



# Polymerization-induced shrinkage of dual cements through different thicknesses of ceramic materials

## *Encogimiento por polimerización de cementos duales a través de distintos grosores de cerámica*

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### ABSTRACT

Dual resin based cements used for indirect aesthetic restorations sustain shrinkage due to polymerization, which can increase as the ceramic restoration thickness increases. This shrinkage generates contraction efforts which induce problems in the inner phase located between the tooth and restoration. The objective of this study was to determine the influence exerted by the thickness of the ceramic restoration in the polymerization shrinkage of three dual luting cements. 1, 1.5 and 2 mm thick IPS Empress® ceramic disks were manufactured. Polymerization shrinkage of cements Variolink II (Ivoclar, Vivadent, Liechtenstein), Maxcem (Kerr, Orange, USA) and Duolink (Bisco, Schaumburg, USA) was assessed using the Watts and Cash method. For each cement, 10 control determinations were performed impacting the light without using a ceramic disk; 10 impacting the light through a 1 mm ceramic disk, 10 through a 1.5 ceramic disk and 10 through a 2 mm ceramic disk. Results were analyzed with ANOVA. Statistically significant differences were found among the three cements in the control group when compared to experimental cements. Variolink II was the cement exhibiting lesser shrinkage percentage in all groups. Thickness of restorations significantly influenced polymerization shrinkage. This fact must be well taken into account by the clinical operator when dealing with dental preparations.

**Key words:** Dual cements, shrinkage, polymerization.

**Palabras clave:** Cementos duales, encogimiento, polimerización.

### RESUMEN

Los cementos a base de resina dual utilizados para la cementación de las restauraciones estéticas indirectas presentan encogimiento por polimerización, el cual puede incrementarse al aumentar el grosor de las restauraciones cerámicas; dicho encogimiento genera esfuerzos de contracción que son responsables de los problemas en la interfase diente-restauración. El objetivo de este estudio fue determinar la influencia del grosor de cerámica en el encogimiento por polimerización de tres cementos duales. Se realizaron discos de cerámica IPS Empress® de 1, 1.5 y 2 mm de grosor, se calculó el encogimiento por polimerización de los cementos Variolink II (Ivoclar Vivadent, Liechtenstein), Maxcem (Kerr, Orange, EUA) y Duolink (Bisco, Schaumburg, EUA), mediante el método de Watts y Cash. Se realizaron para cada cemento 10 determinaciones control, incidiendo la luz sin usar un disco de cerámica, 10 incidiendo la luz a través de un disco de cerámica de 1 mm de grosor, 10 a través de un disco de cerámica de 1.5 mm y 10 a través de un disco de 2 mm. Los resultados se analizaron con ANOVA y se encontraron diferencias estadísticamente significativas entre los tres cementos del grupo control y los grupos experimentales. El cemento con menor porcentaje de encogimiento en todos los grupos fue Variolink II. El grosor de las restauraciones influye significativamente en el encogimiento por polimerización, lo que debe ser tomado en cuenta por el clínico durante la preparación dental.

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### INTRODUCTION

In our days, there is great demand for placement of dental restorations offering not just adequate function, but also favorable aesthetics. The dental field has achieved great evolution with the advent of metal-free restorations.<sup>1</sup> Composite resins arrived in the market in the sixties. They have been used as

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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.<sup>2</sup>

With the advent of metal-free materials used for dental restorations, resin based, self-curing cements were introduced. These materials presented suitable colors, quite similar to dental structure. Nevertheless, they presented some disadvantages: work time was very limited, and cementation times could not be controlled by the clinical operator. Due to these factors, resin light-curing cements were introduced to improve the situation. Nevertheless, when using these cements, it was observed that polymerization was not evenly distributed, since the light beam had to impact first on the restoration before reaching the resin cement. This resulted in improper polymerization of the cement.<sup>3</sup>

To redress these limitations, cements based on dual resin came into play. These cements presented light-induced initial polymerization as well as self-polymerization. We must mention that when they harden, this type of cements, as well as resins, experience polymerization-induced shrinkage.<sup>3,4</sup>

Polymerization-induced shrinkage takes place due to the fact that molecules of a resin matrix are far from each other, at a average 4 nm, before polymerization. When they polymerize and establish covalent union among themselves, that distance is reduced to 1.5 nm, and this results in the material's volume reduction.<sup>5</sup>

The aforementioned, clinically corresponds to a space generated between the tooth and the restoration. This space allows passage of bacteria, which favor the presence of secondary caries, postoperative tooth sensitivity or pulpitis, restoration discoloring at the inner phase with dental tissue. These are but a few characteristics which have repercussions with respect to the success or failure or the final restoration.<sup>1-3,5-7</sup>

