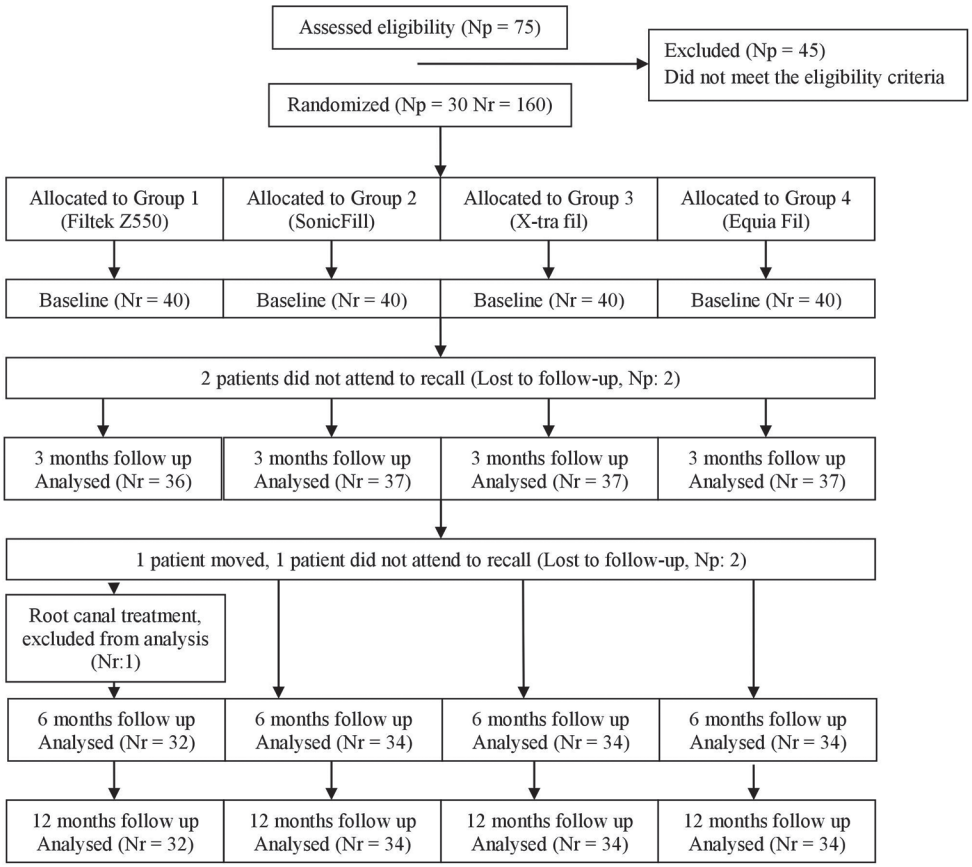

Figure 1: Flow diagram. Np: Number of patients, Nr: Number of restorations

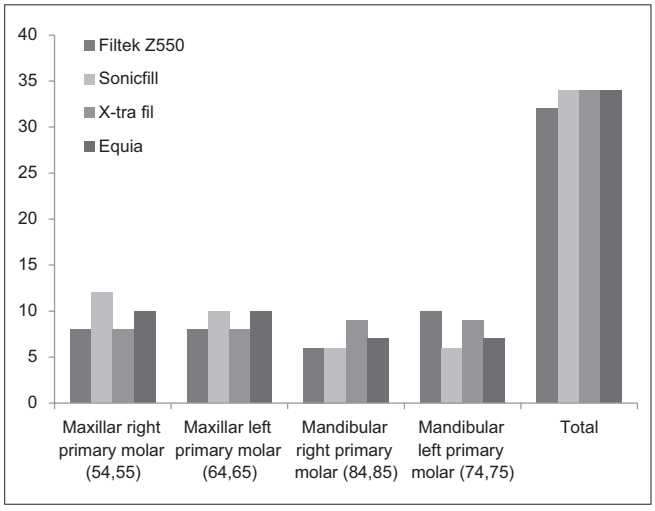

Figure 2: Distribution of materials according to dental arches

adjacent to the restoration (secondary caries) did not detect in study groups. Although different scores were recorded, there were no statistically significant differences between the restoration groups in terms of marginal discoloration at 3, 6, and 12 months ($P > 0.05$, Table 3). After 1 year, two Filtek Z550 restorations (6.25%), two Sonicfill restorations (5.88%), two X-tra fil restorations (5.88%), and four Equia restorations (11.76%) received Bravo scores. Charlie's scores were not recorded for any of the groups.

