Glass ionomers: the material of choice in paediatric dentistry?

Thomas Trentesaux,[1] Caroline Leverd,[2] Mathilde Laumaille,[3] Marion Jayet,[4] Caroline Delfosse[5]

The range of indications for glass ionomers in paediatric dentistry is extremely varied (early childhood caries, deep carious lesions on mature and immature teeth, etc.). Review of these materials that have undergone significant technical advances.

Although in France, glass ionomer cements (GIC) are mainly used by dentists to lute prosthetic pieces, it must be noted that they are less commonly used as a restorative material. In 2012, 56% of restorations were made from composites in comparison with 17% from glass ionomers[1]. According to the report by the French National Agency for Medical Product Safety (Agence Nationale de Sécurité du Médicament et des produits de santé, ANSM) of April 2015, 100% of dentists in France were using composites in 2012, compared with 40% using glass ionomers, which represent 15-25% of direct restorations[2]. These glass ionomers (GI) still suffer from a poor reputation. This reputation stems from the first glass ionomers developed in the 1970s by Wilson and Kent, as a result of their low resistance to flexion and abrasion. These were low viscosity GIs. Slow maturation and stabilization of moisture exchanges were required to achieve properties close to those of composites after one year. They have since undergone significant improvements and are now an excellent alternative to amalgam. Amalgam should now only be used as an exception, in particular for use in deciduous dentition (last resort use)[3]. GIs can also be a substitute for composites which, on a biological level, can pose a certain number of risks. Therefore, although usage restrictions may exist in some clinical situations, their indications are numerous when treating early childhood caries, deep carious lesions in mature and immature teeth, mineralisation defects, interceptive treatment and so on.

[1] Thomas Trentesaux
MCU-PH; Paediatric Dentistry; University of Lille, University of Paris Descartes; Laboratory of Medical Ethics and Forensic Medicine (EA 4569)

[2] Caroline Leverd
Intern in Dentistry; 3rd year Paediatric Dentistry; University of Lille

[3] Mathilde Laumaille
AHU, Paediatric Dentistry, University of Lille

[4] Marion Jayet
6th year student; Paediatric Dentistry; University of Lille

[5] Caroline Delfosse
MCU-PH; Paediatric Dentistry; University of Lille, Centre of Research in Clinical Dentistry (EA 4847); University of Auvergne

Composition and classification

GIs are composed of a mix of organic acids (polyacrylic acid, tartaric acid and itaconic acid) and fluoroaluminosilicate glass particles. The use of the first low-viscosity GIs was quickly abandoned due to their weak mechanical properties and great sensitivity to the moist conditions of the mouth. New GIs then started to appear on the market. Some GIs have been modified with the addition of resin (RMGI), others are condensable after modification of the liquid/ powder ratio and the particle size (high-viscosity GI - HVGI). The addition of freeze-dried polyacrylic acid to the powder makes it less sensitive to osmosis[1]. One last family (sometimes classified in the HVGI family) is strengthened with very small fillers (< 4 μm), which accelerate the setting of

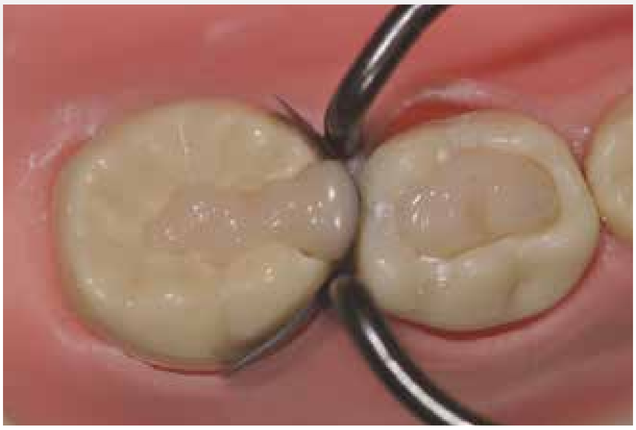

Figure 1: Glass ionomer with a shiny appearance once placed in the cavity.