It is important to mention the fact that shrinkage due to polymerization is directly associated to some factors such as speed in which light is absorbed and the amount of the light absorbed by the resin cement during polymerization. These circumstances might be related to the thickness of the restoration.<sup>6,7</sup>

Increasing thickness of indirect restorations elicits a reduction of amount of absorbed light by the resin cement. This causes deficiencies in the cement's physical and mechanical properties, and, in turn, physiological aggression to tooth tissues,

due to cement components which did no experience a reaction.<sup>2,9-11</sup>

All dentists are responsible for performing dental preparations with proper characteristics to allow for the placement of uniform thickness, metal free restorations suitable for polymerization of different cements.<sup>12,13</sup>

The aim of the present study was to determine the influence borne by different thicknesses of ceramic materials in the shrinkage due to polymerization of three dual cements based on resin.

## MATERIALS AND METHODS

For this research paper, Watts & Cash<sup>14</sup> method was used to calculate polymerization shrinkage of dual resin based cements.

This method was possible due to the fact that resin based materials possess the property to adhere to glass, thus enabling to measure shrinkage. When light is applied to the material, glass flexes due to volumetric reduction. This flexion is indirectly measured by a LVDT (Lineal Variable Differential Transformer) type transducer. With IPS Empress® (Ivoclar, Vivadent, Liechstentein ) ceramic injection system three disks of different thicknesses (1, 1.5 and 2 mm) were manufactured. These disks were made-up with A3 color to be used in the experiment.

A copper ring (18.58 mm internal diameter and 1.01 height) was used for shrinkage tests.

Three dual resin based cements were used: Variolink II (Ivoclar Vivadent Liechstentein) Maxcem (Kerr, Orange USA), and Duolink (Bisco, Schaumburg USA). For each test, portions of 0.123 to 0.16 g were taken to perform each determination.

Ten control determinations were performed for each dual cement, impacting direct light coming from a polymerization lamp (Visilux 2, 3M, USA), ten determinations were performed impacting the light through a 1mm thick ceramic disk (group 1), ten impacting light through the 1.5 mm thick ceramic disk (group 1.5) and ten impacting light through a 2 mm thick ceramic disk (group 2).

Each cement was dispensed on a glass slab preserving the same relationship with respect to base and catalyzing agent. Two of the dual cements used provided special nozzles for mixing (Duolink, and Maxcem), while the third cement (Variolink II) was manually mixed.

To undertake each determination, once the Variolink II cement was mixed, it was placed in the center of

the copper ring which was mounted on a slide with the help of a cement spatula.

To undertake each determination of Dualink and Maxcem cements, these were apportioned on the glass slab, and at the same time, they were mixed with the help of the mixing nozzle, to later be placed, with the help of a cement spatula, in the center of the slide containing a copper ring.

Each sample was covered with a cover-slip before being placed in the instrument for measuring polymerization shrinkage.

To measure polymerization shrinkage a LVDT (London, UK) displacement transducer was used. A computer program (PICO ADC-16) was equally used to record data.

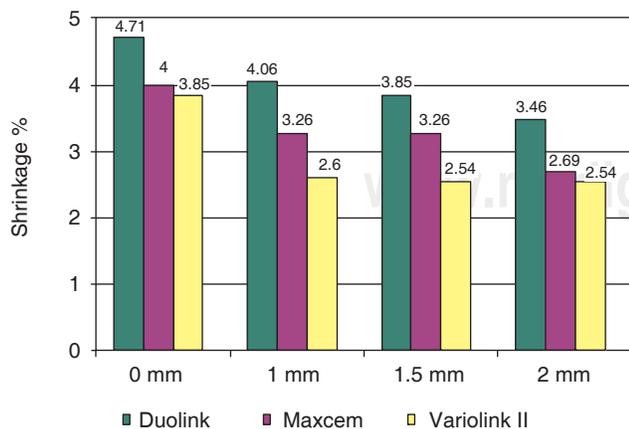
### RESULTS

With the help of Watts and Cash methods<sup>4</sup> shrinkage average values were obtained for each cement in the control group as well as groups 1, 1.5 and 2. These data are reflected in *Figure 1*.

Results were analyzed with one-way ANOVA test. Groups were compared with the Turkey test, using Sigma Start 2.0 to find statistical differences among obtained values.

To perform determinations in the control group in which no ceramic disk was used, and in groups 1, 1.5 and 2, statistically significant differences were found among all three cements ( $p < 0.001$ ).

Likewise, control group shrinkage values were compared with shrinkage values of groups 1, 1.5 and 2 of the same cement.



**Figure 1.** Shrinkage average values for control group cements and group 1, 1.5 and 2 cements.

In cement Variolink II, statistically significant differences were found among control group and groups 1, 1.5 and 2.

