Review

Polyacid-modified composite resins (“compomers”) and their use in clinical dentistry

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Clinical performance

Abstract

Objectives. This paper describes the chemistry and properties of polyacid-modified composite resins (“compomers”) designed for use in clinical dentistry, and reviews the literature in this area.

Methods. Information has been obtained from over 50 published articles appearing in the dental and biomaterials literature, with studies being principally identified through MedLine.

Results. Published work shows that polyacid-modified composite resins constitute a discrete class of polymeric repair material for use in dentistry. Their distinction is that they contain hydrophilic components, and these cause water to be drawn into the material following cure. This triggers an acid–base reaction, and gives the materials certain clinically-desirable properties (fluoride release, buffering capability) that are also associated with glass-ionomer cements. The water uptake leads to a decline in certain, though not all, physical properties. However, clinical studies have shown these materials to perform acceptably in a variety of applications (Class I, Class II and Class V cavities, as fissure sealants and as orthodontic band cements), especially in children’s teeth.

Conclusions/significance. Polyacid-modified composite resins constitute a versatile class of dental repair material, whose bioactivity confers clinical advantages, and which are particularly useful in children’s dentistry.

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1. Definition and distinctiveness

Polyacid-modified composite resins, known trivially as compomers, are a group of aesthetic materials for the restoration of teeth damaged by dental caries [1]. They were introduced to the profession in the early 1990s [2], and were presented as a new class of dental material designed to combine the aesthetics of traditional composite resins with the fluoride release and adhesion of glass-ionomer cements. The trivial name was devised from the names of these two “parent” materials, the “comp” coming from composite, and “omer” from ionomer [3].

The term polyacid-modified composite resin was originally proposed for these materials in 1994 [3] and has been widely adopted both by manufacturers and researchers since that time. However, it has been criticised on the grounds that it “…may over-emphasize a structural characteristic of no or little consequence” [3]. This is a somewhat strange criticism, since to formulate these materials, manufacturers have modified them specifically by the introduction of acid-functional macro-monomers. They are, therefore, without question “polyacid modified”. Whether this modification confers clinical benefits, or indeed whether these materials can usefully be considered to be distinctive materials is more debatable. The conclusion of Ruse is that “…they are, after all, just another dental composite” [3], but this seems to the present author to be somewhat extreme, and there is considerable evidence that compomers possess characteristic properties, and are therefore distinct from conventional composite resins.

Nonetheless, polyacid-modified composite resins have been studied widely, both in terms of their materials science and their clinical applications. After more than a decade of research and clinical use, it is therefore timely to review their status. This paper does that, and has involved a comprehensive search of the literature using Medline. It is not, however, a catalogue of publications, but is a critical review, based on the author’s many years of research on these materials.

2. Composition and setting

A key feature of compomers is that they contain no water and the majority of components are the same as for composite resins. Typically these are bulky macro-monomers, such as bisglycidyl ether dimethacrylate (bisGMA) or its derivatives and/or urethane dimethacrylate, which are blended with viscosity-reducing diluents, such as triethylene glycol dimethacrylate (TEGDMA). These polymer systems are filled with non-reactive inorganic powders, such as quartz or a silicate glass, for example STA3SIO [3]. These powders are coated with a silane to promote bonding between the filler and the matrix in the set material [3]. In addition, compomers contain additional monomers that differ from those in conventional composites, which contain acidic functional groups. The most widely used monomer of this type is so-called TCB, which is a di-ester of 2-hydroxyethyl methacrylate with butane tetracarboxylic acid [5]. This acid-functional monomer is very much a minor component and compomers also contain some reactive glass powder of the type used in glass-ionomer cements [1].

Despite the presence of these additional components, compomers are similar to composite resins in that they are fundamentally hydrophilic, though less so than conventional composite resins. They set by a polymerization reaction, and only once set do the minority hydrophilic constituents draw water from the surrounding tissues [6,7], so require bespoke bonding agents of the type used with conventional composite resins [7], and their fluoride release levels are significantly lower than those of glass-ionomer cements [8]. Such low levels of fluoride release have been shown to compromise the degree of protection afforded by these materials in vitro experiments using an artificial caries medium [10].