Figure 2: Progressive gelation of glass ionomer. It can be shaped when it turns matt.

the matrix (high-density glass ionomers - HDGI) (table 1). For both HVGIs and HDGIs, a coating is used to markedly increase the long-term mechanical properties (impregnated protected GI). This treatment comprises a nanofilled self-adhesive resin that combines extreme hydrophilic properties with very low viscosity. It compensates for the microporosity of GI[4] which is thus protected from desiccation and occlusal microtrauma for several months. Hence, GI can mature in optimised conditions[1]. GIs, which have long required hand-mixing of the powder and liquid, are today presented in a capsule, which saves time, is easier to use and improves the quality of the mixture.

An acid-base reaction

During the first phase, the H+ ions of the acid attack the surface of the glass particles, liberating in particular the calcium and aluminium ions. The ion release is facilitated by the tartaric acid which forms complexes between them. A polysalt is thus created that hardens gradually[5]. It should be noted that in a clinical setting, the GI has a glossy appearance during this phase. Humidity must be controlled, as this reticulation phenomenon is not stable. The mechanical properties would therefore be altered by desiccation or, in contrast, by excessive moisture addition. The GI should not be manipulated during this phase in order not to disturb the chemical bond. Phase two entails gelation of the material. It becomes matt, at which point it can be shaped (Fig. 1 and 2). The total time of the procedure is around three minutes, but this can vary depending on the type of GI and the manufacturer. Phase three entails maturation of the material. LVGIs required almost one year to reach the mechanical properties of a composite. This time has been reduced to a few hours for the latest generation of GIs.

Unique and numerous properties

One of the main benefits of these materials is their natural adhesion to dental tissues. This adhesion takes place through the ionic reaction of the carboxylate groups on the polyacid molecules with the phosphate ions from the tooth surface[4] and with the charged positive ions of the hydroxyapatite. An interfacial ion-exchange layer is formed. In clinical practice, this intrinsic adhesion obviates the need to use an adhesive. Nevertheless, in order to improve micro-mechanical adhesion, the use of a conditioner is recommended for treating the tooth surface. The latter reduces surface tension, eliminates the smear layer and partially demineralises the dentinal tubules. The wetting of the glass ionomer will be improved. This surface treatment is composed of a polyacrylic acid with concentrations between 10 and 20% for an application time of 10 to 20 seconds, depending on the dilution. This conditioner has become redundant for the latest generation of glass ionomers HDGI, which is intrinsically more acidic and does not require this usage. However, this information should be treated with care, as although the adhesion values remain comparable in the short term, this is not the case after six months, especially since the conditioner contributes to a reinforcement of the seal[6]. In contrast, its use is truly recommended when placing GI-based sealants in order to ensure their longevity. An excellent seal, which is an essential

Figure 3: Preparation for glass ionomer presenting a secondary cavity to ensure a maximum base.

Figure 4: Placement of a Lumicontrast® sectional matrix (Polydentia).

factor in avoiding pulp inflammation, is also ensured by low levels of polymerisation shrinkage. In addition, the incomplete opening of the tubules by the conditioner limits the occurrence of post-operative hypersensitivity. This seal, combined with the physicochemical properties of the materials, leads to remineralisation of the tooth[7]. GIs are therefore biocompatible and bioactive materials thanks to the release of fluoride, in particular during the first months after their placement, which provides them anti-caries properties.

But what about the true mechanical qualities?

These have significantly increased with the arrival of impregnated, protected HVGI, especially due to the increase in the number of fillers and the variability of their size. The placement of a thin protective coating (35 to 40 μm) increases the GI's hardness and resistance to wear, while also protecting it from moisture contamination[8]. Studies comparing amalgam restorations with GI restorations on deciduous teeth have demonstrated similar survival rates over two years[9]. Randomised clinical studies comparing restorations on permanent or deciduous teeth showed that there is no significant difference between the survival rates of HVGI and amalgam for periods over six years[10]. Other studies showed similar results when posterior restorations with composite and glass ionomer were compared over four years[11].

