Restorative materials in the primary dentition of poli-caries patients*

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Abstract

Background: Despite an overall caries decline in children, still 50-60% of carious primary teeth of 6-year-olds remain untreated, in 3-year-olds 13%. There are an increasing number of poli-caries patients with insufficiently treated primary teeth. Therefore, early treatment is fundamental. **Review:** The assessment and indication for the use of restorative materials can be summarized as follows: *Glass ionomer cements* (GIC) are associated with easy handling and high fluoride release. This makes them attractive especially for Class I cavities in uncooperative children. However, low flexural strength causes high fracture rates in Class II cavities. Further developments (viscous and resin-modified GIC) have improved handling characteristics, but conventional non-resin-modified GIC are still prone to fracture. *Compomers* exhibit a clear potential as an alternative to amalgam. Long-term results are good even in stress-bearing areas. The compliance of the child should at least last long enough for adhesive application. *Resin composites* are still the most time-consuming alternative. Under a correct application protocol, resin composites behave in a similar manner to compomers. Therefore, the effort has to be judged individually. Finally, especially in severely decayed teeth and after endodontic treatment, preformed metal crowns should be taken into account as a last and appropriate alternative to direct restorations. **Conclusion:** Based on the high clinical success rates, compomers with self-etch adhesives can be recommended for restorative therapy in anterior and posterior primary teeth.

Introduction

Despite the existing caries decline in children, the restoration of primary teeth is still not adequate. Recent evaluations in Germany reveal only 40-50% of primary teeth caries treated in 6/7-years-olds [Pieper, 2005] and similar findings occur throughout Europe; 30% of children suffer from unrestored carious lesions. This is astonishing because on the one hand it is well-known that early treatment has a significant impact on oral health. On the other hand it is proven that success rates for both anterior and posterior primary teeth restorations are good.

Morphological characteristics of primary teeth. The paradigm change towards minimally invasive treatment options is also true for primary teeth. Therefore, morphological characteristics of primary teeth gain prominence. Concerning adhesive procedures, the following measures are important: 1) the presence of primless enamel at the tooth surface. 2) the different micromorphology of primary dentine when compared to dentine of permanent teeth, i.e. larger diameters of dentinal tubules and less mineralized dentine (Fig. 1) [Lee and White, 1998; Sumikawa et al., 1999]. Micromorphological investigations generally found resin-dentine interfaces being substantially thicker than in permanent teeth [Nor et al., 1996; Nor et al. 1997].

Excavation. For excavation of soft, light-yellow caries it is advantageous to use hand instruments. Harder carious dentine should be carefully removed with steel burs. Some authors recommend to excavate defensively here in order to not artificially expose the pulp [Staehle and Koch, 1996]. However, recent studies showed that, primarily in proximal carious lesions, irreversible inflammation of the pulp has to be taken into account even before a clinical exposure of the pulp could be detected [Duggal et al., 2002]. With good child behaviour success can be achieved in order to prevent early loss of primary teeth.

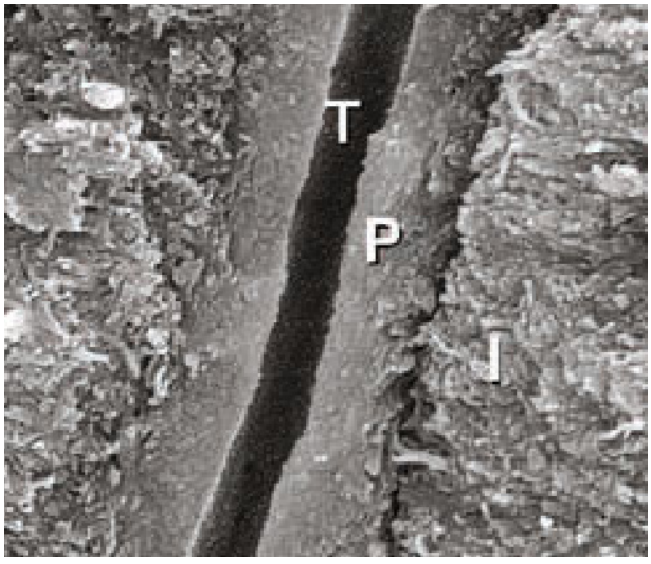

Figure 1. Primary dentine, fractured specimen under a SEM. Tubules are larger (up to 10 µm), dentine is less mineralized than permanent dentine.

