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The State-of-the-Art of ART Sealants

Abstract: Sealing caries-prone pits and fissure systems is an effective caries-preventive measure. There are basically two types of sealant materials: glass-ionomer and resin-based materials. Low- and medium-viscosity glass-ionomers were initially used and showed a low level of retention. With the advent of the ART approach in the mid-nineties, high-viscosity glass-ionomers were introduced as sealant material and the retention rate of ART sealants increased substantially. As the effectiveness of a sealant is measured by its capacity to prevent (dentine) carious lesion development, sealant retention is considered a surrogate endpoint. The ART sealant protocol is described. Systematic reviews and meta-analysis covering low- medium- and high-viscosity glass-ionomer (ART) sealants have concluded that there is no evidence that either glass-ionomer or resin-based sealants prevent dentine carious lesions better. The annual dentine carious lesion development in teeth with high-viscosity glass-ionomer ART sealants over the first three years is 1%. These ART sealants have a high capacity of preventing carious lesion development. Because no electricity and running water is required, ART sealants can be placed both inside and outside the dental surgery.
Clinical Relevance: High-viscosity glass-ionomer ART sealants can be used alongside resin-based sealants.
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About 25 years ago the Atraumatic Restorative Treatment (ART) approach was introduced in an attempt to manage dental caries in care-deprived communities.[1] Since then, ART has been integrated not only into oral healthcare systems and private practices in developing countries, but also into those of developed nations.[1] As opposed to what the name expresses, the ART approach not only consists of restoring tooth cavities (ART restorations) but also of sealing caries-prone pits and fissures (ART sealants). This article describes and discusses the effectiveness of ART sealants.

ART sealants are defined by the fact that a high-viscosity glass-ionomer is placed over caries-prone pits and fissures under finger pressure and hand instruments, such as an excavator and an applier/carver, are used for adjusting the bite and removing excess material. The protocol for application of an ART sealant is presented in Table 1 and illustrated in Figure 1.

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When are ART sealants indicated?

A sealant is placed to allow easy plaque removal from pit and fissure systems. A sealant changes a morphologically uneven surface into a smooth surface. Well-placed sealants remain effective as long as they are regularly kept free of plaque. They are indicated for use in children with high caries risk. Factors that determine this risk include:

- Past caries experience in primary dentition;
- Deep pits and fissures;
- Active enamel carious lesions; and
- Operator experience.[2,3]

So, sealing any pits and fissures, irrespective of the state of the caries risk of the child, should be considered over-treatment.

The indication for placing an ART sealant is not different from that for placing a resin-based sealant. However, glass-ionomers are more hydrophilic than resin-based materials. It is therefore logical to assume that a glass-ionomer rather than a resin-based material should be used in sealing caries-prone pits and fissures which cannot be kept absolutely moisture-free, such as in erupting molars and in children with behaviour problems. This does not mean that glass-ionomer (ART) sealants can be placed under 'wet' conditions. As far as possible, the ART protocol should be followed (Table 1). However, placing a resin-based sealant under moist to wet conditions is contra-indicated. Unfortunately, very few studies have investigated this topic.

Recently, a study comparing glass-ionomer (ART) and resin-based sealants in erupting molars was published.[4] Using a low-viscosity glass-ionomer sealant material in erupting molar teeth, the study showed no differences between the caries-preventive effect of the glass-ionomer and the resin-based sealant after 2 years. The authors suggested that glass-ionomers might be a better material for sealing partially erupted molars. A pilot study

