Diametral tensile strength of two Brazilian resin-modified glass ionomers cements: influence of the powder/liquid ratio

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Received for publication: March 23, 2007
Accepted: May 14, 2007

Abstract
The aim of this study was to evaluate the influence of powder/liquid ratio in the diametral tensile strength of two resin-modified glass ionomers cements (RMGIC). Two Brazilian brands of RMGIC: Resiglass R (RG: Biodinâmica) and Vitro Fil LC (VF: DFL) were used. Each product was mixed in two different powder/liquid ratios, (1:1) 1 scoop of powder to one drop of liquid or (1:2) 1 scoop of powder to 2 drops of liquid. The control was considered the powder/liquid ratio recommended by each manufacturer (RG 1:1 and VF 1:2 P/L). Four groups (n=5) with sample dimensions of 2.5 and 5.0 mm (thickness and diameter respectively) were tested. Diametral Tensile Test was performed in a mechanical testing machine (EMIC DL 500). Data obtained were submitted to One-way ANOVA and Tukey's multiple comparisons test (α=5%). For both national RMGICs, the experimental variations in the powder/liquid ratio led to an increase in diametral tensile strength when compared to the ratios advocated by the manufacturers. Group VL manipulated with experimental ratio 1:1 showed statistically the highest (25.54±2.38 MPa) DTS mean among the tested groups whereas Resinglass R manipulated with 1:1 ratio, as advocated by manufacturer, showed statistically the lowest DTS mean (9.27±1.37 MPa). A review and further adjustments in the ratios recommended by the manufacturers of both resin-modified glass ionomers cements investigated is necessary.

Key Words:
tensile strength, dental cements, ionomer, resin

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Introduction

The success of glass ionomers (glass polyalkenoate cements) relies on the advantages showed by the product, such as its slow release of the fluoride, its adhesion to the tooth structure without any pre-treatment and its biocompatibility with dental tissues. However, its poor physical properties, such as low flexural strength and fracture toughness make adverse its use in stress bearing areas[1].

To improve some of the mechanical properties and the bond strength of glass-ionomer cements (GICs), resinous components were incorporated into these ionomers and new products have being originated, such as the acid-modified composites (compomers) and resin-modified GICs (RMGICs)[2].

The resin-modified glass-ionomer cements (RMGICs) were commercially introduced in 1989 with the proposal of being used in a variety of different applications: Class II or V placements (particularly, cervical erosive lesions and carious radicular surfaces); primary teeth restorations; construction of cores (specially in vital teeth); restorations using sandwich techniques; and in cases where it is necessary the use of radiopaque restorations[3].

Since the introduction of GICs in the early 1970s, the cements constituents (powder and liquid parts) have generally been supplied separately being their relative proportions determined by the technical experience of the operator[4].

Powder/liquid ratio of resin-modified glass ionomer cements could determine significant influences on the ionomers mechanical properties[1,3-4].

The diametral tensile strength test is a simple method, easyly reproduced, to detect alterations in the mechanical strength of the RMGICs

The aim of this study was to evaluate the influence of the powder/liquid ratio on the diametral tensile strength of two commercially available resin-modified glass ionomers cements (RMGICs). The investigated null hypothesis was that variations in the powder/liquid mixing ratio should not influence the diametral tensile strength values of both RMGICs studied.

Material and Methods

Powder/liquid (P/L) ratios of two national brands of resin-modified glass-ionomer cements were tested (Table 1). For each RMGIC, the hand-mixing amount of powder and liquid recommended by the manufacturers were weighed (Table 2) and used as control (1:1 = 1 scoop of powder to 1 drop of liquid in case of Resiglass "R" Restore and 1:2 =1 scoop of powder to 2 drops of liquid in case of Vitro Fil LC). Each product was then prepared in two different powder/liquid ratios, the proportions were of 1 scoop of powder to one drop of liquid (P/L 1:1) and of 1 scoop of powder to 2 drops of liquid (P/L 1:2). The samples were prepared by only one operator. A steel mould, with central hole dimensions of 2,5 x 5,0 mm (height and diameter respectively), was used to obtain

Table 1 - RMGICs tested in this study

Product	Manufacturer	Powder/liquid (P/L) ratio	Chemical composition		Batch no.#
			Powder	Liquid	
Resiglass "R" Restore	Biodinâmica Quim. E Farmac. Ltda., Ibiporã, PR, Brazil	1:1- manufacturer (Control) 0.18g:0.03g 1:2 - increased 0.18g:0.07g	Alumin-strontium silicate, filler, activators and iron oxide	HEMA (2-hydroxiethyl-metacrylate), tartaric and polyacrylic acid aqueous solution, benzoil peroxide and camphorquinone	933/03
Vitro Fil LC	DFL Indústria e Comércio Ltda., Rio de Janeiro, RJ, Brazil	1:1 – diminished 0.11g:0.03g 1:2 – manufacturer (Control) 0.11g:0.06g	Strontium glass, iorganic fillers, poly acrylic and tartaric acid, metacrylate adhesive powder, benzoil peroxide and camphorquinone	Metacrylate hydroxide, special nono-micron excipient, poly acrylic and tartaric acids, deionized water, several initiators and camphorquinone	0406536

