Clinical use of Filtek™ Silorane
Low Shrink Posterior Restorative

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From the moment 3M introduced composites in 1964, they have been continuously developed to enhance their mechanical properties, abrasion resistance, colour and bond strength. But the problem of polymerisation shrinkage, and its effect on the marginal integrity of restorations, remained essentially unsolved.

Every time a dentist restores a tooth using composites, he takes great care to ensure a perfectly shaped margin – a smooth transition between tooth substance and restoration, free of irregularities and gaps. Yet, even with a perfect application technique, the chemical reaction and associated shrinkage of the composite used are beyond the dentist’s control.

All composites are subject to shrinkage, and therefore achieving permanent marginal integrity is always a challenge. Ten years of intensive research and development have gone into Filtek™ Silorane Low Shrink Posterior Restorative from 3M ESPE, a completely new type of composite based on the innovative silorane chemistry. This scientific breakthrough provides the long-sought-after solution for minimal polymerisation shrinkage and minimal shrinkage stress. The silorane-based composite comes with a dedicated adhesive.
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Clinical cases* with Filtek™ Silorane Low Shrink Posterior Restorative

The following case studies demonstrate the technique for posterior restorations using Filtek™ Silorane in a variety of situations. In contrast to complex layering techniques, which require the use of composites in various shades and opacities, all the restorations presented here were performed with a single composite (and no stains for customisation). The chameleon effect of Filtek™ Silorane, which has been optimised for use in the posterior region, means that very good aesthetics are achieved in spite of the simple layering technique and a range of just four shades. Filtek™ Silorane was used in combination with the specially developed Silorane System Adhesive, which ensures compatibility with the silorane chemistry of the composite. The adhesive is a two-step self-etch adhesive.

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Curriculum Vitae

Dental Medicine studies at the University of Tübingen, Germany

1998 – 2002: Instructor, Lecturer, Department of Conservative Dentistry, University Hospital Tübingen (Head: Prof. Dr. C. Löst)

2000: Dr. med. dent. Thesis

2002: Assistant Professor, Senior Lecturer, Department of Conservative Dentistry, Tübingen

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2006: Establishment of the Centre of Dental Traumatology Basel, together with Prof. Dr. A. Filippi

* Clinical cases from 2007
Case 1: Cusp build-up with Filtek™ Silorane

This case study focuses on the restoration of an upper molar. The existing, inadequate restoration led to the development of secondary caries and, presumably as a consequence, to a fracturing of the distolingual cusp. Following complete removal of the caries, the self-conditioning adhesive system (Silorane System Adhesive), which was specially developed for use in combination with Filtek™ Silorane, is ideal for creating an adhesive bond between the tooth substance and the restorative Filtek™ Silorane. As the approximal contact was preserved in its entirety, no time-consuming matrix technique was required. The distolingual wall was built up to create a purely occlusal cavity, thus making it easy to achieve an anatomically correct restoration by applying horizontal and diagonal layers. After removal of the rubber dam, the occlusion was checked. Minor corrections to the distolingual cusp of the tooth were required. Two weeks after treatment, the restoration was virtually invisible, thanks to the material’s chameleon effect and the enamel-like surface after polishing.
Build-up of marginal ridge and distolingual cusp

Removal of matrix

Application of Filtek™ Silorane

Horizontal layer on cavity floor

Build-up of buccal sections of occlusal surface

Completion of restoration

Restoration after 2 weeks: Buccal view

Restoration after 2 weeks: Distolingual view
**Case 2: Amalgam replacement with Filtek™ Silorane**

The following clinical case highlights the replacement of an inadequate amalgam restoration on a lower molar. Following caries removal and preparation of the cavity margins, mesially and distally contoured section matrices were placed and secured with wooden wedges and separating rings. In this way, the approximal tooth contours were ideally reproduced, making it possible to create a restoration without any excess material. The self-etching Silorane primer was rubbed into the cavity, dried with an air stream and light-cured. Then the Silorane bonding agent was applied, immediately dried with an air stream and light cured. Using the centripetal layering technique, the marginal ridges were first of all built up to an optimal height using Filtek™ Silorane. After removal of the matrices, the shallow cavity was further built up with two diagonal layers, respecting the tooth anatomy.
Removal of separating rings

Removal of section matrices

Build-up of lingual sections of occlusal surface

Completion of restoration
Case 3: mod restorations with Filtek™ Supreme XT Universal Restorative (tooth 15) and Filtek™ Silorane (tooth 16)

The case study shows the reconstruction of teeth 15 (upper right second premolar) and 16 (upper right first molar) after removal of the old, fractured restorations. The premolar was built up with Filtek™ Supreme XT prior to commencing reconstruction of the large cavity on tooth 16, which involved three surfaces. The dentine surface was conditioned with the special two-step adhesive system (Silorane System Adhesive primer and bonding agent) and the first layer of Filtek™ Silorane was applied to the cavity floor. Then the marginal ridges were built up. Subsequent removal of the matrix facilitated anatomical modelling of the occlusal contours. The necessary finishing and polishing steps can thus be reduced to a minimum. A comparison of the two restored teeth demonstrates that similar results can be achieved with siloranes in the posterior region as with special „aesthetic composites“ employing the monochromatic layering technique.
Application of Filtek™ Silorane composite

