

Effect of a neutral citrate solution on the fluoride release of resin-modified glass ionomer and polyacid-modified composite resin cements

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Abstract

The effect of 0.01 mol/l citrate solution at pH = 7 on the fluoride release is compared for the resin-modified glass ionomer cements (RM-GIC) GC Lining LC, PhotacBond, Vitremer and Vitrebond and for the polyacid-modified composite resins (PAM-C) Variglass and Dyract by means of the six-month fluoride release profiles at 37°C. The fluoride release of both RM-GIC and PAM-C increases in the neutral citrate solution as compared to water, which can be explained by the ability of citrate to complex metal ions and hence to degrade the glass as well as the polysalt matrix of the cement. Although RM-GIC release more fluoride than PAM-C in water as well as in citrate solution, the relative increase in fluoride release upon immersion in citrate solution is most pronounced for PAM-C. Whereas for the latter citrate affects both the short-term and long-term fluoride release, for RM-GIC only the long-term fluoride release is affected. This suggests that the action of citrate increases with decreasing importance of the polysalt formation in the hardening of the material. This could be explained on the basis of the difference in the chemical properties of the cement matrix. © 2000 Elsevier Science Ltd. All rights reserved.

Keywords: Citrate; Complexing agent; Fluoride release profiles; Resin-modified glass ionomers; Polyacid-modified composite resins

1. Introduction

Glass ionomer cements (GIC), developed by Wilson and Kent in 1969, are widely used in clinical dentistry [1,2]. The adhesion to calcified tissues and the ability to release and take up fluoride are considered the major advantages of these materials [2–5]. The fluoride ions can be incorporated in tooth enamel and dentin or can interfere with the adherence of bacteria or bacterial growth. The latter properties are generally associated with a caries prophylactic effect and are determined by the chemical form and distribution of the fluoride in the cement [6–8].

In the mouth and especially in plaque, organic acids such as lactic acid and citric acid are found originating mainly from a bacterial activity [9]. The low pH associated with these acids results in an increase of the fluoride release of GIC [10–12]. In addition, indications were found that the complexing ability of the anion of these organic acids also contributes to an enhanced fluoride release of GIC [10,11,13]. Apart from the rather limited study of Gao et al. [13], little is known, however, about the effect of organic acids on the fluoride release of the more recently introduced resin-modified glass ionomers (RM-GIC) and polyacid-modified composites (PAM-C) whose setting is partially or completely based on a photo-initiated radical polymerization. Moreover, the fact that the extent of complex formation generally increases with increasing pH would imply that the presence of organic anions could result in an enhanced fluoride release of GIC at or near neutral pH.

In the present study, this possibility is further investigated by comparing the fluoride release of RM-GIC and

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Table 1
Formulations used in the present study

| Type | Product | Manufacturer | Powder | Liquid | Batch no. |
|---------------------|----------------------------|--|---|--|-------------------------|
| RM-GIC ^a | Vitrebond | 3M, USA | (Zn)FAISi ^c -glass | PAMA ^e , HEMA ^f , photo-activator, water | P/19921123 |
| | Vitremer | 3M, USA | FAISi-glass, redox initiator | PAA ^d with pendent methacrylate groups, HEMA, photoactivator, water | P/19930312 L19930212 |
| | PhotacBond GC Lining LC | ESPE, Germany GC Industr. Corp., Japan | FAISi-glass FAISi-glass, camphorquinone | PAMA, photo-activator, water PAA, HEMA, photo-activator, water | 10 14216 |
| PAM-C ^b | Variglass | Caulk, Dentsply, Germany | (Sr)FAISi-glass | PAA, HEMA, TEGDMA ^g , 2,6-di-ter-butyl-4-methylphenol | L/920814 P/9202265 |
| | Dyract | DeTrey, Dentsply, Germany | (Sr)FAISi-glass | TCB ⁱ , UDMA ^h | 921082 |

^aRM-GIC: resin-modified glass ionomer.

^bPAM-C: polyacid-modified resin composite.

^cFAISi: fluoroaluminosilicate glass.

^dPAA: polyacrylic acid.

^ePAMA: copolymer of acrylic and maleic acid.

^fHEMA: 2-hydroxyethylmethacrylate.

^gTEGDMA: triethyleneglycoldimethylmethacrylate.

^hUDMA: urethane dimethacrylate.

ⁱTCB: bifunctional monomer.

PAM-C in a neutral citrate solution with that previously determined in water [14]. Citrate is well suited for such a study in view of its strong complexing ability with metal ions (M^{z+}) such as Al^{3+} and Ca^{2+} which are matrix-forming cations in GIC [15,16]. To minimize the influence of H^+ ions, the experiments are performed at pH 7.

2. Materials and methods

In the present study, the same formulations used in a previous investigation of the fluoride release in water [14] were investigated (see Table 1). Five cylindrical specimens (6 mm in diameter and 3 mm thick) of each of the formulations were made according to the instructions of the manufacturer, using a fresh mix for each sample. Vitrebond, Vitremer, GC Lining LC and Variglass were hand-mixed. PhotacBond was mixed using a Silamat (Vivadent, Schaan, Liechtenstein). For Dyract no mixing was needed. The cement paste was poured (Vitrebond, GC Lining LC, Variglass) or injected (Vitremer, PhotacBond, Dyract) into a split-ring stainless-steel mould, the cement was covered with celluloid strips and excess of material was removed. The mould was closed and the material was set by light-curing on both sides following the instructions of the manufacturer.

After curing, all specimens were transferred into individual polyethylene flasks containing 25 ml 0.01 mol/l

citric acid adjusted to pH 7 with NaOH. The flasks were shaken in a water bath at $37.0 \pm 0.1^\circ C$ at a rate sufficient for a good homogenization of the solutions without causing turbulence. The citrate solution was renewed at 0.25, 1, 2, 3, 4, 7, 14, 21, 28, 56, 84, 112, 140 and 168 days after the start of the elution. At each change the discs were thoroughly rinsed with water, quickly blotted with filter paper and immediately transferred in fresh neutral citrate solution for further elution.

The concentration of fluoride eluted from each sample during the consecutive elutions was determined after dilution (1 : 1) of the solution with TISAB (total ionic strength adjustment buffer) using a reference and fluoride ion-selective electrode connected to an ORION 940 Ion-analyser equipped with a 960 Autochemistry system (Orion Research Inc., Boston, MA, USA). The electrode pair was calibrated twice a day with a multiple standard addition method resulting in a calibration curve between 0.003 and 0.2 mmol F/L. After the measurement of two sample solutions, the electrode response was checked with a standard solution in order to compensate for an eventual drift of the standard electrode potential. The accuracy of the fluoride determinations was determined as 10% of the amount analysed. The amount of fluoride eluted from the materials was converted into micrograms of F per unit surface area ($\mu g/cm^2$) [5,17,18]. The cumulative fluoride release was calculated for each sample by adding the amounts of fluoride released during the consecutive elutions.

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