A new concept for dentin replacement in posterior composite restorations

In stress-bearing posterior applications, composite restoratives have been used as an esthetic alternative to metallic restorations for more than two decades, and their popularity has steadily increased, especially in the last few years. The first clinical data gathered for posterior restorations in the early 1980s, particularly with regard to mechanical properties, were not encouraging. The abrasion resistance of those early composites was so low that fillings lost their contours. Fractures, marginal breakdown and marginal leakage caused by polymerization shrinkage also limited the durability of composite restorations. These shortcomings have been considerably reduced by recent improvements of both composites and adhesive systems. However, the negative effects of polymerization shrinkage – such as insufficient marginal integrity, unsatisfactory adhesion to cavity walls, or cusp deflections – continue to be the greatest problem of composite restoratives. The stress developed during polymerization results from the shrinkage effects occurring when the monomers react to form a polymer. Therefore, limiting this polymerization stress without sacrificing the high degree of conversion (which is essential for good mechanical properties of the material) seems to be a promising element in synergistic approaches to the problems associated with shrinkage.

In light-cured composites, the organic phase of the uncured composite paste contains free, uncombined methacrylate monomers. Upon initiation of light curing, these monomers combine, in a free radical process, to form larger oligomers and finally the long-chain, cross-linked, cured polymer. Since the distances between the individual components of the polymer formed are shorter than between the individual monomers before this reaction, polymerization leads to a net loss of volume. This effect is referred to as polymerization shrinkage. As long as the monomers are able to move freely, because they are not yet part of a network, there is only little or no development of polymerization stress. However, as more monomers react, the developing polymer network begins to become rigid, in part due to increasing covalent bond formation (cross-linking) between adjacent polymer chains. As the mobility of the monomers essentially ceases, any further shrinkage of the system results in an increase in polymerization stress. This stress is not only trapped in the composite itself, but also exerts forces on any interface to which the composite is bonded by means of adhesive pretreatment.

The transfer of this polymerization stress is the cause of numerous clinical problems. In a well-bonded composite restoration, the stress resulting from polymerization shrinkage is transferred through the interface with the tooth structure and may cause deformation. This tooth deformation may result in enamel fracture, cuspal movement and cracked cusps. An influence of cavity design on the transfer of polymerization stress is documented in the dental literature. The term “C-Factor” describes this influence; it relates the number of composite restoration surfaces bonded to the tooth by an adhesive to the number of unabonded surfaces. The higher the C-Factor, the greater the stress-related forces acting on the cavity walls. It is apparent that Class I and II cavities have the highest C-Factors, making these restoration types most susceptible to the effects of polymerization stress.

In a less well-bonded restoration, polymerization stress may initiate debonding of the composite from the tooth (adhesive failure) if the forces developed exceed the bond strength. The resulting gap between the restoration and the cavity walls may produce post-operative sensitivity, microleakage, and/or secondary caries. Further, internal stress of the composite has the potential to initiate micro-cracking within the restorative. If the bonding to the cavity walls is strong enough to avoid gap formation during hardening, the stress concentrated inside the composite can still produce micro-cracks. As a result of this phenomenon, a restored tooth remains under stress even when there is no functional loading. This implies a greater risk of failure during tooth function. Therefore, controlling the amount of polymerization stress due to shrinkage may in all probability improve the clinical success of composite systems.

**SDR Smart Dentin Replacement Composite**

In traditional methacrylate-based composites, visible light curing proceeds rapidly, especially directly after photo-initiation. This rapid polymerization leads to a rapid increase in polymerization stress. The polymer chains cross-link at a high rate. Thus, the developing polymer undergoes a significant amount of shrinkage, and the network is unable to relieve the resulting stress due to its adhesion to the cavity walls. This explains why, despite efforts to reduce polymerization shrinkage, the effects of the resulting stress are evident across a wide range of composites with sometimes very different shrinkage values. If trapped stress caused by polymerization shrinkage is not dissipated, adverse effects will always be present.

