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| ORIGINAL

Diametral tensile strength of conventional glass ionomer cements with modified powder ratio for uses in atraumatic restorative treatment

Resistência à tração diametral de cimentos de ionômero de vidro convencionais modificados na razão de pó para uso em tratamento restaurador atraumático

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ABSTRACT

Objective: To identify the diametral tensile strength of Brazilian brands of conventional glass ionomer cements (GIC) when modified powder ratio in their composition compared to each other, and with high viscosity glass ionomer cement for Atraumatic Restorative Treatment (ART). **Methods**: Experimental study with five groups (n=10 each) and specimens (2.5 mm in height and 5.0 mm in diameter), considering G1 (Maxxion R-MR), G2 (Vidrion R-VR) and G3 Vitro molar (VM-control) according to manufacturer recommending powder/liquid (1:1), G4 (MR) and G5 (VR) plus powder (2:1). The specimens were stored in an oven at 37 ± 1 ° C for 1 day. Diametral Tensile Test was performed by the Instron model 4444. Means differences were tested by Student´s T-Test (α = 5%). **Results**: There significant differences were in the means (standard deviation) of diametral tensile strength of MR (1:1) 4.24 (±1.47) and MR (2:1), 5.74 (±1.51) (p=0.039) and VR (1:1) 4.50 (±1.27) and VR (2:1) 6.20 (±1.89) (p=0.029). When comparing MR and VR (2:1) with MV (1:1) 4.82 (±1.17), VR 2: 1, 6.20 (±1.89) showed significant differences (p=0.0336). **Conclusion**: There was a significant increase in the means of diametral tensile strength of Brazilian brands conventional GICs when powder increment, approaching the performance observed by the high viscosity GIC.

Indexing terms: Dental cements. Glass ionomer cements. Tensile strength.

RESUMO

Objetivo*: Identificar a resistência à tração diametral de marcas nacionais de cimentos de ionômero de vidro (CIV) convencionais quando acrescidos de pó em sua composição comparados entre si e com cimento de ionômero de vidro de alta viscosidade para*

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Tratamento Restaurador Atraumático (TRA). ***Métodos****: Pesquisa experimental com cinco grupos (n=10 cada) e confeccionados corpos de prova (2,5 mm de altura e 5,0 mm de diâmetro), considerando G1 (Maxxion R/FGM-MR), G2 (Vidrion R/SS White-VR) e G3 Vitro molar (DFL-VM-controle) manipulados segundo fabricante pó/líquido (1:1), G4 (MR) e G5 (VR) acrescidos de pó (2:1). Os espécimes foram armazenados em estufa a 37 ± 1° C por 1 dia. Teste de Tração Diametral foi realizado pelo equipamento Instron modelo 4444. As diferenças das médias foram testadas pelo Test T de Student (α=5%).* ***Resultados****: Foram encontradas diferenças significativas das médias (desvio-padrão) de resistência à tração diametral de MR (1:1) 4,24 (±1,47) e MR (2:1), 5,74(±1,51) (p=0,039) e VR (1:1) 4,50 (±1,27) e VR (2:1) 6,20(± 1,89) (p=0,029). Quando da comparação entre MR e VR (2:1) com VM (1:1) 4,82(±1,17), VR 2:1, 6,20 (±1,89) apresentou média superior e significante (p=0,0336).* ***Conclusão****: Observou-se aumento significativo nas médias de resistência mecânica à tração diametral dos CIVs convencionais nacionais a partir do incremento de pó, aproximando-se do desempenho observado pelo CIV de alta viscosidade.*

Termos de indexação: *Resistência à tração. Cimento de ionômero de vidro. Cimentos dentários.*

INTRODUCTION

The concept of minimal intervention Dentistry has evolved as a result of scientific knowledge about the caries process and the development of biocompatible and biomimetic materials [1,2]. Among restorative materials, GICs have currently demonstrated properties such as biocompatibility, fluoride release, excellent linear thermal expansion/contraction coefficient and elasticity modulus, being considered the only restorative material with chemical bond to the tooth structure [2].

In addition, GICs have many uses in Dentistry, such as the only restorative option in the Atraumatic Restorative Treatment (ART) [3], suggesting the use of minimal tooth cavity preparations and effective and safe restorative materials, in which ART is an alternative technique adopted for caries control in the context of inequalities in Brazilian oral health and in the context of public health [4-6].

It is known that the high prevalence and incidence of caries is a public health problem, especially in the context of low family income and among those who have no access to public health services [7]. According to the 2010 Brazilian Oral Health Survey, almost 60% of preschool children had caries experience and for the 12-year-old age group, the decayed component of the DMFT is still the most prevalent [8]. According to literature, the survival rate of ART was at least 93% in the first year [9,10]. Furthermore, ART is evidenced as a public health strategy due to its broad covering of restauration needs in schoolchildren, low cost, effectiveness against caries, minimal intervention and repair needs [11].

For restorative materials used in ART, high viscosity GICs are the most indicated due to their surface hardness, although presenting higher cost compared to conventional materials [9-11]. However, experimental studies that have evaluated powder/liquid ratio changes of conventional and high viscosity cements are scarce in literature [12,13].