First layer of Filtek™ Silorane on the cavity floor

Build-up of marginal ridges

Removal of matrix

Build-up of palatal sections of occlusal surface

Completion of restoration

Situation immediately after polishing

Clinical situation after 6 weeks
Case 4: Minimally invasive restorative treatment with Filtek™ Silorane

The following clinical case study describes the restorative treatment performed following excavation of hidden fissure caries in the distal pits of an upper molar and a superficial lesion in the central pit. The existing restoration, located lingually in relation to the deep caries, was also removed. The resulting distal cavity reflects the extent of the severely undermining caries. The consequent unfavourable C factor of the cavity meant that a composite with minimal polymerisation shrinkage and reduced polymerisation stress offered advantages. Following application of the special adhesive system, the cavity was restored with Filtek™ Silorane in three layers. The restoration was finished and polished using conventional rotary instruments.
Achieving volumetric shrinkage of less than 1 %* with Filtek™ Silorane

Composites have been used in restorative dentistry with increasing success for over 40 years. Bis-GMA, historically the most important monomer building block for these products, was developed back in 1958, whilst UV curing and polymerisation with visible light were introduced in 1973 and 1977, respectively [1]. Recent years have seen further development of the initiators used and, in particular, optimisation of the fillers. The combination of micro- and macrofillers gave rise to hybrid filler technology in the 1990s, which made it possible, for the first time, to produce composites which offer both aesthetics and high mechanical strength. In 2001, 3M ESPE introduced a genuine nanocomposite in the form of Filtek™ Supreme Restorative, comprised of nanoparticles which are in the nanometre range, which enables extremely aesthetic results to be achieved.

Up until now, all composites have been based on methacrylate technology, which entails unavoidable volumetric shrinkage and polymerisation stress. Previous technological innovations designed to reduce volumetric shrinkage, for example by increasing the proportion of fillers, produced only small improvements [2]. Some years ago, 3M ESPE recognised that the only way to reduce polymerisation shrinkage significantly was by changing the resin matrix. Consequently, they launched a research project dedicated to this purpose. After ten years of intensive research and development, Filtek™ Silorane, with its revolutionary new resin matrix, is now available.

Silorane as the technical basis for < 1 %* volumetric shrinkage

The patented chemical basis of Filtek™ Silorane consists of ring-shaped molecules, which polymerise by a ring-opening process, largely compensating for the shrinkage that occurs during cationic polymerisation of the silorane (Fig. 1). The result: less than 1 %* shrinkage. In contrast, during the radical crosslinking of the linear methacrylate monomers, the chemical bonding process requires the individual building blocks to come together so closely that a large proportion of the volume is lost. The resulting problem is volumetric shrinkage on the order of 1.6 % to 3.4 %.

Cyclic monomers: silorane

Linear monomers: methacrylate

* < 1 % volumetric shrinkage tested by bonded disc method. [3]
In this process, shrinkage forces occur, which are termed polymerisation stress, or simply stress. Finite element analysis shows the spatial distribution and varying level of the stress which occurs with Filtek™ Silorane and the methacrylate composite QuiXfil™ (Fig. 2). What is striking is not only that the stress values of the methacrylate composite in the cavity are considerably higher than with Filtek™ Silorane, but also that the buccal and lingual surfaces display significant areas with higher stress values – precisely where enamel cracks are often observed in still-healthy dental hard tissue.

This model is supported by independent in vitro studies on tooth deformation, in which Filtek™ Silorane restorations on molars displayed the lowest level of cusp deformation by a considerable margin [4]. In summary, it can be said that polymerisation shrinkage and stress are of equal importance. Nothing is gained by only reducing shrinkage or only reducing stress: shrinkage automatically means stress!

![Finite element analysis of stress development with Filtek™ Silorane and QuiXfil™](image)

**Fig. 2** Finite element analysis of stress development with Filtek™ Silorane and QuiXfil™: With Filtek™ Silorane there are no areas of high stress (grey and light yellow).

Source: Dr. Versluis, University of Minnesota (unpublished)

**The significance of polymerisation shrinkage and stress in clinical application**

Low polymerisation shrinkage has long been high on dentists’ wish lists – and with good reason. Detachment of composites from the cavity floor, marginal discoloration, microleakage and even secondary caries are among the consequences of high shrinkage (Fig. 3). Apart from the marginal gap problem, high shrinkage and high stress may be the reason for enamel cracks in the restored tooth. In addition, high volumetric shrinkage is frequently cited as the cause of postoperative sensitivity.
Other properties of Filtek™ Silorane

The silorane technology also enables very low water absorption, combined with minimal exogenous discoloration and high dimensional stability under the conditions of the oral environment. The cationically ring-opening silorane chemistry also breaks new ground by allowing a working time of up to 9 minutes under full surgery lighting, whilst the curing time with a modern LED lamp (e.g. 3M ESPE Elipar™ FreeLight 2) is still only 20 seconds. To ensure the best possible performance in terms of marginal integrity, a dedicated adhesive was specially developed for the new chemistry of the composite. This adhesive system comprises a self-etching primer and a co-ordinated bonding agent.

Filtek™ Silorane studies

More than 40 in vitro and in vivo studies* have already been conducted with Filtek™ Silorane. The in vivo studies with the new composite have been running for almost two years at two European universities. The one-year results of the in vivo studies [5] and the final results of the in vitro studies are very convincing, and demonstrate a new milestone in restorative dentistry.

References


* The current studies have been compiled in a study booklet. The brochure is available to download as a PDF file on the Internet at www.3mespe.com