Table 2 - Means of diametral tensile strength (± SD)

	Resiglass "R" Restore	Vitro Fil LC
P/L Ratio 1:1	9.27 (± 1.37) c	* 25.54 (±2.38) a
P/L Ratio 1:2	* 19.11 (± 3.29) b	20.51 (±2.32) ab

To the comparisons among P/L Ratios of the same material asterisk (*) indicates that the mean is statistically superior (p<0.05).
Means followed by different short leters indicate statistically significant differences between the tested groups (p<0.05).

standardized specimens. Then the mould was slightly over-filled with the different materials. Acetate strips were then placed on the materials in the mold (bottom and top) which were covered with glass slides. The samples' sides were covered with an acetate strip to prevent the setting cement from adhering to the glass and to guarantee the smoothness of the surfaces. Axial hand pressure was then applied for 20 seconds while excess material was extruded from the top of the mould.

A pilot study calculated the sample size and determined that 5 cylindrical samples of each group should be prepared by hand-mixing the relative proportions of the powder and liquid constituents. All of the following experiments were performed in an air conditioned room set at 22^{o}C. The cements were mixed according to the manufacturer´s instructions, placed in a mould and both surfaces, of all the samples, were photocured for 20s using a halogens light photocuring unit (XL 3000, 3M ESPE St Paul, MN, USA) with irradiance d" 500 mW/cm^2.

Ten minutes after the completion of mixing, the specimens were removed from the mould and then stored in a stove kept at 37±1^{o}C and 95±5^{o}C relative humidity, for 24 hours, in an attempt to simulate the oral environment more closely. The top and bottom surfaces of the samples were ground flat and polished using silicon carbide abrasive paper 600 grit. Specimens with non-uniform borders, residual surface defects or any other visually apparent defect were discarded. Before each sample was tested, the diameter and the height of the specimen were measured by a digital sliding calliper (Mitutoyo Corp, Japan). After that, the samples were diametraly loaded using a universal testing machine (EMIC DL 500, São José dos Pinhais, PR, Brazil), at a cross-head speed of 1mm/min. The maximum load to failure was recorded and the procedure repeated so that a minimum of five nominally identical standard cylindrical specimens had been fractured for each powder/liquid mixing ratio investigated.

The DTS was calculated by the formula: 2P/ =pDT, where: P= load applied; D= diameter of the cylinder, T= thickness of the cylinder, p= (constant) 3,14. DTS values [kgf/cm^2] were converted into MPa as follows: DTS[MPa]=DTS[Kgf/cm2] x 0.09807[5] .

Normality and variances were checked by Kolmogorov-Smirnov's test and equal variance test respectively, as a preliminary condition for parametric test. One-Way Analysis of variance (ANOVA) and Tukey's multiple comparisons test were performed at significance level of p<0.05. Additionally to DTS test, mass of powder and liquid of glass ionomer cements were weighed with a precision balance to 0.01 mg (Gehaka, Brazil).

Results

For both national RMGICs, the experimental variation in the powder/liquid ratio led to an increase in diametral tensile strength when compared with the ratio advocated by the manufacturers (Figure 1). Statistically, the group VL, manipulated with the experimental ratio of 1:1, showed the highest DTS mean between the groups tested, whereas the Resinglass R, manipulated with 1:1 ratio (as advocated by manufacturer), showed the lowest DTS mean.

Characterization of weight (1:1 Powder/Liquid proportion respectively) was of 0.18g/0.03g for Resinglass R and of 0.11/ 0.06g for Vitro Fil LC.

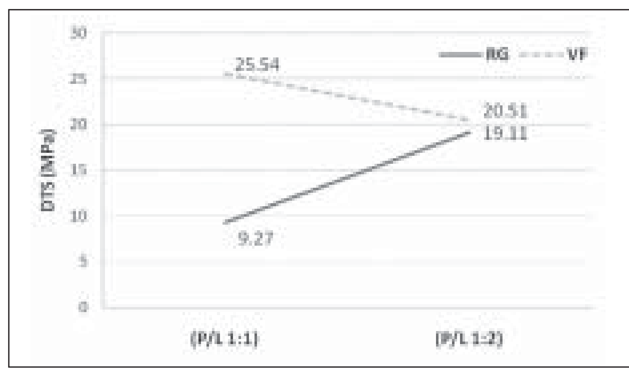

Fig. 1 - *Ilustration of DTS obtained according to different proportions*

Discussion

This study investigated the effects of modifying the powder/ liquid ratios on the diametral tensile strength of two brands of resin-modified glass-ionomer cements commercially available in the brazilian market. RMGIC, fluoroaluminoisilicate glasses generally react with a liquid containing HEMA (2-hydroxyethyl metacrylate, a polyacid and water. For light-cured glass ionomer materials, both the curing depth by light irradiation and the maturation of cure by chemical setting (acid/base reaction) have an important influence on the physical properties of the hardened materials (Young et al, 2004). In our study, to fabricate all the cylindrical specimens of RMGICs, each surface of the specimens was irradiated for 20s and maturated in distilled water at 37^{o}C for 1 hour before the testing.

