Journal of Dentistry 51 (2016) 29–35

Contents lists available at ScienceDirect

Journal of Dentistry

journal homepage: www.intl.elsevierhealth.com/journals/jden

Posterior bulk-filled resin composite restorations: A 5-year randomized controlled clinical study

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ARTICLE INFO

Article history:
Received 18 April 2016
Received in revised form 17 May 2016
Accepted 25 May 2016

Keywords:
Bulk fill
Dental restorations
Clinical
Resin composite
Nano
Posterior
Self etch adhesive

ABSTRACT

Objective: To evaluate in a randomized controlled study the 5-year clinical durability of a flowable resin composite bulk-fill technique in Class I and Class II restorations.
Material and methods: 38 pairs Class I and 62 pairs Class II restorations were placed in 44 male and 42 female (mean age 52.4 years). Each patient received at least two, as similar as possible, extended Class I or Class II restorations. In all cavities, a 1-step self-etch adhesive (Xeno V+) was applied. Randomized, one of the cavities of each pair received the flowable bulk-filled resin composite (SDR), in increments up to 4 mm as needed to fill the cavity 2 mm short of the occlusal cavosurface. The occlusal part was completed with the nano-hybrid resin composite (Ceram X mono+). In the other cavity, the resin composite-only (Ceram X mono+) was placed in 2 mm increments. The restorations were evaluated using slightly modified USPHS criteria at baseline and then yearly during 5 years. Caries risk and bruxing habits of the participants were estimated.
Results: No post-operative sensitivity was reported. At 5-year 183, 68 Class I and 115 Class II, restorations were evaluated. Ten restorations failed (5.5%), all Class II, 4 SDR-CeramX mono+ and 6 CeramX mono +-only restorations. The main reasons for failure were tooth fracture (6) and secondary caries (4). The annual failure rate (AFR) for all restorations (Class I and II) was for the bulk-filled-1.1% and for the resin composite-only restorations 1.3% ($p = 0.12$). For the Class II restorations, the AFR was 1.4% and 2.1%, respectively.
Conclusion: The stress decreasing flowable bulk-fill resin composite technique showed good durability during the 5-year follow-up.
Clinical significance: The use of a 4 mm incremental technique with the flowable bulk-fill resin composite showed during the 5-year follow up slightly better, but not statistical significant, durability compared to the conventional 2 mm layering technique in posterior resin composite restorations.

1. Introduction

In many countries, resin composites have been used increasingly in posterior teeth after the ban of amalgam in these countries. Developments during the years in chemical composition, filler reinforcement and adhesive techniques have resulted in many new or modified categories of materials. It has been stated that the polymerization of the resin matrix may challenge the stability of the restoration. Depending on the concentration, the type and the flexibility of the reacting groups, polymerization shrinkage is manifested as different degrees of shrinkage stress when monomer molecules are converted into a polymer network. The shrinkage stress may result in marginal deficiencies, enamel fractures, cuspal movements and cracked cusps, which in their turn may give microleakage, post-operative sensitivity and secondary caries [1]. Different restorative techniques and resin composites have been used during the years to minimize the shrinkage stress [2]. The clinical evidence that these can improve clinical effectiveness is, however, weak [3,4]. Aside from the material properties, influence of the operator and patient factors play an important role determining the clinical durability of the resin-based restorations. Traditionally, resin composites have been placed in increments of 2 mm by an horizontal or oblique incremental layering technique, to ensure optimal light penetration and conversion. A recent development in resin composite technology is the introduction of a group of products introduced as the so-called "bulk-fill resin composites" [5]. This group of

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http://dx.doi.org/10.1016/j.jdent.2016.05.008
0300-5712/

materials include both low– and high viscosity materials, which have in common that they can be cured in up to 4 mm layers. The low viscosity materials have to be covered with an occlusal layer of conventional hybrid resin composite, which is not necessary for the high viscous materials. Concern about the mechanical stability in stress-bearing restorations of bulk-fill resin composites and absence of long-term clinical studies may discourage the clinicians to use the technique. Despite numerous in vitro publications, the clinical evidence of the modified layering technique is almost totally missing. So far, only for the first marketed flowable bulk-fill resin composite (SDR; Dentsply DeTrey), 3-year results have been reported in a randomized clinical evaluation [6,7]. For none of the other products in the bulk-fill resin composite group there has been published clinical evidence.

