Clinical evaluation of low shrinkage resin composites in class II restorations - two years follow up

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Abstract

The **aim** of this study was to compare 24 months clinical performance of two low shrinkage resin composite materials - silorane (Filtek Silorane) composite and methacrylate nano-composite (Filtek Ultimate).

Materials and methods: The clinical study included 37 patients. Total of 56 class II restorations were made. Restorations were observed at baseline, after 6,12,24 months according to United States Public Health System modified criteria. Statistical analysis was performed by SPSS version 17 and a Criterion Pirson (χ^2) was used to compare the data.

Results: Filtek Silorane and Filtek Ultimate performed statistically similar at two years. All changes observed for marginal staining, marginal adaptation and anatomical form in both studied materials were clinically acceptable.

Conclusions: Although acceptable two years performance of Filtek Silorane, this study did not find any advantages of the silorane based composite over the methacrylate based nano-composite, combined with 3-step total-etch adhesive system.

Keywords: Filtek Silorane, clinical evaluation, class II restorations

Background

Worldwide, dental resin composites become the primary choice for direct posterior restorations [1,2,3]. Their application provides better aesthetics; less invasive preparation is possible due to the micromechanical and adhesive bonding with hard dental tissues; strengthening of the dental structures remaining after the preparation is achieved [2,4].

The application of composite fillings in the molar area is still associated with problems. Clinical data suggested that the most common reasons for the replacement of these restorations are secondary caries and fractures of the restorations [2,5].

The polymerization shrinkage of the organic matrix remains the basic problem of composite materials. The clinical consequences of this disadvantage are micro permeability, dental hypersensitivity, secondary caries, damage to the dental pulp. Cracks in the enamel may appear or deepen [2,4,5].

There are two main strategies to reduce polymerization shrinkage [6]:

1. By reducing the reactive groups per unit volume of the polymer matrix.

This can be achieved by:

a) Increasing the filler load.

b) Increasing the molecular weight of the reactive groups in the organic matrix.

2. By using a different type of organic matrix.

The introduction of nanotechnologies in the production of dental composites has contributed to increasing the filler load [7,8]. Materials have been created that include nanoparticles as well as nanoclusters. The size of the elements of the inorganic phase is on average 1–100 nm. 58–71% of the composite material volume is filled, which reduces the shrinkage during polymerization to 1,6 - 1.9% [7,8].

A great achievement in the development of the polymer matrix was the creation of the silorane composite. The polymer matrix is a revolutionary new - silorane matrix [6]. Due to the polymerization reaction - cationic, ring-opening, the polymerization shrinkage was reduced below 1% [6,7]. Silorane composite has aroused great interest in dental science circles. A number of laboratory comparative studies have been performed, proving the reduced shrinkage and showing comparable physic-mechanical properties with already established methacrylate composites [5,6,7].

Clinical application and durability are the main criteria for assessing the restorative materials.

Aim

The aim of the present study was to compare the performance of the silorane (Filtek Silorane) composite with well accepted methacrylate nano-composite (Filtek Ultimate) for 24 months in class II restorations.

Material and methods

The clinical study included 37 patients aged 18 to 57 years living in Sofia. They were all familiar with the nature of the study and have signed written informed consent, prepared in accordance with the requirements of Bulgarian Dental Association.

A total of 56 class II cavities were selected.

The criteria for selection of patients and class II lesions are listed in Table 1.

Table 1. Criteria for selection of patients and cases of class II lesions

Patients	Class II lesions
➤ Over 18 years	➤ Vital teeth
➤ No data on bruxism and bruxomania	➤ Presence of teeth adjacent to the defects
➤ Lack of periodontal disease	➤ Antagonists without ceramic restorations, located against future restorations
➤ Consent to participate in the study and attend check-ups	➤ Lesion size 1/3 to 2/3 MTP
➤ Lack of data on allergies to composite materials or their components	➤ Primary or secondary caries
➤ Good oral hygiene	

Two low-shrinkage materials were used:

1. Filtek Ultimate - nano-composite with conventional dimethacrylate matrix.
2. Filtek Silorane - an innovative composite with silorane matrix.