An Alpha score was recorded for all restorations in marginal adaptation at 3 months ($P > 0.05$). Equia, however, exhibited poorer marginal adaptation at 6 and 12 months ($P < 0.05$, Table 3). Three Equia restorations were assigned Bravo scores (8.82%) after 6 months. At 12 months, three more Equia restorations received Bravo scores (17.65%). There were no statistically significant differences between the composite restorations ($P > 0.05$), and one restoration from each composite group was given a Bravo score (3.125% for Filtek Z550 and, 2.94% for Sonic fill and X-tra fil) after 1 year.

The success rates of each composite group after 1 year in retention were 100% with all of them receiving Alpha scores, whereas a failure rate of 17.65% was observed for the Equia restorations. Three Equia restorations received Bravo scores at the 3-month point, three more at the 6-month point, and one more at the 12-month point and one received a Charlie score at the 1-year point. Equia thus exhibited statistically significant differences between the 6-month and 1-year points, relative to the other restorative materials ($P < 0.05$, Table 3). No

Table 1: Characteristics of restorative materials and adhesive systems used in the study

Material	Type	Manufacturer	Composition	
Filtek Z550	Nano-hybrid	3M ESPE, USA	Bis-GMA, Bis-EMA, UDMA, TEGDMA, PEGDMA	
SonicFill	Hybrid	Kerr Corporation, USA	Bis-GMA, TEGDMA, Bis-EMA, SIMA	
X-tra fil	Hybrid	Voco, Germany	Bis-GMA, UDMA, TEGDMA	
Equia Fil	High-viscosity glass ionomer cement	GC Corporation, Japan	Powder: 95% strontium fluoroaluminosilicate glass, 5% polyacrylic acid	Liquid: 40% aqueous, polyacrylic acid
Clearfil SE Bond	Self-etching bonding agents	Kuraray, Japan	Primer: HEMA 10-30%, MDP, camphorquinone, water, hydrophobic aliphatic dimethacrylate	Bond: Bis-GMA 25-45%, HEMA 20-40%, MDP, colloidal silica, camphorquinone, initiator, aliphaticdimethacrylate

Table 2: Clinical evaluation scores of the all restorative materials at 3, 6, and 12 months