The results of these studies justify the use of GIs for occlusal cavities, cervical lesions and small-sized proximal restorations. One six-year study examining the restoration of 1,231 Class II cavities in deciduous teeth presented a success rate of 97.42%[12]. However, creating larger proximal cavities or mesial-occlusal-distal cavities increased the risk of fractures[13]. Restoring cavities in direct contact with heavy occlusal forces alters the durability of the restoration and explains the contraindication against restoring the cusp with this type of material. As far as placing sealants is concerned, Liu demonstrated that there is no difference at 24 months in the ability of a composite resin and a GI to prevent the occurrence of sulcus caries[14]. Mickenautsch evidenced in a systematic review of the literature that there are no significant differences in terms of preventing carious lesions at 48 months in comparison with a composite resin-based sealant, which is often considered as the reference[15].

Additional studies should be conducted to confirm these results over a longer term.

In order to improve the clinical longevity of restorations, two elements in particular should be considered: cavity preparation and the use of a coating. Soft cavities with rounded angles are sought to prioritise saving tissue that, however, present sufficient base to favour the occurrence secondary caries, in particular on primary deciduous molars, which have a strong cervical constriction (Fig. 3).

The use of a coating increases the mechanical properties of the GI [4, 16]. Its use is nevertheless disputed in deciduous teeth. In fact, when their presence in the mouth is limited, it can be prudent in terms of biocompatibility to avoid the use of surface resin when the restorative material does not contain it. In this case, it can be replaced by a cocoa butter type of product (GC), which means humidity can be controlled during the first maturation phases.

Figure 5: Material required to place a sealant using the press finger technique (glass ionomer, Fuji Triage®, GC).

Figure 6: Pre-operative view of 36.

Figure 7: Cleaning of the sulcus.

Figure 8: Application of cavity conditioner (GC) for 10 seconds, gentle rinsing and drying.

Figure 9: Placement of Fuji Triage® (GC).

Figure 10: Application of cocoa butter on the tip of the index finger

Figure 11: Pressing the index finger onto the occlusal surface of 36 to ensure that the GI penetrates into the pits and fissures. Removal of excess.

Figure 12: Post-operative view.

Clinical indications

The spectrum of indications of GIs in paediatric dentistry is extremely varied: sealants, restorations of cervical lesions, temporary or permanent anterior restorations (choice of shade varies depending on the manufacturer), restorations of occlusal cavities, small proximal cavities[17], pulp protection and treatment of deep carious lesions, structural defects [18], traumas, and so on. Their use is indicated both for deciduous dentition and immature or mature permanent dentition. Condensable glass ionomers are an excellent alternative to amalgam[19], and also to composites in terms of biocompatibility. Although the material is reputed to possess low technique-sensitivity, operating protocols must be followed. Indeed, many failures stem from non-compliance with the working time, a poor choice of matrix, poorly adapted preparation or injection of an inadequate amount of material leading to air bubbles or issues with the seal. Humidity must also be controlled to guarantee that restorations will last. The use of a dam is optional but, as well as controlling humidity, using one provides greater comfort to both the young patient and the practitioner. The quality of the matrix is crucial for the success of the restoration (Fig. 4).

Figures 5 to 12 show the placement of a sealant on 36 using Fuji Triage from GC with the press finger technique. The latter enables the material to penetrate into pits and fissures thanks to controlled pressure on the occlusal surface.

Conclusion

Glass ionomers should take on an increasingly significant role in our treatment strategies. Long criticised for their lack of mechanical strength and their poor aesthetic qualities, the latest generations of GIs (high-viscosity GIs and high-density GIs, associated with a surface treatment) are excellent alternatives to amalgam or composite resins. These biocompatible materials can be used for impermeable, durable restorations that limit the recurrence of caries. They perfectly meet the challenges of minimally invasive dentistry, save dental tissue and preserve pulp vitality.

Key points

- Glass ionomers are biocompatible materials that are intrinsicly adhesive.
- Using a coating improves the mechanical and aesthetic qualities.
- Glass ionomers have multiple indications, both in deciduous and permanent teeth.
- Glass ionomers constitute, depending on the clinical situation, an alternative to both amalgam and composites.
- The press finger technique can be used to seal pits and sulci quickly.

