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Linear Shrinkage of Dual Resin-based Cements Using Ceramic Discs

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Abstract

The dual-resin-based cements used for cementing indirect aesthetic restorations exhibit polymerization shrinkage, which decreases with increasing thickness of ceramic restorations. Shrinkage generates contraction stresses that are responsible for problems at the tooth-restoration interface. The objective of this study was to determine the influence of ceramic thickness on the shrinkage by polymerization of three dual resin-based cements. IPS Empress® ceramic discs (thick: 1.0, 1.5 and 2.0 mm) were manufactured. Polymerization shrinkage percentage of cements Variolink II (Ivoclar, Vivadent, Liechtenstein), Maxcem (Kerr, Orange, USA) and Duolink (Bisco, Schaumburg, USA) was calculated using the Watts and Cash method. For each dual resin-based cement forty samples, ten for each ceramic disc thickness (no disc, 1.0, 1.5 and 2.0 mm) were photocured. Results were analysed with ANOVA. Statistically significant differences were found among the control group when compared to dual resin-based cements. Variolink presented lesser shrinkage percentage. The restorations thickness significantly influences polymerization shrinkage. The clinician must consider this fact during his dental protocol.

Keywords: *Dual cements; Shrinkage; Polymerization; Ceramic thickness; Resin-based cements*

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Introduction

Now a day, there is a great demand for dental restorations that offer an adequate function and favourable aesthetic. The dental field has achieved great evolution with the advent of metal-free restorations. [1] Composite resins arrived in the market in the sixties. They have been used as restorative material for carious lesions, erosions and fractures. They have also been used as adhesion material for brackets. Recently, they have been used as adhesive cement for resin and porcelain indirect restorations. [2] The appearance of metal-free materials used for dental restorations, resin-based and self-curing cements were introduced. These materials presented suitable colours, quite similar to dental structure. Nevertheless, they presented some disadvantages: work time was very limited, and the clinical operator could not control cementation times. Due to these factors, resin light-curing cements were introduced to improve the situation. However, when the clinical operator uses these cements, it was observed that the resin-based cement did not cured properly. First the restoration absorbs a lot of energy of the light and the resin-based cement does not polymerize properly. [3] Dual resin-based cements solved this problem.

They exhibit both light-induced polymerization and auto-polymerization. However, these types of dual cements, as well as restoration resins, present polymerization shrinkage. [3,4] The polymerization shrinkage produces a space between the tooth and the restoration. This allows the entry of bacteria that favour the presence of caries with secondary postoperative tooth sensitivity or pulpitis, changes in the colour of the restoration at the interface with the dental tissue, and other problems. These changes have an impact on final restoration success or failure. [1-3, 5-7] In general terms, polymerization shrinkage depends on the rate with which the material absorbs light during polymerization, a circumstance that is related to the material thickness. [7,8] An increase in the thickness of the indirect restorations produces a reduction in the amount of light absorbed by the resin-based cement. This causes a deficiency in the physical properties of the cement and, in turn, a physiological aggression to the dental tissues due to the cement components that did not react. [2, 9-11] All dentists are responsible for performing dental preparations with proper characteristics to allow for the placement of uniform thickness of metal free restorations suitable for polymerization of different cements. [12,13] The objective of this study was to evaluate the polymerization shrinkage percentage of three dual resin-based cements by interposing ceramic discs of different thicknesses.

Materials and Methods

Watts & Cash [14] method was used to calculate polymerization shrinkage of dual resin-based cements. A copper ring (internal diameter: 19 mm; height: 1 mm) was used for polymerization contraction tests. This method is possible because dental materials based on resin have the property of adhering a glass. The adhesion allows measuring the contraction when the material receives the light of a light-cure lamp. The glass is deflected by the volumetric reduction of the dental material. LVDT transducer indirectly measures this deflexion. Figure 1.