USPHS Criteria	3 months			6 months			12 months		
	Alpha	Bravo	Charlie	Alpha	Bravo	Charlie	Alpha	Bravo	Charlie
Retention									
Equia	33 (97.06%)	1 (2.94%)	0 (0%)	30*(88.24%)	4 (11.76%)	0 (0%)	28*(82.35%)	5 (14.71%)	1 (2.94%)
Filtek Z550	32 (100%)	0 (0%)	0 (0%)	32 (100%)	0 (0%)	0 (0%)	32 (100%)	0 (0%)	0 (0%)
Sonicfill	34 (100%)	0 (0%)	0 (0%)	34 (100%)	0 (0%)	0 (0%)	34 (100%)	0 (0%)	0 (0%)
X-tra fil	34 (100%)	0 (0%)	0 (0%)	34 (100%)	0 (0%)	0 (0%)	34 (100%)	0 (0%)	0 (0%)
Marginal adaptation									
Equia	34 (100%)	0 (0%)	0 (0%)	31*(91.18%)	3 (8.82%)	0 (0%)	28*(82.35%)	6 (17.65%)	0 (0%)
Filtek Z550	32 (100%)	0 (0%)	0 (0%)	32 (100%)	0 (0%)	0 (0%)	31 (96.87%)	1 (3.12%)	0 (0%)
Sonicfill	34 (100%)	0 (0%)	0 (0%)	34 (100%)	0 (0%)	0 (0%)	33 (97.06%)	1 (2,94%)	0 (0%)
X-tra fil	34 (100%)	0 (0%)	0 (0%)	34 (100%)	0 (0%)	0 (0%)	33 (97.06%)	1 (2,94%)	0 (0%)
Marginal discoloration									
Equia	34 (100%)	0 (0%)	0 (0%)	32 (94.12%)	2 (5.88%)	0 (0%)	30 (88.24%)	4 (11.76%)	0 (0%)
Filtek Z550	32 (100%)	0 (0%)	0 (0%)	31 (96.87%)	1 (3.12%)	0 (0%)	30 (93.75%)	2 (6.75%)	0 (0%)
Sonicfill	34 (100%)	0 (0%)	0 (0%)	33 (97.06%)	1 (2.94%)	0 (0%)	32 (94.12%)	2 (5.88%)	0 (0%)
X-tra fil	34 (100%)	0 (0%)	0 (0%)	33 (97.06%)	1 (2.94%)	0 (0%)	32 (94.12%)	2 (5.88%)	0 (0%)
Color match									
Equia	34 (100%)	0 (0%)	0 (0%)	34 (100%)	0 (0%)	0 (0%)	34 (100%)	0 (0%)	0 (0%)
Filtek Z550	32 (100%)	0 (0%)	0 (0%)	32 (100%)	0 (0%)	0 (0%)	32 (100%)	0 (0%)	0 (0%)
Sonicfill	34 (100%)	0 (0%)	0 (0%)	34 (100%)	0 (0%)	0 (0%)	34 (100%)	0 (0%)	0 (0%)
X-tra fil	34 (100%)	0 (0%)	0 (0%)	34 (100%)	0 (0%)	0 (0%)	34 (100%)	0 (0%)	0 (0%)
Anatomical form									
Equia	34 (100%)	0 (0%)	0 (0%)	34 (100%)	0 (0%)	0 (0%)	34 (100%)	0 (0%)	0 (0%)
Filtek Z550	32 (100%)	0 (0%)	0 (0%)	32 (100%)	0 (0%)	0 (0%)	32 (100%)	0 (0%)	0 (0%)
Sonicfill	34 (100%)	0 (0%)	0 (0%)	34 (100%)	0 (0%)	0 (0%)	34 (100%)	0 (0%)	0 (0%)
X-tra fil	34 (100%)	0 (0%)	0 (0%)	34 (100%)	0 (0%)	0 (0%)	34 (100%)	0 (0%)	0 (0%)
Secondary caries									
Equia	34 (100%)	0 (0%)	-	34 (100%)	0 (0%)	-	34 (100%)	0 (0%)	-
Filtek Z550	32 (100%)	0 (0%)	-	32 (100%)	0 (0%)	-	32 (100%)	0 (0%)	-
Sonicfill	34 (100%)	0 (0%)	-	34 (100%)	0 (0%)	-	34 (100%)	0 (0%)	-
X-tra fil	34 (100%)	0 (0%)	-	34 (100%)	0 (0%)	-	34 (100%)	0 (0%)	-
Postoperative sensitivity									
Equia	34 (100%)	0 (0%)	-	34 (100%)	0 (0%)	-	34 (100%)	0 (0%)	-
Filtek Z550	32 (100%)	0 (0%)	-	32 (100%)	0 (0%)	-	32 (100%)	0 (0%)	-
Sonicfill	34 (100%)	0 (0%)	-	34 (100%)	0 (0%)	-	34 (100%)	0 (0%)	-
X-tra fil	34 (100%)	0 (0%)	-	34 (100%)	0 (0%)	-	34 (100%)	0 (0%)	-

USPHS, US Public Health Service. Descriptions: Alpha; ideal clinical outcome. Bravo; clinically acceptable. Charlie; clinically unacceptable. *Indicates a significant difference in comparison to the performance of restorative materials according to Pearson's Chi-square-test ($P<0.05$)

significant differences occurred between the restoration groups in terms of retention after 3 months ($P > 0.05$).

