INTRODUCTION

Traditionally, more extensive restorations on vital teeth were performed using non-adhesive techniques. The materials of choice were gold, porcelain and metallic ceramics. These were placed either intra- or extra-coronally, and relied on the preparation having near-parallel walls, assisted by a luting cement to fill the marginal gap and help with the retention process. With the development of new materials and techniques for bonding to the vital tooth, there has been a blurring of the methods used and often restorations rely on a multitude of factors for retention which incorporate both mechanical and adhesive principles.

The keywords were used in PubMed to search for relevant articles. Totally, 127 articles were found, of which 68 did not have full text access. From the remaining 59 articles, 31 were published before 2000. The review included 28 articles these were published after the year 2000 and included materials other than the conventional materials used. The aim of this review is to help the clinician decide which newer materials to use in different situations. It also provides evidences for the rationale behind these decisions.

ORMOCERS

Ormocers (derived from organically modified ceramic) were initially used in the field of science and technology (e.g., for special surfaces like protective coatings, non-stick surfaces, anti-static coatings and non-reflective coatings). In contrast to conventional composites, the ormocer matrix is not only organic but also inorganic. Therefore, monomers are better embedded in the matrix, and this reduces the release of monomers.

Ormocers basically consist of three components – organic and inorganic portions and the polysiloxanes. The proportions of those components can affect the mechanical, thermal and optical qualities of the material:

1. The organic polymers influence the polarity, the ability to cross link, hardness and optical behavior.
2. The glass and ceramic components contribute to the expansion and stability.
3. The polysiloxanes influence the elasticity, interface properties and processing.
4. The ceramic and glass are bound to the organic portion by silane molecules.

After polymerization, the organic portion of the methacrylate groups forms a three-dimensional network. Even after several attempts to create a better restorative material using ormocers, their adaptation property was significantly lower when compared to composites, after cyclical loading in a laboratory test. Nevertheless, no differences were found in a 4 years clinical comparison of AdmiraR (ormocer) and Tetric CeramR (hybrid composite).

At the same filler content, ormocers have a reduced polymerization shrinkage compared to hybrid composites or at a lower filler content of the ormocer the polymerization shrinkage is equal to that of a conventional composite. Rosin et al. investigated the clinical performance of ormocer restorations in a clinical trial after 1 and 2 years. The clinical application was satisfactory, but the marginal adaptation and use in Class V restorations was a concern. As opposed to this, a study found no significant difference in the durability of restorations between ormocers and resin based systems. But, the 5 years
control showed that ormocers had a much more potential for discoloration.[5]

Ormocer (DefiniteR) failed to meet the needs for restoration durability compared to conventional composite resin for class II restorations, in a 1 year trial. Al-Hiyasat et al. checked the cytotoxicity of different filling materials and their flowables (AdmiraR, Z250R, Tetric CeramR). The ormocer had the maximum cytotoxicity in the regular composites but the lowest in regards to the flowables. This has been rejected by another study, which showed that an ormocer (CeramXR) released significantly less Bis-GMA, TEGDMA or UDMA when compared to a nanohybrid composite (Filtek supreme XTR) and a self-curing composite (Clearfil CoreR).[6] With respect to microhardness, the ormocers are comparable with hybrid composites, but their wear resistance is lower. This contradicts other studies, which have shown less wear for ormocers [Figure 1].[7]

COMPMOMER

The word “compomer” comes from composite and glassionomer. The material itself is a Polyacrylic-/polycarboxylic acid modified composite. Compomers are composed of composite and glass ionomer components. It tries to mix the desirable qualities of both materials: the fluoride release and easy handling of the glass ionomers and the esthetic aspects of the composites. Compomers contain various monomers (e.g., UDMA) and also contains dicarboxylic acids, which in contrast to those in traditional glass ionomers have polymerisable double bonds.[8]

The fluoroaluminiumsilicate glasses of glass ionomer cements are found in compomers. The particle size of fillers in compomers ranges from 0.2 μm up to 10 μm. These materials show unsatisfactory retention when no pre-treatment of the tooth is done with an adhesive system.

The basic properties of these adhesives basically are not different from adhesives used for composite restorations. The compomers setting reaction relies on the polymerization of acidic monomers.[9] The acid-base reaction, which starts only after water absorption, is limited to the superficial layers. Although, for a narrow range of indications, certain colored compomer materials (Comp naturR) can generate interest in adults compomers due to their low abrasion resistance are most appropriate for restorations of the deciduous dentition [Figure 2].[10]

In cervical restorations, compomer restorations performed better than resin-modified glass ionomers but not as well as hybrid composites. The fluoride release of compomers improved quickly in the first 24 h, but decreased equally quickly. Compomer can be recharged with fluoride from the oral environment leading in longer lasting caries prevention.[11] A study showed that caries development adjacent to a compomer restorations (Dyract eXtraR) was lesser than adjacent to composite restorations (Spectrum TPHR). The release of fluoride over the next 28 days after the placement of compomers had an inhibitory effect on caries in the adjacent tooth. The release of fluoride was more in deciduous teeth than in permanent teeth. However, a clinical study showed no difference in new caries development in children who received compomer restorations compared to those who had amalgam restorations. The ability to regenerate fluoride is because of the glass component and the hydro-gel layer.[12]