Key words: restorative materials, primary teeth, children
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Restorative materials for primary teeth

Amalgam. This material has delivered acceptable results in primary teeth for over a century. Mean survival time per year was estimated to be around 3 years, mean reason for failure was secondary caries [Kilpatrick, 1993, Mjor et al., 2002]. Hickel et al. [2005] calculated an 8% annual failure rate for amalgam in primary molars. During the last two decades, amalgam was considerably reduced due to inadequate pseudo-biological critique, but also due to aesthetic demands of parents.

Viscous Glass Ionomer Cements. Viscous GIC (VGIC) are packable and therefore of some interest [Burke et al., 2002]. However, due to their low flexural strength and fatigue performance, being about the same as conventional GIC, the indication spectrum remains limited. Although filler sizes were considerably reduced compared with formerly, the 'polishabilty' is still poor. Our study with a metal-reinforced VGIC (Hi-Dense, Shofu) exactly matches preclinical findings in the laboratory [Krämer and Frankenberger, 2001]. In vitro we found flexural properties and fatigue to be in the same in a range of older materials [Frankenberger et al., 1999a], and in vivo this was confirmed by a substantial fracture rate in class II cavities. After two years of clinical service, more than 40% of class II restorations had failed (bulk fracture or retention loss; Fig. 2). Clinical trials confirmed a success rate severely compromised by poor flexural strength characteristics [Ostlund et al., 1992; Espelid et al., 1999; Hubel and Majare, 2003]. On the other hand, the fast and easy handling made it favourable for class I defects and in uncooperative children.

Resin-modified GIC. Resin-modified GIC (RMGIC) is used for both anterior and posterior cavities [Qvist et al., 2004b]. From the beginning it was thought to be advantageous to be achieving the polymerization process by visible light, however, small increments (<3mm) are mandatory [Burke et al., 1990]. But RMGIC contain large glass particles which lead to a visible surface roughness. (Fig. 3).

Figure 2. VGIC suffer from low flexural strength and fatigue. After two years, the isthmus is cracked, the filling had to be removed.

Figure 3. RMGIC performs well also in class II cavities (Photac Fil, 3M Espe, 75 MO). However, the clinical view exhibits poor polishability.

RMGIC have been investigated in several clinical trials [Espelid et al., 1999; Qvist et al., 2004a; Qvist et al., 2004b]. Compared with VGIC, improved flexural strength seems to be responsible for increased success rates being characterized by less marginal and bulk fractures. Even compared with amalgam, RMGIC were more successful [Qvist et al., 2004b]. The main advantages are high fluoride release and consequently less secondary caries, which was also confirmed histologically by Donly at al. [1999] who reported an inhibition of enamel demineralization at restoration margins in vivo. Recent trends concerning the further development of RMGIC are focussing on smaller filler particles for improved polishability and aesthetics. The relatively high percentage of HEMA (hydroxy-ethyl methacrylate; 10-12%wt.), however, will hardly be reduced. Further toxicological assessments have yet to clarify whether these restorations are biologically unsafe [Reichl et al., 2002].

Adhesion to primary tooth hard tissues. Since the 1970's, minimal intervention has also been described for primary teeth [Roulet, 1977]. Enamel etching with phosphoric acid, however, is problematic due to the presence of a prismless layer at the surface [Ripa et al., 1966]. This layer is ~30-100 µm thick with increasing thickness in the molar series. Also the "prismless" enamel contains prisms, but irregularly arranged (Fig. 5) [Ripa et al., 1966; Kodaka et al., 1989; Whittaker, 1982]. In order to achieve a durable etching pattern, the surface has to be bevelled and then a regular enamel bond is achievable with 30 s phosphoric acid etching [Smutka et al., 1978; Hosoya, 1991; Garcia-Godoy and Gwinnett, 1991; Gwinnett an Garcia-Godoy, 1992;].

