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Report on the clinical technique of thermo-curing glass-ionomer sealant

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Controversy exists regarding the general safety of resin sealants and in particular their use in children, due to the possible leaching of non-polymerized monomers including bisphenol A. A thermally cured high-viscosity glass-ionomer cement (GIC) is suggested as a first-choice sealant material. An innovative approach of thermo-curing the GIC during placement is presented. The step-by-step clinical procedure and rationale for the biomimetic thermo-cured glass-ionomer fissure sealant are introduced and described. A thermally cured GIC sealant may provide long-term caries protection to fissures and pits without the need to maintain and reseal. GICs are both biocompatible and biomimetic resulting in formation of fluorapatite, the ultimate protection against dental caries. *(Quintessence Int 2015;46:699–705; doi: 10.3290/j.qi.a34179)*

Key words: glass ionomer, pediatric dentistry, sealant

Sealants are dental resins that are applied to the pits and fissures of teeth to inhibit and prevent dental caries. Approximately 90% of caries lesions are found in the pits and fissures of permanent posterior teeth.[1] They act as a physical barrier preventing oral bacteria and dietary carbohydrates from creating the acid conditions that result in caries.[2] Application of pit and fissure sealants and topical fluorides are procedures widely used in the prevention of dental caries, and their effectiveness has been proved in studies and systematic reviews.[2-7]

The most popular fissure sealants are resin-based. Controversy exists regarding the general safety of resin sealants and in particular their use in children, due to the possible leaching of non-polymerized monomers.[8] Biocompatibility is an important feature of any material designed for use within the body. An ideal restorative material should also be biomimetic. A biomimetic material aims to follow the natural mineralization processes taking place in the mouth. Glass-ionomer cements (GICs) are both biocompatible[9-11] and biomimetic.[12-16] Conventional GIC materials have a semipermeable surface, which allows calcium and phosphate ions that are present in saliva to pass through the sealant and combine with the fluoride to produce remineralization of the enamel as fluorapatite. Recently the use of thermal curing of GIC has been introduced, which improves the physical properties of these materials making them a close-to-ideal material for pit and fissure sealants in children.[17-22]

The step-by-step clinical procedure and rationale for the biomimetic thermo-cured glass-ionomer fissure sealant are introduced and described.

STEP-BY-STEP CLINICAL PROCEDURE

The procedure and clinical tips for placing GIC sealants are described below and illustrated in Figs 1 to 7.

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Fig 1 Cotton roll or Dri-Angle isolation is the most common method.

Fig 2 Following conditioning and rinsing, a high-viscosity glass ionomer is immediately placed on the tooth.

Isolation

Cotton roll or Dri-Angle® isolation is the most common method (Fig 1). Cotton rolls are held in place with either cotton roll holders or fingers, and a saliva ejector can also be employed to provide additional moisture control. The wet absorbents (cotton rolls and/or Dri-Angles) may need to be replaced once during the sealant procedure.

Conditioning

Several methods of cleaning or preparing fissures have been advocated over the years, prior to resin sealant placement. When placing GIC sealants the enamel surface is both cleaned and conditioned during the same step. Etchants such as phosphoric acid are contraindicated. A polyacrylic acid may be used such as Dentin Conditioner (GC America) for 10 seconds; however, the authors suggest using sodium hypochlorite (Dakin's solution) diluted to a concentration of approximately 1% to 1.5% for 5 to 10 seconds applied with a microbrush or sponge as a disinfectant.[23]

Clinical tip: To avoid rejection, inform young patients that the cleaning solution may taste somewhat like "swimming pool" water.

The tooth is rinsed with water to remove the conditioning agent and only slightly dried; care should be taken not to desiccate the enamel.

Sealant placement and curing

A high-viscosity capsulated GIC should be used. The use of hand-mixed products is not recommended due to lack of uniformity and the resultant increase in the material's solubility and decrease in wear resistance. While the tooth is being conditioned, the dental assistant activates the GIC capsule as per the manufacturer's instructions.

The material is immediately placed on the tooth, which is slightly overfilled (Fig 2); the entire occlusal surface is covered with cement (Fig 3).

The clinician pushes the material deep into the fissures and smooths it onto the tooth with a petroleum jelly (Vaseline®) to protect the material from premature ion diffusion during setting (Fig 4).

An explorer is used to remove excess material mesially and distally.

The patient is asked to occlude; some clinicians may opt to skip this step. A heat source (high output LED lamp, minimum 1200 mW) is immediately applied to the material for 60 seconds. The lamp is placed close to the material and remains stationary in one spot (Fig 5).

Clinical tip: Only use a high-energy irradiation lamp. A minimum amount of energy (temperature) is needed for initiating the accelerated process. An easy trick to check whether your LED device generates sufficient heat is to shine the lamp on your finger. Within 10 seconds the irradiated spot should be so hot that you have to withdraw the lamp quickly.

After heat curing there is no need for additional protection of the GIC surface with resin varnishes or gloss.

Fig 3 The occlusal table is slightly overfilled; the entire occlusal surface is covered with cement.