Polymerization in light-cured compomers has been studied using FTIR [3,11], as has the secondary neutralization process [3,11,12]. The polymerization was followed by studying the rate of disappearance of the peaks at 1700-1730, 1630 and 1230-1320 cm$^{-1}$, all of which are associated with C=O double bonds [3,11]. It was found that these peaks disappeared rapidly on exposure to light, so that reaction had proceeded to a substantial extent by 150 s. Despite this, the degree of conversion was only of the order of 50% or less after this time [13]. Polymerization was found to continue after the light was switched off, though at a slower rate, and to proceed for up to 60 h post-irradiation. This phase of the degree of polymerization, $x$, could be described by an equation of the form:

$$x = A + B \ln t$$

where $t$ is the time. For the material Dyract AP, values were $A = 27.7 \pm 0.3 \text{%,}$ and $B = 2.15 \pm 0.01 \text{%,}$ whereas for Compoglass F, $A = 40.3 \pm 0.1 \text{%,}$ and $B = 1.98 \pm 0.06 \text{%.}$ Depth of light penetration was found to be low, due to a combination of absorption by initiator molecules higher up in the specimen, and light.
scattering. This led to the occurrence of fewer free radicals at greater depths [13]. However, despite the observation that polymerization continues for up to 60 h, these materials have generally been found not to increase in strength beyond 24 h even when stored under completely dry conditions [13]. On the other hand, a study using diametral tensile strength to determine changes in mechanical properties showed that strength of Dyract rose from 25 MPa at 1 h to 43 MPa at 24 h [14], a change that is consistent with the continuation of polymerization well after irradiation has been completed.

A detailed study of curing depth in composites and some representative composite resins has been published [15]. Samples were prepared in split stainless steel moulds and cured for 40 s with a light of output 800 mW/cm². Depth of cure was determined either by scraping away uncured material with a plastic spatula from the end that was furthest away from the light, or by using a penetrometer. Results showed that these two techniques gave no significant differences in depth of cure values [15]. Cure depths varied widely, depending on the brand and shade of composite and type of composite resin, but overall findings for composites were broadly comparable to those for composite resins. Thus, although there is a problem of light penetration at greater depths, it is no worse than for conventional composite resins, and does not lead to materials with significantly different depth of cure characteristics.

Polymerization in composites is associated with a contraction stress, as it is in conventional composite resins. This has been studied in detail by Chen et al. [16], who showed that the composite F2000 (3M) had the relatively high maximum stress of 3.41 ± 0.99 MPa, whereas Dyract had a value of only 1.27 ± 0.04 MPa. These values were similar to those found for hybrid composites in dry conditions, but the differences between them were considered important. It was suggested that the rapid development and high value of contraction force could be a possible cause of failure of the bond to the tooth [16], and that Dyract might prove superior in maintaining a bond with the cavity walls because of its low shrinkage stress.

To date commercial composites have all been formulated with carboxylic acid monomers. However, a report has recently appeared of an experimental study that employed a monomer with phosphonic acid functionality [17]. This study involved the setting properties, mechanical strength, wear characteristics and fluoride release of two experimental formulations and compared them with the clinical material Dyract AP. The acidic monomer employed, vinyl phosphonic acid (VPA), was found to inhibit free radical polymerization, so that compared with Dyract AP, the acidic monomer had to be used at very low levels. The formulation containing the least VPA gave the better results, having a depth of cure that compared with Dyract AP, and similar properties of compressive and biaxial flexure strength and fluoride release. Both VPA-containing formulations had superior wear behaviour to Dyract AP, as assessed by a tooth-brush abrasion apparatus using an aqueous slurry of pumice as the test medium. Overall, the study showed that VPA has the potential to be used in the formulation of composites, but that it conferred no particular advantages over the carboxylic acid monomers employed to date [17].

The effect of volume filler fraction on mechanical properties of composites has been studied [18]. Viscosity of the uncured composite paste was found to increase with increasing filler content, but above 20–30% filler volume, there was no improvement in either compressive strength or diametral compressive strength. These findings are what would be expected for a composite system and seem to have made a very modest contribution to an understanding of the formulation requirements of composites.

### 3. Effect of water uptake

A distinctive feature of composites is that, following the initial polymerization reaction [11], they take up small amounts of moisture in situ, and this triggers an acid-base reaction between the reactive glass filler and the acid groups of the functional monomer [3,4]. Among other features, this process causes fluoride to be released from the glass filler to the matrix, from where it can readily be released into the mouth, and act as an anticariogenic agent [10,19]. Polymerization is associated with contraction and the development of measurable stresses [16], and it may be that the sorption of water plays some part in reducing these stresses in vivo.

