6 The Role of Glass-ionomers in Paediatric Dentistry

David John Manton and Katie Bach

Abstract

Children provide many challenges in clinical dentistry and behaviour management. All dental care provided for a child should consider the characteristics of that individual such as age, behavioural capabilities and 'total treatment load'. Especially in the child at high risk of dental caries, the use of low-viscosity glass-ionomer cements (GICs) in timely protection of 'at-risk' surfaces of molar teeth is of great benefit. The selection of an appropriate restorative material can be influenced by the caries risk, age to exfoliation of the primary tooth, size and position of the carious lesion, pulpal status and other factors such as appearance. GICs are the primary material of choice for the cementation of preformed metal crowns and are also useful in sealing over pulpotomy agents to maintain seal and pulpal health. The use of GIC in orthodontics, especially in those individuals with increased caries risk, is advisable. Whether used as a band or bracket cement, GIC decreases the risk and extent of white spot lesion formation around orthodontic fixtures, and if applied accordingly, bond strengths are high enough to undertake orthodontic care efficiently.

6.1 Introduction

Glass-ionomer cements (GICs) are one of the materials that are highly suited for use in children; however, due to the apparent simplicity of its use and often claimed (but sometimes overstated) widespread suitability for many restorative situations, it is also prone to misuse as well. From pit and fissure sealing to temporisation of a carious lesion to definitive restorative care, GIC can be used widely in the child; however, like all materials, the suitability of GIC should be considered in the context of the individual case.

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6.2 Prevention of Caries

In the developing child, the occlusal surfaces of the first permanent molars are at high risk for the development of carious lesions due to the inability to clean the pits and fissures effectively, so protection of these surfaces in a child is imperative to reduce the need for restorative care. The risk of occlusal caries can be reduced by the placement of fissure sealants on these surfaces (Beauchamp et al. 2008). Traditionally, the fissure sealant of choice has been resin based; however, for resin sealants to be successful, excellent moisture control must be obtained, and this often relies on the placement of rubber dam (Simonsen and Neal 2011). For many children, it is not possible to achieve adequate moisture control due to inability to place a rubber dam clamp, often due to partial tooth eruption or behavioural issues.

Glass-ionomer cements can provide an effective alternative option for fissure sealing, where moisture control or access may prove difficult (Fig. 6.1). This may be advantageous in young children with partially erupted teeth or in patients with special needs. It must be appreciated that these surface protectants may not have retention rates as successful as traditional resin sealants placed in a carefully controlled environment. However, the important issue to consider is that prevention of caries is the outcome of interest with sealants, and many studies report that caries prevention is similar between resin- and GIC-based sealants. Using an impression technique, Frencken et al. (2007) reported micro-retention of GIC in the base of the fissures in teeth that appeared to have lost their GIC sealant, possibly providing a mechanism and explanation of why complete retention may not be as important for GICs as it is for resin-based sealants (Fig. 6.2). The leaching of fluoride from the sealant is another mechanism that may influence caries prevention, especially with the high fluoride release of low-viscosity products such as Fuji VII/Fuji Triage (GC Corp, Tokyo, Japan).

Whilst resin-based sealants have higher retention rates, this does not necessarily equate to higher rates of caries prevention (Ulusu et al. 2012). Much of the evidence regarding both resin and GIC sealants may be affected by selection and publication bias (Simonsen 1996). The literature does not suggest that there is any difference between the caries-preventive effects of GIC and resin-based fissure sealants (Mickenautsch and Yengopal 2011). When GIC sealants clinically appear partially or totally lost, often the base of the fissures still remains sealed (Mickenautsch et al. 2011). There is evidence to suggest that whilst the bulk of the GIC sealant material placed may be lost within 2–3 years post-placement, newly erupted teeth that are sealed with GIC show a significantly lower dentine caries rate than those that were not sealed (Taifour et al. 2003).