The distribution by types of cavities, teeth and materials is shown in Table 2.

Table. 2. Distribution of class II cavities by teeth, location and material used

Teeth

➤ Clinical procedures:

Class II cavity preparation, including removal of an old restoration in the presence of secondary caries and carious tissues removal. In a primary lesion cavity design was restricted to eliminate carious tissues. Ensuring resistance of the cavity through minimally invasive preparation; rounding of the inner corners of the cavity. The vestibular, lingual and gingival proximal margins of the cavities were not beveled.

Restoration procedures were performed after insulation of the working field with a saliva ejector and cotton rolls or placement of a rubber dam in cases of difficult isolation from oral liquids. An appropriate matrix system (Meta Fix or Palodent V3 Matrix) and a wooden wedges were applied. Two different adhesives and adhesive protocols were used for each material:

For Filtek Ultimate - three steps total etch system: OptiBond FL adhesive (Kerr)

For Filtek Silorane - two steps self-etch Silorane System Adhesive (3M ESPE).

Adhesive systems were applied according to manufacturer instructions.

Resin composites were placed in 2mm increments, each. An oblique application technique was used. Each layer was polymerized for 20 sec.

The polymerization steps were made with diode lamp Elipar Freeligth 2 (3M ESPE) - light output power 1200 mW/cm². After completion of the restoration adjustment, finishing and polishing were performed.

➤ Clinical evaluation of class II restorations

The clinical assessment of the baseline condition (one week after placement) of the restorations, as well as the assessment after 6, 12 and 24 months of their placement was made according to modified USPHS criteria (united states public health service criteria). The criteria are listed in Table 3.

Table 3. Modified USPHS criteria

Criteria	Code	Definition
1. Marginal staining	Alpha (A)	No staining along cavo-surface margin
	Bravo (B)	<50% of cavo-surface margin affected by stain (removable, localized)
	Charlie (C)	>50% of cavo-surface margin affected by stain (cannot be removed by polishing)
2. Marginal adaption	Alpha (A)	Restoration closely adapted to the tooth. No crevice visible. No explorer catch at the margins.
	Bravo (B)	Explorer catches. No visible evidence of a crevice into which the explorer could penetrate. No dentin visible.
	Charlie (C)	Explorer penetrates into a crevice that is of a depth that exposes dentin.
3. Anatomical form	Alpha (A)	Optimal - the filling is a continuation of the anatomical form of the tooth.
	Bravo (B)	Signs of material loss without exposed dentin. Clinically acceptable form
	Charlie (C)	Obvious material loss, exposed dentinal surface. Clinically unacceptable form
4. Secondary caries	Alpha (A)	Absent
	Charlie (C)	Present
5. Proximal contact	Alpha (A)	Tight interdental contact - silk floss passes with effort between the teeth.
	Bravo (B)	Weak interdental contact - silk floss passes without much effort between the teeth.
	Charlie (C)	Clinically unacceptable contact - food retention and trauma to the interdental papilla
6. Restoration loss	Alpha (A)	Restoration with preserved integrity
	Bravo (B)	Partial or localized restoration loss - clinically acceptable
	Charlie (C)	Complete loss of restoration

The comparative clinical trial was conducted over a period of 24 months. At all stages of the study 56 II class direct composite restorations were evaluated.

Results

The dynamics of changes in the restorations registered in the clinical trial according to the modified USPHS criteria are listed in Table 3.

