Siloranes – perfectly suited for use in the posterior

Dr. Gabriel Krastl, Department of Periodontology, Endontology and Cariology, Basel University Dental Hospital
Prof. Karl-Heinz Kunzelmann, Restorative Dentistry and Periodontology, University of Munich

Apart from aesthetic and functional aspects, the main goal of a restoration is to achieve a bacteria-proof seal of the cavity to prevent an infection of the endodontic system. However, it is difficult to fulfill this requirement using methacrylate-based filling materials. The reduction of intermolecular monomer interspaces in the context of a polymerization reaction results in volumetric shrinkage of the composites and leads to the development of marginal gaps, marginal discolorations and in unfavorable cases even to secondary caries.

Different strategies are possible to avoid these problems. Polymerization shrinkage can be compensated e.g. by a high percentage of fillers in the composite, by employing certain layering techniques, and by a good adhesion to the tooth. In the past decades, improvements were mainly based on the filler technology.

While highly esthetic composites enable dentists to produce restorations in previously unmatched quality, the problem of shrinkage is still a topic of concern. On closer inspection, however, it becomes clear that groundbreaking changes on the basis of the current chemistry are unlikely – whereas the development of new low-shrink monomers might be the key to the problem. At present, there is only one product available which is based on a new matrix chemistry: Filtek™ Silorane (3M™ ESPE™). It is composed of the monomers siloxane and oxirane which combine hydrophobic properties and biocompatibility with mechanical stability and low shrinkage. The material is based on a ring-opening chemistry and cationic polymerization. This means that siloranes shrink during polymerization, but the ring-opening step in the polymerization compensates for a great extent for the shrinkage that occurs in the process [12]. Additionally, the chemistry of the filler surfaces had to be changed and a new adhesive system had to be developed for the “silorane chemistry” [6].

Indications for siloranes

At present, siloranes are suitable for posterior restorations and are indicated for class I and II cavities. The mechanical properties of Filtek Silorane are similar to those of clinically proven methacrylate-based composites [7]. Generally, direct fillings are not indicated in cases where chewing forces have to be borne exclusively by the filling material and a supportive function of the tooth is missing. As soon as the load of chewing is borne in part by the enamel as well, composites should be well suited as filling materials.

The use of rubber dam is highly advisable for silorane fillings, since a contamination with blood, saliva or sulcus fluid during the application could have negative consequences. This fact can be explained by highly hydrophobic material characteristics and therefore low moisture tolerance – the recommendation of using rubber dam, however, applies to other composites as well.

Filtek Silorane comes in four shades (A2, A3, B2, C2). These are sufficient for the posterior region particularly in the case of purely intracoronal defects even in demanding esthetic situations.

Preparation of the hard tooth structure

Cavity preparation follows the general rules of an adhesive bonding technique. The healthy tooth substance should be preserved as much as possible. Due to lower shrinkage, a thin enamel wall which hardly supports the dentine can be left. The finish of the enamel margins follows with a fine-grained diamond to bevel the preparation margin. This increases the probability of cutting the enamel prisms perpendicular to the longitudinal axis. Moreover, enamel prisms which are “loosened” during the preparation are removed. Otherwise, these might lead to cohesive cracks in the enamel after placement of the filling material. As an alternative to the diamonds, elastic polishers can also be used to remove loose enamel prisms.

Siloranes have been shown to have very good biocompatibility characteristics. Cytotoxicity, mutagenicity and allergenic potential are similar or better than for conventional composites [3], [10]. However, the dentist has to bear in mind that the adhesive system used for Filtek Silorane contains methacrylate chemistry, i.e. the Filtek Silorane System cannot be employed as an alternative to methacrylates in cases of intolerance.

The Silorane Adhesive System

Due to a highly different chemistry compared to methacrylate-based composites, an appropriate adhesive system has to be used – the Silorane System Adhesive. This two-step self-etch system does not (as might be expected) contain ring-opening monomers, but it includes conventional methacrylate-based monomers such as HEMA, TEGDMA and BisGMA. The development of a self-etch adhesive system on silorane basis is difficult from a chemical point of view because acidic components initiate the opening of the epoxide rings.

