

Effect of Time on the Diametral Tensile Strength of Resin-Modified Restorative Glass Ionomer Cements and Compomer

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The aim of this study was to analyze the diametral tensile strengths of three resin-modified restorative glass ionomer cements - Vitremer, Fuji II LC and Photac Fil and one compomer - Dyract. They were tested at 1 hour, 1 day and 1 week. Kratos testing machine was used to load the specimens at a cross-head speed of 0.5 mm/min. The data were analyzed by two-way ANOVA and Tukey's test that showed statistically significant differences among the materials. The tested materials presented an increase in strength from 1 hour to 1 week and were as follows for each material respectively: Vitremer (19.22-27.29), Fuji II LC (23.91-28.67), Photac Fil (19.35-22.86), Dyract (28.83-46.95). Dyract presented the highest strengths.

Key Words: glass ionomer, compomer, diametral tensile strength.

INTRODUCTION

Glass ionomer cements were divulged by Wilson and Kent (1). Since then their applications in operative dentistry have steadily increased. Glass ionomer cements can be used for filling, lining, basing, luting or as a core build-up material. These materials exhibit the advantageous properties of a coefficient of thermal expansion similar to natural tooth structure, a physicochemical bond to enamel, dentin and cementum, biocompatibility, and the release of fluoride.

However, there are some limitations in their applications due to low early mechanical strength and short working time. Conventional glass ionomer materials have also shown moisture sensitivity especially during the initial stages of the setting reaction (2).

To help overcome these problems, resin components were added to the conventional glass ionomer cements, and part of the water component was replaced by a water/hydroxyethylmethacrylate (HEMA) mixture in some glass ionomer brands. The reaction of the resin-

modified glass ionomer cements is said to be a dual mechanism: the normal glass ionomer cement acid-base reaction and a free radical or photochemical polymerization process similar to that used in composite resins (3). With this incorporation, restorations, fixing of orthodontic brackets and bands and core build-up became easier. Resin-modified glass ionomer materials allow a longer working time plus the possibility to complete a crown preparation in the same session without losing the advantages of the conventional materials.

Recently, other materials were marketed claiming also to be glass ionomer cements or multi-purpose materials. In fact, these materials are resins modified by polyacids. They do not have the typical acid-base reaction, but they confuse the users with misleading advertising.

Mechanical strength is an important factor that has to be analyzed for clinical success of dental restorations. The diametral tensile test provides a simple method for measurement of the tensile strength of brittle mate-

rials like glass ionomers cements.

The aim of this study was to analyze the diametral tensile strength of three resin-modified restorative glass ionomer cements and one compomer.

MATERIAL AND METHODS

Three resin-modified restorative glass-ionomer cements: Vitremer (3M), Fuji IILC (GC) and Photac Fil (ESPE) and one compomer Dyract (Dentsply) were tested (Table 1).

Five specimens (6 mm in diameter and 3 mm in height) were prepared for each material for each time period. All samples were made according to ADA specification number 27. The materials (Vitremer and Fuji II LC) were manipulated according to manufacturer instructions, weighing powder and liquid. The environmental temperature was controlled and the materials were mixed with a plastic instrument on a glass plate that was refrigerated and dry. The capsulated material (Photac Fil) was mixed using a proprietary capsules mixer (Capmix, ESPE, Seefeld, Germany). After mixing, Vitremer and Fuji II LC were put into plastic capsules and injected by syringe (Centrix) into stainless steel molds that were previously coated with a nonreactive lubricant (solid vaseline). Photac Fil and Dyract were put into the matrixes by using proprietary syringes. The specimens were light-cured with an activating light (LX 1500, 3M, St. Paul, MN, USA). The activation times were in accordance with manufacturer recommendations. Two minutes after the start of the mix, the assembly was placed in an oven at $37 \pm 1^\circ\text{C}$ and $95 \pm 5\%$ relative humidity, and allowed to remain 15 min. The specimens were then ejected from the mold and stored in 20 ml of deionized water at $37 \pm 1^\circ\text{C}$. The diametral tensile strength was measured after 1 hour, 1

day and 1 week of storage. A special device was constructed to position the specimens with its diameter coinciding with the directions of the compressive force from platens of machine. Tests were made in a Kratos Universal Testing Machine (Kratos Equipments, São Paulo, SP, Brazil) with load 1, scale 4 and cross-head speed of 0.5 mm/min. Diametral tensile strength (DTS) was expressed in kg/cm^2 . $\text{DTS} = 2P/\pi dh$ where P was the force used in kg, d and h were, respectively, diameter and height of specimens in cm. The values were converted to MPa using the conversion number 0.09807. The results were subjected to two-way ANOVA at the 95% level of confidence to analyze the influence of materials and storage periods, and the Tukey test for multiple comparison.

RESULTS

The means \pm SD of diametral tensile strengths are reported in Figure 1. All tested materials showed an increase in strength from 1 hour to 1 week ($p < 0.05$). For the 1-h period, Dyract and Fuji II LC presented the highest strengths with no statistically significant difference between them. There was also no statistical difference between Vitremer and Photac Fil. For the 24-h period, Dyract had significantly higher strength ($p < 0.05$) than Fuji II LC, Photac Fil and Vitremer which were statistically similar. At the 1-week period, Dyract had the highest and Photac Fil the lowest strength ($p < 0.05$). There was no statistical difference between Fuji II LC and Vitremer.