When comparing average shrinking values when using Maxcem cement, statistically significant differences were found among control group and groups 1, 1.5 and 2.

When assessing shrinking values of Duolink cement, statistically significant differences were found between control group and groups 1, 1.5 and 2.

### DISCUSSION

Dual resin based cements used for cementing indirect aesthetic restorations generate forces as a result of polymerization shrinkage, which can be responsible for most problems encountered in the tooth-restoration internal phase.

One of the factors participating in the development of shrinkage due to polymerization is the thickness of the restoration. This characteristic determines light absorption at the layer of resin cement.

In this research, 1, 1.5 and 2 mm ceramic thicknesses were chosen, since these are thicknesses that might be encountered in certain clinical situations of ceramic material restorations. Nevertheless, it must be borne in mind that there are specific clinical situations where ceramic material is used to restore a greater tooth surface. This is the case of teeth which are rotated, or tilted towards lingual or vestibular direction.

When speaking of ceramic restorations thickness, some authors like Cardash (1993)<sup>8</sup> propose that, in resin cements, in order to obtain better physical properties, it is advisable to attain 2 mm ceramic thickness, which would allow the cement to adequately absorb light.

Dumfahrt (1999) recommends that, when carving anterior teeth an incisal ridge reduction be performed to enable this area to have a 1 to 1.5 mm porcelain thickness.

This research recorded behavior of different dual resin based cements. Polymerization shrinkage was observed to decrease in all groups when increasing thickness of the ceramic disk.

This decrease was statistically significant, although, to date, no studies have been conducted where shrinkage percentage of dual resin based cements is assessed when increasing ceramic thickness. Some researchers like Uctasli (1994)<sup>9</sup> and El-Mowafy (1999)<sup>10</sup> mention the fact that, when

increasing thickness of a ceramic restoration, the resin cement hardness is decreased. Studies by Jung (2006).<sup>11</sup> agree with this theory. He points out the fact that increasing the thickness of ceramic disks has a negative effect on healing depth as well as on physical and mechanical properties of resin cements.

Braga (2005)<sup>1</sup> mentions the fact that there are as well factors to be considered related to the composition of the cement. These factors are: amount of organic and inorganic matrix as well as particle size which also influence polymerization shrinkage.

Cements used for the present study presented variable amounts of filling material: Variolink II possessed 73.4% filling material, Maxcem 67% and Duolink 50-70%. In all groups, Variolink II was the cement presenting lesser amount of shrinkage. This behavior is related with the high inorganic content present in this cement. According to studies conducted by Aw (2001)<sup>5</sup> and Labella (1999)<sup>7</sup> the greater the amount of inorganic material and lesser amount of organic matrix, there will be lesser amount of double links (bonds) which will produce lesser amount of conversion and lesser shrinkage. In the same way, it is important to take into account the size of the filling particle. Cements used for this study presented different particle sizes. Variolink II cement presents a 0.7  $\mu\text{m}$  average particle size. Duolink possesses a 1  $\mu\text{m}$  particle size, and Maxcem presents a 3.6  $\mu\text{m}$  particle size. As mentioned before, Variolink II was the cement which showed lesser amounts of shrinkage. It must be noted that it was the cement presenting smaller particles. Aw (2001),<sup>5</sup> as a result of his research, mentions the fact that smaller particles cause lesser polymerization shrinkage. Small filling particles confer viscosity to the cement, thus allowing it to flow during the onset of polymerization. Therefore, contraction forces are released, thus decreasing polymerization shrinkage.

It is important to also point out the fact that, during this research, Variolink II cement was mixed manually, unlike the two other participating cements.

When materials are manually mixed, numerous and sizable bubbles or pores are produced. Alster (1992)<sup>3</sup> described decrease in contraction effort produced when intentionally incorporating pores into a material. Porosities are distributed along all the area and provide an internal free surface which eases the flow of material and alleviates contraction efforts in the surrounding area. Therefore, we

might conclude that in the present research, the low polymerization shrinkage percentage observed in Variolink cement, when compared with the other two participants, might be related to its manual manipulation.

## CONCLUSIONS

Increase of ceramic restoration thickness brings as a consequence decrease of polymerization shrinkage in dual resin based cements.

Manual mixing of dual resin based cements causes porosities in the material, which allow for the release of the contraction effort, thus resulting in decrease of shrinkage due to cement polymerization.

It would be advisable to conduct further studies where dual resin based cements are used through different thicknesses of ceramic, to later assess physical and mechanical properties which, in turn, can be altered when increasing ceramic thickness.

It would as well be advisable to conduct studies where lamps with polymerization programs were included, since, the fact of shrinkage due to polymerization depends on many circumstances not just the thickness of ceramic restorations.

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