The hydro-gel layer is, in turn, dependent on the acid-base reaction. Therefore, both the fluoride release and the fluoride re-uptake are greatest in glass ionomers followed by compomers and then by composites. The increased water absorption of the compomer compared to conventional composite results in marginal discolouration interfering with esthetics particularly in the anterior teeth. Compomers are also contraindicated for large core build-ups due to their poor abrasion resistance.[13]

SILORANE

The name of this material class refers to its chemical composition from siloxanes and oxirans. This product class aims to have lower shrinkage, longer resistance to color change and less marginal disintegration. The silorane monomer ring differs obviously from the chain-monomers of hybrid composites.

The hydrophobic properties of the material are caused by siloxanes. Exogenous discoloration and water absorption are reduced. The oxirane rings are responsible for the physical properties and the low shrinkage. Siloranes are polymerized by a cationic reaction in contrast to methacrylates, which crosslink via radicals.[14] The photoinitiator system is based on three components: light absorbing camphor chinon, an electron donor (e.g., amine) and an idonium salt. The camphor chinon
is activated and reacts with the electron donor, which reduces the iodonium salt to an acidic cation in the process. This starts the opening process of the oxirane ring. The opening of the oxirane rings during the polymerization process compensates to some degree for the polymerization shrinkage. The fillers in Filtek SiloraneR, the only silorane material on the market at the moment, consist of 0.1-2.0 μm quartz particles and radiopaque yttrium fluoride.[15]

A comprehensive study of Filtek SiloraneR was carried out by Weinmann et al.: It confirms the low shrinkage (<1%) and found that the light stability of the silorane was 7 times longer than for methacrylates. The siloranes low shrinkage causes lower contraction stress. The silorane-based filling materials have low water absorption and water solubility. The adhesion of streptococci observed on the surface of silorane restorations was low, maybe because of its hydrophobic properties. Siloranes show good stability in various media and compared to conventional composites they are less prone to changes if kept in ethanol. Filtek SiloraneR has good polishing characteristics. The material showed little color change after artificial ageing, and the surface gloss was retained.[16-18]

The clinical application of siloranes is limited to the posteriors because few shades available.

Because of the hydrophobic properties the appropriate adhesive system must be used for silorane restorations. Dentists both value and recognize the challenge of the relatively high viscosity. At the moment, the weak radiopacity is a disadvantage since the limitations of the restoration are difficult to recognize on radiographs.[19]

**CEROMER**

Due to the increasing patient demand for esthetic, biocompatible restorations, materials that exhibit a natural appearance, strength, and durability have been developed. Researchers have explored several alternatives for achieving this objective, including the use of inlay or onlay restorations fabricated of direct composite resin, ceramic, and ceramic optimized polymer (Ceromer) materials. The advancements associated with computer-aided design/computer-aided manufacturing and milled restorations have further increased the clinician’s ability to deliver predictable, durable restorations.[19-22] While direct Class II composite restorations can provide clinical advantages with regard to esthetics, reduced patient expense, and efficiency, clinicians must simultaneously address several material and procedural limitations (e.g., polymerization shrinkage, microleakage, postoperative sensitivity). Although conventional ceramic or ceromer inlays and onlays are clinically superior to direct composite restorations, these modalities increase treatment expense and require multiple visits to facilitate placement.

The use of direct inlays or glass insert restorations was introduced in the early 1980s in the form of beta quartz glass inserts. Utilizing this technology, sites prepared for direct composite resin restorations were megafilled with prepolymerized glass inserts to reduce polymerization shrinkage and impart strength to the definitive restorations. Sites treated in this manner have exhibited a sevenfold lower coefficient of thermal expansion as compared to amalgam and have demonstrated the ability to reduce polymerization shrinkage by 50-70%. Use of the inserts is intended to improve the wear characteristics of composite restorations by providing a solid surface for contact against the opposing dentition, and also permits them to function as acceptable megafiller for composite resin.[23] The glass inserts, however, are also characterized by clinical deficiencies that include the poor esthetic blending of the insert and composite materials, and marginal failure due to the gap that often forms between the insert and the restorative margins.