DISCUSSION

All the tested materials presented an increase in diametral tensile strength during the experiment. This increase can be explained by the setting reaction of glass ionomer cements. Calcium polycarboxylate is formed in the first 5-7 min after mixture. Aluminum polycarboxylate which is more stable and improves the mechanical properties of the cement takes a mean of 24 h to be formed. Moreover, there is a continuance of HEMA polymerization reaction after irradiation for at least 24 h (4).

Table 1. Identification of the tested materials.

| Material | Manufacturer | Type | Batch Number | Powder/Liquid |
|------------|-------------------------|-------------------------------|--------------|---------------|
| Vitremer | 3M St. Paul, MN | resin-modified | 19930823 | 2.5g/1.0g |
| Fuji II LC | GC Chicago, IL | resin-modified | 270751 | 3.0g/1.0g |
| Photac Fil | ESPE Norristown, PA | resin-modified/ capsulated | 17242 | 5.0g/1.0g |
| Dyract | Dentsply Milford, DE | compomer/compules | 950427 | - |

Resin-modified glass ionomer cements have shown higher diametral tensile strength than conventional glass ionomers (5,6). However, composites have presented better scores than both conventional and resin-modified glass ionomer materials (6,7). Due to the addition of resin, these materials have the normal glass ionomer cement acid-base reaction and a free-radical or photochemical polymerization process (3). In this system, there is lack of water because it was replaced by a water/HEMA mixture. For this reason, the polymerization of HEMA is the initial set and the acid-base reaction proceeds more slowly (8). Consequently, there is longer working time, rapid set and early water contamination resistance.

The addition of resin does not negatively affect the other properties of conventional glass ionomers. Fluoride release, for example, is equivalent (9,10) or higher than conventional materials (10-12). Fluoride has an antibacterial effect once the prevalence of *Streptococcus mutans* decreases after placement of glass ionomer restorations (13). These materials are also able to take up fluoride from solutions or gels and subsequently release it (14,15). Fluoride release from amalgams and composites is clearly less than glass ionomers (16,17). It is important to know that long-term fluoride release does not cause any degradation of physical properties of these materials (18).

The compomer Dyract had significantly higher strength at all time periods ($p < 0.05$), except at 1 h when it was statistically similar to Fuji II LC. However,

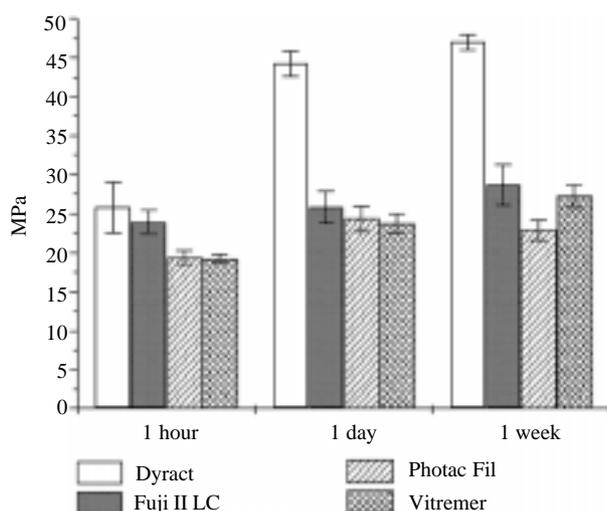


Figure 1. Comparison of the diametral tensile strength among the materials at the three time periods.

Levartovsky et al. (19) reported that composites have shown better diametral tensile strength than compomers. This material is not a glass ionomer cement because it does not have the auto-setting acid-base reaction and does not exhibit the typical properties of true glass ionomer cements (20). In fact, it is a resin modified by polyacids.

The diametral tensile strength test is applicable only for brittle materials. If a material deforms excessively during the test, the resulting strength is not valid. In this experiment, a special device was constructed for the positioning of the specimens with their diameters coinciding with the direction of the compressive force from platens of the machine. All tested samples presented a failure plane that divided the specimens into two equal parts, confirming that the data were valid.

We conclude that the tested materials presented an increase in diametral tensile strength from 1 hour to 1 week. No current material is ideal. For clinical success, dentists must be aware of the properties of the material, choose materials accordingly and manipulate them properly.

RESUMO

Cefaly DFG, Valarelli FP, Seabra BGM, Mondelli RFL, Navarro MFL. Efeito do tempo na resistência à tração diametral de cimentos de ionômero de vidro modificados por resina e compômero. *Braz Dent J* 2001;12(3):201-204.

O objetivo desse estudo foi analisar a resistência à tração diametral de três cimentos de ionômero de vidro modificados por resina - Vitremer, Fuji II LC e Photac Fil e um compômero - Dyract. Os materiais foram testados após 1 hora, 1 dia e 1 semana. A máquina de testes Kratos foi utilizada a uma velocidade de 0,5 mm/min. Os dados foram analisados pelos testes ANOVA a dois critérios e teste de Tukey e mostrou diferenças estatisticamente significantes entre os materiais. Os materiais testados apresentaram um aumento na resistência de 1 hora para 1 semana, como segue: Vitremer (19,22-27,29), Fuji II LC (23,91-28,67), Photac Fil (19,35-22,86) e Dyract (28,83-46,95). O Dyract apresentou as maiores resistências.

Unitermos: cimento de ionômero de vidro, compômero, resistência à tração diametral.

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