The aim of this randomized controlled study was to further investigate, in large and deep Class I and Class II cavities, the 5-year durability of the flowable bulk fil resin composite SDR. In a intraindividual comparison the bulk-fill restoration was compared with a nano-hybrid resin composite-only restoration placed and cured with a 2 mm layering technique. The null hypothesis tested was that there would be no differences in clinical durability between restorations placed with the bulk-fill technique and those without.

2. Material and methods

During October–December 2010, all adult patients attending the Public Dental Health Service clinic at the Dental School Umeå and a private dental clinic in Copenhagen, who needed one or two pair similar Class I or Class II restorations, were asked to participate in the follow up. All patients invited, participated in the study. No participant was excluded because of high caries activity, periodontal condition or parafunctional habits in order to mirror the whole patient population. All patients were informed on the background of the study, which was approved by the ethics committee of the University of Umeå (Dnr 07–152 M) and followed recent CONSORT and FDI recommendations. Reasons for placement of the resin composite restorations were primary and secondary carious lesions, fracture of old fillings or replacement because of aesthetic or other reasons. In order to make an intra-individual comparison possible, each patient received two or four as similar sized and located restorations as possible. The majority of the cavities were deep and had extended sizes. There was no limitation in the thickness of the remaining cusps. The cavity pairs in each individual were after cavity preparation randomly distributed to be restored with either the experimental or the control restoration according to a predetermined scheme of randomization. The participants were not aware in which cavity, the experimental and control restoration were placed. In the deepest part of the experimental cavity an intermediate of the SDR flowable RC (Dentsply/DeTrey, Konstanz, Germany; Table 1) was placed in layers of 4 mm. The flowable resin composite was covered with a 2 mm occlusal layer of the nano-hybrid resin composite Ceram X mono+ (Dentsply/DeTrey; from now on called Ceram X). The control restoration was filled incrementally with 2 mm layers of Ceram X (resin composite-only restoration). All teeth were in occlusion and had at least one proximal contact with an adjacent tooth. Thirty-eight pairs Class I and 62 pairs Class II restorations were placed in 82 patients (44 men, 42 women) with a mean age of 52.4 years (20–86). The distribution of the involved experimental teeth is shown in Table 2. The sample size was calculated on the basis of previous sample size calculations performed in similar designed studies of posterior restoration evaluations. The theoretical sample size was set to 40 restorations per group to determine significant differences in outcomes at the 95% confidence level, with an alpha value = 0.05 and 80% power [6]. Significant differences between material groups in similar intraindividual comparison design evaluations have been possible to determine with this sample size [7–9]. The number of participants was increased to safeguard for possible drop outs.

2.1. Clinical procedure

The clinical procedure has been described earlier [6]. Existing restorations and/or caries were removed under constant water cooling. No bevels were prepared. The operative field was carefully isolated with cotton rolls and suction device. For all Class II cavities a thin metallic matrix was used and carefully wedging was performed with wooden wedges (Kerr/Hawe Neos, Switzerland). The cavities were cleaned by thoroughly rinsing with water. In none of the cavities $Ca(OH)_2$ or other base materials was applied. Application of the 1-step self etching adhesive XenoV+ (DeTrey Dentsply) in both cavities was performed according to the manufacturers instructions (Table 1). After 20 s gently agitating, the solvent was evaporated thoroughly during at least 5s. Curing was then performed with a well controlled high power curing unit (Smartlite PS, Dentsply/DeTrey) for at least 10s. In the SDR cavity, the flow material was dispensed directly into the cavity from the compula tip using slow steady pressure, starting dispensing at the deepest portion of the cavity, keeping the tip close to the cavity floor. The tip was gradually withdrawn as the cavity was filled. The material was available in one semi-transluscent universal shade. It was placed in bulk increments up to 4 mm as needed to fill the cavity 2 mm short of the occlusal cavosurface. After curing of the flow increment(s)(20s), the occlusal part of the restoration was completed using the Ceram X resin composite material. In the control cavity the resin composite Ceram X was applied in 2 mm layers with, if possible, an oblique layering technique. Selected resin composite instruments (Hu-Friedy Mfg. Co., Chicago, Ill, USA) were used. The pairs of restorations with each of the two restorative combinations were placed by two experienced operators (JvD, UP). After checking the occlusion/articulation and contouring with finishing diamond burs, the final polishing was performed with the Shofu polishing system (Brownie; Shofy Dental Cooperation, Kyota, Japan) and finishing strips (GC finishing strips, Tokyo, Japan).