The role of the reactive glass in the water uptake process has been considered in one report [20]. A conventional composite resin formulation was used as the matrix phase, with filler being either an unreactive glass, Raysorb T-4000, or the ionomer glass G338, whose composition and properties have been described extensively in the literature [21–23]. In each case, the glass was used both with and without a coating of silane coupling agent (+methacryloxy propyl trimethoxysilane). Results were as shown in Table 1.

The results show that silanation reduced the water uptake for both of the glasses and also improved the strength. However, incorporating G338 rather than Raysorb T-4000 gave an inferior result since it took up more water and was of lower strength. Previous studies of water sorption by composite resins have shown that the water accumulates around the filler particles [24], so that one conclusion of the study is that G338 is more hydrophilic than Raysorb T-4000. This suggests that it provides part of the driving force for water uptake by composites, and also that it is responsible for a decline in their overall mechanical properties relative to conventional composite resins.

Composites are designed to absorb water [3,11], and are able to up to the order of 2–3.5% by mass of water on soaking [3]. This water uptake has been shown to be accompanied by neutralization of the carboxylic acid groups, as shown by changes in bands at 1705 and 1555 cm⁻¹. The former band

<table>
<thead>
<tr>
<th>Filler</th>
<th>Biaxial flexure strength (MPa)</th>
<th>Net water uptake (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raysorb T-4000 (silane-free)</td>
<td>148.8 (S.D. 11.0)</td>
<td>0.4 (S.D. 0.0)</td>
</tr>
<tr>
<td>Rayso CT-4000 (silane-free)</td>
<td>152.0 (S.D. 6.1)</td>
<td>0.1 (S.D. 0.0)</td>
</tr>
<tr>
<td>G338 (silane-free)</td>
<td>38.4 (S.D. 4.7)</td>
<td>1.0 (S.D. 0.3)</td>
</tr>
<tr>
<td>G338 (silanated)</td>
<td>68.0 (S.D. 6.0)</td>
<td>0.7 (S.D. 0.3)</td>
</tr>
</tbody>
</table>

Table 1 – Properties of composite formulations containing glass fillers (from Adelung et al. [20])
arises from the presence of carboxylic acid groups within the material, and gradually reduces in intensity on exposure to water. By contrast the latter band arises from the presence of carboxylate salts, and shows a corresponding increase in intensity with time [11,12]. Neutralization has been shown to be controlled by rate of water diffusion [11] and is therefore fairly slow.

Although compomers are designed to take up water in order to promote a later neutralization, these processes have been shown to have an adverse effect on many of their mechanical properties. For example, Nicholson and Alsarheed [25] showed that compressive strength of early compomer formulations declined significantly on storage in physiological saline solution, whereas Dahl et al. showed that flexural strength of Dyract AF and Compoglass F declined on storage in water [26]. In the latter case, the changes were striking, with losses of between 30 and 40% after 3 months. This behaviour differs from that of traditional dental composite resins, which have been found to take up modest amounts of water, but to show no significant changes in mechanical properties [26]. Huang et al. confirmed these differences using ultimate tensile strength (UTS) determinations on hour-glass shaped specimens [27]. When stored in water, Dyract AF showed a significant drop in UTS after 90 days and 180 days compared with the 1-day result, whereas the composite resin Spectrum TPH showed no changes. Dyract AF itself showed no such changes when stored in silicone fluid for up to 180 days [27].

The most comprehensive study of the adverse effect of water on compomers appears to be that of Adusei et al. [13]. In this study, the compomers Dyract AF, F2000 and Compoglass F were studied following storage under wet or dry conditions for up to 4 weeks, and their compressive, biaxial flexure and diametral tensile strengths determined. In general after 24h, no differences were found under wet or dry conditions for any of the materials, but by 4 weeks, for most materials all measures of strength had tended to decline (see Table 2). Hence, whichever means are used to characterise strength, there is generally a decline associated with the with water uptake and neutralization processes.

In our study the effect of ethanol on restorative materials was considered, as well as water, and it was found that the composoer Dyract Posterior was weakened [28]. Evaluation was by the shear punch test, with specimens stored at 37°C for 1 week in air, in distilled water, or in 75% ethanol–water. Dyract Posterior was found to give a significantly lower shear punch strength compared with the control stored in dry air in both water and 75% ethanol.

Not all physical properties have been found to show a decline with long term storage in water. Both microtensile strength and surface hardness appear to be unaffected. According to Mendonca et al., microtensile strength increased slightly but significantly for Dyract AF after 6 months in water, and did not decline to any extent for Dyract, Freedom or F2000 [29] after the same storage period. In a study of surface hardness, Bayindir and Yildiz [30] showed that the hardness of the components Hyvac and Dyract did not change significantly after 60 days storage in water.