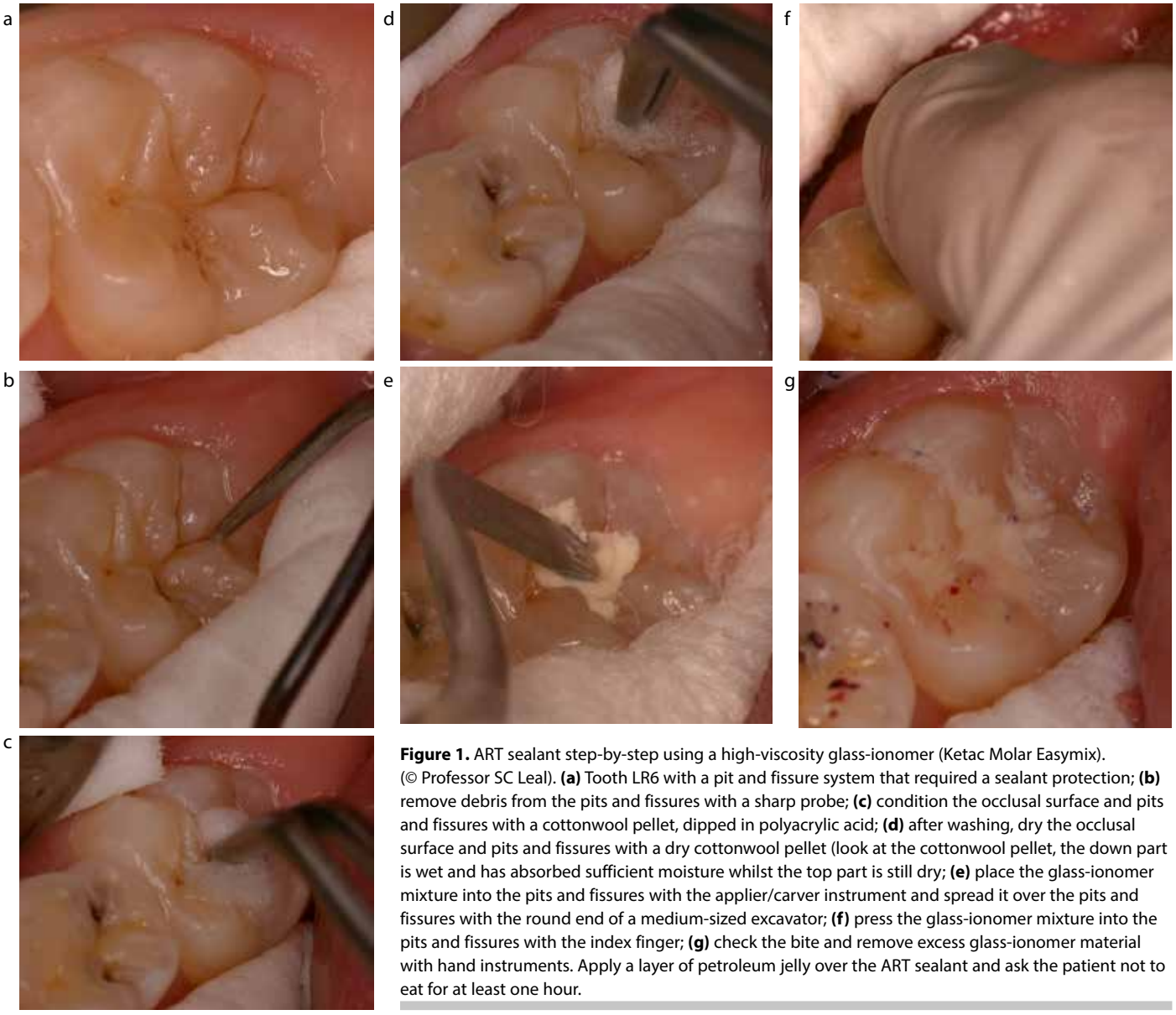

Figure 1. ART sealant step-by-step using a high-viscosity glass-ionomer (Ketac Molar Easymix). (© Professor SC Leal). **(a)** Tooth LR6 with a pit and fissure system that required a sealant protection; **(b)** remove debris from the pits and fissures with a sharp probe; **(c)** condition the occlusal surface and pits and fissures with a cottonwool pellet, dipped in polyacrylic acid; **(d)** after washing, dry the occlusal surface and pits and fissures with a dry cottonwool pellet (look at the cottonwool pellet, the down part is wet and has absorbed sufficient moisture whilst the top part is still dry; **(e)** place the glass-ionomer mixture into the pits and fissures with the applier/carver instrument and spread it over the pits and fissures with the round end of a medium-sized excavator; **(f)** press the glass-ionomer mixture into the pits and fissures with the index finger; **(g)** check the bite and remove excess glass-ionomer material with hand instruments. Apply a layer of petroleum jelly over the ART sealant and ask the patient not to eat for at least one hour.

investigated the dentine carious lesion preventive effect of a high-viscosity glass-ionomer ART sealant in newly erupted and erupting first molars.[5] This study, carried out in Syria, showed that initially unerupted first molars had a 2.1 times higher chance than sealed newly erupted and erupting first molars of developing cavitated dentine lesions, in a high caries risk population of 6–7 year-olds after 5 years.

