Original Article

Compressive strength of glass ionomer cements used for atraumatic restorative treatment

Resistência à compressão de cimentos de ionômero de vidro utilizados no tratamento restaurador atraumático

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Abstract

Purpose: This study evaluated the compressive strength of five glass ionomer cements (Ketac Molar, Fuji IX, Magic Glass, Vidrion R, and Vitro Molar) as a function of storage period (1 hour and 24 hours).

Methods: Sixteen specimens of each material were fabricated according to ISO/DP #7489 Specification using a 6×12 mm (diameter and height) matrix. After setting, specimens were stored in distilled water at 37 °C. Eight specimens per cement were subjected to the compressive strength test in a universal testing machine after 1 hour, and the other eight specimens were tested after 24 hours. Data were analyzed by ANOVA and Tukey's test (α=5%).

Results: The compressive strength mean values (kgf) after 1 and 24 hours were: Ketac Molar: 218.75 and 297.88; Fuji IX: 335.75 and 350.88; Magic Glass: 61.50 and 140.13; Vidrion R: 142.38 and 230.88; and Vitro Molar: 183.38 and 297.50. After 1 hour Fuji IX had the highest compressive strength. All materials but Fuji IX showed higher compressive strength in 24 hours than in 1 hour. After 24 hours, no significant differences were found among Fuji IX, Ketac Molar, and Vitro Molar. Magic Glass had the lowest compressive strength in both storage periods.

Conclusion: Fuji IX showed the best results after 1 hour. After 24-hour storage, Fuji IX, Ketac Molar, and Vitro Molar had similar performance.

Key words: Glass ionomer cements; compressive strength; atraumatic restorative treatment

Resumo

Objetivo: Este estudo avaliou a resistência à compressão de 5 cimentos de ionômero de vidro (Ketac Molar, Fuji IX, Vitro Molar, Magic Glass e Vidrion R), em dois tempos de armazenagem (1 h e 24 h).

Metodologia: Foram confeccionados 16 corpos-de-prova (CP) para cada material (n=8), seguindo as especificações da ISO/DP 7489. Os materiais foram manipulados e inseridos numa matriz desmontável (6 mm de diâmetro e 12 mm de altura). Após a presa os CP foram armazenados em água destilada a 37 °C. Metade dos CP de cada material foi submetida a ensaio de compressão após 1 h e a outra metade foi testada após 24 h. Os resultados foram analisados por ANOVA e teste de Tukey (α=5%).

Resultados: Os valores médios de resistência à compressão (kgf) após 1 h e 24 h foram: Ketac Molar: 218,75 e 297,88; Fuji IX:335,75 e 350,88; Magic Glass:61,50 e 140,13; Vidrion R:142,38 e 230,88, e Vitro Molar:183,38 e 297,50. Em 1 h o Fuji IX apresentou a maior resistência à compressão. Com exceção do Fuji IX, todos os ionômeros apresentaram maior resistência em 24h do que em 1 h. Em 24 h não houve diferença entre Fuji IX, Ketac Molar e Vitro Molar. O cimento Magic Glass apresentou os menores valores nos 2 tempos.

Conclusão: O cimento Fuji IX apresentou os melhores resultados após 1 h. Após 24 h de armazenamento, Fuji IX, Ketac Molar e Vitro Molar tiveram desempenho similar.

Palavras-chave: Cimento de ionômero de vidro; resistência à compressão; tratamento restaurador atraumático

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Introduction

Currently several clinical approaches to treat caries lesions focus on the maximum preservation of dental structures. Considering this context, in the 80's an innovative restorative treatment for carious lesions based on principles of minimal loss of dentin and enamel during caries removal and use of fluoride releasing materials was introduced. This technique named Atraumatic Restorative Treatment (ART) was developed at the University of Darl es Salaam, Tanzanian, as a pilot project and part of a local oral health program (1). Glass Ionomer cements (GIC) are the material of choice for ART due to their ability to bond to dental structures (2) and capacity of releasing and uptaking fluoride, thus working as a constant source of fluoride in the oral cavity (3).