Considering the high prevalence of caries in Brazil [6], the importance of ART as a minimally invasive and low cost technique of public health scope [8,9], GICs as the only restorative option [3] and the Brazilian context of using conventional GICs for such procedures [4], this study aims to identify the diametral tensile strength of conventional GICs when modified powder is added to their composition, compared to each other, and with high viscosity GICs, considering their indications for ART and other possibilities of powder/liquid ratio for its use.

METHODS

This is an experimental study. Powder/liquid (P/ L) ratios of conventional GIC brands, Vidrion R (SS White Dentistry Ltda, Rio de Janeiro, Brazil) and Maxxion R (FGM, Joinville, Brazil) and high-viscosity Vitro Molar (DFL, Rio de Janeiro, Brazil) were tested (table 1).

Five groups were considered, Group 1 (G1) was composed of GIC MR; Group 2 (G2) was composed of GIC VR; Group (G3) was composed of GIC VM; G4 and G5, GIC MR and VR modified in the powder/liquid ratio, respectively.

Table 1. Product, Manufacturer, powder and liquid chemical composition and ratio and GICs classification used.

Product	Manufacturer	Chemical Powder composition	Chemical Liquid composition	Classification	Powder/liquid ratio*
Maxxion R (MR)	FGM	Micronized glass ionomer; Iron oxides; Silica and Zirconia; Potassium fluoride	Polyacrylic acid and tartaric acid; Deionized water	Conventional	1:1 2:1
Vidrion R (VR)	S.S. White Dental products Ltda	Sodium aluminum calcium fluorsilicate; Barium sulfate; Polyacrylic acid; Pigments	Tartaric acid; Distilled water	Conventional	1:1 2:1
Vitro molar (VM)	DFL	Barium and aluminum silicate; distilled water	Polyacrylic acid; Tartaric	High Viscosity	1:1

Note: *Cements were weighed with a precision balance.

Groups 1, 2 and 3 followed manufacturer's specifications, in which recommend the ratio of 1 scoop of powder to 1 drop of liquid, and were it used as controls. Groups 4 and 5 represented 2: 1 powder/liquid ratio, which means 2 scoops of powder to 1 drop of liquid.

Only one operator prepared the samples. An additional silicone mould (Adsil, Vigodent, Rio de Janeiro, Brazil), with central hole dimensions of 2.5 x 5.0 mm (height and diameter, respectively) was used to obtain standardized specimens. The material was manipulated with plastic spatula and glass plate for 45 seconds. The powder was added to the liquid in two stages, the second one after the complete homogenization of the first one.

Before the mould was overfilled with different materials, it was duly sealed with vaseline. Then, specimens were covered on top with acetate strip and glass slides aimed to eliminate excess and flatten the surface. Axial hand pressure was then applied for 20 seconds, while excess material was extruded from the top of the mould [14]. Ten minutes after mixing completion, specimens were removed from the mould and then stored in stove maintained at 37 ± 1ºC and 95 ± 5ºC relative humidity, for 24 hours, seeking more close similarity with the oral environment. All samples with irregular surfaces and defects were discarded. Before each specimen was tested, the diameter and height of samples were measured using a calliper [14].

Tensile strength

Specimens were submitted to the Diametral Tensile Strength test on Instron mechanical testing machine, model 4444 (Instron Corp, Canton, Mass, USA), with cross-head speed of 1mm / min. The maximum failure load was recorded, and the procedure was repeated so that identical standard cylindrical specimens had been fractured for each investigated powder/liquid ratio. The diametral traction was calculated using the formula: 2P / = pDT, where: P = applied load; D = cylinder diameter, T = cylinder thickness, p = 3.14 (constant). Diametral traction values [kgf / cm^2] were converted into MPa as follows: diametral traction [MPa] = diametral traction [Kgf / cm^2] x 0.09807512 [14].

Data analysis

Student's T test was performed for the differences in means between each powder modified GIC group (tests) and the high viscosity group (control) and, comparison in each group of conventional GIC, ratios of 1: 1 and 2: 1. Statistical significance level was considered α = 5%. Analyses were performed using the STATA 13.0 statistical software (Statacorp 2013).

Ethical issues

Due the fact that specimens were made with Dentistry restorative materials, the present study did not submitted to the Ethics Committee in research with humans or animals.

RESULTS

When comparing the means of resistance to diametral tensile strength for the groups MR (1:1), 4.24 (± 1.47) and MR (2:1), 5.74 (± 1.51) and VR (1:1) 4.50 (± 1.27) and VR (2: 1) 6.20 (± 1.89) statistical differences were observed, respectively p value = 0.039 and p value= 0.029.

Considering the means (standard deviation) between each group of powder modified GICs and the high viscosity GIC group, no significant statistical differences were observed between the MR group, 5.74 (± 1.51) and the VM group, 4, 82 (± 1.17) (p = 0.0753).

However, when comparing the means between the group VR (2:1) and VM, a significant difference could be observed, and VR (2:1), presented higher mean of resistance to diametral tensile strength (Table 2).