Glass-ionomer sealants have the added benefit that they may be placed outside the traditional ‘dental environment’, as they can be placed with limited dental instrumentation and infrastructure. This may have added benefits in developing

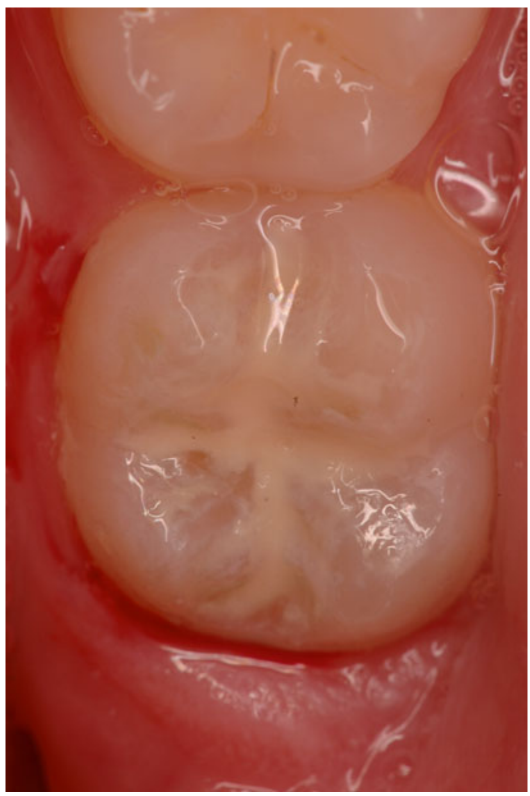

Fig. 6.1 Glass-ionomer sealant (Fuji IX GP Extra, GC Corp, Tokyo, Japan) on first permanent molar (Courtesy of A/Prof J. Lucas)

countries or for school-based sealant programmes, especially as they can be hand mixed, negating the need for electricity for a triturator or suction and a light-curing unit required for resin-based sealants. However, this is not to suggest that GIC sealants can be placed in an environment heavily contaminated by saliva, as this will reduce the sealing capability and retention rate, although nowhere near the effect contamination has on resin-based sealants – environmental