Table 4. Changes in the restorations registered according to the modified USPHS criteria

Criteria \ Material	Period	baseline		6 months		12 months		24 months	
		F.S.	F.U.	F.S.	F.U.	F.S.	F.U.	F.S.	F.U.
		(n=25)	(n=31)	(n=25)	(n=31)	(n=25)	(n=31)	(n=25)	(n=31)
1.Marginal staining									
Alpha	25	31	24	30	24	29	22	29	
Bravo	-	-	1	1	1	2	3	2	
Charlie	-	-	-	-	-	-	-	-	
2. Marginal adaption									
Alpha	25	31	25	30	23	28	21	28	
Bravo	-	-	-	1	2	3	4	3	
Charlie	-	-	-	-	-	-	-	-	
3. Anatomical form									
Alpha	25	31	25	31	24	31	21	29	
Bravo	-	-	-	-	1	-	4	2	
Charlie	-	-	-	-	-	-	-	-	
4. Secondary caries									
Alpha	25	31	25	31	25	31	25	31	
Charlie	-	-	-	-	-	-	-	-	
5. Proximal contact									
Alpha	25	31	25	31	25	31	25	31	
Bravo	-	-	-	-	-	-	-	-	
Charlie	-	-	-	-	-	-	-	-	
6. Restoration loss									
Alpha	25	31	25	31	25	31	25	31	
Bravo	-	-	-	-	-	-	-	-	
Charlie	-	-	-	-	-	-	-	-	

For the criteria proximal contact, secondary caries and loss of restoration, no changes were registered in both materials. There were changes in the criteria for marginal staining, marginal adaptation and anatomical form in both studied resin composites. The comparative results after the statistical analysis are presented in tables 5 - 7.

Table. 5. Comparative analysis - marginal staining

material time period	Filtek Ultimate				Filtek Silorane			
	Alpha		Of total		Alpha		Of total	
	n	%	n	%	n	%	n	%
baseline	31	100	31	100	25	100	25	100
24 months	29	93.5	31	100	22	88	25	100
$\chi^2=1.263, p=0.261>0.05$								

Table. 6. Comparative analysis - marginal adaptation: F.Ultimate / F.Silorane

Marginal adaptation								
material time period	Filtek Ultimate				Filtek Silorane			
	Alpha		Of total		Alpha		Of total	
	n	%	n	%	n	%	n	%
baseline	31	100	31	100	25	100	25	100
24 months	28	90.3	31	100	21	84	25	100
$\chi^2=0.506, p=0.477>0.05$								

Table. 7. Comparative analysis - anatomical form

Anatomical form								
material time period	Filtek Ultimate				Filtek Silorane			
	Alpha		Of total		Alpha		Of total	
	n	%	n	%	n	%	n	%
baseline	31	100	31	100	25	100	25	100
24 months	29	93.5	31	100	21	84	25	100
$\chi^2=1.319, p=0.251>0.05$								

Alfa ratings decreased for marginal staining, marginal adaptation and anatomical form for both restorative materials, although this reduction did not result in statistical differences among them for the 24-month clinical follow-up period.

By all criteria, the two tested materials remained clinically acceptable for a period of 24 months.

Discussion

The clinical trial was conducted over a period of 24 months, covering the criteria for a medium-term prospective study [9]. Modified USPHS criteria used are the most commonly applied direct method for clinical evaluation of fillings and restorative materials [1,3,9,10].

The clinical criteria selected have to reflect the reduced polymerization shrinkage, micropermeability, sorption and solubility as well as biodegradation resistance achieved by the silorane matrix. For this reason, the marginal staining, the marginal adaptation, the anatomical form, the secondary caries, the proximal contact, the integrity of the filling were analyzed.

The USPHS criteria are designed to take into account absolute differences (acceptable / unacceptable) [9]. Reimbursements with alpha and bravo scores are clinically acceptable, with minimal differences between them. Charlie and delta assessments indicate clinically unacceptable performance. For the 2-years follow up period, the fillings of both materials - Filtek Ultimate and Filtek Silorane, remain as clinically acceptable in all studied criteria. For secondary caries, proximal contact and restoration integrity, the fillings retain alpha levels. For the marginal staining, the marginal adaptation and the anatomical form there are registered indicators alpha and bravo.