As the number of such comparative studies is low, more studies investigating the efficacy and effectiveness of high-viscosity glass-ionomers (ART) and resin-based sealant materials for use in erupting and newly erupted molar teeth are needed. Currently, there is insufficient evidence to establish which method the dental practitioner should use for sealing pits and fissures in erupting and newly-erupted molars.

Why could sealing erupting molars be important? During the 1 to 1.5 year eruption phase, molar teeth are most vulnerable to demineralization. In contrast, with fully erupted molars, larger parts of occlusal surfaces in erupting molars are covered by plaque that remains in place for longer periods of time.[6] Depending on the caries risk situation of the child, occlusal surfaces should either be cleaned regularly or be sealed. The effectiveness of cleaning is increased if parents are properly trained.

How effective are ART sealants?

Retention of sealants

Retention of sealant material should not be considered the endpoint for determining the success of a sealant, as biological outcomes take preference over mechanical outcomes.[7] So, should teeth with partially lost sealants be resealed? A sealant should be considered a temporary treatment. It is meant to assist the young

1. Isolate the tooth with cottonwool rolls. Keep the treatment area free from saliva.
2. Gently remove plaque and food debris from the deepest parts of the pits and fissures with an explorer.
3. Wash the pits and fissures, using wet cottonwool pellets.
4. Apply enamel conditioner into the pits and fissures according to the manufacturer's instructions. Condition for the specified time.
5. Immediately wash the pits and fissures, using wet cottonwool pellets to clean off the conditioner. Wash 2–3 times.
6. Dry the pits and fissures with cottonwool pellets. Do not use the 3-way syringe. The enamel surface should not be desiccated.
7. Mix the glass-ionomer and apply it in all pits and fissures with the round end of the ART applier/carver instrument or shake the encapsulated glass-ionomer in a suitable mixing machine and extrude the mixture into all pits and fissures.
8. Rub a small amount of petroleum jelly on the gloved index finger.
9. Press the glass-ionomer mixture into the pits and fissures with the index finger (press-finger technique). Then, remove finger sideways after 10–15 seconds.
10. Remove visible excess of mixture with the carver or a large excavator.
11. Check the bite, using the articulation paper, and adjust until comfortable.
12. Remove the petroleum jelly top surface with the carver or a large excavator when the mixture is partly set.
13. Apply a new layer of petroleum jelly.
14. Remove the cottonwool rolls.
15. Ask the patient not to eat for at least one hour.

Table 1. Step-by-step description of the placement of an ART sealant.[22]

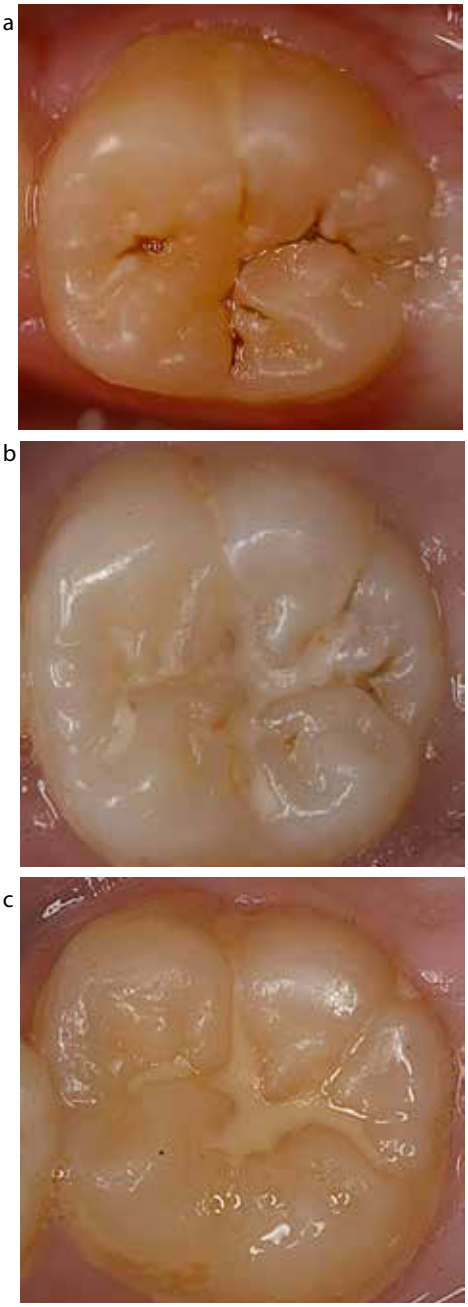

Figure 2. (a) Sealant completely disappeared from the occlusal surface but not from the buccal surface; **(b)** partially: and **(c)** fully retained high-viscosity glass-ionomer (Ketac Molar Easymix) ART sealants after 2 years[12] (© Dr JE Frencken).