In the traditional, methacrylate-based composite systems widely used today, the most common approach to reducing the effects of polymerization stress is to incorporate inorganic fillers into the polymerizable resin matrix, so as to reduce shrinkage by reducing the resin portion of the composite. Of course, there is a practical limit to the amount of fillers that can be added without affecting the clinical usability of the material. Although the polymerization shrinkage is greatly reduced in these highly filled systems, there is still a dramatic increase in the stiffness or elasticity modulus due to the inclusion of fillers, keeping the stress high.

Alternatively, one could develop a composite with a lower overall modulus to reduce the effects of polymerization stress. Unfortunately, in the commonly available methacrylate composites, a low final modulus results in inferior mechanical properties and is therefore not a practical solution. Another approach would be to replace the methacrylate chemistry with a different resin chemistry. But this would also require altering the materials that are used in conjunction with the new composite system (e.g. adhesives).

The low-viscosity, flowable composite “SDR Smart Dentin Replacement” (DENTSPLY DE-TREY; Konstanz, Germany) is based on the traditional methacrylate chemistry. However, it contains a UDMA-based polymerization modulator, designed to permit internal reduction of the stress caused by polymerization shrinkage by means of a slower modulus development in the curing phase without any decrease in the rate of polymerization or degree of conversion. The functional groups of this methacrylate allow it to react with other typical methacrylate systems, which are currently used in almost all composites. Thus, traditional methacrylate-based etch&rinse or self-etch adhesives react with SDR in...
Bulk-fill in 4mm increments every time.

SDR™ is up to 40% quicker and easier than conventional layering.

SDR’s unique and patented formulation can be bulk-filled in increments of 4mm, making restorations less cumbersome, quicker and easier. Its flowable viscosity results in excellent cavity adaptation, which significantly reduces post-operative sensitivity.

Small things. Big difference.

EARN REWARDS
dentsplyrewards.co.uk

LEARN ABOUT IT
dentsplyacademy.co.uk

CONTACT US
dentsply.co.uk +44 (0)800 072 3313

*Data on file

THE MAKERS OF
ASH® INSTRUMENTS | CAVITRON™ | PROTAPER® | SANI-TIP® | SPECTRUM®
the same way as with conventional composites. SDR has the required physical and mechanical properties for use as a posterior bulk-fill flowable base. SDR (filler content: 68 per cent by weight, 44 per cent by volume) is indicated for use as a bulk-fill base in Class I and II direct composite restorations and as a cavity liner. After curing, the SDR base has to be covered with a methacrylate-based universal or posterior composite to reconstruct the occlusal anatomy.

Clinical Case

The following clinical case report describes step by step the replacement of an old amalgam filling in a lower molar by an SDR (DENTSPLY DeTREY) composite restoration.

A female patient reported occasional pain caused by osmotic or thermal stimuli in a first lower molar, which had been restored with amalgam. During clinical examination, the tooth responded normally to a vitality test, and a percussion test did not show any abnormalities, either. Probing of the accessible areas of the mesio-proximal box floor with a pointed probe showed a small marginal gap. The patient agreed to the replacement of her amalgam filling. Having been informed about various treatment options, the patient wished to receive a direct composite restoration, placed in the new SDR technique.

First, external deposits were thoroughly removed from the molar, using a fluoride-free prophylaxis paste and a rubber cup. The amalgam was carefully removed, without unnecessarily damaging the remaining tooth structure, caries was excavated, and the cavity was fully prepared and then finished using a fine-grit diamond. The dam separates the treatment site from the oral cavity, ensures effective and clean working conditions and prevents any contamination with blood, sublingual fluid or saliva. Contamination of enamel and dentin would greatly reduce the adhesion of the composite to the tooth structure, so that a successful, long-lasting restoration with optimal marginal integrity could not be guaranteed. Besides, the dam protects patients from irritants, such as the adhesive system. The rubber dam is therefore an important tool for work simplification and quality assurance in the adhesive technique. The effort required to apply the dam is very low and also compensated for by eliminating the need to change cotton rolls and allow the patients to rinse their mouths.