Our results confirm the conclusions of Opdam et al. (2014) for improved resilience of modern composite restorations with a registered failure of 1.8% over a 5-year period. The authors found that clinically successful materials did not show unacceptable results during the first years. At the same time, the fact must be taken into account that the materials in the present study were applied under controlled conditions: on vital teeth with a lesion size of 1 / 3 – 2 / 3 inter cuspal distance. Patients selected were with no data on bruxism and bruxomania, with a good oral hygiene and were relatively caries resistant. The fillings were made by specialists in conservative dentistry, fully complying with the working protocol of studied composite materials. These are factors that, according to evidence from scientific studies, ensure durability and longevity of the restorations [1,11, 12].

There were dynamics in the results for both materials, registered by the criteria marginal adaptation, marginal staining. These are criteria related to the polymerization shrinkage and stress generated by the composite material to the tooth structures [12].

F. Silorane is designed to eliminate polymerization shrinkage of composites. As already mentioned, its polymerization shrinkage is less than 1% [6,7]. According to other studies, the shrinkage of the silorane composite is 1.4% [13], which is closer to the polymerization shrinkage of F. Ultimate of 1.9%. According to the literature, F. Silorane has a high modulus of elasticity, a prerequisite for higher polymerization stress [13,14]. Laboratory data on the material are contradictory.

The benefits of F. Silorane over the conventional dimethacrylate nano-composite F. Ultimate have not been demonstrated in the present clinical study.

In the current study, F. Silorane showed 1 specimen with localized marginal staining at 6 months (4%), at 12 months the specimens increased to 3 (12%), and the result was maintained in the second year. There was no difference in statistical significance within the material group ($p > 0.05$) for the two-year follow-up

period, nor in the comparison with the F. Ultimate group ($p > 0.05$). At F. Ultimate at the end of the study, the samples with marginal staining were 2 out of 31 restorations (4%).

For the marginal adaptation - at the end of the research period for F. Silorane there are registered restorations with a grade of bravo in 16% (4 out of 25 filings). The result is borderline compared to the F. Silorane group and has no statistically significant difference with the final indicators of F. Ultimate (9.7%).

Marginal staining and changes in marginal adaptation can be a consequence of poor adhesive bond with hard dental tissues [14,15].

The adhesive system of the silorane composite is a two step self-etching. This leads to a weaker connection with the enamel structures. The primer of the material has a relatively low pH = 2.7, containing copolymers binding it to hydroxyl apatite (similar to Vitrebond). In connection with this statement, a study was conducted [16], establishing a strong surface reaction and weak inter- and intracrystalline demineralization, followed by weak polymer infiltration to the enamel. With regard to dentin, a strong, stable and stable connection is established.

In the present study Filtek Ultimate is applied with a three-step total-etch adhesive system (OptiBond FL), perceived in scientific circles as the "gold standard" in connection with hard dental tissues - both enamel and dentin [17].

According to scientific conclusions [18, 19] filings with marginal staining are prone 3.8 times more often to develop secondary caries in the next 5 years, compared with restorations without marginal staining. In the presence of a marginal defect, the probability of clinical failure increases by 5.3 times in 5 years.

There were dynamics in the anatomical form criterion. After 2 years, no statistically significant difference was found compared to baseline in the two groups ($p > 0.05$). No difference was found between the two studied materials. F. Ultimate showed some superiority (6.5%) over F. Silorane (12%) in regard to loss of material. This observation supports the views on high abrasion resistance of nano-composites [9]. Similar clinical results have been reported by other researchers [3,18,19,20]. They also concluded that the silorane composite did not significantly improve the properties of distal restorations despite the reduced polymerization shrinkage, reduced water sorption, and reduced solubility found in laboratory studies.

Conclusion

By all criteria, the two tested materials remained clinically acceptable for a period of 24 months. Although acceptable two years performance of Filtek Silorane, this study did not find any advantages of the silorane based composite over the methacrylate based nano-composite, combined with 3-step total-etch adhesive system.

