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Sorption and solubility characteristics of self-adhesive resin cements

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ABSTRACT

Objective. The aim of this in vitro study was to evaluate some sorption characteristics [sorption (*S*), solubility (*SL*) and the percentages of mass change (M_g%), solubility (SL%) as well as sorbed liquid (S%)] of self-adhesive resin cements when immersed in distilled water and lactic acid.

Methods. A disc-shaped specimen of each self-adhesive resin cements [G-Cem (GC), SmartCem™ 2 (SC2), RelyX™ U100 (R1), RelyX™ Unicem 2 (RU2)] were prepared in a split-Teflon mold and irradiated by an Optilux 501 light cure at 580 mW/cm^2 for 40 s in eight overlapping sections each side. The volume of each specimen was calculated and placed inside a desiccator containing anhydrous calcium chloride, then weighed on an analytical electronic balance. Two independent groups were established according to the immersion media or liquids (distilled water and 0.01 M lactic acid) maintained at 37 °C for the time intervals: 1, 6, 12, 24, 48 and 168 h, where the sorption (*S*) property (μg/mm^3) was calculated. However, the *SL*, M_g%, SL% and S% were measured after 168 h of immersion. The data were statistically analyzed by repeated measures ANOVA, one-way ANOVA and post hoc Tukey's test ($p < 0.05$).

Results. Analysis of variance revealed highly significant differences between the materials for the sorption and solubility values examined with some exceptions ($p < 0.05$). However, independent samples *T*-test expressed significant differences of all the sorption values between both water and lactic acid media for the resin cements with some border significances ($p > 0.05$). The highest liquid's sorption was exhibited by GC material after immersion in lactic acid for 168 h period followed by SC2 (37.83 and 34.15 μg/mm^3, respectively), while the lowest sorption was presented by RU2 cement after 1 h immersion period in water (3.89 μg/mm^3). Stereomicroscope showed homogenous surface topography in RU2 and R1 samples, while some striated cracks and microvoids were observed in GC and SC2 materials, respectively. The *SL* values followed this order: RU2 < R1 < SC2 < GC.

Significance. Knowing the best self-adhesive cement that can provide less sorption and solubility values will help the dentist to choose the most suitable luting material for indirect restorations.

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1. Introduction

Resin-based cements are widely used luting material because of their enhanced ability to bond tooth surface to several indirect restorations. Nowadays, there has been a marked increase in the development of dual-cured resin cements because of their ability to be self cured under indirect esthetic polymeric or ceramic restorations. Compared to conventional luting agents, these resin cements can achieve better marginal seal, show retentive capability and possess adequate physical and mechanical properties, such as increased fracture resistance of overlying restorations, along with an optimal esthetic result [1,2]. The properties of resin luting agents have been improved by modifying their composition. Resin cements can be classified either by their mechanism of interaction to the tooth substance or by their mode of cure. Conventional resin cements require the application of a total-etch system or a self-etching primer. More recently, new materials were introduced called self-adhesive resin cements that were applied immediately to enamel and dentin without previous use of an adhesive system [3].

These self-adhesive dual-cured resin cements become increasingly common and mostly used for bonding the indirect restorations. They have been invented to simplify the resin bonding process and minimize the steps as well as the time consumed during the bonding procedures. They are being attractive for this option, as well as for being dual-cured and easy to use with no need for dental tissues pretreatment [3]. These cements were manufactured on a new technology of monomers, fillers and initiators. According to manufacturers, these products include acidic and hydrophilic monomers in their composition, which simultaneously demineralize and infiltrate enamel and dentin, resulting in a strong bonding [4,5]. The organic matrix of some of them is based on a newly developed multifunctional phosphoric-acid methacrylate system (phosphates and phosphonates groups), while others are based on carboxylic acid group [6]. These acidic monomer groups are provided in specific concentration that can demineralize and condition enamel and dentin as well as allow adhesion to the tooth surface through micromechanical retention [7]. Therefore, they require no conditioning or priming pretreatment step for the tooth surface. One of these cements is RelyX™ Unicem possessing functionalized monomers of phosphate groups that are claimed to react with calcium ions of hydroxyapatite of the tooth substance, which results in a chemical bonding, thus adding more retention [7]. The remaining phosphoric acid groups of the methacrylate monomers are neutralized by other ions released from the fillers during the setting reactions, while the released fluoride ions are absorbed by the tooth structure. It is claimed by manufacturer that immediately after mixing, the formed paste is very acidic, and then within few minutes the pH value starts to increase reaching a neutral level after 24 h [8]. Therefore, by these reactions, the phosphoric acid is neutralized and the resin cement becomes hydrophobic. Its initial hydrophilicity is important to achieve wetting of the tooth, while hyrdophobicity developed later is endeavor to facilitate bonding. This mechanism of action of the new self-adhesive cement is crucial for its application on the tooth surface and essential prerequisite for its long-term stability.

The sorption properties of the resin cement materials have an important value in terms of durability of indirect restorations. The ideal luting material should be impenetrable to oral fluids and resists dissolution over the life-time of the restoration. In the oral environment, there is more sensitivity of the restoration to moisture that may increase the risk of bond degradation and cement dissolution at the marginal gap. In consequence, this can result in weakening and fracture of the indirect restoration [9]. Other properties such as restoration's retention, tooth sensitivity, microleakage and secondary caries are also affected by the sorption ability of the cement [10,11]. Moreover, sorption and solubility can influence strength, biocompatibility, dimensional and color stability of polymeric-based cements [10]. For example, slight water sorption may have an essential effect in compensating polymerization shrinkage of the resin, thus relieving internal stresses created during shrinkage, and possibly improving marginal seal by decreasing gaps [12].

It is important to understand the sorption and solubility characteristics of the resin cements, which have been exhaustively studied by many researchers [10,13,14]. Most of the previous studies examined the sorption and solubility of polymeric materials as composite, soft lining and acrylic denture base resins in different immersion media such as water, artificial saliva and ethanol [14–16]. However, few researches have evaluated the effect of acids produced by human dental plaque such as lactic acid on these properties. Moreover, several earlier studies have shown that lactic and other acids produced by dental plaque had detrimental effects on softening and surface degradation of polymeric resin materials [17,18]. Studies about the action of this acid on the newly developed self-adhesive resin cements may increase the knowledge regarding their durability in the oral environment. Thus, it is essential to analyze the sorption and solubility characteristics of these cements when they are immersed, not only in water and artificial saliva, but also in lactic acid. Therefore, the aim of this in vitro study was to evaluate the sorption and solubility characteristics [sorption (*S*), solubility (*SL*) and percentage of mass change (M_g%), resin solubility (SL%) and sorbed liquid (S%)] of some self-adhesive resin cements when immersed in distilled water and lactic acid. The tested null hypotheses were: (1) there are no differences in sorption (*S*) of these cements after being immersed in the two liquids at different time intervals, (2) there are no differences between the cements for the values of each of the followings: *SL*, M_g%, SL% and S%, after 168 h of immersion in the two liquids, (3) there is no difference between the two liquids with respect to all sorption and solubility characteristics examined.

2. Materials and methods

2.1. *Materials*

Four self-adhesive resin cements were investigated in this study: G-Cem (GC Corporation), SmartCem™ 2 (Dentsply DeTrey), RelyX™ U100 (3M-ESPE), RelyX™ Unicem 2 automix