Dentine bonding in primary teeth is still contradictory [Perdigao et al. 1994; Perdigao et al. 1999]. In primary teeth, dentine bonding plays a different role than in permanent teeth. A bonded resin composite restoration in permanent teeth will be successfully retained when the enamel bond is

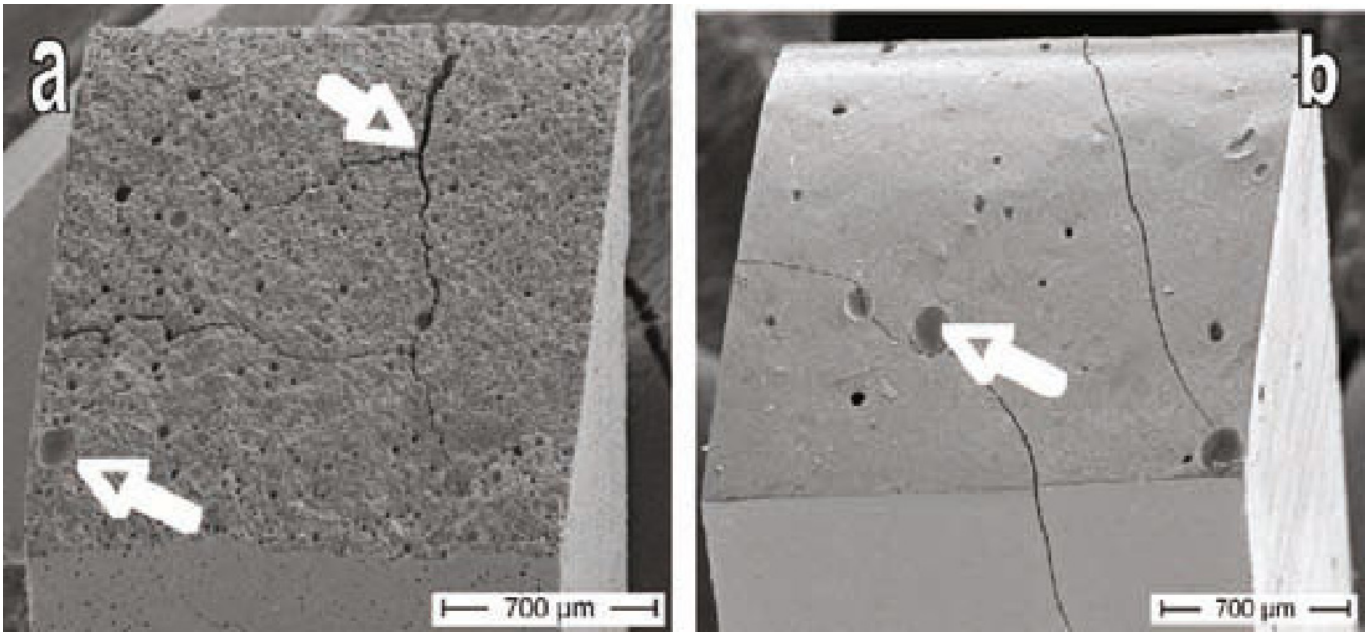

Figure 4. SEM image of fractured specimens of Photac Fil (a) and an experimental RMGIC (b). The smaller average filler particle size results in smoother fracture surfaces. The arrows indicate voids after mixing and cracks due to SEM vacuum.