The results of the intragroup comparisons between the baseline and each evaluation period were as follows:

Table 3: Results of Pearson's Chi-square-test

Criteria assessed	Material	*P* for evaluation period		
		3 months	6 months	12 months
Marginal discoloration	Equia	1.00	0.899	0.747
	Filtek Z550	1.00	0.899	0.747
	Sonicfill	1.00	0.899	0.747
	X-tra fil	1.00	0.899	0.747
Marginal adaptation	Equia	1.00	0.029[a]	0.034[a]
	Filtek Z550	1.00	0.029[b]	0.034[b]
	Sonicfill	1.00	0.029[b]	0.034[b]
	X-tra fil	1.00	0.029[b]	0.034[b]
Retention	Equia	0.397	0.007[a]	0.005[a]
	Filtek Z550	0.397	0.007[b]	0.005[b]
	Sonicfill	0.397	0.007[b]	0.005[b]
	X-tra fil	0.397	0.007[b]	0.005[b]

Different letters show significant levels between the restorative materials at $P<0.05$

for each group, statistically significant differences were observed in marginal discoloration at the 6- and 12-month points ($P < 0.05$). Regarding marginal adaptation, a significant difference was observed between the 6- and 12-month results for Equia ($P < 0.05$). When the retention-related data for the Equia material were evaluated over time, the difference between the results at the 3-, 6-, and 12-month points were statistically significant ($P < 0.05$).

Discussion

The clinical efficacy of the tested restorative materials was determined by performing clinical and radiographic evaluations at 3, 6, and 12 months according to the modified-USPHS criteria. The results showed that Equia exhibited somewhat lower scores in the marginal adaptation and retention criteria relative to the BCs and CR after 1 year. Therefore, the null hypothesis was rejected.

In pediatric dentistry, especially, completing dental treatment over a short time is crucial. The CRs require a technique-sensitive and time-consuming clinical procedure, whereas BCs and HVGICs have time-saving characteristics and can be placed in bulk, making the restorative treatment less stressful and more comfortable.[3,16] Therefore, they are excellent for application in pediatric dentistry. Our study design focused on primary molars and compared the clinical performance of widely used CR Filtek Z550 with newly developed restorative materials Equia, Sonicfill, and X-tra fil, which are less technique-sensitive. The clinical performance of the examined restorative materials was evaluated via modified-USPHS criteria used in numerous in-vivo studies in children.[7,17] These criteria were easily applied to clinical practice.

Clinical trials with Equia as a permanent restorative material have thus far been conducted mostly on permanent teeth, and limited data were available on their performance with class II cavities in primary teeth.[18-20] Gürgan *et al.*[18] compared the clinical performance of Equia and a micro-filled hybrid composite (Gradia Direct Posterior) in permanent teeth, based on the modified USPHS criteria, and found that after 4 years, the success rates of class I and II composite restorations were 100%, whereas the failure rate was 7.7% for class II Equia restorations. The two restorative materials further differed significantly in marginal discoloration, anatomical form, color matching, secondary caries, postoperative sensitivity, surface texture, and retention.

Friedly *et al.*[19] evaluated the clinical performance of the Equia system when used for permanent restorations in posterior teeth over 24 months. After 2 years, nine of class II restorations were in need of repair or replacement. These authors found that large cavities exhibited more volume loss, with Equia exhibiting clinically acceptable performance with class I cavities and smaller class II cavities.

Türkün and Kanik[20] evaluated the Equia system in a 6-year randomized prospective study of permanent teeth. In their study, the Equia system received an Alpha score in 88% of the instances in terms of the retention criteria at the end of a 12-month clinical evaluation. They concluded that Equia exhibited acceptable clinical performance according to modified USPHS criteria for class I restorations and moderate to large-size class II restorations over the 6-year study.