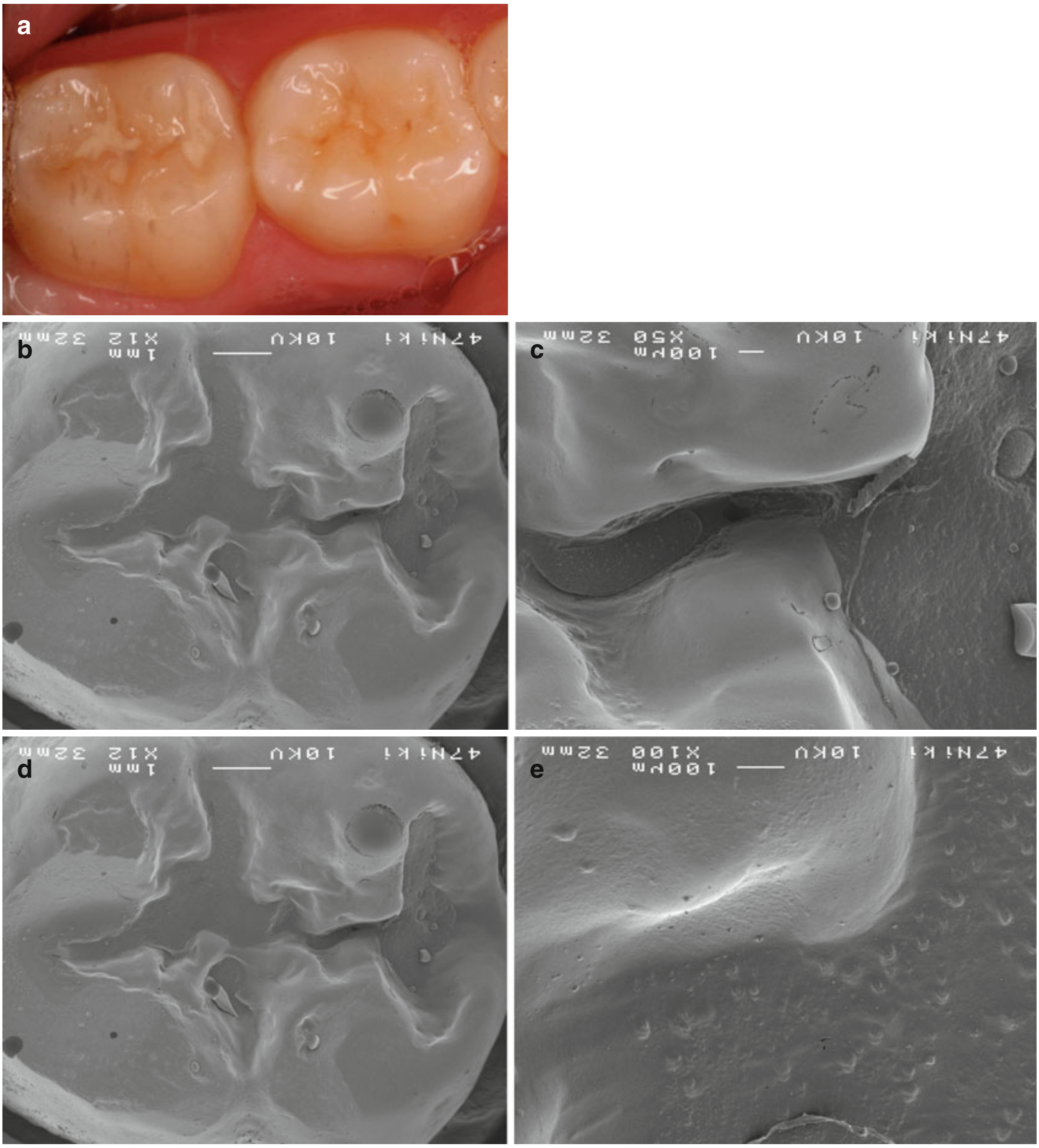

Fig. 6.2 Glass-ionomer cement (Fuji IX, GC Corp) sealant placed on tooth 46 (13 years previously) and tooth 47 (12 years previously). (**a**) Clinical image of GIC sealant. (**b**) SEM of resin replica of remnant GIC in 47 fissure (area highlighted in Fig. 6.2a is highlighted here) (×12). (**c**) SEM of resin replica of remnant GIC in 47 fissure: higher magnification of area outlined in Figs. 6.2a, b (×50). (**d**) SEM of close surface adaptation of GIC in 47 fissure (×12). (**e**) SEM of close surface adaptation of GIC in 47 fissure: higher magnification of area outlined in Fig. 6.2d (×100) (Courtesy of Prof J. Frencken)

control is still important for GIC sealants (Kulczyk et al. 2005; Farmer et al. 2014).

6.3 Effects on Approximal Surfaces

GIC sealants may have some benefit in promoting remineralisation and inhibiting demineralisation in approximal surfaces. They were shown to be effective as a sealant of approximal white spot lesions after the teeth had been separated to obtain direct access (Trairatvorakul et al. 2011). There is evidence to suggest that fluoride-containing glass-ionomer sealants also provide protection to teeth immediately adjacent to the sealed tooth (Cagetti et al. 2014). It has been reported that the distal surfaces of second primary molars next to first permanent molars sealed with a glass-ionomer have significantly lower levels of carious lesion development than those approximating a first permanent molar sealed with a resin-based material (Cagetti et al. 2014).

6.4 Restorative Care

The atraumatic restorative treatment or ART technique, developed by Frencken and Holmgren, was first published in 1994 (Frencken et al. 1994). This technique allows a carious lesion to be prepared using hand instruments for carious tissue removal and restored using an adhesive material such as GIC. This technique is more often than not carried out without local anaesthetic. The ART technique should be used with careful case selection and is not a gold standard alternative to conventional tooth preparation and restoration where this is available.