Table 2. Means comparison of diametral tensile strength of powder/liquid ratio for high viscosity GIC (1:1) and conventional Vidrion R GIC when increased powder (2:1). Palhoça, Santa Catarina (n = 20).

	Diametral Tensile Strength			
Group	Mean	Standard deviation	Confidence Interval 95%	p value*
VITRO MOLAR (1:1) (n=10)	4,82	1,17	4,00;5,67	0,0336
VIDRION R (2:1) (n=10)	6,20	1,89	4,84;7,56	

*Teste de T de Student.

DISCUSSION

The present study proposed to evaluate the diametral tensile strength of three different commercial GIC brands in their normal compositions and when powder for two conventional GIC brands was added. Statistical differences were observed when comparing groups 1 and 4, Maxxion R (1: 1) and Maxxion R (2: 1) and groups 2 and 5, Vidrion R (1: 1) and Vidrion R (2: 1), respectively.

The option of this study to verify the increase in resistance to diametral tensile strength was due to the fact that according to literature, GICs are widely used in dental practices, as it has the capacity of releasing fluoride, allowing tooth remineralization, in addition to its excellent cost-benefit ratio [12]. Although the literature evidences low tensile strength coefficients for conventional GICs, there is also a consensus that such materials are used to repair teeth that have suffered from caries damage, including efforts to improve their mechanical properties due to the similarity with the mechanical properties of teeth [13].

When compared to modified resin, conventional GICs present lower tensile strength, compression and mechanical resistance [3,4]. Considering wear resistance tests of conventional GICs, they tend to lose their marginal adaptation, although without damage to the tooth [13]. Despite evidence on the sensitivity of GICs to changes in dosage [14], there is recognition that changes in proportions can result in advantageous clinical characteristics, as long as the time of 45 to 60 seconds of GIC manipulation is respected [14,15].

It is also known that, when using GICs in clinical practice, Dentists tend to make changes in their hand-mixed and / or dosage technique with the purpose to reduce working time, empirically suggesting that changes may improve certain clinical situations and increase their resistance [12,14].

When comparing conventional GICs to each other, considering the manufacturer's specifications and when modified with the addition of powder, significant increase in their resistance to diametral tensile strength could be verified, corroborating literature in which the addition of powder increases the contents of Fluorine Silicate, Aluminum and Polyacrylic Acid, which are components responsible for the resistance of conventional GICs [16-18].

To compare each group of conventional powder modified GICs and high viscosity GIC group, the resistance of diametral tensile strength was significantly higher to VR GIC with modified powder when compared to VM GIC. There is a gap in comparative studies of conventional GICs with powder increment, with those of high viscosity. However, some authors evidenced significant increase in the surface hardness of GIC Vitro Molar, when increasing the powder content, compared to the proportion indicated by the manufacturer. However, no significant differences were found in the comparison between the GIC Vitro Molar group added of 50% powder and GICs hand-mixed according to manufacturer's recommendation, Fuji IX for the surface hardness test and Gold Label 9 for resistance to flexion [14,15].

According to a randomized clinical trial conducted with high viscosity GIC and low-cost conventional GIC, both according to manufacturer's specifications applied in a school environment, high success rate of low-cost GIC restorations after six months was evidenced; however, after one year of follow-up, restorations performed with high viscosity GIC were more successful [19]. However, in a study carried out to investigate the survival rate of three GIC brands, including low-cost GICs applied in proximal tooth surface with ART technique, no significant statistical differences were found regarding the performance of the different brands [20].

The results of this study suggest that the increase in the powder content, from conventional GICs to ART, could be an alternative for the improvement in it resistance to diametral tensile strength. In addition, a greater hand-mixing ease was confirmed by the addition of standardized powder, since there was an increase in GIC viscosity when compared to the conventional proportion [14,15]. Thus, it is believed in work optimization, safety, and greater comfort for patients, considering their indication for use in places other than the dental office, in addition to ensuring the use of GICs as an important means of minimally invasive dentistry [1].

Although this study has evidenced significant results for conventional GIC when the powder/liquid ratio is increased in comparison with high viscosity GIC, complementary studies evaluating working time, surface roughness, flexural strength, tensile strength, and bond dentin strength are suggested to consolidate new possibilities of the powder/liquid ratio of conventional GICs as a safe and effective option in the control of caries when using ART.

CONCLUSION

There was a significant increase in the average mechanical resistance to diametral tensile strength of conventional GICs with increase in the powder content, approaching the behavior observed by high-viscosity GIC. This finding suggests new possibilities for the use of conventional GICs when using ART, considered an important minimally invasive technique in Dentistry.

The effectiveness of the diametral tensile strength test, suggested by literature, is confirmed as a simple and easy-to-reproduce method to observe and identify changes in the mechanical strength of GICs when powder is added.

Collaborators

FS Vieira, contributed to the study conception, developed of the experimental design, writing of the manuscript and approval of the final version. RP Pereira, contributed to the developed of the experimental design, critical review of the article, and approval of the final version. SXS Costa, contributed to the critical review of the article, and approval of the final version. DR Figueiredo, contributed to the study conception, with the experimental design, with data analysis, writing of the manuscript, and approval of the final version.

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