2.2. Evaluation

At baseline (after placement of the restorations) and than yearly during the whole follow up, the restorations were assessed by the following parameters: anatomic form, marginal adaptation, marginal discoloration, surface roughness, color match and secondary caries by slightly modified USPHS criteria according to van Dijken 1986 (Table 3) [10]. The follow up registrations were performed blindly by both operators at their clinics and at regular intervals by two calibrated evaluators. During the evaluation sessions, evaluators did not know which restorative material group the scoring concerned. The participants were asked at the next visit and all recalls if they had experienced symptoms in the region of the experimental teeth The caries risk for each participant and their parafunctional habits activity at baseline and during the follow ups was estimated by the treating clinician by means of clinical and socio-demographic information routinely available at the annual clinical examinations, e.g. incipient caries lesions, former caries history, frequency, dietary habits, oral hygien, medications, salivary properties and symptoms related to bruxing activity [11,12].

Table 1
Resin composites and adhesive system used.

Material	Composition	Type	Application steps	Manufacturer
SDR	Filler: Barium-alumino-fluoro-borosilicate glass, strontium alumino-fluoro-silicate glass. Filler content: w:68%, v:45% Matrix: modified urethane dimethacrylate resin, ethoxylated bisphenol-A dimethacrylate (EBPADMA), triethyleneglycol dimethacrylate, camphorquinone, butylated hydroxyl toluene, uv stabilizer, titanium oxide,iron oxide pigments. The SDR flow base is covered with at least 2 mm RC.		4 mm layers, light cured 20 s	Dentsply DeTrey, Konstanz, Germany
Ceram X mono +	Filler: Barium-aluminium-borosilicate glass (1.1–1.5 μm), methacrylate functionalized silicone dioxide nano filler (10 nm). Filler content w:76%, v:57% Matrix: Methacrylate modified polysiloxane, dimethacrylate resin, ethyl-4-(dimethylamino)benzoate, fluorescent pigment, UV stabilizer, stabilizer, camphorquinone, titanium oxide pigments, aluminium silicate pigments	nanohybrid 76% w/w filler 57% v/v filler average size nanofillers 10 nm and nano particles 2.3 nm	2 mm layers, light cured 20–30 s	Dentsply DeTrey,
Xeno V+		1-component one-step self-etching adhesive	apply primer 20 s, careful air drying for >5 s, light cured 10s.	Dentsply DeTrey

Table 2
Distribution of the experimental restorations.

Surfaces	Mandibula		Maxilla		
	Premolars	Molars	Premolars	Molars	
Class I	2	25	13	36	76
Class II	33	40	19	32	124
	35	65	32	68	200

Table 3
Modified USPHS criteria for direct clinical evaluation (modified after van Dijken 1986).

Category	Score (acceptable/unacceptable)		Criteria
Anatomical form	0		The restoration is contiguous with tooth anatomy
	1		Slightly under- or over-contoured restoration; marginal ridges slightly undercontoured; contact slightly open (may be self-correcting); occlusal height reduced locally
		2	Restoration is undercontoured, dentin or base exposed; contact is faulty, not self-correcting; occlusal height reduced; occlusion affected
		3	Restoration is missing partially or totally; fracture of tooth structure; shows traumatic occlusion; restoration causes pain in tooth or adjacent tissue
Marginal adaptation	0		Restoration is contiguous with existing anatomic form, explorer does not catch
	1		Explorer catches, no crevice is visible into which explorer will penetrate
	2		Crevice at margin, enamel exposed
		3	Obvious crevice at margin, dentin or base exposed
		4	restoration mobile, fractured or missing
Color match	0		Very good color match
	1		Good color match
	2		Slight mismatch in color, shade or translucency
		3	Obvious mismatch, outside the normal range
		4	Gross mismatch
Marginal discoloration	0		No discoloration evident
	1		Slight staining, can be polished away
	2		Obvious staining can not be polished away
		3	Gross staining
Surface roughness	0		Smooth surface
	1		Slightly rough or pitted
	2		Rough, cannot be refinished
		3	Surface deeply pitted, irregular grooves
Caries	0		No evidence of caries contiguous with the margin of the restoration
		1	Caries is evident contiguous with the margin of the restoration

Statistical analysis

The characteristics of the restorations are described by descriptive statistics using cumulative frequency distributions of the scores. The experimental and control restorative techniques were compared intra-individually with the non parametric Friedman's two-way analysis of variance test [13].