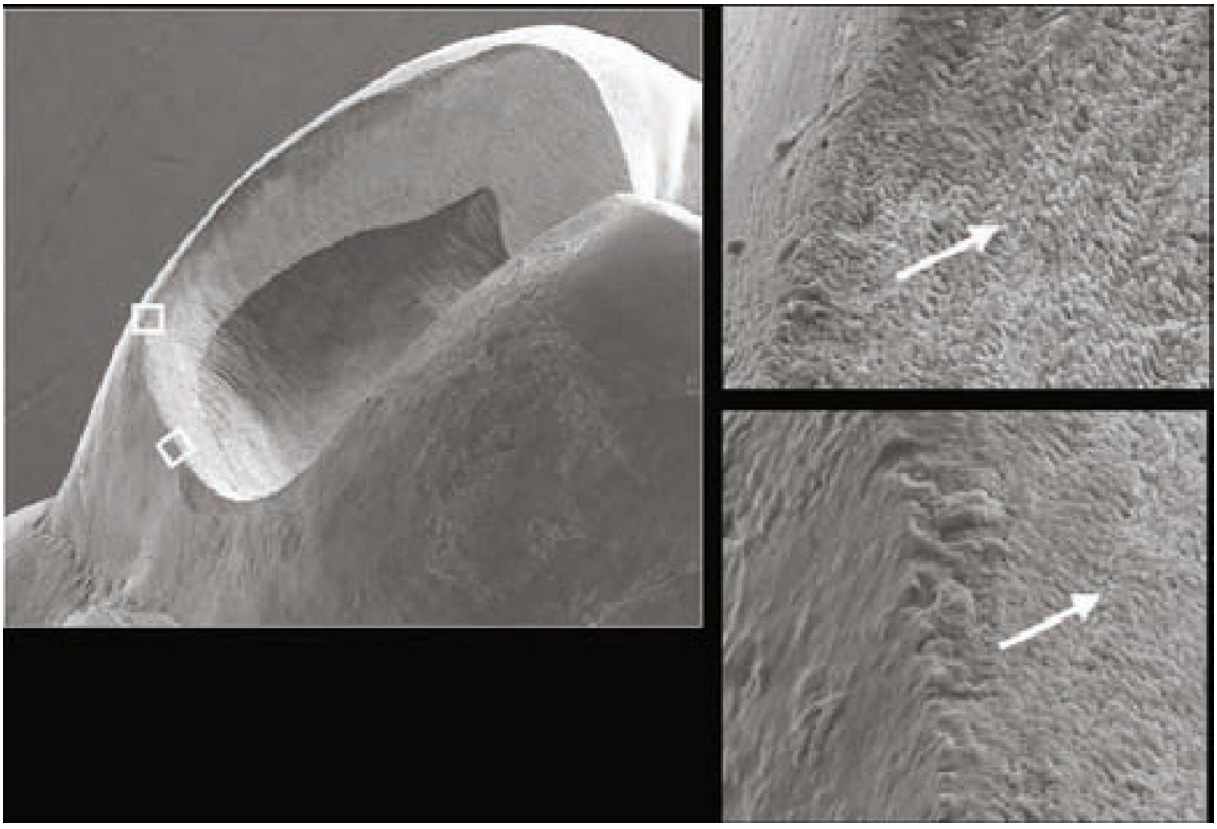

Figure 5. SEM image of a class II cavity without bevel. The arrows indicate two different areas with regular prisms towards the enamel-dentin junction and irregularly arranged prisms in the prismless surface layer.

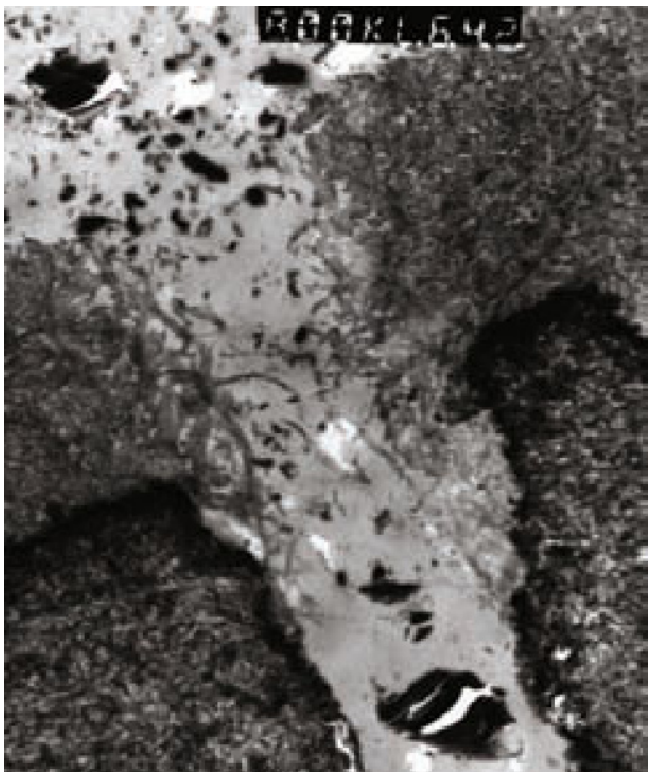

Figure 6. TEM image of a resin-dentin interface in a primary molar bonded with OptiBond FL after 10 s phosphoric acid etching. The hybrid layer is as thick as after 15-20 s etching on permanent dentin.

working. Dentine adhesion is needed for good internal sealing and reduction of postoperative hypersensitivities. The contrary is true for primary teeth where the bonding area in dentine is considerably larger and has a significant impact on restoration retention. Micromorphological features such as giant tubules and less mineralization are key factors for good dentine adhesion and therefore clinical survival [Lee and White, 1998; Sumikawa et al., 1999]. Thicker hybrid layers after total etching and consecutive poor penetration by monomers was believed to be responsible for suboptimal dentine bonding to primary teeth [Malferrari et al., 1995; Nor et al., 1996; Fritz et al., 1997; Nor et al. 1997].