### 4. Properties of compomers

#### 4.1. Mechanical properties

There have been numerous studies of mechanical properties of compomers, and typical values have been reported for a range of properties, including compressive, biaxial flexure and diametral tensile strengths, fracture toughness and surface hardness. In general these properties do not differ much, if at all, from those of conventional composite resins.

One mechanical property of compomers that does differ significantly from those of conventional composite resins is toughness. In a study of three compomers and three conventional composites, single-edged notched specimens were used to determine fracture toughness, following 1 week storage in water [31]. For composites fracture toughness fell in the range 1.75–1.92 MPa m$^{1/2}$, whereas for compomers it fell in the range 0.97–1.23 MPa m$^{1/2}$. The authors of this study concluded that, in view of this reduced resistance to crack propagation, compomers should not be used in stress-bearing areas.

#### 4.2. Fluoride release

Compomers are designed to release fluoride in clinically beneficial amounts. Fluoride is present in the reactive glass filler, and becomes available for release following reaction of this glass with the acid functional groups, triggered by moisture uptake. In addition, commercial compomers contain fluoride compounds such as strontium fluoride or ytterbium fluoride, which are capable of releasing free fluoride ion under clinical conditions, and augment the relatively low level of release that occurs from the polysalt species that develops. Fluoride release occurs to enhanced extents in acidic conditions [32,33], and in lactate buffer has been shown to be diffusion-based [32]. A plot of cumulative fluoride release against square root of time was found to remain linear for up to 169h, and to follow the equation:

$$M = a + b \sqrt{T}$$

throughout this time. SEM examination of the materials exposed to lactate buffer showed that they developed voids

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**Table 2 - Losses in strength (MPa) after 4 weeks storage for various commercial compomers [13]**

<table>
<thead>
<tr>
<th>Material/Test</th>
<th>Dry conditions (significance)</th>
<th>Change in distilled water (4 weeks)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dyract AF</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Compressive</td>
<td>213.1–206.0 (NS)</td>
<td>208.7–125.1 (p &lt; 0.01)</td>
</tr>
<tr>
<td>Biaxial flexure</td>
<td>165.3–188.6 (NS)</td>
<td>168.6–137.0 (p &lt; 0.01)</td>
</tr>
<tr>
<td>Diametral tensile</td>
<td>40.0–40.2 (NS)</td>
<td>35.1–23.9 (p &lt; 0.01)</td>
</tr>
<tr>
<td><strong>Compoglass F</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Compressive</td>
<td>110.0–93.8 (NS)</td>
<td>82.7–79.5 (NS)</td>
</tr>
<tr>
<td>Biaxial flexure</td>
<td>167.9–174.5 (NS)</td>
<td>149.1–129.2 (p &lt; 0.01)</td>
</tr>
<tr>
<td>Diametral tensile</td>
<td>36.4–50.6 (p &lt; 0.01)</td>
<td>36.7–26.1 (p &lt; 0.01)</td>
</tr>
<tr>
<td><strong>F2000</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Compressive</td>
<td>213.1-172.5 (p &lt; 0.05)</td>
<td>208.7–147.8 (p &lt; 0.01)</td>
</tr>
<tr>
<td>Biaxial flexure</td>
<td>172.4–188.9 (NS)</td>
<td>155.4–157.6 (NS)</td>
</tr>
<tr>
<td>Diametral tensile</td>
<td>37.6–45.4 (NS)</td>
<td>35.4–24.9 (p &lt; 0.01)</td>
</tr>
</tbody>
</table>
and other surface irregularities, and these clearly assist fluoride release from these comomers. Other equations have been used to describe fluoride release profiles from compomers. Xu and Burgess [33] have suggested two possible equations, one for high-fluoride releasing comomers, which gives the release as:

$$F_L = F_0 (1 - \exp(-kt) + \alpha)$$

On the other hand, for most comomers, and also fluoride-releasing composite resins, a better equation is:

$$F_L = F_0^{\frac{1}{t_{\text{eq}} + t}} + \alpha$$

These authors also demonstrated that fluoride-releasing ability of comomers can be regenerated by using a topical fluoride agent. High-release comomers appear to have greater recharge capacity than low-release ones [33].