3. Results

No postoperative symptoms were reported at baseline or at the other recalls. At five year 183 restorations, 68 Class I and 115 Class II were evaluated. Fourteen restorations eight Class II (4P,4M; 4SDR/RC and 4RC-only) and six Class I (2P,4 M; 3SDR/RC and 3 RC-only) could not be observed due to moving of two –, death of four – and disease of one participant(s). Two Class I restorations (1 SDR/RC and 1 RC-only) were replaced because of primary caries in one of the proximal surfaces of the restoration teeth, and one Class II (RC-only) restoration tooth became included in a large bridge therapy, all during the last 6 months period before the 5th year recall. These were not considered as restoration failures. During the 5-year follow upp, 10 restorations (5.5%), all Class II, failed, 4 SDR/RC (3P,1 M; 6.9%) and 6 RC-only (6M; 10.3%) restorations. No Class I restoration failed. Three defects were observed, 2 small chip fractures which were polished and a restoration with a porosity, which was filled out. The year of failure and reason for failure of the failed restorations are given in Table 4. The scores at baseline, 1, 3 and 5 years for all the evaluated restorations are given as relative frequencies in Table 5. The modified USPHS scores of the Class II and Class I restorations separately are given in Tables 6 and 7, respectively. For all restorations (Class I and II) the annual failure rate (AFR) was 1,1%, for all SDR/RC the AFR was 1.1% and for the RC-only AFR was 1.3%. For the Class I restorations the AFR was 0% in both groups. For the Class II restorations, the SDR/RC group showed an AFR **o**f 1.4% and the RC-only group an AFR 2.1%. The overall differences between the experimental and controll restorations for the evaluated variables in both cavity classes were not significant ($p = 0.12$). Seven of the ten failures were observed in female participants. Eighteen participants were estimated as having high caries risk and sixteen showed mild to severe parafunctional habits during the observation period. All caries lesions were observed in high caries risk participants. Six of the eight fractures (cusp and material) occurred in bruxing participants.

4. Discussion

The durability of the restorations placed with the bulk-fill technique was clinical acceptable in the 5-year follow up and the AFR was comparable with the results of earlier, similar designed randomized, resin composite evaluations [14,16]. The bulk-filled restorations group showed a 1.4% AFR and the restorations in the resin composite-only group a 2.1% AFR. No statistical difference was observed between the restorations with and without SDR and the hypothesis was therefore accepted. These AFR's can be compared with results in an earlier published 8 year follow upp study of the evaluated resin composite [20]. In that study, Ceram X Class II restorations placed with a one step self-etch adhesive, the predecessor of Xeno V, were compared with restorations bonded with a two-step etch-and-rinse adhesive, in a similar intraindividual comparison design as the present study. The AFR's at 5 yrs were 1.8% and 1.2%, respectivally for the two adhesive groups. The results showed clear clinical evidence that the use of thicker resin composite increments with the flowable composite resulted in acceptable durability, A technique, which can save curing time but may also have advantages in several clinical situations like deep cavities and other localisations difficult to reach with the curing unit. The good durability in the present 5-year follow up situated the SDR flowable bulk fill technique between the lower AFR frequency materials. All failures in the present study were observed in Class II restorations. The low failure frequency of Class I restorations have been reported earlier [17]. Earlier clinical resin composite studies comprised much larger numbers of Class I restorations than recently published studies as shown in a current review [15]. The value of inclusion of Class I restorations in posterior resin composite trials should therefore be questioned. The variability in physico-mechanical properties within currently available resin composites claiming to belong to the "bulk-fill" group is large. Therefore the conclusion from the present study can only be made for the investigated flowable bulk-fill technique and not for the whole group [18–20]. The variety within the bulk-fill group was confirmed recently in an in vitro study observing that SDR showed significantly higher mechanical properties but lower conversion than another bulk-fill flowable resin composite [21].