This technique may be useful in populations where access to conventional dentistry is not available or in young and uncooperative children where access to general anaesthesia may be limited. A definitive diagnosis must be made before considering whether ART is an appropriate treatment; teeth with signs and symptoms of irreversible pulpitis, or those with lesions that extend to the pulp on radiographs, are not appropriate for this mode of treatment. The extent of the lesion must also be assessed as ART has higher success rates in teeth with single surface lesions compared to multiple surfaces (Frencken et al. 2007). The site of the lesion also has some influence, with survival rates after 6.4 years of non-occlusal posterior restorations reported to be 80.2 %, as compared to 64.8 % for occlusal posterior restorations (Frencken et al. 2007).

Glass-ionomer cement is an ideal material for this treatment as it is relatively cheap and adheres well to the tooth structure and can be hand mixed if necessary, although some would consider the quality of capsule-mixed GIC to be higher than hand mixed. As ART is usually carried out in environments with limited dental infrastructure or in pre-cooperative or uncooperative children, obtaining a retentive cavity preparation or ideal moisture control may be difficult; therefore, GIC becomes a more favourable material compared to resin composite and silver amalgam. However, the clinician should not ignore the effect of good moisture control on the success of GIC restorations. In hot and humid areas, care taken over maintaining 'normal' temperatures of the materials should be considered, as setting times and handling characteristics can vary greatly, often to the detriment of the success of the procedure.

6.5 'Contemporary' Carious Tissue Removal

A relatively recent treatment modality in dentistry, which coincides with the increased popularity of ART, is that of a more conservative attitude towards dentine caries removal (Borges et al. 2012). Teeth must be carefully selected for this procedure; clinical and radiographic diagnosis must rule out any signs and symptoms of pulpitis unable to be reversed or the presence of periapical lesions. The technique relies on the removal of the soft infected dentine and recommends leaving a small amount of firmer affected dentine. This serves to preserve tooth structure and to avoid carious or iatrogenic pulp exposure, with improved outcomes in both primary and permanent teeth (Ricketts et al. 2013). The main limitation with this concept is that it is basically impossible to determine what is affected or infected dentine in the clinical situation – and physical features such as hardness or resistance to the excavation instrument should be considered as a primary indicator, although these are also prone to subjective variability. A sound perimeter is required so that a seal can be obtained at the margins, decreasing the chance of leakage and subsequent lesion progression (Fig. 6.3).

For any restorative technique to be successful, there must be arrest of the carious process, hardening (remineralisation) of the dentine on the cavity floor, and the formation of reactionary dentine to provide protection to the pulp. The material placed over the pulp must provide an adequate seal, and antibacterial properties may be of advantage, although the seal is the primary feature the clinician should seek (Duque et al. 2009). Historically, calcium hydroxide cements have been used for both direct and indirect pulp capping. However, they have some disadvantages such as high solubility and low-compression resistance, and they do not bond well to dentine (Duque et al. 2009). There is now evidence indicating that GICs may assist with the remineralisation process of the affected dentine, due to their antibacterial properties, ion exchange capabilities involving strontium and fluoride, and favourable bonding characteristics to dentine (Duque et al. 2009; Watson et al. 2014). Recently a calcium-based remineralising agent, casein phosphopeptide-amorphous calcium phosphate (CPP-ACP), has been added to a low-viscosity GIC material to increase calcium ion release (Fuji VII EP, GC Corp, Tokyo Japan). However, there is limited evidence whether this material increases remineralisation of dentine due to its high concentration of bioavailable calcium and phosphate. The recent introduction and promotion of a calcium silicate cement (Biodentine®, Septodont, Saint-Maur-des-Fossés, France) as a dentine substitute has created another option for coverage of deep lesions. Recent research indicates that Biodentine may produce better outcomes at 12 months compared with glass-ionomer cement in deep lesions at least three-quarters into the dentine when it is used as an indirect pulp capping material. However, further research with longer-term follow-up and increased subject numbers is needed (Hashem et al. 2015).