Our results showed that the Equia system had an Alpha retention rate (82%) similar to that of previous studies that focused on permanent molars.[19,20] However, the results of our study did not fully agree with those of Gürgan *et al.*[18] These authors reported a 100% success rate for Equia fillings in class II cavities in the retention criteria at the end of a 12-month clinical evaluation. This may be because glass ionomer restoratives have different degrees of bonding to primary and permanent tooth surfaces. However, the restoration cavity size has been shown to be a determining factor in the performance of Equia, with fillings in class I cavities performing notably better than those in class II cavities.[21] These findings were consistent with those of Frankenberger *et al.*,[22] who found that coated HVGIC fillings did not perform as well in class II cavities as they did in class I cavities, with fractures being the leading reason for retention failure in class II restorations.

Our results, showed no statistical differences between the evaluated clinical parameters for BCs and CRs when

applied to class II restorations, with the BCs and CRs being equally successful in clinical applications. Similar results have been reported in previous clinical trials conducted on permanent teeth.[23-25]

The HVGICs exhibited a superior color-matching with the adjacent tooth structures due to the increased translucency of the material, the presence of small glass particles, and newly developed resin-based coating materials.[20] The perceived color matching of the CRs to the tooth structure is acceptable and may be associated with its high translucency reflecting the shade and degree of translucency.[26] Furthermore, the CRs used in the present study contained ≥70 wt.% fillers; some studies have shown that composites with a high filler content exhibit superior color matching.[27,28]

According to our radiographic evaluation results, no restoration failed because of the development of secondary caries. This could be due to the good oral hygiene of the patients.[29] Furthermore, the absence of any secondary caries in the Equia group may be a result of the acid-/base-resistant layer or release of fluoride ions from Equia.[30,31]

Marginal discoloration of the composites is usually a result of a failure in the polishing process, unsatisfactory bonding, or the development of a gap due to polymerization shrinkage between the cavity wall and the restoration.[32] In this study, mostly Alpha scores were allocated for the marginal discoloration criteria. It is widely accepted that the application of CRs to cavities in 2 mm layers reduces the incidence of marginal discoloration. Filtek Z550 was applied in 2 mm layers, which yielded results consistent with those obtained by Bayraktar *et al.*[25] The BCs used in our study were applied in 4 mm layers. The results of prior studies that addressed the depth of polymerization of these materials revealed that the Sonicfill and X-tra fil materials had a high degree of polymerization.[33,34] However, marginal discoloration was moderate, and Bravo scores were assigned to some composite restorations. This may be because phosphoric acid etching was not used.[35]

For Equia restorations, the degree of marginal discoloration was clinically acceptable (Bravo) although this was noted in only a few cases over the 1-year study period. Equia probably undergoes color changes because of the self-adhesion properties of the glass ionomers to enamel and dentin tissue, without the need for adhesive bonding systems.[20] This could, however, also be attributed to the dietary habits of the patient and the associated pigment absorption by the antagonist's teeth during mastication.[18]

The polymerization shrinkage of the composites and type of bonding agent were found to influence the marginal adaptation of the composite restorations.[36] Inadequate polymerization may lead to marginal microleakage and decreased bonding strength in CR restorations.[37] Recent studies evaluated the polymerization properties of BCs, and these materials exhibited acceptable polymerization properties with 4-mm increments.[33,34] Campos *et al.*[38] studied the in-vitro marginal adaptation of BCs in class II cavities using scanning electron microscopy. They concluded that BCs exhibited adequate marginal adaptation and similar behavior to standard composites. The current study indicated that all the studied composite materials exhibited satisfactory marginal adaptation after 12 months, and the type of adhesive system could be related to the success of the marginal adaptation criteria.[39]

Among the bulk-fill materials, Equia received an 82% Alpha score for marginal adaptation, which was consistent with the result of previous similar clinical trials conducted on permanent teeth.[18,20] However, no Charlie score was assigned to any of the Equia restorations. This may be explained by the presence of a resin coating layer that isolated the restoration from all external contamination, increased the resistance of the GIC, and improved the marginal sealing and esthetics of the restoration.[8]

Corroborating the result of previous studies, all the composite restorations in this study exhibited a similar degree of wear resistance to adjacent teeth structures and did not lose anatomical form at the end of the study period.[40,41] An investigation into the effects of surface coverage on the clinical performance of restorative materials revealed that GICs showed high microhardness and wear-resistance values when combined with Gc Coat Plus.[42] Therefore, Equia had a successful anatomical form and the use of Gc Coat Plus contributed to the clinical performance of the material.