The flowable bulk-fill resin composite SDR is claimed to have a lower polymerization shrinkage, due to the inclusion of a high molecular weight polymerization modulator, which is chemically embedded in the center of the polymerizable backbone of the monomer. The patented modified UDMA has a higher molecular weight (849 9/mol) than conventional UDMA (470 g/mol), Bis-GMA (512 g/mol) and other monomers. Shrinkage could be reduced by decreasing the numbers of reactive sites per unit volume [22]. The polymerization stress of SDR was claimed to be reduced directly during curing resulting in a slower modulus development, allowing for stress reduction without decreasing conversion rate [2,5,23–26]. The lower shrinkage stress values have been comfirmed for the flowable bulk-fill resin composite compared to regular flowable resin composites, but also compared

Table 4
Failed restorations during the 5 year evaluation, tooth type, year and reason of failure. All were Class II restorations.

	Tooth type	Year of failure	Reason of failure
XenoV+/SDR/CeramX mono+	P P	2	Tooth fracture
	M	2	Caries and tooth fracture
	M	2	Caries
		3	Tooth fracture
XenoV+/CeramX mono+	M	1	Tooth fracture
	M	2	Caries and tooth fracture
	M	3	Tooth fracture
	M	3	Resin composite fracture
	M	4	Caries
	M	5	Resin composite fracture

Table 5
Scores for the evaluated Class I and Class II at baseline (76 and 124), 3 years (74 and 122) and 5 years (65 and 115) of the restorations XenoV+/SDR-CeramX mono+ and XenoV+/CeramX mono+ given as relative frequencies (%). C = CeramX mono+.

		0	1	2	3	4
Anatomical form	XenoV+/SDR/C baseline	95.0	5.0	0	0	
	XenoV+/C baseline	98.0	2.0	0	0	
	XenoV+/SDR/C 3 year	94.9	2.0	0	3.1	
	XenoV+/C 3 year XenoV+/SDR/C 5 year	97.0	0	1.0	2.0	
	XenoV+/C 5 year	91.2	5.5	0	3.3	
		87.8	6.7	1.1	4.4	
Marginal adaptation	XenoV+/SDR/C baseline	99.0	1.0	0	0	0
	XenoV+/C baseline	100	0	0	0	0
	XenoV+/SDR/C 3 year	87.8	9.1	0	0	3.1
	XenoV+/C 3 year XenoV+/SDR/C 5 year	92.9	4.1	1.0	0	2.0
	XenoV+/C 5 year	74.7	22.0	0	0	3.3
		86.7	6.7	2.2	0	4.4
Color match	XenoV+/SDR/C baseline	60.0	38.0	2.0	0	0
	XenoV+/C baseline	65.0	33.0	2.0	0	0
	XenoV+/SDR/C 3 year	45.3	47.3	7.4	0	0
	XenoV+/C 3 year XenoV+/SDR/C 5 year	53.7	41.1	5.2	0	0
	XenoV+/C 5 year	37.9	47.2	14.9	0	0
		39.5	51.2	8.1	1.2	0
Marginal discoloration	XenoV+/SDR/C baseline	100	0	0	0	
	XenoV+/C baseline	100	0	0	0	
	XenoV+/SDR/C 3 year	82.1	15.8	2.5	0	
	XenoV+/C 3 year	90.5	6.3	3.2	0	
	XenoV+/SDR/C 5 year	73.6	17.2	9.2	0	
	XenoV+/C 5 year	80.2	15.1	4.7	0	
Surface roughness	XenoV+/SDR/C baseline	99.0	1.0	0	0	
	XenoV+/C baseline	99.0	1.0	0	0	
	XenoV+/SDR/C 3 year	92.6	7.4	0	0	
	XenoV+/C 3 year XenoV+/SDR/C 5 year	97.9	2.1	0	0	
	XenoV+/C 5 year	89.7	9.2	1.1	0	
		93.0	7.0	0	0	
Caries	XenoV+/SDR/C baseline	100	0			
	XenoV+/C baseline	100	0			
	XenoV+/SDR/C 3 year	98.0	2.0			
	XenoV+/C 3 year	100	0			
	XenoV+/SDR/C 5 year	97.8	2.2			
	XenoV+/C 5 year	97.8	2.2			