Glass-ionomer cements may be used as a conventional restorative material in carefully selected cases. There are several factors that should be considered when selecting a restorative material for the primary dentition. The age of the child and caries risk are the first factors that should be considered, in conjunction with the size of the lesion. Caries risk is often thought of as a static factor; however, it can vary throughout life, so consistent assessment is necessary to allow the clinician to make informed decisions regarding the most appropriate preventive and restorative care of the child. The estimated time until tooth exfoliation is another important factor that varies with tooth type. Location of the lesion to be restored with respect to functional load also influences material selection, and the use of GIC in areas of high loading or in poorly supported multi-surface lesions is often inappropriate.

Glass-ionomer cements are a good base material for two-surface resin composite restorations in children. With options of the 'open' or 'closed' sandwich technique, this restoration is comprised of a GIC or resin-modified GIC (RMGIC) base that is sealed with a resin composite restoration. The open technique leaves a layer of GIC material exposed at the gingival margin of the approximal box. It is advisable to avoid having GIC at the contact point, due to possible material wear and subsequent loss of arch space. The success of open sandwich restorations has been reported to be high (Atieh 2008). The closed sandwich uses GIC as a dentine seal with resin composite enclosing the GIC. With this technique, the presence of enamel at the gingival floor of the cavity preparation is an advantage as bond strengths are increased and microleakage decreased compared to a dentine margin.

Cavity design is based around removal of soft demineralised necrotic dentine and establishment of a sound perimeter or margin. Currently, there is a lack of evidence-based definitions that relate to the treatment of carious lesions, such as what is 'hard' dentine, what is necrotic dentine, how does the clinician identify these conditions and