individual and his/her parents/carers to keep vulnerable tooth surfaces free of carious lesions during a period in life in which tooth cleaning is still being learned and is not fully under control. The lifespan of a sealant in the first molar should, therefore, be about 5 years. During this period, emphasis should be placed on improving the child's behaviour regarding plaque control and sugar intake. Obviously, children who remain at high risk of caries will benefit from resealing material-defective sealants. However, resealing once the caries risk is low is not required.

When the retention of glass-ionomer and resin-based sealants is compared, resin-based sealants are longer retained.[8] However, with the launch of high-viscosity glass-ionomers in the mid-Nineties,[9] the retention rate of glass-ionomer (ART) sealants has increased substantially in comparison to those of the low- and medium-viscosity glass-ionomers previously used.[10]

A meta-analysis that included studies up to February 2010 concluded that the mean annual failure rate of completely lost high-viscosity glass-ionomer ART sealants over the first three years was 9.3%.[11] This finding corroborates the result of the latest published sealant retention study, which showed a 2-year survival rate of fully and partially retained high-viscosity glass-ionomer (Ketac Molar Easymix) ART sealant, in occlusal surfaces, of 78% compared to the 86% for resin-based sealants (Clinpro) (Figure 2).[12] These retention survival percentages are much higher than those obtained for low- and medium-viscosity glass-ionomer sealants in the Eighties and early Nineties.[13,14] Clearly, as an integral part of the ART approach, high-viscosity glass-ionomers should be used to seal caries-prone pits and fissures.

Caries prevention with sealants

Already in the mid-Nineties, Simonsen[15] concluded his critical review saying that the evidence of the caries-preventive effect of low- and medium-viscosity glass-ionomer and resin-based sealants was equivocal. This conclusion matched the outcome of a systematic review[16] which included twice as many publications as that of Simonsen.[15] Three recently published systematic reviews and meta-analyses, which had meanwhile included high-viscosity glass-ionomer ART sealants, showed the same conclusion as the two previously mentioned reviews: that there is no evidence that the dentine carious lesion-preventive effect of the one sealant