to high viscous nano- and hybrid resin composites and even to the low shrinkage silorane-based resin composite Filtek Silorane [22,25]. This may explain why SDR improved dentin bond strength when filling high C-factor cavities in bulk compared to a hybrid resin composite and a flowable resin composite [27]. However, no difference in bond strength was observed when an incremental filling technique was used or when bonding to a low C-factor surface. In another in vitro study, SDR showed significantly higher bond strength values than did a conventional nano-filler resin composite in Class II MOD preparations with deep proximal boxes [28]. Moorthy et al. observed that bulk filling with SDR significantly reduced cuspal deflection in Class II cavities in premolars compared with a conventional resin composite, there the restorations were restored in an oblique incremental filling technique. No difference in the amount of cuspal deflection was shown with another bulk-fill material [29]. For the life expectancy of a restoration, shrinkage stress is only one of the included factors. Stress formation is a temporary situation, which can be compensated for by good marginal bond strength, stress relaxation and hygroscopic expansion. Maintaining acceptable interfacial adaptation and cure are other important aspects to ensure adequate clinical behaviour. [30]. The lower cuspal flexure of SDR compared to incrementally cured conventional resin composites was recently reported [30]. Filling in bulk or increments made no significant difference in marginal quality or cuspal flexure for SDR. The bulk-fill resin composite provided better adaptation to the cavity walls and floor compared with a control conventional resin composite [30]. Kim et al. [22] reported that bulk-fill high-viscosity resin composites showed interfacial debonding after light-curing similar to conventional resin composites. Low-viscosity bulk-fill resin composites, especially SDR, showed in contrast much better results than conventional low-viscosity resin composites, which was explained by their lower shrinkage and modulus values [22]. Fronza et al. observed that SDR demonstrated the lowest proportion of internal gaps [31]. A main concern regarding the bulk-fill technique is whether the resin composite cures enough. Bucuta and Ilie showed that the flowable bulk-fill resin composite is more transluscent for blue light than conventional resin composites. Increase of the filler size and consequently lowering the specific surface between fillers and organic matrix reduces light scattering [32]. The increased depth of cure and homogeneous cure through the entire 4-mm depth for SDR has been confirmed in several in vitro studies [21,23,30,33–35].

The main reason for failure in this study was cusp fracture independent of the placement technique. This is in contrast to other studies where caries and/or material fracture were the main reasons for failure of resin composites. Four of totally ten failures were cusp fracture-only and two other failures were cusp fracture in combination with caries. The cusp fractures were similar distributed between the groups and therefore the bulk-fill material can be excluded as reason for failure. Another reason to explain the cusp fractures could be inferior bonding properties of the adhesive system used. However in a recent 3 year clinical study of the adhesive system in Class I and Class II cavities no cusp fractures were observed [9]. The majority of the fractures were observed in participants with parafunctional habits, confirming

Table 6
Scores at baseline (n = 124), after 3 years (n = 122), and after 5 year (n = 115) for the evaluated Class II restorations of XenoV+/SDR-CeramX mono+ and XenoV+/CeramX mono+ given as relative frequencies (%). C = CeramX mono+.

		0	1	2	3	4
Anatomical form	XenoV+/SDR/C baseline	91.9	8.1	0	0	
	XenoV+/C baseline	96.8	3.2	0	0	
	XenoV+/SDR/C 3 year	91.8	3.3	0	4.9	
	XenoV+/C 3 year	95.1	0	1.6	3.3	
	XenoV+/SDR/C 5 year	87.7	7.0	0	5.3	
	XenoV+/C 5 year	82.1	8.9	1.8	7.2	
Marginal adaptation	XenoV+/SDR/C baseline	98.4	1.6	0	0	0
	XenoV+/C baseline	100	0	0	0	0
	XenoV+/SDR/C 3 year	85.2	9.9	0	0	4.9
	XenoV+/C 3 year	88.5	6.6	1.6	0	3.3
	XenoV+/SDR/C 5 year	63.1	31.6	0	0	5.3
	XenoV+/C 5 year	78.5	10.7	3.6	0	7.2
Color match	XenoV+/SDR/C baseline	59.7	37.1	3.2	0	0
	XenoV+/C baseline	62.9	35.5	1.6	0	0
	XenoV+/SDR/C 3 year	41.4	50.0	8.6	0	0
	XenoV+/C 3 year	50.0	44.8	5.2	0	0
	XenoV+/SDR/C 5 year	32.1	49.1	18.8	0	0
	XenoV+/C 5 year	30.8	59.6	9.6	0	0
Marginal discoloration	XenoV+/SDR/C baseline	100	0	0	0	
	XenoV+/C baseline	100	0	0	0	
	XenoV+/SDR/C 3 year	72.4	24.1	3.5	0	
	XenoV+/C 3 year	84.5	10.3	5.2	0	
	XenoV+/SDR/C 5 year	64.1	20.8	15.1	0	
	XenoV+/C 5 year	71.2	23.1	5.7	0	
Surface roughness	XenoV+/SDR/C baseline	98.4	1.6	0	0	
	XenoV+/C baseline	98.4	1.6	0	0	
	XenoV+/SDR/C 3 year	89.7	10.3	0	0	
	XenoV+/C 3 year	96.5	3.5	0	0	
	XenoV+/SDR/C 5 year	84.9	13.2	1.9	0	
	XenoV+/C 5 year	90.4	9.6	0	0	
Caries	XenoV+/SDR/C baseline	100	0			
	XenoV+/C baseline	100	0			
	XenoV+/SDR/C 3 year	96.7	3.3			
	XenoV+/C 3 year	100	0			
	XenoV+/SDR/C 5 year	97.8	2.2			
	XenoV+/C 5 year	97.8	2.2			