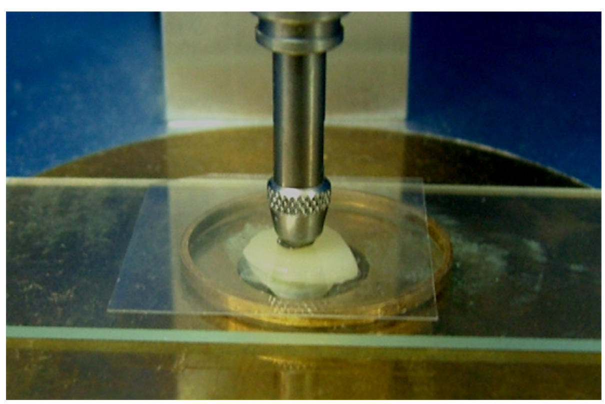

Figure 1: *Slide; copper ring; dual resin-based sample; coverslip and LVDT transducer.*

Using appropriate equations that relate glass deflexions; the polymerization shrinkage percentage is calculated. Three ceramic discs (A3) of different thicknesses (1.0, 1.5 and 2.0 mm) were manufactured using IPS Empress® (Ivoclar, Vivadent, Liechstentein) ceramic injection system. Three dual resin-based cements were used: Variolink II (Ivoclar Vivadent Liechstentein); Maxcem (Kerr, Orange USA), and Duolink (Bisco, Schaumburg USA). Samples (0.14 ± 0.02 g) were prepared according to manufacturer instructions for each measurement and were light-cured for 40 s using a light-curing unit (Visilux 2, 3M, USA) at 400 mW/cm^2. For each dual resin-based cement forty samples, ten for each ceramic disc thickness (no disc, 1.0, 1.5 and 2.0 mm) were photocured. Each sample was placed in the centre of the copper ring. The copper ring was mounted on a slide. The sample was covered with a coverslip. The assembly was placed in the contraction device. Figure 2.

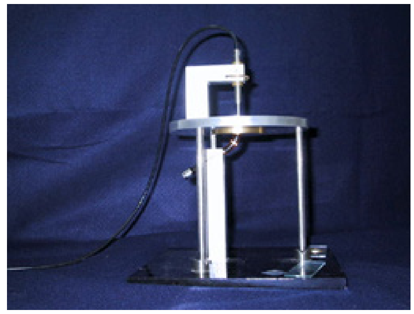

Figure 2: *Contraction device without light-curing unit.*

A data acquisition program (PICO ADC-16) was used to obtain voltage data. The voltage values were used to calculate the polymerization shrinkage. Linear displacement measurements induced by polymerization contraction are described in detail by Watts & Cash [14].

Figure 3 shows the system schematic arrangement to measure the polymerization contraction using ceramic discs of variable thickness.

One-way ANOVA test (Sigma Stat 2.0) was used to analyse results. Dual resin-based cements were compared using Tukey test to find statistically significant differences.

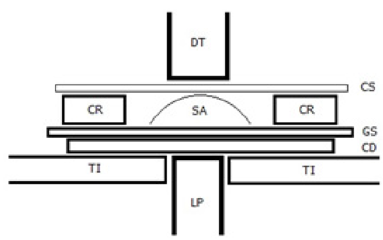

Figure 3: *The contraction measurement instrument: schematic arrangement. DT: displacement transducer; CS: coverslip; CR: copper ring; SA: dual cement resin base sample; GS: slide; CD: variable thickness ceramic disk; IT: instrument table; LP: lamp probe.*

Results and Discussion

Photopolymerization shrinkage average values (%) of each dual resin-based cement were obtained. These data are reflected in Figure 4.

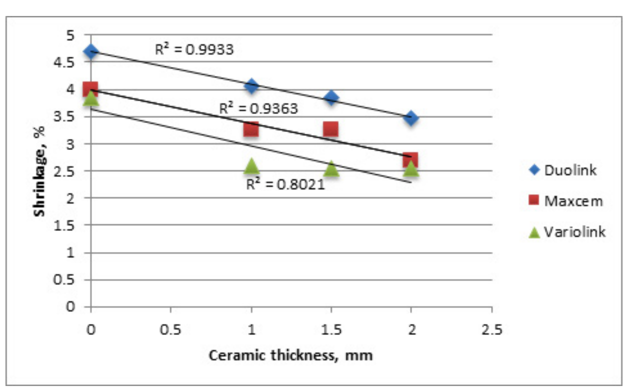

Figure 4: *Shrinkage vs. ceramic thickness linear behaviour of dual resin-based cements.*

Each plot includes ten measurements that present the shrinkage data of the resin-based cement. As shown, the highest shrinkage values belong to Duo link. It is dual-cured resin-based cement with 60% average weight percentage of filler particles, 1.0 μm of particle size. The lowest values belong to Variolink (73% filler average weight percentage and 0.7 μm. Three resin-based cements showed a linear behaviour. Statistically significant differences were found among all three dual resin-based cements and no ceramic disc sample, ($p < 0.001$).