The Silorane System Adhesive Primer is in its composition comparable to conventional products. The Silorane System Adhesive Bond is providing the compatibility to the highly hydrophobic silorane matrix. The phosphate group of the acidic methacrylates in the bond interacts with the oxirane groups in the silorane and enables a chemical bond between the adhesive layer and the composite. Etching with phosphoric acid is not required according to the manufacturer (except for unprepared enamel).
Previously unpublished data, however, indicate that an additional etching step (exclusively on enamel) improves the marginal quality – it is therefore recommended by the authors.

The self-conditioning Silorane System Adhesive Primer has an oily consistency. According to manufacturers’ instructions, it is rubbed in for 15 seconds, gently dried with air and light polymerized for ten seconds. This step is essential to avoid an intermixture with the second hydrophilic component, the Silorane System Adhesive Bond. In contrast to the Silorane System Adhesive Primer, the bond has a much higher, honey-like viscosity. If the bottle is not shaken before use for a temporary reduction of the viscosity, it may be difficult to dispense it. An application with a Microbrush applicator (Microbrush international) leaves a visible layer at the cavity walls and in the area of the cavity margin. Against the background of a low abrasion resistance of the comparably low-filled bonding, a thick bonding layer should be avoided in the marginal areas. For thinning out the layer in these areas, a combination of air-drying and brushing out of the cavity turned out to be a suitable strategy. Hereby, it is almost unavoidable that the material also comes into contact with the unprepared tooth surface. This fact has to be borne in mind for the finishing step. After having light-cured the bond for ten seconds, the cavity is ready to be treated with the silorane material.

**Application and layering technique**

When using materials with significantly reduced polymerization shrinkage, the question arises if layering is still necessary. For Filtek Silorane, it clearly is. The reason is a depth of curing of maximally 2.5 mm of the material which makes layering essential in cases of deep cavities. Out of a number of different layering techniques, the oblique technique turned out to be most successful. The first layer is applied horizontally at the cavity floor, while further layers are obliquely positioned taking into account the c-factor and a maximal layer thickness of 2.5 mm per increment. The last two layers build the contour of the occlusal surface.

Class II cavities have to be treated with an adequate matrix technique which seals the defect in the cervical area and at the same time optimally simulates the approximal contour of the tooth. For most cases, contoured partial matrices work best. By now, anatomically formed matrices are available for the classical matrix retainer.

Before employing the layering technique described above, the marginal ridge can be built up to the optimal height with a thin composite layer in the first step. This layering technique transforms the class II cavity into a class I. Afterwards, the matrix can be removed to simplify the subsequent layering steps. When using the material for the first time, one will notice that its viscosity is high. Due to its thixotropic properties it can be adapted easily to the cavity floor if sufficient pressure is used. Even large areas of the occlusal surfaces and cusps can be built up without problems of slumping because of its high stability.

The modulation of the different layers is possible without pressure of time, because Filtek Silorane exhibits a low sensitivity to light. The polymerization time recommended by the manufacturer is at least 40 seconds for all halogen lamps and 20 seconds for LEDs with an intensity greater than 1000 mW/cm². The minimum intensity for both has to be 500 mW/cm².

**Finish and polishing**

Due to an adequate anatomical layering, the finishing and polishing steps can be reduced to a minimum. Particular attention should be paid to the removal of excessive silorane bond on the tooth surface. This is often difficult because the enamel surface is conditioned by the self-etching primer and the largely transparent bond is barely visible. To remove the material, the use of a sickle scaler or a scalpel (# 12) turned out to be valuable.

With a filler size between 0.1 and 2 µm (mean filler size 0.47 µm), the conditions for polishing are similar to traditional micro hybrid composites. With conventional instruments, highly satisfying polishing results can be achieved.