The depth of the cavity (mesial box floor) was measured with a graduated periodontal probe, because SDR can be bulk-placed in increments of up to 4 mm. The restorations are completed by reconstructing the occlusal anatomy with approx. 2 mm of a methacrylate-based universal or posterior composite. The convex shape of the sectional metal matrix can be slightly customized prior to application by careful deformation with thumb and forefinger. The tension ring helps to separate the teeth, so as to compensate for the matrix thickness. The vertical extensions of this ring, reaching into the interdental space, adapted the contoured matrix band to the sides of the proximal box. A plastic wedge (Flexiwedge, Common Sense Dental Products Inc., Spring Lake, MI, USA) was used to tightly adapt the matrix in the cervical area. The wedge was used only to avoid any cervical excess and did not have to be forced into the interdental space, since composites do not require a high packing pressure. To optimize the contours, the matrix can be carefully bent against the adjacent tooth with a medium-sized ball plunger (cold deformation). The creation of a physiologically contoured proximal surface in close contact with the adjacent tooth is still a challenge in composite restorations. Unlike amalgam, composites show a certain degree of viscoelastic recovery after deformation, which is often undesirable and makes the adaptation of the matrix to the adjacent tooth by packing pressure more difficult.

The self-etch, one-component, tert-butanol-based adhesive Xeno V (DENTSPLY DeTREY) was used for bonding. The adhesive was generously applied to and distributed over the cavity surface with a minibrush. It was important to ensure that all parts of the cavity were adequately wetted by the adhesive. After gently rubbing the adhesive into the tooth structure for 20 seconds, the solvent was carefully evaporated with the aid of oil-free air; then the adhesive was light-cured for 20 seconds. The result was a shiny cavity surface, uniformly covered with the adhesive. At this point, the cavity should be thoroughly checked for any non-shiny surfaces, which may indicate that insufficient amounts of adhesive have been applied to these areas. In the worst case, this may lead to reduced adhesion of the restorative to these areas and inadequate dentin sealing, possibly resulting in postoperative hypersensitivity. If such areas are found during visual inspection, they will need selective reapplication of the adhesive.

SDR composite (DENTSPLY DeTREY), available in one translucent universal shade, was then bulk-placed in the cavity as a base in a 4 mm increment directly from the Compula Tip, starting at the deepest part of the defect. To avoid any air inclusions, the thin metal cannula of the Compula Tip should always be immersed in the material during extrusion. Thanks to its flowable consistency, the composite increment self-levels within a few seconds. Any air bubbles visible in the material should be eliminated using a probe tip. The composite was light-cured (intensity: > 550 mW/cm²) for at least 20 seconds.

Next, Ceram-X Mono+ composite (DENTSPLY DeTREY) was used to carefully sculpt the occlusal surface and complete the restoration. When reconstructing the occlusal anatomy, it is important to sculpt the surface with great care and remove any excess while the material is uncured. This will substantially facilitate the subsequent finishing procedure and reduce it to only a few steps. After light-curing for 20 seconds, the restoration was checked for any imperfections, and then the sectional metal matrix was removed. In the region of the proximal extension, the material was additionally light-cured from buccal and oral.

The polymerized restoration was already well-contoured. After rubber dam removal, the fissure relief and the fossae were further outlined with a pear-shaped diamond finisher. In the next step of the standardized finishing sequence, a round-end bullet-shaped diamond finisher was used to increase the convexity of the triangular ridges and create harmonious transitions between the various features of the occlusal anatomy. After eliminating occlusal interferences and adjusting static and dynamic occlusion, polishing discs were used to contour and pre-polish the proximal surfaces, as far as accessible. Then the restoration was satin-polished using composite polishing tools. The final high-shine polish was achieved with the aid of a composite polishing paste. The mesial view shows the seamless transition between composite material and tooth structure and the details of the occlusal anatomy. The treatment was concluded by applying fluoride varnish to the tooth with a foam rubber pellet.

Conclusion

The importance of composite-based direct restorations will continue to increase in the future. The use of these materials for high-quality permanent restorations in stress-bearing posterior applications is supported by scientific evidence, and their reliability is documented in the dental literature. The results of an extensive meta-analysis have shown that their annual loss rates are not significantly different from those of amalgam fillings. Minimally invasive treatment protocols, combined with the recent progress in early caries detection, will further improve the survival rates of these composite restorations. However, the basic prerequisites for high-quality direct composite restorations with good marginal integrity continue to include the careful use of a matrix system (if proximal surfaces are involved), an effective dentin adhesive and the proper application and adequate polymerization of the composite.