The longevity of restoration is influenced by various factors, including the expertise and technique of the operator, properties of the dental materials, use of rubber dams, and pediatric patient-dependent factors, such as behavior, high caries risk, and age.[43] Additionally, the location and size of the restoration and occlusal factors, such as bruxing and clenching, also determine the retention of restorations.[44]

The high success rates of the restorative materials used in this study may be because the restorations were undertaken by an experienced operator. Similar clinical performances of GIC and BC restorations may result from the fact that both materials exhibit a similar degree of adhesion to the cavity walls.[1]

The limitations of this study included the inability to introduce a blind operator and patient dropouts.

Furthermore, the study was conducted only on cooperative children at a single clinic, which may have limited the variability of the sample. Therefore, the findings of this trial may not be directly applicable to noncooperative children. Given, however, that the university's pediatric dentistry clinic receives a large number of patients of various ages, nationalities, socioeconomic levels, and dental needs, the sample was deemed sufficiently diverse. Rubber-dam isolation could be preferred to avoid moisture contamination in this study, however, it is sometimes impossible to properly use the rubber dam for working on children with a limited attention span.

The acceptable clinical success rates of the tooth-colored restorations examined in this study revealed that they can be used to functionally restore primary molars with class II carious lesions and that there were no significant differences between the materials at the end of the 12-month trial. Long-term follow-up studies may be more informative for evaluating the long-term clinical success rates of the restorative materials, as a 12-month follow-up period may not be sufficiently long to provide detailed information about the clinical success rates of restorative materials.

Conclusion

Based on the results of this clinical study, the following conclusions can be made:

1. The bulk-fill and nano-hybrid CRs exhibited similar and clinically successful performance after 1-year
2. Equia exhibited minor changes at the end of the 1-year trial, but the clinical effectiveness of Equia was acceptable for class II cavities at the end of the trial.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of interest

There are no conflicts of interest.