Among a variety of bond-strength studies in primary teeth, it was unanimously reported that multi-step adhesives do not represent the same gold standard as in the permanent dentition [Frankenberger et al., 1997; El-Kalla and Garcia-Godoy, 1998; Garcia-Godoy and Hosoya, 1998]. The same is true for total etching [De Araujo et al., 1997; Frankenberger et al. 1997]. However, due to limited space there is no doubt that totally bonded restorations behave significantly better than cements in terms of marginal adaptation and microleakage [Royse et al. 1996; Berg, 1998]. Older adhesives such as Scotchbond 2 are not advantageous in primary teeth [Elkins and McCourt, 1993]. Filled adhesives may be promising from laboratory results; however, this could never be verified in vivo (Fig 6) [Mazzeo et al., 1995; Frankenberger et al., 1999b,]. Functional loading exhibited good performance of compomers even when used with simplified adhesives [El-Kalla and Garcia-Godoy, 1998; El-Kalla, 1999]. This may be attributed to easy handling under the, often, poor cooperation of children in the surgery/operatory [El-Kalla, 1999]. Clinical studies showed that additional phosphoric acid etching with Prime & Bond NT® did not deliver better clinical results [Turgut et al.; 2004]. Furthermore, this is based on minor mineralization of primary dentine so that acidic attacks, such as acid or acidic primer, may be reduced to 50% of the time that needs to be used in permanent teeth without reducing performance [Casagrande et al., 2005; Sardella et al., 2005]. Results on caries-affected dentine beneath carious lesions show promising results as well [Frankenberger et al., 1997].

Compomer. Compomers (polyacid-modified resin composites, COM) were introduced in 1994 for posterior and anterior restorations [Ernst et al., 1995; Garcia-Godoy et al., 2000]. Today more than 60% of restorations in primary teeth are tooth-coloured [Tran and Messer, 2003]. COMs are commonly used with one-step adhesives which apparently deliver dentine adhesions being sufficient to no longer use retentive preparations [Qvist et al., 2004a]. Roeters investigated Dyract® (Dentsply, Konstanz, Germany) in classes I and II in primary molars demonstrating long-term success [Roeters et al., 1998]. Compared with GIC, improved flexural properties were verified in vivo by low fracture rates. After three years of clinical service, wear was also not a problem (Fig. 7). According to the authors, an average compliance is sufficient for clinical success and secondary caries does not play a major role. Prime & Bond® alone was used without any lining, and no hypersensitivities or pulpitis were found [Roeters et al., 1998]. A split-mouth study with a COM (Compoglass®, Ivoclar Vivadent, Schaan, Liechtenstein) and a resin composite (TPH-Spectrum, Dentsply) did not reveal differences between materials [Attin et al., 2001].

Figure 7. After 3 years, 54 distal restoration exhibits an acceptable marginal adaptation. Colour and anatomical shape are compromised, however, the restoration is serviceable.

Figure 8. Glimmer restoration (Twinky Star, Voco, Cuxhaven, Germany) after 4 years. Neither gaps nor wear are detrimental factors.