There are different methods to evaluate glass ionomer cements. Wilson and Lewis (1980) (4) analyzed their mechanical properties, which are of utmost importance when using ART technique, considering that there is no standard cavity preparation, additional adhesive system application or even occlusal adjustment. Moreover, adjustments have to be made while the material is still plastic, a clinical situation that was named as technique of *Insensitive Materials* by Frencken et al. (5).

The dental literature provides studies on the mechanical properties of glass ionomer cements, such as diametral tensile strength (6), flexure strength (7) and compressive strength (8-10). However, most of these studies evaluated conventional or resin-modified glass ionomer cements (10-12), and few tested new materials for ART, probably because they were more recently introduced in the market. Another aspect is that strength of these materials has been evaluated only following a 24-hour period after manipulation (13), 7 days (7), or in 24 hours and 7 days (14). Some glass ionomer materials, particularly conventional cements, have a setting period that lasts for more than 24 hours (15), and good mechanical strength is an important property during the first setting hours because of occlusion loading and masticatory stresses after the restoration is finished.

Therefore, the objective of this study was to compare the compressive strength of four glass ionomer cements employed for the ART technique and one conventional material, after storage periods of 1 hour and 24 hours following manipulation.

Methods

The materials tested, its respective manufacturers and batch numbers are presented in Table 1. A collapsible metallic matrix with a central perforation with 6 mm of diameter and 12 mm of height was used for the fabrication of specimens according to ISO/DP 7489 Specification (1986) (8) for glass ionomer materials. Materials were manipulated according to the powder/liquid ratios recommended by each manufacturer and inserted in the metallic matrices previously isolated with solid vaseline (EMFAL – MG-Brazil) using a Centrix syringe (DFL Ind. – RJ-Brazil). The bottom surface of the matrix was protected with a polyester strip. Materials were inserted slowly to allow an adequate flowing and to avoid formation of voids. In addition, another polyester strip was placed on the top under a second glass slab in order to obtain a regular and flat surface. Sixteen specimens for each material were prepared and divided into two subgroups (n=8) according to the period of storage prior to testing: 1 hour and 24 hours.

Table 1. Materials tested and respective manufacturers and batch numbers.

Materials	Manufacturers	Batch number	
		Powder	Liquid
Ketac Molar	3M – ESPE (Minnesota-USA)	0026	0133
Fuji Ix	GC (Tokyo-Japan)	0205271	0205131
Magic Glass	Vigodent (Rio de Janeiro-Brazil)	5IV020	5IV025
Vidrion R	SS White (Rio de Janeiro-Brazil)	00M	020M
Vitro Molar	DFL (Rio de Janeiro-Brazil)	0304359	0304359

All specimens were stored in distilled water at 37 ºC during the first hour after setting. Afterwards, 8 specimens of each tested material were removed from the matrices and subjected to a compressive strength test in an Otto Wolpert-Werke (Ludwigshafen, Germany) universal testing machine at a crosshead speed of 0.5 mm/min. The other remaining 8 specimens of each tested material were removed from the matrices and stored in plastic bottles containing 20 mL of distilled water. They were maintained at 37 ºC for an additional period of 23 hours before the compressive strength test as described previously. Compressive strength data (kgf) were analyzed by means of two-way ANOVA and Tukey's test at a significance level of 5%.

Results

Mean compressive strength values obtained for the evaluated glass ionomer cements after the two storage periods are shown in Table 2. Only Fuji IX cement had no statistically significant difference in compressive strength values between 1 and 24 hours storage periods. For all other materials, strength values increased following 24 hours. Fuji IX also presented the highest values when compared to the other materials after the first hour.

After 24-hour storage, Fuji IX, Ketac Molar and Vitro Molar presented the highest compressive strength values, so that no statistically significant difference was observed among them. Vidrion-R obtained lower values when compared to the last cited materials, but was superior to Magic Glass, which presented the lowest compressive strength values either after 1 or 24 hour-storage.