References

1. Gaintantzopoulou MD, Gopinath VK, Zinelis S. Evaluation of cavity wall adaptation of bulk esthetic materials to restore class II cavities in primary molars. Clin Oral Investig 2017;21:1063-70.
2. Ilie N, Schöner C, Bücher K, Hickel R. An in-vitro assessment of the shear bond strength of bulk-fill resin composites to permanent and deciduous teeth. J Dent 2014;42:850-5.
3. Altan H, Göztas Z, Arslanoglu Z. Bulk-Fill restorative materials in primary tooth: An intrapulpal temperature changes study. Contemp Clin Dent 2018;9:52-7.
4. Scholtanus JD, Huysmans MC. Clinical failure of Class-II restorations of a highly viscous glass-ionomer material over a 6-year period: A retrospective study. J Dent 2007;35:156-62.
5. Dowling AD, Fleming GJ. Are encapsulated anterior glass-ionomer restoratives better than their hand-mixed equivalents?. J Dent 2009;37:133-40.
6. Bonifacio CC, Werner A, Kleverlaan CJ. Coating glass-ionomer cements with a nanofilled resin. Acta Odontol Scand 2012;70:471-7.
7. Ersin NK, Candan Ü, Aykut A, Önçağ Ö, Eronat C, Köse T. A clinical evaluation of resin-based composite and glass ionomer cement restorations placed in primary teeth using the ART approach. J Am Dent Assoc 2006;137:1529-36.
8. Diem VTK, Tyas MJ, Hien CN, Phuong LH, Khanh ND. The effect of a nano-filled resin coating on the 3- year clinical performance of a conventional high-viscosity glass-ionomer cement. Clin Oral Investig 2014;18:753-9.
9. van Dijken JW, Pallesen U. Randomized 3-year clinical evaluation of class I and II posterior resin restorations placed with a bulk-fill resin composite and a one-step self-etching adhesive. J Adhes Dent 2015;17:81-8.
10. Ilie N, Kessler A, Durner J. Influence of various irradiation processes on the mechanical properties and polymerisation kinetics of bulk-fill resin based composites. J Dent 2013;41:695-702.
11. Hirata R, Kabbach W, de Andrade OS, Bonfante EA, Giannini M, Coelho PG. Bulk fill composites: An anatomic sculpting technique. J Esthet Restor Dent 2015;27:335-43.
12. Czasch P, Ilie N. *In vitro* comparison of mechanical properties and degree of cure of bulk fill composites. Clin Oral Investig 2013;17:227-35.
13. Zorzin J, Maier E, Harre S, Fey T, Belli R, Lohbauer U, *et al.* Bulk-fill resin composites: Polymerization properties and extended light curing. Dent Mater 2015;31:293-301.
14. Mahmoud SH, El-Embaby AE, AbdAllah AM. Clinical performance of ormocer, nanofilled, and nanoceramic resin composites in Class I and Class II restorations: A three-year evaluation. Oper Dent 2014;39:32-42.
15. Cvar J, Ryge G. Reprint of criteria for the clinical evaluation of dental restorative materials. Clin Oral Investig 2005;9:215-32.
16. El-Safty S, Silikas N, Watts DC. Creep deformation of restorative resin-composites intended for bulk-fill placement. Dent Mater 2012;28:928-35.
17. Casagrande L, Dalpian DM, Ardenghi TM, Zanatta FB, Balbinot CE, García-Godoy F, *et al.* Randomized clinical trial of adhesive restorations in primary molars. 18-month results. Am J Dent 2013;26:351-5.
18. Gürgan S, Kutuk ZB, Ergin E, Oztas SS, Cakir FY. Four-year randomized clinical trial to evaluate the clinical performance of a glass ionomer restorative system. Oper Dent 2015;40:134-43.
19. Friedl K, Hiller KA, Friedl KH. Clinical performance of a new glass ionomer based restoration system: A retrospective cohort