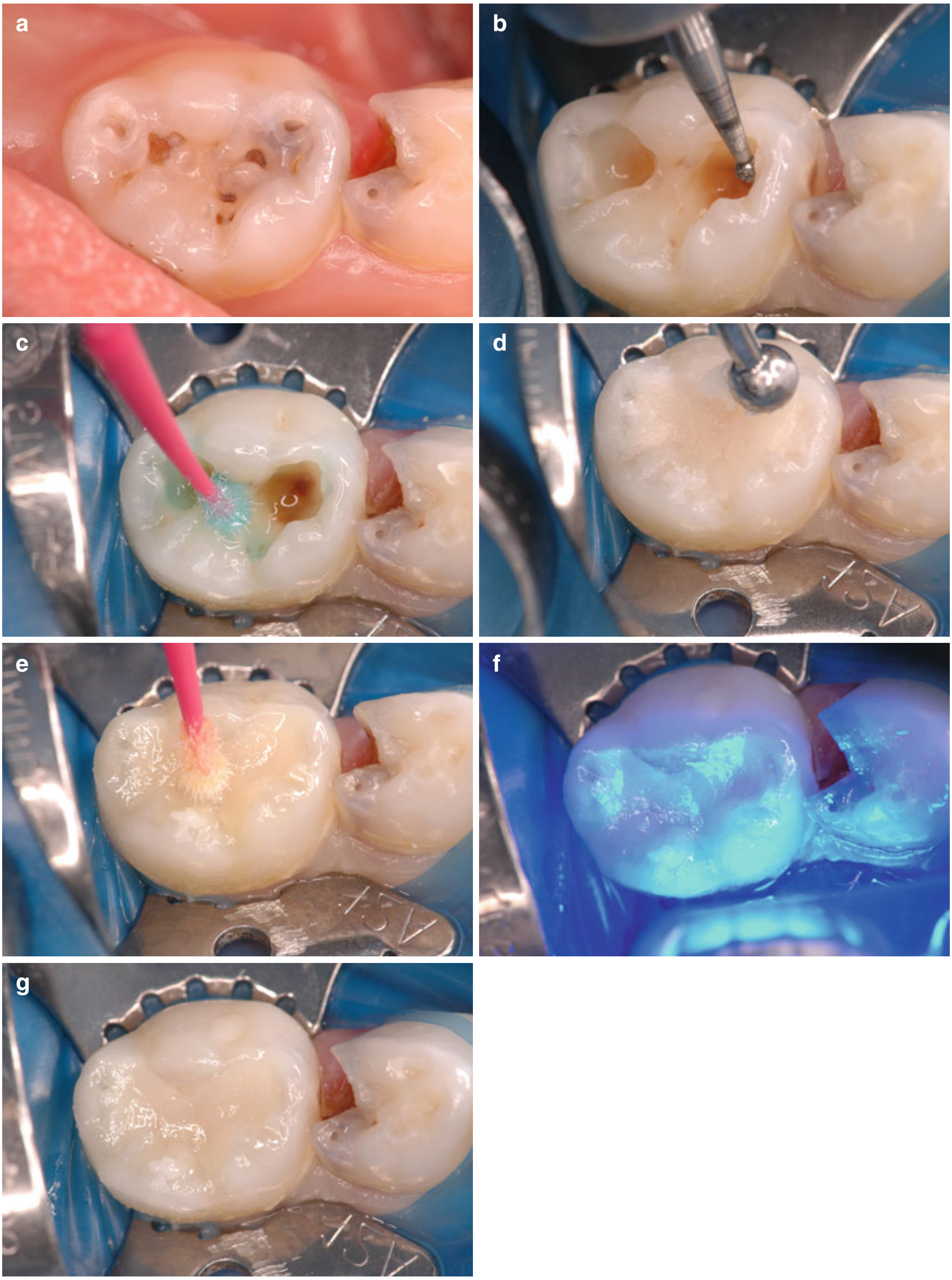

Fig. 6.3 Placement of GIC (Fuji IX) restoration in second primary molar. (**a**) Occlusal (pit and fissure) carious lesions. (**b**) Removal of degraded carious tissue. (**c**) Conditioning of prepared surfaces (note residual hard stained dentine). (**d**) Placement of GIC restorative (Fuji IX Extra, GC Corp). (**e**) Placement of resin laminate coating (G-bond, GC Corp). (**f**) Light-curing of resin laminate coating. (**g**) Final restoration. Note the carious lesion in the first primary molar. This would be suitable for preformed crown placement luted with low-viscosity GIC over GIC core – with pulp therapy if indicated (Courtesy of A/Prof J. Lucas)

also what a sound margin actually is? Fortunately, the recently established International Caries Consensus Collaboration (ICCC) is establishing guidelines for these often subjective definitions.

It is recommended that after a pulpotomy is performed on a primary molar tooth, a preformed metal crown is cemented with GIC. This provides protection of the remaining structure and a high success rate when compared to an intra-coronal tooth-coloured restoration (Kindelan et al. 2008; Hutcheson et al. 2012).

GICs can be effective materials for the cementation of preformed metallic crowns, which rely on high retentive strength and a good marginal seal to ensure that they are a successful restoration (Yilmaz et al. 2004). Poor seal may lead to the development of biofilm at the margins and subsequent microleakage, both of which may result in the development of a new carious lesion or periodontal complications. Another major issue with the lack of patency of a cement seal is the problem with pulpal health, and leakage increases the chances of pulp inflammation and necrosis, whether a pulpotomy has been undertaken or not. Adhesive cements such as glass-ionomer cements have the advantage of providing a mechanical and adhesive bond between the stainless steel crown and the tooth (Memarpour et al. 2011).

Whilst preformed metallic crowns are the most durable restorations we have in paediatric dentistry, they are still prone to wear due to excessive occlusal forces. With significant wear, areas of the occlusal surface of the crown can be perforated, exposing the luting cement and tooth structure below. In cases where the crown is soundly sealed at the gingival margin and displays no movement or signs of symptoms, one option is for the occlusal surface to be repaired, especially if the tooth is within a few years of exfoliation, with the other option being crown replacement. The material that is chosen to repair the crown must display satisfactory sealing ability to both the crown and the tooth surface, as well as create a seal that will prevent microleakage that can lead to failure of the repair or the crown/pulp complex itself. It has been shown that preformed metallic crowns that have been repaired with a GIC display lower levels of microleakage than crowns that were repaired with a resin composite (Yilmaz et al. 2011). Crown repair would usually be appropriate when the tooth is within a year or two of exfoliating; if the child is younger than this, replacement is more appropriate.