Table 2. Mean compressive strength values (kgf) of the glass ionomer materials according to the storage period in distilled water at 37 °C.

Materials	1 hour	24 hours
Fuji IX (GC)	335.75±35.9 [a]	350.87±30.1 [a]
Ketac Molar (3M ESPE)	218.75±40.6 [b]	297.88±60.2 [a]
Vitro Molar (DFL)	183.38±31.4 [bc]	297.50±67.5 [a]
Vidrion R (SS WHITE)	142.38±14.2 [c]	230.88±34.7 [b]
Magic Glass (Vigodent)	61.50±11.6 [d]	140.13±26.1 [c]

Different superscript letters indicate statistically significant differences ($P<0.05$).

Discussion

ART is a minimum invasive technique that combines preventive and curative methods (5) and is indicated for the permanent and deciduous dentitions (17). This technique may help to reduce the amount of tooth extraction in both dentitions and can be employed in any part of the world (18), as demonstrated in South Africa (19). Dental materials used in ART, particularly the glass ionomer cements, should have adequate mechanical properties, and *in vitro* studies may help to prevent early failures to some extent. Previous studies have evaluated the compressive strength of conventional and resin-reinforced glass ionomer cements, including those indicated for ART. However, most assays were performed after storage periods longer than 24 hours (7,14,20,21). It is important to compare the physical properties of glass ionomer cements between the periods of 1 and 24 hours because their final setting is achieved after 24 hours, and they usually present lower strength values during the first hours. Immediately after the restoration is finished, the material is already subjected to occlusal forces, even during swallowing, and thus adequate mechanical strength is necessary.

In the present study, only Fuji IX showed similar results after 1- and 24-hour storage, which may be an important factor for posterior tooth restorations. Yap et al. (21) also observed that this material had similar compressive strength after 24 hours, 7 and 30 days. Additionally, comparing Fuji IX and Fuji IX Fast, which is a glass ionomer with quick setting, Yap et al. (14) found no difference in compressive strength between those materials after 24 hours and 7 days. However, Algera et al. (10) observed that Fuji IX Fast had higher compressive strength values in 24 hours than after 1 hour. For all other materials evaluated in this study, compressive strength values increased after 24 hours, which was reported before (22).

Fuji IX was one of the first materials indicated for ART and has already proved to achieve clinical success in several countries according to the World Health Organization. Other materials also indicated for ART and with lower cost than Fuji IX were introduced, but few studies compared them to Fuji IX. The present study showed that in the period of 24 hours Fuji IX, Vitro Molar, and Ketac Molar had equivalent compressive strength values. Similar findings were reported by Koenraads et al. (23) comparing the compressive strength of Fuji IX and Ketac Molar in class II restorations either when the specimens were stored in water or were termocycled.

ART is usually performed in areas of disadvantaged population with shortage of resources and difficulties of access to dental care. The cost among these materials is quite significant, and dental practitioners should consider the best cost-benefit relationship. The present study tested a conventional restorative glass ionomer cement (Vidrion R), which is also a commonly used material in the clinical practice. Most glass ionomer materials indicated for ART, except for Magic Glass, proved to have higher compressive strength than this restorative material probably due to the differences in chemical composition. Manufacturers seek to improve mechanical properties by modifying some characteristics, *e.g.*, high quantity of glass particles in the powder and powder/liquid ratio. However, further studies testing diametral tensile strength and flexural strength, as well as clinical follow-up must be performed to provide final evidence of short- and long-term clinical performance of materials for ART in areas of occlusal loading.

Conclusions

According to the results obtained in the compressive strength tests, Fuji IX presented the best results after 1 hour. Following 24-hour storage, Fuji IX, Ketac Molar, and Vitro Molar had similar performance. Except for Fuji IX, all materials presented higher compressive strength values after 24 hours than after 1 hour.

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