The conventional way of determining fluoride release is to employ an ion-selective electrode, and to treat the sample solution with an equal volume of the decomplexing TISAB (total ionic strength adjustment buffer). This liberates fluoride from any potential complexes, and enables to full amount of fluoride to be determined. However, in this study [34], the amount of fluoride without TISAB was also determined, thus obtaining a value for the “free” fluoride in the samples. Results obtained are shown in Table 3, and demonstrate that, though the total fluoride release is greater in acidic conditions, the amount of free fluoride is much less.

The authors speculated that the complexation was caused by the elevated levels of aluminium released under acidic conditions. As an example, for Compoglass F, aluminium concentration rose from 4.68 ppm in water to 104 ppm in lactic acid solution. Aluminium is known to form complexes of the type $\text{AlF}_2^+$ and $\text{AlF}_3^+$ [35] and these have been widely assumed to occur, for example in glass-ionomer cements [36]. However, an alternative suggestion has been made by Billington et al. [37], who have suggested that complexation as monoorthophosphate is also a possibility, and they note that phosphorus levels released by glass-ionomer cements are also typically elevated under acidic conditions. This is also possible for compomers, as their glass filler components are similar to those used in glass-ionomers, and they, too, show elevated phosphorus release under acidic conditions.

### 4.3. Ion release

Ion release by comomers has been studied by Sales et al. [32] and by Nicholson and Czarnecka [34]. Both studies compared neutral and acidic conditions, and both concluded that release of other ions occurred to a greater extent in the acid conditions compared to the neutral ones. The study by Nicholson and Czarnecka is more comprehensive, and shows that comomers release sodium, calcium, strontium, aluminium, phosphorus and silicon in both acidic and neutral conditions, with release levels of all of these ions being greater in acidic conditions compared with neutral ones [33].

### 4.4. Buffering

Comomers have been found to change the pH of lactic acid storage solutions in the direction of neutral [38], and to be repeatable when samples were exposed to fresh lactic acid at weekly intervals over a period of 6 weeks. This behaviour, so-called buffering, has been observed for glass-ionomer cements [39], but was not found for conventional composites [38]. It is therefore a property conferred by the acid-base components of the compomer. Four comomers were used in the study, namely Dyract AP, Compoglass F, Hytac and Ana Compomer, and all increased to pH of the storage solutions by at least 0.26 pH unit. This is less than was observed for glass-ionomers, and as with glass-ionomers, was associated with erosion of the specimens. Buffering has been suggested as being desirable under clinical conditions, since the ability of reduce the acidity of caries-producing acids (mainly lactic) would be expected to reduce the development of caries in vivo [40]. So far, this suggestion is merely speculative, but what is clear from these findings is that comomers share some potentially important chemical features with glass-ionomer cements, and this makes them distinct from conventional composites.

### 5. Clinical applications

Comomers are designed for the same sort of clinical applications as conventional composites. These include Class II [40] and Class V [41,42] cavities, as fissure sealants [43], and as bonding agents for the retention of orthodontic bands [44]. They have been widely used and studied in children’s dentistry, though not exclusively so. Their fluoride release, however, is seen as a useful feature for use in paedodentics, and certain brands have been produced that are specifically aimed at children. For example in America there is a dual-cure compomer known as MagicFil produced by Zenith Dental of Englewood, New Jersey [45] that is available in four bright colours with glitter inclusions, and in Europe there is a similar material known as Twinky Star produced by Voco GmbH in Germany [46].

Clinical results have been reported for all of these potential applications of comomers, and in general findings are positive [47]. They are considered in more detail in the next section.
6. Clinical performance

Right from the time they were first launched, compomers have shown acceptable clinical performance in a variety of clinical applications [48–50]. However, wear characteristics of early materials were poor [51] and there were concerns about their durability. Despite this, the early results were promising [48,52], and more recently, results with newer formulations have also been good.

Typically, compomers have been evaluated against the so-called Ryge criteria [53]. These are designed to standardize the criteria against which dental restorative materials are evaluated in vivo, and include features such as discoloration, marginal integrity, adaptation and anatomical form. These are scored on a simple scheme, typically ranging from alpha (the best) through bravo and charlie in declining order [53].

For example, an evaluation of Dyract AP after 2 years clinical placement showed mainly alpha grades on all Ryge criteria [54], with only minor amounts of marginal discoloration and some loss of marginal integrity. Wear was noted to be acceptable, and to have improved by comparison with early compomer formulations [54].