Fig 4 The clinician pushes the material deep into the fissures and smooths it onto the tooth with a petroleum jelly- or coconut butter-coated gloved finger.

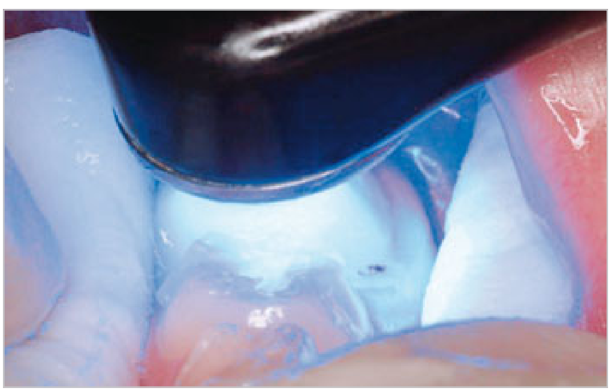

Fig 5 A heat source is immediately applied to the material for 60 seconds.

Fig 6 Immediately following heat cure the material may be polished with high speed/diamond finishing burs and if necessary occlusion may be adjusted.

Immediately following heat cure the material may be polished with high-speed/diamond finishing burs and if necessary occlusion may be adjusted (Fig 6).

Procedure time

The sealant is completed within a total time of 1.5 minutes (Fig 7).

Fig 7 The completed fissure sealant.

DISCUSSION

It is generally accepted that the effectiveness of resin sealants for caries prevention depends on long-term retention.[3,6] Resin sealant effectiveness is directly related to sealant retention, since caries will not occur if the sealant remains in place, completely covering the pits and fissures. Resin-based sealants change the occlusal morphology by forming a micromechanical-bonded resin layer that functions as a physical barrier between the enamel surface and the oral environment. Full retention of sealants is evaluated through visual and tactile examinations. In situations in which a sealant has been lost or partially retained, it has been recommended that a sealant be reapplied to ensure effectiveness. The need for life-long maintenance of resin sealants must be explained to parents before their placement, and enquiries such as "how long do sealants last?" or "for how long do they need to be maintained and resealed?" need to be addressed. Conversely, GIC sealants with their ability to adhere to untreated enamel surfaces and continuous release of fluoride[24] may afford lifetime caries protection. Glass ionomers bond to both enamel and dentin by physicochemical mechanisms following polyacrylic acid conditioning. Incorporation of the released fluoride into the adjacent enamel and dentin enhances caries resistance, remineralizes enamel caries and affected dentin, and alters the bacterial composition and metabolic byproducts of plaque.[25] Although it is generally accepted that resin-based fissure sealants are retained longer than GICs,[26,27] it is unclear as to which sealant type better prevents caries.[28-30] If success is not defined as physical retention of the material but rather as lack of caries, GIC sealants may be judged as being superior to resin sealants.[30] The caries-preventive effect of high-viscosity GIC sealants was found to be between 3.1- and 4.5-times higher than that of composite resin sealants after 3 to 5 years. Unlike resins, GIC sealants do not protect the tooth via a physical barrier but rather through chemical protection. Microscopically, fluoride may be found in fissures which macroscopically may seem to be compromised with only partial retention of the sealant. Torppa-Saarinen and Seppa[31] investigated the pits and fissures of GIC-sealed occlusal surfaces that had been clinically scored as having partial or total loss of sealant under a stereomicroscope or scanning electron microscope and reported that glass-ionomer material was still left at the bottom of the fissures in most of the cases. The residual GIC may eventually be mineralized into fluorapatite, which is very caries-resistant; the slowly dissolving GIC delivers with the assistance of saliva all the required components to form this crystal.[32] It was assumed that this finding was in part the reason why GIC sealants prevented caries even after they appeared to be lost.

Another advantage of GIC sealants is that unlike their hydrophobic resin-based counterparts, GICs are not as moisture-sensitive. Their retention is less dependent on complete moisture control[33] and therefore they may be used in clinical situations such as an erupting permanent first molar.[34]

Conventional GICs present biocompatibility, nonshrinking setting reaction, chemical adhesion to tooth structure, and fluoride release. Fissure sealing with GIC was introduced by McLean and Wilson in 1974;[35] during the last 40 years new formulations of GIC have been successively developed to overcome some clinical drawbacks of the previous ones, especially aiming to improve physical properties.