With the advent of a sonically driven preparation system (e.g., SONICSYS, Ivoclar Vivadent, Amherst, NY; KaVo, Lake Zurich, IL, USA), many of the original limitations of insert technology have been resolved. This sonic system consists of single-sided, diamond-coated tips (40-50 μm coating) that facilitate conservative preparation of mesial and distal surfaces without causing damage to adjacent teeth. The tips – designed for three Class II preparation sizes – attach to an oscillating air scaler unit.[24]

The appropriate tip should be selected based on the size of the preparation required for complete decay removal and finishing of the inlay restoration. The system also contains ceramic inserts – fabricated from a leucite-reinforced glass ceramic material similar to that of a pressed ceramic (i.e. IPS Empress, Ivoclar Vivadent, Amherst, NY, USA) – that are precisely shaped to correspond to the assorted preparation tips. The objective of the technique is to establish a preparation of predictable size and shape to one of the three inserts, thus achieving an “inlay” type restoration in the interproximal region of the tooth. The definitive result is a prefabricated ceramic inlay with marginal tolerance of 81-108 μm in the interproximal area, and 12-21 μm in the gingival bevel areas, which significantly reduces the deficiencies (e.g. microleakage, postoperative sensitivity) of conventional direct composite restorations that are typically associated with polymerization shrinkage. The gingival inclination of the sonically driven preparation instrument is 45°, which is optimal for the acid-etch technique in cervical enamel.[25]

If the proximal preparation margin extends into the dentin, the preparation is completed as soon as the dentinal gingival margin is smooth. Beveling the gingival margin in the dentin does not provide decisive strength advantages for bonding strength. This article demonstrates a clinical protocol that features the preparation and ceramic insert technology utilized to perform direct inlay restorations in the posterior segment.
WHISKER COMPOSITES

Ceramic whiskers were used as fillers in composites. Whiskers were fused with silica particles (nanometer sized), to facilitate silanization, minimize whisker entanglement and improve whisker retention in the resin matrix by increasing the roughness the whisker surfaces. The fracture toughness and flexural strength of whisker composites are almost twice that of currently available composites. These composites supported cell attachment and proliferation, as found in an in vitro study.

The most promising work in composites with modified fillers for both enhanced mechanical properties and remineralizing potential by virtue of calcium and phosphate release has been the work with fused silica whiskers and dicalcium or tetracalcium phosphate nanoparticles. These composites may be stronger and tougher, but the optical properties are not ideal, and their opacity requires them to be self-cured or heat-processed at this point.

Their main action of the whisker composites is because of the whiskers pinning and bridging the cracks. The whiskers are more competent in resisting the cracks as compared to fibers and have lesser chances of being cracked. The whiskers have a tensile strength of about 50 GPa, as opposed to 2.6 GPa of glass fibers.

CLINICAL PROTOCOL

Following proper case selection, diagnosis, and treatment planning for direct inlay restorations, a strict clinical protocol should be followed in order to achieve predictable results. Preparation design utilizing sonic technology and predictable cavity size contributes to the success of the restoration with the ceramic insert. When selecting the design of the inlay or onlay preparation, the “one-half rule” can be applied by the clinician. Instances in which the width of the isthmus is equal to or greater than one half of the buccolingual intercuspal distance, or in which the preparation finish line falls on or above the halfway point of the cuspal incline ridge, are indicated for an onlay restoration. Additional parameters (e.g. occlusal function, position of the tooth in the arch, and degree of enamel support) should also be considered. The smallest preparation instrument that covers the marginal regions and provides axial wall beveling should be selected.

Sonic technology, which cuts less aggressively than rotary instruments, is ideal for finishing and standardization of the proximal box to ensure proper fit of the ceramic inlay. Upon completion of the milled and precise interproximal preparation site, the appropriately sized ceramic insert is selected. Accepted isolation protocols should be followed to eliminate moisture, which may compromise the conventional bonding procedures employed for direct resin restorations. The ceramic insert is subsequently placed into the interproximal preparation and luted with flowable and conventional microhybrid Ceromers (e.g., Tetric Flow; Tetric Ceram, Ivoclar Vivadent, Amherst, NY). The inserts increase depth of cure by conducting the curing light within the composite material, and their light transmission produces a cohesive stress that is directed toward the insert rather than the surface of the restoration. Once complete curing of the dentin layer has been performed, pit and fissure stains are incrementally applied to the surface along with an enamel layer of a reinforced microfill composite resin. Final occlusal adjustments, finishing, and polishing are accomplished in order to complete the esthetic and functional direct resin/composite inlay restoration.

CONCLUSION

Vital restoration not only mechanically replaces the lost part but, acts as a medium through which physical and mechanical forces are transmitted to the tooth and investing tissues. Each tooth has its own stress patterns. A thorough knowledge in dental materials is necessary to understand the physical properties including their response to stress. Before any vital restorative procedure, always check the location of the tooth in the arch and the patient’s occlusal relationship. The functional, non-functional cuspal elements should be noted by examining the involved teeth during static and functional mandibular movements to make a well-informed decision about the material to be used.

REFERENCES

7. Bottenberg P, Alaerts M, Keulemans F. A prospective randomised clinical trial of one bis-GMA-based and two ormocer-based composite restorative systems in class II
Advances in Reinforced Restorations: A Review … Kumar, et al.

5