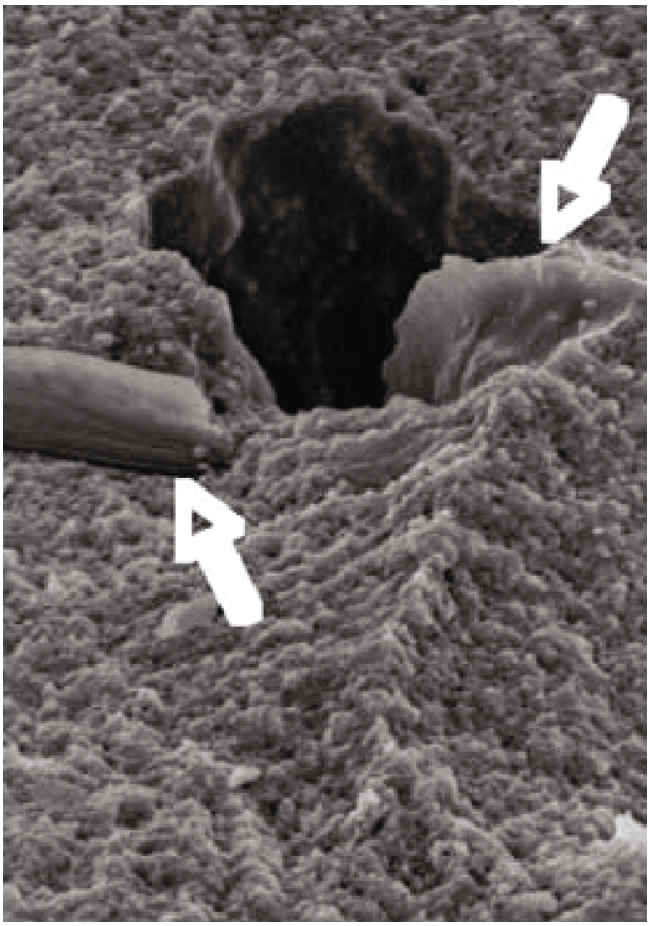

Figure 9. Fractured SEM specimen of the coloured compomer Twinky Star (Voco, Cuxhaven, Germany). This material only contains 0.2% wt. non-silanized glimmer particles, however, being located at the interface (arrows), these particles may be responsible for poor adhesion.

Figure 10a. Anterior defects can be adhesively restored as well. 4 anterior resin composite restorations in a 3-year old.

Figure 10b. 40 months recall: 51 and 61 show marginal imperfections being left unrestored due to imminent exfoliation.

An important aspect for successful treatment with COM is the correct application of adhesives. Qvist et al. [2004a] explicitly recommended to use adhesives, introduced because success rates of Dyract® without adhesive were poor. In anterior cavities, easy handling is advantageous, with an 80% success rate being reported after 18 months 80% [Mortada and King, 2004]. Altogether, COMs represent the ideal way of restoring primary teeth [Hickel et al., 2005]. However, a compliance of at least a few minutes is always required to establish adhesion without contamination.

During the past four years, coloured COMs have become available (Fig. 8) [Croll, 2002]; glimmer particles are responsible for the colour effect. SEM analyses show large non-silanated particles which may represent crucial areas for fractures (Fig. 9). Clinical reports are scarce, and the success of coloured vs. tooth-coloured materials may be doubtful.

Resin composites. Older clinical studies always had the trend that resin composites (RC) were poorer than amalgam. Mjor et al. [2002] reported an average 2-year success rate for tooth-coloured restorations in primary teeth. In vivo specimens exhibited proximally <42% marginal gaps, and even <58% secondary caries, when resin composites were used; 95% of restorations suffered poor contour and surface imperfections [Varpio et al., 1990].

Figure 11. Retained primary molar (65) being restored with a resin composite. The 6 years recall is promising.

Important aspects for RC in primary teeth are the routine use of rubber dam, compliance of the child, and the meticulously applied adhesive. When these conditions can be met, RC are suitable materials. A substantial bevel is recommended to eliminate the prismless layer [Gwinnet and Garcia-Godoy, 1992]. Where phosphoric acid etching is considered, dentine should be etched < 10 secs, otherwise minor penetration of demineralised dentine occurs [Pashley et al., 2004]. Many poor results in the past are attributable to less developed adhesion strategies compared to modern adhesives. Today this view has changed because RCs can be inserted with similar success to COMs. Kupietzky et al. [2005] restored severely decayed anterior teeth with RC build-ups and strip crowns with 80% success after 31 months (Fig. 10) and Attin et al. [2001] reported only a 14 % failure rate with RCs after three years. However, neither Attin et al. [2001] Marks et al. [1999] nor Pascon et al. [2006] were able to demonstrate a significant advantage for RCs in comparison with COMs (Fig. 11).

Conclusions

All restorative techniques exhibit strengths and weaknesses. An assessment of the materials can be summarized as follows:

- GICs are favourable for Class I cavities and in uncooperative children.
- Compomers show best long-term performance in primary teeth. The cooperation has to be sufficient, at least during bonding and layering.
- The biggest effort is needed for resin composites. After rubber dam application and correct establishment of technique-sensitive adhesion, resin composites reach the level of compomers.
- Especially in severely decayed teeth and after endodontic treatment, preformed metal crowns should be taken into account as last and appropriate alternative to direct restorations for poli-caries patients.

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