Recently, an innovative approach to the handling of conventional GICs, utilizing a high-energy heating source, has been introduced; this enhances the retention and improves the physical qualities of GICs.[19-22] As mentioned above, the retention of GIC sealants was far from ideal, with resin sealants being more retentive. One of the causes of this was the very slow setting of the GIC material, which resulted in high solubility and wear rates during the first few weeks following placement. With application of heat during the initial setting phase of glass ionomer, the material's setting time is significantly reduced, resulting in improved mechanical properties. Recent studies have shown that additional energy (heat) during setting will not only decrease the setting time but also increase the strength, surface hardness, and chemical stability of the material.[17,18,20-22,36] In practice, a modern LED light-curing device can also be used to deliver sufficient heat (> 1200 mW at the tip brings about a temperature of 60 to 65°C). Thus self-curing GIC may be set on command by heat. The resultant increases in compressive and flexural strengths of thermal-cured GICs make them similar to resin composites.[17,36] In addition, thermal-cured GIC does not require resin protection against premature ion exchange with the environment due to the accelerated and shortened vulnerable first phase and the increased wear and solubility resistance. Although the setting process is shortened, it is recommended that the surface of the material be covered with petroleum jelly to protect the material from any premature ion diffusion during setting.

Finally, parents may question the placement of resin sealants, raising concerns with the potential health hazard these materials may contain. The controversy with resin sealants has intensified, with new studies raising doubts as to the biocompatibility and possible toxicity of these materials. Transient amounts of bisphenol A (BPA) may be detected in the saliva of some patients immediately after initial application of certain sealants as a result of the action of salivary enzymes on bisphenol-dimethacrylate (bis-DMA), a component of some sealant materials.[37-40] Recently data have begun to emerge to indicate that BPA exposures, even those in the range generally experienced by the US population, may have adverse effects on human health.[41,42] Dental resins are composed primarily of BPA derivatives rather than pure BPA. These derivatives are liquid monomers that polymerize into a solid after either chemical or light curing. BPA may be found as an impurity in dental resins; although pure BPA is not a component of dental resin, it has been detected in saliva after resin placement as a result of hydrolysis of bis-DMA by salivary esterases.[37]

A 2000 study by Fung et al[39] measured urinary BPA levels before and after the placement of dental sealants and found that BPA levels peaked at 6.4 times baseline 1 hour after placement, then returned to baseline after 24 hours.[39] Conversely, a recent study examined 495 children aged 8 to 9 years. Oral examinations and urine sample analyses were conducted. BPA concentrations in urine were higher in children with 11 or more surfaces restored with sealants and resin composites than in those with zero restored surfaces.[43] Fissure dental sealants that contain BPA may pose a hidden risk to children and an attempt should be made to minimize human exposure to BPA in dental materials as a health precaution. The elective placement in a healthy child of resin sealants which may be a potential source of a toxic substance should be reconsidered, especially since non-resin sealants are available.

Glass ionomers are more biocompatible and biomimetic than resin materials. The biocompatibility aspects of GICs have been intensively studied and in general the cytotoxicity of fully set conventional preparations was shown to be minimal.[10,11] They contain minerals found in the enamel and ultimately cause a fluorapatite-like material to form around and deep in the sealed fissures (Fig 8). This layer is very resistant to decay.[44] Fluorapatite requires ten times more acid to dissolve than hydroxyapatite. The fluorapatite-forming process is slow and it can take up to 3 years before complete mineralization is complete. For this reason it is preferable to use thicker GICs. Due to their hydrophilic and capillary properties they will be forced to the bottom of the fissure. Conventional GICs exhibit good biocompatibility due to the following properties:

- Low temperature setting exothermic reaction[45]
- Rapid neutralization[46]
- Release of generally benign ions from the set cement. GICs release sodium, aluminum, silicon, phosphorus, and fluoride under neutral conditions, and also calcium under acidic conditions.[47,48] Apart from aluminum, these ions are acceptable in the body and useful for a variety of physiologic processes, some of which are associated with remineralization of the tooth surface. Aluminum may be of concern since it has the potential to be toxic towards the central nervous system, the skeleton, and the hematopoietic system.[49] However, total amounts of aluminum released from GICs are low,[47] and coupled with the low bioavailability of alumi-

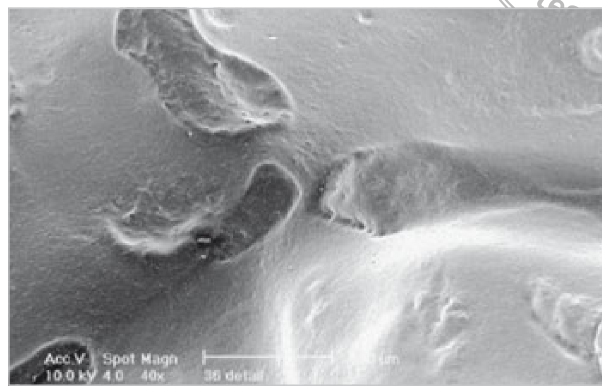

Fig 8 Electron microscope replica image of a first permanent molar sealed 4 years previously with GIC (scale bar: 600 µm). Fissures are mineralized with natural fluorapatite and are not visible anymore.

num in the gastrointestinal tract, this may not be a clinically significant issue. There have certainly been no reported adverse effects of these materials, and they are generally considered to be highly biocompatible when used in clinical dentistry.

CONCLUSION

A thermally cured GIC sealant may provide long-term caries protection to fissures and pits without the need to maintain and reseal. GICs are both biocompatible and biomimetic resulting in formation of fluorapatite, the ultimate protection against dental caries.

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