References

1. Blique M. Restaurations partielles directes : les ciments verre ionomère. In Médecine buccodentaire conservatrice et restauratrice. Espace ID. Concepts. 2014. 176p.

2. Agence Nationale de Sécurité du Médicament et des produits de santé. Le mercure des amalgames dentaires. Actualisation des données. Avril 2015. 93p.

3. Agence Nationale de Sécurité du Médicament et des produits de santé. Le mercure des amalgames dentaires. Recommandations, à l'attention des professionnels de santé, à respecter lors de l'utilisation des amalgames dentaires. Décembre 2014. 4p.

4. Lohbauer U et al. Strength and wear resistance of a dental glass ionomer cement with a novel nanofilled resin coating. Am J Dent 2011 ; 24 (2) : 124-128.

5. Dursun E. Les ciments verres ionomères à haute viscosité. Partie 1 - Présentation, composition et propriétés. Biomatériaux cliniques 2016 ; 1 (1) : 26-32.

6. Hoshida S et al. Effect of conditioning and aging on the bond strenght an interfacial morphology of glass-ionomer cement bonded to dentin. J Adhes Dent 2015 ; 17 (2) : 141-146.

7. Kuhn E, Chibinski AC, Reis A, Wambier DS. The role of glass ionomer cement on the remineralization of infected dentin : an in vivo study. Pediatr Dent 2014 ; 36 (4) : 118-124.

8. Basso M et al. Glassionomer cement for permanent dental restorations : a 48-months, multi-centre, prospective clinical trial. Stoma Edu J 2015 ; 2 (1) : 25-35.

9. de Amorim RG et al. Amalgam and ART restorations in children : a controlled clinical trial. Clin Oral Investig 2014 ; 18 (1) : 117-124.

10. Mickenautsch S, Yengopal V. Failure rate of atraumatic restorative treatment using high-viscosity glass-ionomer cement compared to that of conventional amalgam restorative treatment in primary and permanent teeth : a systematic review update – II. J Minim Interv Dent 2012 ; 5 : 213-72.

11. Gurgan S et al. Four-year randomized clinical trial to evaluate the clinical performance of a glass ionomer restorative system. Oper Dent 2015 ; 40 (2) : 134-143

12. Webman M et al. A retrospective study of the 3-year survival rate of resin-modified glass-ionomer cement class II restorations in primary molars. J of Clin Ped Dent 2016 ; 40 (1) : 8-13.

13. Klinke T et al. Clinical performance during 48 months of two current glass ionomer restorative systems with coatings : a randomized clinical trial in the field. Trials 2016 ; 17 (1) : 239.

14. Bao Ying Liu, Xiao Y, Hung Chu C, Chin Man LO E. Glass ionomer ART sealant and fluoride-releasing resin sealant in fissure caries prevention -results from a randomized clinical trial. BMC Oral Health 2014 ; 14 : 54.

15. Mickenautsch S, Yengopal V. Caries-preventive effect of high viscosity glass ionomer and resin-based fissure sealants on permanent teeth : a systematic review of clinical trials. PLoS One 2016 ; 11 (1) : e0146512.

16. Diem VT et al. The effect of a nano-filled resin coating on the 3-year clinical performance of a conventional high-viscosity glass-ionomer cement. Clin Oral Investig 2014 ; 18 (3) : 753- 759.

17. Dursun E et al. Restaurations aux ciments verre ionomère (CVI). In Fiches pratiques d'odontologie pédiatrique. Ed. Cdp. 2014. 347p.

18. Fragelli CM et al. Molar incisor hypomineralization (MIH) conservative treatment management to restore affected teeth. Braz Oral Res 2015 ; 29 (1) : 1-7.

19. Hilgert L et al. Is hight-viscosity glass-ionomer cement a successor to amalgam for treating primary molars ? Dental materials 2014 ; 30 (10) : 1172-1178.