In clinical practice, dental practioneers tend to use the same resin-modified glass ionomer cement at different consistencies, which correspond to different clinical applications. Sometimes, professionals modify the ratios at the time of the mixture due to the desire of reducing either the time of work and viscosity. On the other hand a manufacturer offers different consistencies and viscosities for the same product category, i.e. luting, restorative or restorative with atraumatic restorative treatment – ART. Generally there are more proportions adjustments than chemical variations in these different products from same manufacturer.

The powder/liquid variations, resulting from operator's variability) have been reported in the literature and authors have been noticing that glass ionomer cements have been mixed to a wide range of powder/liquid ratios, generally in consistencies different from those recommended by the manufacturers. In an attempt to eliminate the induced variability of the operator on mixing, GICs have been supplied in an encapsulated form, where the optimum powder and liquid proportions are pre-determined and supplied as capsules. However, these systems are more expensive than the conventional hand-mixed ones, making difficult their use in clinical practice[1,3-4].

Modifications in the released volume of the liquid are dependent on the position of the liquid vial when it is held to disperse a drop of liquid, as the liquid volume will vary depending on the inclusion of air bubbles[4]. In this research, to dispense a drop of liquid with precision, the vial was held vertically, aiming to avoid the air bubbles.

According to the results of the present study, the null hypothesis should be rejected. Variations in the powder/liquid ratios had an influence on the mechanical property of RMGICs tested in this study. This finding was in accordance with the GIC´s study of Fleming et al.[4], who attested that a decrease in the powder content reduces the concentration of the reinforcing glass particles in the set material and it results in a reduction of the load bearing capacity of the GIC in the mouth. This effect is well described in the literature[6].

Both the studied resin-modified glass ionomers cements showed a better performance after their powder/liquid proportions were altered. Based on the results, a revision and further changes in the weight proportion between powder and liquid should be considered. Consequently adjustments of shape and dimensions of the spoon or the powder dispenser may be sufficient instead of a major chemical modification of these marked products.

The diametral tensile strength test is an easy and rapid test, but it is applicable only for brittle materials, like Glass Ionomer Cements. For these materials values of diametral tensile strength generally are reproducible[7]. In the present study the failure pattern plane divided the specimens into two equal parts, confirming that the data were valid, since complex failure may lead to not reliable data.

Otherwise, it is important to notice that, in the present study, the influence of the powder/liquid mixing regime was just evaluated in terms of diametral tensile strength. Other clinically relevant properties such as flow, working time, setting time, solubility, radiopacity, compressive strength and surface roughness were not taken into consideration. A study examining the effect of different powder/liquid (P/L) ratios on the fracture toughness of commercial resin-modified glass ionomer cement (Fuji II LC and Vitremer) and conventional glass ionomer cement (Fuji II), verified that this intrinsic property of the material was not greatly influenced by the P/L ratio[2]. Also, in a 3-year clinical trial, with Fuji II LC, to evaluate retention in adhesive Class V restorations, it was demonstrated that the powder/liquid ratio should be low enough to create low-viscosity mixtures which promote wetting and, consequently, a stronger union[3].

In agreement with the present study, the different powder/liquid ratios specified by the manufacturers may be one of the factors contributing to a favorable clinical outcome in high stress-bearing areas.

Based on the limitations of the experimental design of the present study, it was verified that:

1. Variations in the powder/liquid ratios of RMGICs national brands influenced the diametral tensile strength of these restorative materials
2. A review and further adjustments in the ratios recommended by the manufacturers of both resin-modified glass ionomers cements investigated is necessary.

References

1. Fleming GJP, Farooq AA, Barralet JE. Influence of powder/liquid mixing ratio on the performance of a restorative glass-ionomer dental cement. Biomaterials. 2003; 24: 4173-9.
2. Mitsuhashi A, Hanaoka K, Teranaka T. Fracture toughness of resin-modified glass ionomer restorative materials: effect of powder/liquid ratio and powder particle size reduction on fracture toughness. Dent Mater. 2003; 19: 747-57.
3. Wilder AD, Boghosian AA, Bayne SC, Heymann HO, Sturdevant JR, Roberson TM. Effect of powder/liquid ratio on the clinical and laboratory performance of resin-modified glass ionomers. J Dent. 1998; 26: 369-77.
4. Young AM, Rafeeka SA, Howlett JA. FTIR investigation of monomer polymerisation and polyacid neutralisation kinetics and mechanisms in various aesthetic dental restorative materials. Biomaterials. 2004; 25: 823-33.
5. Bresciani E, Barata TJE, Fagundes TC, Adachi A, Terrin MM, Navarro MFL. Compressive and diametral tensile strength of glass ionomer cements. J Appl Oral Sci. 2004; 12: 344-8.
6. Cefaly DFG, Franco EB, Mondelli RFL, Francisconi PAS, Navarro MFL. Diametral tensile strength and water sorption of glass-ionomer cements used in atraumatic restorative treatment. J Appl Oral Sci. 2003; 11: 96-101.
7. Anusavice K J. Phillips' science of dental materials. 11. ed. Philadelphia: WB Saunders; 2003.