study. Dent Mater 2011;27:1031-7.
20. Türkün LS, Kanık ÖA. Prospective six-year clinical study evaluating reinforced glass ionomer cements with resin coating on posterior teeth: Quo vadis?. Oper Dent 2016;41:587-98.
21. Klinke T, Daboul A, Turek A, Frankenberger R, Hickel R, Biffar R. Clinical performance during 48 months of two current glass ionomer restorative systems with coatings: A randomized clinical trial in the field. Trials 2016;17:239.
22. Frankenberger R, Garcia-Godoy F, Kramer N. Clinical performance of viscous glass ionomer cement in posterior cavities over two years. Int J Dent 2009;2009:781462. doi: 10.1155/2009/781462.
23. Akalın TT, Bozkurt FO, Kusdemir M, Özsoy A, Özcan, M. Clinical evaluation of sonic-activated high viscosity bulk-fill nanohybrid resin composite restorations in class II cavities: A prospective clinical study up to 2 years. Eur J Prosthodont Restor Dent 2018;26:152-60.
24. Atabek D, Aktaş N, Sakaryali D, Bani M. Two-year clinical performance of sonic-resin placement system in posterior restorations. Quintessence Int 2017;48:743-51.
25. Bayraktar Y, Ercan E, Hamidi MM, Çolak H. One-year clinical evaluation of different types of bulk-fill composites. J Investig Clin Dent 2017;8. doi: 10.1111/jicd. 12210.
26. Abdelraouf RM, Habib NA. Color-matching and blending-effect of universal shade bulk-fill-resin-composite in resin-composite-models and natural teeth. Biomed Res Int 2016;2016:4183432.
27. Nasim I, Neelakantan P, Sujeer R, Subbarao CV. Color stability of microfilled, microhybrid and nanocomposite resins:-an *in vitro* study. J Dent 2010;38(Suppl 2):e137-42.
28. Arregui M, Giner L, Ferrari M, Valles M, Mercade M. Six-month color change and water sorption of 9 new-generation flowable composites in 6 staining solutions. Braz Oral Res 2016;30:e123.
29. Yengopal V, Harneker SY, Patel N, Siegfried N. Dental fillings for the treatment of caries in the primary dentition. Cochrane Database Syst Rev 2009;CD004483. doi: 10.1002/14651858. CD004483.pub2.
30. Pereira PN, Inokoshi S, Yamada T, Tagami J. Microhardness of *in vitro* caries inhibition zone adjacent to conventional and resin-modified glass ionomer cements. Dent Mater 1998;14:179-85.
31. Thanjal NK, Billington RW, Shahid S, Luo J, Hill RG, Pearson GJ. Kinetics of fluoride ion release from dental restorative glass ionomer cements: The influence of ultrasound, radiant heat and glass composition. J Mater Sci Mater Med 2010;21:589-95.
32. Yip KH, Poon BK, Chu FC, Poon EC, Kong FY, Smales RJ. Clinical evaluation of packable and conventional hybrid resin-based composites for posterior restorations in permanent teeth: Results at 12 months. J Am Dent Assoc 2003;134:1581-9.
33. Tauböck TT, Jäger F, Attin T. Polymerization shrinkage and shrinkage force kinetics of high-and low-viscosity dimethacrylate-and ormocer-based bulk-fill resin composites. Odontology 2018; 1-8.
34. Campodonico CE, Tantbirojn D, Olin PS, Versluis A. Cuspal deflection and depth of cure in resin-based composite restorations filled by using bulk, incremental and transtooth-illumination techniques. J Am Dent Assoc 2011;142:1176-82.
35. Çelik Ç, Arhun N, Yamanel K. Clinical evaluation of resin-based composites in posterior restorations: A 3-year study. Med Princ Pract 2014;23:453-59.
36. Ferracane JL. Developing a more complete understanding of stresses produced in dental composites during polymerization. Dent Mater 2005;21:36-42.
37. Kusgoz A, Ülker M, Yesilyurt C, Yoldas OH, Ozil M, Tanriver M. Silorane-based composite: Depth of cure, surface hardness, degree of conversion, and cervical microleakage in Class II cavities. J Esthet Restor Dent 2011;23:324-35.
38. Campos EA, Ardu S, Lefever D, Jassé FF, Bortolotto T, Krejci I. Marginal adaptation of class II cavities restored with bulk-fill composites. J Dent 2014;42:575-81.
39. Casselli DS, Faria-e-Silva AL, Casselli H, Martins LR. Effect of curing unit and adhesive system on marginal adaptation of composite restorations. Gen Dent 2012;60:e408-12.
40. Gonulol N, Ozer S, Tunc ES. Effect of a third-generation LED LCU on microhardness of tooth-colored restorative materials. Int J Paediatr Dent 2016;26:376-82.
41. Dionysopoulos D, Tolidis K, Gerasimou P. The effect of composition, temperature and post-irradiation curing of bulk fill resin composites on polymerization efficiency. Mat Res 2016;19:466-73.
42. Lohbauer U, Krämer N, Siedschlag G, Schubert EW, Lauerer B, Müller FA, *et al.* Strength and wear resistance of a dental glass-ionomer cement with a novel nanofilled resin coating. Am J Dent 2011;24:124-8.
43. Chisini LA, Collares K, Cademartori MG, de Oliveira LJ, Conde MC, Demarco FF, *et al.* Restorations in primary teeth: A systematic review on survival and reasons for failures. Int J Paediatr Dent 2018;28:123-39.
44. Demarco FF, Correa MB, Cenci MS, Moraes RR, Opdam NJ. Longevity of posterior composite restorations: Not only a matter of materials. Dent Mater 2012;28:87-101.