Table 7
Scores at baseline (n = 76), 3 years (n = 74) and at 5 years (n = 68) for the evaluated Class I restorations of XenoV+/SDR-CeramX mono+ and XenoV+/CeramX mono+ given as relative frequencies (%). C = CeramX mono+.

		0	1	2	3	4
Anatomical form	XenoV+/SDR/C baseline	100	0	0	0	
	XenoV+/C baseline	100	0	0	0	
	XenoV+/SDR/C 3 year	100	0	0	0	
	XenoV+/C 3 year	100	0	0	0	
	XenoV+/SDR/C 5 year	97.1	2.4	0	0	
	XenoV+/C 5 year	97.1	2.9	0	0	
Marginal adaptation	XenoV+/SDR/C baseline	100	0	0	0	0
	XenoV+/C baseline	100	0	0	0	0
	XenoV+/SDR/C 3 year	91.9	8.1	0	0	0
	XenoV+/C 3 year	100	0	0	0	0
	XenoV+/SDR/C 5 year	91.2	8.8	0	0	0
	XenoV+/C 5 year	100	0	0	0	0
Color match	XenoV+/SDR/C baseline	60.5	39.5	0	0	0
	XenoV+/C baseline	68.5	28.9	2.6	0	0
	XenoV+/SDR/C 3 year	51.4	43.2	5.4	0	0
	XenoV+/C 3 year	59.5	35.1	5.4	0	0
	XenoV+/SDR/C 5 year	47.1	44.1	8.8	0	0
	XenoV+/C 5 year	53.1	38.2	5.8	2.9	0
Marginal discoloration	XenoV+/SDR/C baseline	100	0	0	0	
	XenoV+/C baseline	100	0	0	0	
	XenoV+/SDR/C 3 year	97.3	2.7	0	0	
	XenoV+/C 3 year	100	0	0	0	
	XenoV+/SDR/C 5 year	88.4	11.6	0	0	
	XenoV+/C 5 year	94.2	2.9	2.9	0	
Surface roughness	XenoV+/SDR/C baseline	100	0	0	0	
	XenoV+/C baseline	100	0	0	0	
	XenoV+/SDR/C 3 year	97.3	2.7	0	0	
	XenoV+/C 3 year	100	0	0	0	
	XenoV+/SDR/C 5 year	97.1	2.9	0	0	
	XenoV+/C 5 year	97.1	2.9	0	0	
Caries	XenoV+/SDR/C baseline	100	0			
	XenoV+/C baseline	100	0			
	XenoV+/SDR/C 3 year	100	0			
	XenoV+/C 3 year	100	0			
	XenoV+/SDR/C 5 year	100	0			
	XenoV+/C 5 year	100	0			

earlier findings [14,15]. Cusp fractures are still a significant dental health problem in older adults who received posterior amalgam restorations. In the present study almost all included cavities were replacements of older restorations which had been placed in cavities with macro-mechanical retention. It can be concluded that during the five year evaluation acceptable clinical results were obtained with the new bulk-fill technique, similar to conventional incremental placement techniques. No failures were observed in Class I restorations. For the bulk-fill and resin composite-only Class II restorations the AFR's were 1.4% and 2.1%, respectively.

Conflict of interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

Acknowledgements

The support from the County Council of Västerbotten and DeTrey/Dentsply is gratefully acknowledged.

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