References

1. Demarco FF, Corrêa MB, Cenci MS, Moraes RR, Opdam NJ. Longevity of posterior composite restorations: not only a matter of materials. Dent Mater. 2012 ;28(1):87-101.
2. Ferracane JL. Resin-based composite performance: are there some things we can't predict? Dent Mater. 2013 ;29(1):51-8.
3. Dilsad F., Ergin E., Attar N. et al. Comparison of laser- and bur-prepared class I cavities restored with two different low-shrinkage composite resins: a randomized, controlled 60-month clinical trial. Clin Oral Invest. 2020; 24: 357–368.
4. Ferracane, JL. Resin composite-State of the art. Dent Mater; 2011; 27: 29-38

5. Miletic, V. Dental Composite Materials for Direct Restorations; Springer: New York, NY, USA, 2017, VIII-305
6. Weinmann W., Thalacker C., Guggenberg R. Siloranes in dental composites. Dent Mater. 2005; 21:68-74
7. Sakaguchi R.L., J.M. Powers. Craig's Restorative Dental Materials, Philadelphia, USA, Elsevier Mosby, 13th edition, 2012, XVI-400
8. Sideridou ID, Karabela MM, Vouvoudi ECh. Physical properties of current dental nanohybrid and nanofill light-cured resin composites. Dent Mater. 2011;27(6):598-607
9. Nicheva S. Indirect adhesive restoration of endodontically treated masticatory teeth with composite fillings, dissertation for educational and scientific degree "Doctor", Plovdiv, 2014
10. Opdam NJ, van de Sande FH, Bronkhorst E, Cenci MS, Bottenberg P, Pallesen U, Gaengler P, Lindberg A, Huysmans MC, van Dijken JW. Longevity of posterior composite restorations: a systematic review and meta-analysis. J Dent Res. 2014;93(10):943-9
11. Opdam NJ, Bronkhorst EM, Roeters JM, Loomans BA. A retrospective clinical study on longevity of posterior composite and amalgam restorations. Dent Mater. 2007;23(1):2-8
12. Sarret, DC. Clinical challenges and the relevance of materials testing for posterior composite restorations. Dent Mater; 2005; 21:9-20
13. Boaro LC, Gonçalves F, Guimarães TC, Ferracane JL, Versluis A, Braga RR. Polymerization stress, shrinkage and elastic modulus of current low-shrinkage restorative composites. Dent Mater. 2010 Dec;26(12):1144-50
14. Shi L, Wang X, Zhao Q, Zhang Y, Zhang L, Ren Y, Chen Z. Evaluation of packable and conventional hybrid resin composites in Class I restorations: three-year results of a randomized, double-blind and controlled clinical trial. Oper Dent. 2010;35(1):11-9
15. Deliperi S., Bradwell D.N., Alleman D. Clinical evaluation of stress-reducing direct composite restorations in structurally compromised molars: A 2-year report. Operative Dentistry; 2012; 37(2):109-116
16. Mine A, De Munck J, Van Ende A, Cardoso MV, Kuboki T, Yoshida Y, Van Meerbeek B. TEM characterization of a silorane composite bonded to enamel/dentin. Dent Mater. 2010;26(6):524-32
17. Van Meerbeek B, De Munck J, Yoshida Y, Inoue S, Vargas M, Vijay P, Van Landuyt K, Lambrechts P, Vanherle G. Buonocore memorial lecture. Adhesion to enamel and dentin: current status and future challenges. Oper Dent. 2003;28(3):215-35
18. Attia R.M., Etman WM., Genaid.T.M. One year clinical follow up of a silorane-based versus a methacrylate-based composite resin. Tanta Dental Journal. 2014; 11:12-20
19. Baracco B, Perdigão J, Cabrera E, Ceballos L. Two-year clinical performance of a low-shrinkage composite in posterior restorations. Oper Dent. 2013 Nov-Dec;38(6):591-600
20. Vangelov L., Markova K., Miteva Ts. Application of Filtek Silorane - initial observations and prospective clinical trial for 12 months. J of IMAB. 2010; 16(4):58-62

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