Finishing and polishing with discs (Sof-Lex, 3M ESPE) leads to microscopically excellent results, however, this method is not applicable for occlusal surfaces because of numerous concave or for dimensional reasons inaccessible areas. The use of siliccone polishing points (Jiffy Polishers Points medium, Ultradent) results in a smooth and silk-matte surface. The surface is polished quickly to a high gloss with polishing brushes which are doped with silicium carbide (Occloush, Kerr Hawe). The gloss retention is subject to limitations due to the filler technology. A few months later, the filling seems to be a bit duller, an effect which becomes particularly visible after air-drying. However, this is not an esthetic constraint in the posterior region. Adhesion of oral microorganisms seems to be reduced compared to conventional methacrylate-based composites with similar surface roughness. This is explained by the hydrophobic properties of the material [2].

**Radiopacity**

While it is difficult to answer the question of what is the optimal level of radiopacity, the radiopacity of Filtek Silorane is certainly moderate compared to many other materials and could be optimized. In general, dentine adhesives are not radiopaque. When the coat of dentine adhesive is slightly thicker than usual, it becomes more difficult to interpret the radiograph with respect to the differential diagnosis. Today, it is unlikely that an intact filling will be restored because of a high translucency below that filling. Moreover, modern excavation methods tend to leave dentine in the cavity which can remineralize. All these aspects have to be taken into account and currently lead to a lively discussion on radiopacity.

**Conclusion**

Abandoning the methacrylate chemistry seems a big step in the improvement of composites. Due to favorable mechanical, biological and optical properties, siloranes are perfectly suited for use in the posterior tooth area. Their most important positive potential is their unequalled low polymerization shrinkage of < 1 %. For the evaluation of siloranes, it has to be considered that their optimization has just begun while conventional composites have been subject to optimization for 50 years. While the potential to optimize methacrylate-based composites is almost exhausted, it is now the task of the silorane-developers to show and use the potential of siloranes.
The case shows the procedure of a filling treatment of a single occlusal cavity with Filtek™ Silorane.

Fig. 1 Amalgam filling with a defective margin at the distal side and suspected secondary caries.

Fig. 2 Situation after complete excavation of caries and preparation of the restoration margins with a slight bevel.

Fig. 3 Selective enamel etch with phosphoric acid for 20 sec.

Fig. 4 After rinsing-off the phosphoric acid and cautious drying of the cavity (do not overdry!), the etching pattern is just visible.

Fig. 5 Application of the primer.

Fig. 6 Situation after cautious air-drying and light-curing of the primer.

Fig. 7 Application of the bonding material.

Fig. 8 After polymerization, particularly in the area of the mesiopalatal cusp (at the cavity margin), a bonding layer becomes visible which was accidentally not thinned out sufficiently.

Fig. 9 Application of material into the cavity for the first layer on the cavity floor.

Fig. 10 Oblique layer to achieve an anatomically correct build-up of the buccal load-bearing surfaces up to the central fissure.
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Correspondency address:
OA Dr. Gabriel Krastl
Klinik für Parodontologie, Endodontologie und Kariologie
Universitätskliniken für Zahnmedizin
Hebelstr. 3
4056 Basel · SWITZERLAND
E-Mail: Gabriel.krastl@unibas.ch

Literature

Fig. 11 The second oblique layer is placed palatally in the area of the occlusal cavity and builds up the mesial part of the palatal extension as well.

Fig. 12 Completion of the restoration with a last oblique layer in the area of the distopalatal cusp.

Fig. 13 Situation after finishing and polishing.

Fig. 14 Removal of the rubber dam.

Fig. 15 Four months after the treatment, the margin becomes visible after curing and with the aid of magnification tools, particularly the area of the palatal cusp where the bonding layer was not thinned out sufficiently (see Fig. 8). The imperfection of the margin might have been caused by a stronger abrasion of the lower filled bonding.

Fig. 16 Situation after finishing of the marginal areas with 3M ESPE Sof-Lex™ disk.