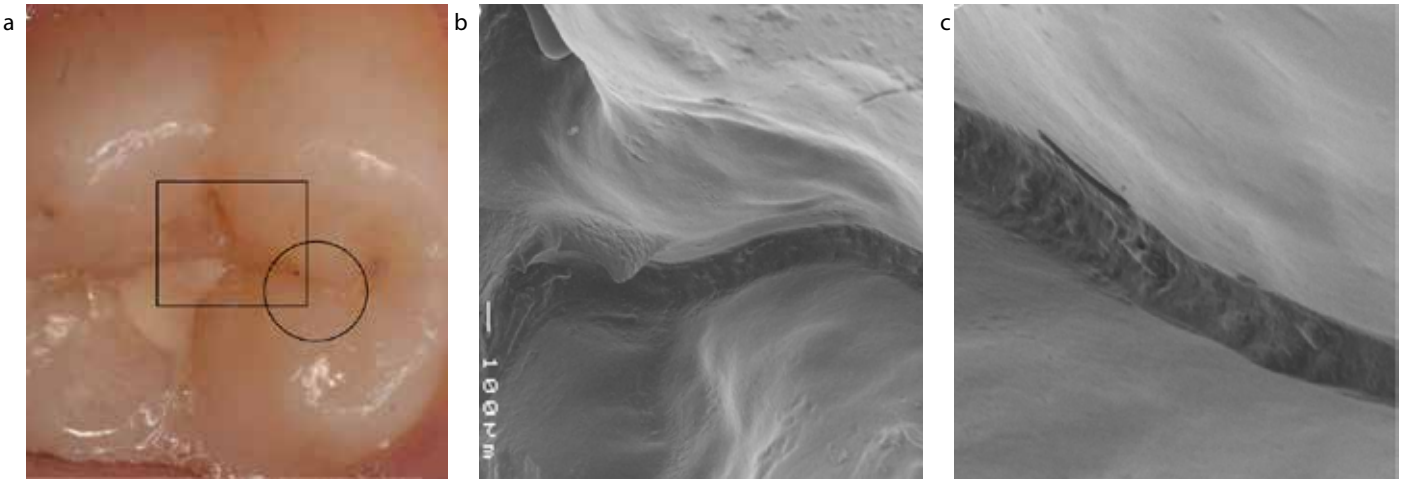

Figure 3. (a) Clinically undetected glass-ionomer material (KetacMolar) 8 years after sealing the occlusal surface of tooth LL7. The connecting fissure from mesial to central pit is clinically free of glass-ionomer material. **(b)** The SEM image (50x) showing the fissure to be filled with a substance that is connected to the visible glass-ionomer. **(c)** Enlargement of **(b)** (SEM: 100x). The fissure is clearly filled with a material which is most likely remnants of the high-viscosity glass-ionomer sealant material.[22] (© Dr JE Frencken).

material is better than that of the other.[17-19] The De Amorim *et al*[11] meta-analysis reported a mean annual dentine carious lesion incidence rate over the first three years in pits and fissures previously sealed according to the ART protocol, of 1%. This outcome is in line with a randomized clinical trial that reported a mean annual dentine carious lesion development for ART high-viscosity glass-ionomer (Fuji IX, GC America, Alsip, USA) sealants of 2% in comparison to that of 5% for the resin-based *Delton* (Dentsply International, York, USA) sealants over a 5-year period.[20] This high preventive effect of ART high-viscosity glass-ionomer sealants was also reported for the latest published glass-ionomer and resin-based comparison study. After 2 years, 2% of the pits and fissures sealed according to the ART procedure with the high-viscosity glass-ionomer *Ketac Molar Easymix* had developed a dentine carious lesion, in comparison to the 1% observed in pits and fissures sealed with the resin sealant *Clinpro*.[21]

Possible extra reason for the effectiveness of glass-ionomer sealants

The findings of these systematic reviews and meta-analysis may be a surprise to many, particularly as resin-based sealant materials are retained longer than the glass-ionomer sealant materials and should, therefore, automatically have a high dentine carious lesion-preventive effect. More than two decades ago, Mejàre and Mjör,[13] and Torppa-Saarinen and Seppå[22] discovered that, in situations where the low-viscosity glass-ionomer sealant material used had completely disappeared clinically, remnants were observed in the deeper parts of the pits and fissure systems. They ascribed the remnants as being most probably glass-ionomer. They further suggested that the relative absence of dentine carious lesions in relation to the high level of clinically completely disappeared glass-ionomer sealants might, among others, be explained by the presence of those remnants. The remnants might allow the removal of plaque from a less than normal depth of the pits and fissure system and thus better control possible demineralization. This possible explanation for the low level of dentine carious lesions observed in pits and fissures previously sealed with glass-ionomers received further support from a case study.[23] Four long-term (8–13 years) high-viscosity glass-ionomer ART sealants were subjected to SEM investigations (Figure 3). In all these sealants, remnants were observed on places that had been clinically assessed as not containing glass-ionomer material. These remnants appeared to be glass-ionomer. Considering the excellent adhesion of glass-ionomers to enamel, and the fact that the material fractures in itself rather than at the enamel-sealant interface,[24] the remnants might indeed be part of a glass-ionomer sealant. This phenomenon needs further investigation.

Latest development regarding dental materials

It is known that Bisphenol A (BPA) derivatives are released from most resin-based dental materials.[25,26] These substances have recently been linked to a number of biological disorders.[27-29] This has led the World Dental Association (FDI) to issue a policy statement on BPA, discouraging its use in the manufacturing of dental materials, highlighting greater awareness and importance of caries prevention, thereby reducing the need for dental restorative materials.[30]

As the future regarding BPA-containing dental materials is uncertain, the dental profession can assure the public that it is able to manage caries lesions through the use of sealants because of the availability of a non-BPA containing (ART) high-viscosity glass-ionomer sealant that has a high level of effectiveness.

Conclusion

Systematic reviews have shown that the caries-preventive effect of either glass-ionomer-based or resin-based materials are comparable. High-viscosity glass-

ionomers appear to be retained longer than low- and medium-viscosity glass-ionomers, but shorter than resin-based sealant materials. High-viscosity glass-ionomer ART sealants have a high ability to prevent carious lesion development. Because no electricity and running water is required, ART sealants can be placed both inside and outside the dental surgery.

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