Compomers have been widely used in Class V restorations. For example, the compomers Dyract AP, Compoglass F and F2000 were evaluated for use in this application over a 2-year period [54]. This study concluded that, after this time, all three materials showed an acceptable level of clinical performance. Not all compomer materials have proved so acceptable: in a 1-year study of Class V restorations, the material Freedom scored “bravo” or “charlie” for all the examined criteria (colour match, marginal discoloration, caries, anatomical form, marginal integrity and surface texture), whereas F2000 scored mainly “alpha” [41]. This shows that compomers are not all the same, but have properties which vary between brands, according to precise details of their formulation.

Colour stability has been found to be somewhat of a problem with compomers in a few studies. This is not entirely surprising, given that they are designed to take up water, which is likely to alter appearance through a change in refractive index, and also to carry with it coloured chemical species (stains) from certain foodstuffs such as coffee and red wine.

In a 3-year study of Class V restorations of Dyract, Demirci et al. [42] found that all Ryge criteria were good, except those relating to colour change, i.e. colour stability and marginal discoloration. In both of these there were significant changes [42]. A 5-year study essentially confirmed this finding [55], and suggested that the performance of Dyract was superior to that of the resin-modified glass-ionomer cement Vitremer [55]. This superiority of compomers over resin-modified glass-ionomers has been reported by others [56] and seems to be a general observation in appropriate clinical applications.

Compomers have been used as fissure sealants [43], and a clinical study examined the teeth of children aged between 7 and 10 years sealed by the compomer Dyract Seal. Sealed teeth were examined post-operatively at 3, 6, 12 and 24 months, and were also evaluated by the Ryge criteria. In general Dyract Seal behaved as well as a conventional composite resin sealant, except on the criterion of marginal integrity, showing that this material was acceptable for its clinical application, at least of the 24 months period of the study [43].

Compomers have also been used for Class I [49] and Class II restorations [49]. In the Class I study, they were used in composite laminate restorations, and were shown to perform as well as conventional composite resins [46]. In the Class II study, they were studied over 7 years in children aged between 3.6 and 14.9 years. Again performance was indistinguishable from that of conventional composite resins.

Lastly, compomers have been employed as cements for orthodontic bands and there have been a number of full studies of compomers in this application [48,57]. Results have been generally extremely good for compomers, except in the realms of taste, as determined by the patient, and in which compomers scored less well than glass-ionomers. Thus, compomers have been shown to have acceptable performance as materials for use in orthodontic band retention, though the final choice of cementing agent could be left to patients. If they found the taste of the compomer particularly objectionable, a resin-modified glass-ionomer could be used equally effectively instead.

7. Conclusions

Compomers have been developed as distinctive materials for use as repair materials in clinical dentistry. The presence in them of minor amounts of both acid-functional monomer and basic ionomer-type glass confers new properties; namely the ability to draw in moisture to trigger an acid-base reaction, leading to the capacity to release fluoride and buffer acidic environments. However, these clinically desirable features come at a price, since water uptake has been shown in several studies to be associated with reductions in strength over periods of only a few weeks of up to 40% in some instances. Conversely, clinical studies have shown that these materials perform well in a variety of applications: Class I, Class II and Class V restorations, as fissure sealants, and as orthodontic band cements. Overall, the major conclusion from these clinical results is that compomers perform well, and are suited to their suggested uses in dental restoration. The reduction in strength due to water uptake does not seem to be important clinically and these materials are suited to use in vivo.

Appendix A. Commercial compomer brands discussed

<table>
<thead>
<tr>
<th>Brand</th>
<th>Manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ana Compomer</td>
<td>Nordiska Dental, Sweden</td>
</tr>
<tr>
<td>Dyract</td>
<td>Dentsply, Konstanz, Germany</td>
</tr>
<tr>
<td>Dyract AP</td>
<td>Dentsply, Konstanz, Germany</td>
</tr>
<tr>
<td>Dyract Cem</td>
<td>Dentsply, Konstanz, Germany</td>
</tr>
<tr>
<td>Dyract Posterier</td>
<td>Dentsply, Konstanz, Germany</td>
</tr>
<tr>
<td>Dyract Seal</td>
<td>Ivoclar-Vivadent, Liechtenstein</td>
</tr>
<tr>
<td>Compoglass</td>
<td>Ivoclar-Vivadent, Liechtenstein</td>
</tr>
<tr>
<td>Compoglass F</td>
<td>Ivoclar-Vivadent, Liechtenstein</td>
</tr>
</tbody>
</table>
REFERENCES


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