Dental care of the paediatric patient involves the consideration of a number of factors, including caries risk, age, behavioural capabilities and compliance of the child and the parents. Following are two cases illustrating differing clinical scenarios.

Clinical examples:

1. A 3-year-old male – the current high caries risk was illustrated by a highly cariogenic diet of processed foods, soft drinks and frequent snacking, poor oral hygiene and intermittent use of fluoridated toothpaste. After discussion of the risk factors with his mother, it was felt that it was unlikely that the caries risk would change in the short term. After examination and bitewing radiography, eight approximal lesions in the first and second primary molars, all cavitated and reaching the inner half of the dentine, were noted. Due to the limited ability to change caries risk, it was suggested that these teeth were restored with preformed (stainless steel) crowns cemented with a low-viscosity GIC, with pulp treatment as appropriate. This is due to the high long-term success rate of preformed crowns and the ability to 'seal off' other surfaces of the tooth at risk of developing carious lesions in the future.
2. An 8-year-old female – with high caries risk during childhood; however, this is decreasing due to a low cariogenic diet and excellent oral hygiene (assisted by her parents), so it can be considered that her caries risk is likely to become low. After examination and bitewing radiography, two approximal lesions on the distal surfaces of the maxillary second primary molars limited to the outer half of the dentine were noted. She is dentally advanced, so therefore the use of GIC or RMGIC is appropriate due to the relatively short survival time before exfoliation and her decrease in

caries risk. Care should be taken in examining the mesial surfaces of the first permanent molars when restoring the teeth, as white spot lesions may be present.

6.6 Endodontic Care

The use of GICs in the endodontic care of children can be widespread. As previously mentioned, maintenance of retention and seal of a preformed metal crown is implicitly associated with pulpal health. Other uses of GICs include orthograde and retrograde canal/apical seal and repair of root resorptive defects and perforations (De Bruyne and De Moor 2004). More recently, the use of calcium silicate cements such as mineral trioxide aggregate (MTA) and Biodentine® has taken the place of GIC in many of these endodontic procedures such as perforation and resorptive defect repair as well as apical sealing (Watson et al. 2014).

6.7 Orthodontic Care

Glass-ionomer cements have many applications in orthodontic practice. GICs can be used to cement orthodontic molar bands. These molar bands may be used as anchorage in full fixed appliances or for orthodontic appliances such as quad helices, band and loop space maintainers or habit-breaking devices. De-cementation is a common reason for failure of these appliances. However, there may be some advantage associated with a weaker bond when compared to resin-based cements, as these appliances will all eventually need to be removed, preferably without damaging any tooth structure. Another advantage is that if more than one cementation point exists, an issue with resin-based cements is that one area of adhesion can fail. However, the strength of the remaining bond allows the appliance to stay in place, with a potential for leakage and subsequent demineralisation of the underlying tooth structure, due to the inability of the patient to clean this surface. On the other hand, when there is cement failure of a bracket to the enamel, the tendency for GIC-based cements is to fail completely and the bracket debonds; this decreases the chance of enamel demineralisation from partial cement failure. The release of fluoride from the GIC-based cement also decreases demineralisation potential under the appliance. More recent RMGIC materials have been reported to have similar bond strengths to resin cements, especially if the enamel surface is pretreated (Cheng et al. 2011).

The downside of using GICs with orthodontic brackets is that they have lower bond strengths than conventional resin cements (Wiltshire 1994). The bond strength of a GIC may be improved by adding resin as in RMGICs. These resin-modified GICs have higher bond strengths and may have an advantage in cementation of brackets (Shimazu et al. 2013).