Dual resin based cements used for cementing indirect aesthetic restorations generate stresses as a result of polymerization shrinkage. It can be responsible for most problems encountered in the tooth-restoration interface.

The polymerization shrinkage of dual resin-based cements may be influenced by several factors, such as different restorations thickness, ceramic thickness, organic and inorganic matrix composition, filler particle type and size, mixed process. These factors determine the absorption of light in the resin-based cement layer.

In this study, 1.0, 1.5 and 2.0 mm ceramic thicknesses were chosen. These are thicknesses that might be encountered in certain clinical situations of ceramic material restorations. There are specific clinical situations where the ceramic material is used to restore a greater tooth surface and may have a greater thickness. This is the case of teeth that are rotated, or tilted towards lingual or vestibular direction. Car dash [8] believes that, in resin cements, in order to obtain better physical properties, it is preferable to use 2 mm ceramic thicknesses that allow adequate absorption of light by the resin-based cement. Dumfahrt [6] recommends that, in anterior teeth an incisal ridge reduction be performed to enable this area to have a 1 to 1.5 mm porcelain thickness.

In actual study, it recorded behaviour of three dual resin-based cements. Polymerization shrinkage was observed to decrease in all groups when increasing thickness of the ceramic disc. This decrease was statistically significant. There are no studies that evaluate the polymerization shrinkage of dual resin-based cements when the thickness of the ceramic increases. Evidence of other physical properties are affected when resin-based cements polymerize through a ceramic are presented by other studies. Uctasli [9] and ElMowafy [10] mention that at higher thickness of a ceramic restoration, lower hardness of the resin cement. Jung [11] showed that an increase in the thickness of ceramic discs has a negative effect on the curing depth and the physical and mechanical properties of resin-based cements.

Braga [1] stated that the polymerization shrinkage is affected by the cement composition (organic and inorganic matrix) and the inorganic particles size. Resin-based cements used in our study present different weight percentage of filler. Variolink II has 73.4% in weight of filler particles, Maxcem 67% and Duolink 50-70%. Variolink II showed the lowest polymerization shrinkage in comparison with Maxcem and Duo link. This behaviour is due to high filler percentage. Aw [5] and Labella [7] showed that at more filler percentage (less organic matrix) therefore less C=C double bonds then low conversion degree and less polymerization shrinkage.

The filler particle size is important. Variolink II has an average particle size of 0.7 μm, Duolink cement 1 μm, and Maxcem cement a particle size of 3.6 μm. Variolink II showed the lowest polymerization shrinkage in comparison with Maxcem and Duo link. Direct relationships exist between surface area of particle fillers and wettability of fillers: low particle size, high wetting. That result is agreed with results of Aw. [5] He found that smaller particles produce lesser polymerization shrinkage.

Other factor that affects the polymerization shrinkage is the mixed process. Variolink II was blended using a manual process; Maxcem and Doling were blended using a mechanical process. Manual mixing of materials produces bubbles; these bubbles are numerous and important size. Mechanical mixing produces bubbles but in little quantities and small in size. Alster [3] intentionally produced bubbles in a material and found that the contraction stress decreased. Therefore, we might conclude that in the present study, the low polymerization shrinkage percentage observed in Variolink II might be related to its manual manipulation.

Conclusions

Within the limitations of the present study, the following conclusions may be drawn:

Increase of ceramic restorations thickness decreased the polymerization shrinkage of the dual resin-based cements.

Factors such as filler particle percentage, filler particle size and mixing process also contributed to polymerization shrinkage reduction of the dual resin-based cements.

When cementing ceramic materials with light and dual-cured resin cements, it is important to understand that the different ceramic material thickness may attenuate the light.

Conflict of interest

The authors have no conflicts of interest. It is an academic study.

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