There is building evidence of the benefits that RMGIC cements may bring for bonding of orthodontic brackets in patients with increased caries risk. In many cases, orthodontic appliances increase an individual's caries risk, with many patients developing white spot lesions adjacent to brackets (Sudjalim et al. 2006; Benson et al. 2013). Apart from the potential of a need for restoration if advanced, these lesions are unsightly and pose a challenge to remineralise with an aesthetic result in an acceptable time period for the patient. Glass-ionomer cements provide the advantage of fluoride release that reduces the progression and extent of carious lesion development (Czochrowska et al. 1998; Benson et al. 2005; Paschos et al. 2015). There are also reported antibacterial effects from a commercially available RMGIC orthodontic lute (Fuji ORTHO LC, GC Corp, Tokyo, Japan) which may have some impact on demineralisation in the local area (Slutzky et al. 2014).

The use of protective coatings around brackets in high-risk patients has been suggested. Materials such as resin-based sealants have been proposed; however, recent in vitro research indicates that low-viscosity high-F-release materials such as GICs may have more of a role in this area, especially due to their long-term fluoride release (Yap et al. 2014).

In some cases, prior or during orthodontic treatment, it may be advantageous to temporarily increase the vertical dimension for occlusal clearance of interferences. Occlusal clearance may be required to correct crossbites or create space to move teeth. This can be achieved with the placement of GIC or RMGIC on the occlusal surfaces of the posterior teeth. This involves no tooth preparation of the teeth and the material is easily removed.

6.8 Parental Concerns

There are growing numbers of parents who have increasing demands with respect to the materials that are used as restorative materials in their children; these are often parents who demand the most aesthetic restoration for their child. Many resin-based sealants and resin composites include in their ingredient list a derivative of bisphenol A (BPA), most often BPA glycidyl dimethacrylate (bis-GMA) (Fleisch et al. 2010). Pure BPA may have some oestrogenic properties and disrupt some endocrine functions, and the evidence suggests that exposure to BPA may have some adverse health effects (Fleisch et al. 2010). Some researchers have suggested that exposure to BPAs may increase the prevalence of hypomineralised enamel defects (Jedeon et al. 2013). The current evidence suggests that exposure to BPA from dental materials is transient and that exposure can be well controlled in the dental surgery as long as the resin cement is cured effectively (Fleisch et al. 2010; Purushothaman et al. 2015). However, in the current climate of 'google medicine' and the ability of parents to find reports from many sources, there can be times where they will be reluctant to consent to some materials being used; unfortunately, these parents may also be those who are reluctant to have fluoride-containing materials placed in their children. Glass-ionomer cements may be useful in these cases provided that the material is clinically indicated and appropriate and that the parent will accept a fluoride-containing restorative material. In these cases, parents must be warned of the limitations of this material over resin composite in certain situations. However, some parents may be concerned about the other constituents of GICs such as aluminium and their putative relationship with neurodegenerative diseases. There is little evidence to support such a relationship; however, clinicians need to be aware of possible concerns of parents and be able to answer their concerns readily.

Conclusions

Glass-ionomer cements can be used in a variety of situations in children from prevention of dental caries to endodontics and orthodontics. The selection of an appropriate restorative material can be influenced by the caries risk, age to exfoliation of the primary tooth, size and position of the carious lesion, pulpal status and other factors such as appearance. GICs may be used as a conventional restorative material in carefully selected cases, as well as in the ART technique, as a base material under resin composite restorations, in the treatment of uncooperative children and those with special needs. They are also useful for the protection of pits/fissures and 'at-risk' surfaces of molar teeth, especially in the child at high risk of dental caries. GICs are the primary material of choice for the cementation of preformed metal crowns and are also useful in sealing over pulpotomy agents to maintain seal and pulpal health. The use of GIC in orthodontics, especially in those individuals with increased caries risk, reduces the risk and extent of white spot lesion formation around orthodontic fixtures. With appropriate treatment planning and consideration of the child's individual needs, the use of GICs can be of great benefit and simplify the treatment for the child and the clinician.

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