Pesquisa Brasileira em Odontopediatria e Clínica Integrada
ISSN: 1519-0501
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Universidade Estadual da Paraíba
Brasil

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Pesquisa Brasileira em Odontopediatria e Clínica Integrada, vol. 16, núm. 1, 2016
Universidade Estadual da Paraíba
Paraíba, Brasil

Available in: http://www.redalyc.org/articulo.oa?id=63749588047

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Brazilian Research in Pediatric Dentistry and Integrated Clinic 2016, 16(1):449-455
DOI: http://dx.doi.org/10.4034/PBOCI.2016.161.47
ISSN 1519-0501

Original Article

Surface Hardness of Glass Ionomer Cements used in Atraumatic Restorative Treatment

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Academic Editors: Alessandro Leite Cavalcanti and Wilton Wilney Nascimento Padilha

Received: 06 November 2015 / Accepted: 14 October 2016 / Published: 16 December 2016

Abstract

Objective: To evaluate the surface hardness of a national glass ionomer cement with increased powder / liquid ratio, suitable for the atraumatic restorative treatment technique. **Material and Methods:** This is a study of the quantitative experimental type, in which 30 specimens were made and divided equally into 03 experimental groups (glass ionomer cement restorative Vitro Molar -DFL in the proportion specified by the manufacturer; glass ionomer cement restorative Vitro molar ratio -DFL modified with incorporation of 50% powder; and Gold Label 9 - GC Corporation in the proportion specified by the manufacturer). After handling, the materials were placed in a Teflon mold for manufacturing the cylindrical samples (5mm x 2 mm), with the aid of a Centrix syringe (Centrix, Shelton, CT, USA). Specimens were stored in liquid petroleum jelly at a temperature 37 ° ± 1 for up to 7 days. The specimens were evaluated by Vickers hardness test at time intervals of 24 hours and 7 days after manufacture. The data were subjected to the Independent Student's-t tests and analysis of variance (ANOVA), and subsequently by Tukey's test at 95% level of significance. **Results:** The setting time positively influenced the hardness of the two glass ionomer cements ($p<0,001$). Cement Gold Label 9 showed higher hardness values than cement Vitro Molar ($p<0,001$), irrespective of the evaluation time interval. The latter in turn, showed improved values when manipulated with the modified powder / liquid ratio (3: 2) ($p<0,001$). **Conclusion:** Vitro Molar glass ionomer cement showed higher hardness values when manipulated with the modified powder/liquid ratio.

Keywords: Dental Atraumatic Restorative Treatment; Glass Ionomer Cements; Hardness.

Introduction

The Atraumatic Restorative Treatment (ART) is an alternative technique that was developed by Frencken in Tanzania, in the 1980s, with the aim of meeting the restorative needs in developing countries, including the prevention and treatment of dental caries. ART is based on the use of manual instruments both for access and partial removal of carious tissue, normally making it unnecessary to use anesthesia [1,2]. It has low operating costs, dispensing the use of conventional dental equipment. In this context, ART represents an excellent resource for extending access to treatment, diminishing costs and offering a large number of patients an improvement in oral health, since there is a repressed demand by persons who have never been to the dentist and require dental care [1-3].

The ART technique was developed with the use of high viscosity glass ionomer cements, which lead to easier operating conditions, shorter working time and faster setting, in addition to presenting good results in Class1 restorations [4]. In Brazil, glass ionomer cements were launched for this purpose, however, these ionomers are very fluid, making it difficult to insert the restorative material in the cavity, in addition to presenting inferior properties [5-7]. The lower powder to liquid ratio is probably the responsible for the higher solubility and lower bond strength observed, because it interferes with the ionic bonds between components of the glass ionomer cement and hydroxyapatite from the substrate [8].

Therefore, it is necessary to improve the mechanical properties of the chemically activated glass ionomer cement available in the Brazilian public health system, in order to increase the survival or restorations performed by the ART technique, and its indications. The aim of this study was to evaluate the effects of increasing the powder/liquid ratio, and the surface hardness of a conventional national glass ionomer cement indicated for atraumatic restorative treatment.

Material and Methods

This was a research of the quantitative experimental type. To perform the microhardness assay, the test specimens used were obtained by means of using a circular Teflon matrix with a central perforation, measuring 5 mm in diameter and 2 mm deep. The matrix used had various perforations that allowed the simultaneous fabrication of up to 6 test specimens.

The following restorative materials were evaluated: the restorative glass ionomer cement Vitro Molar (DFL Indústria e Comércio SA, Rio de Janeiro, RJ, Brazil) and Fuji IX sold in Brazil under the name of Gold Label 9 (GC Corporation, USA). The composition of the material are described in Table 1.

A total of 30 test specimens were prepared and divided into three groups of 10 [9-11]: Group 1 (G1) - Vitro Molar cement manipulated in accordance with the manufacturer's recommendations (1 measure of powder to 1 drop of the liquid); Group 2 (G2) – Vitro Molar cement with modification in the proportion (3 measures of powder to 2 drops of the liquid), which represents an increase of 50% of powder in the ratio recommended by the manufacturer); Group 3

(G3) Gold Label 9) cement manipulated in accordance with the manufacturer's recommendations (1 measure of powder to 1 drop of the liquid). For Group 2, a longer period of manipulation - 40 seconds - was required.

Table 1. Materials used in this study with their composition.

Materials	Powder	Liquid
Vitro Molar (DFL Ind. e Com. S.A., Rio de Janeiro, Brazil)	Barium aluminum silicate, dehydrated polyacrylic acid and iron oxide.	Polyacrylic acid, tartaric acid and distilled water.
Gold Label 9 (GC Corporation, USA).	Fluoro-alumino silicate glass and polyacrylic acid poder	Distilled water and polyacrylic acid

After manipulation, the restorative material was inserted into the matrix in a single increment, with the aid of a Centrix syringe (Centrix, Shelton, CT, USA). After insertion, a polyester strip and a glass slide were placed over the material, to eliminate excesses, guarantee a flat surface, and prevent the superficial layer from coming into contact with air. After 10 minutes, the specimens were removed from the matrix, marked on the side with a ballpoint pen in order to facilitate identification of the surface to be tested during the surface hardness assay. After this the specimens were individually stored in an oily solution (Vaselina Líquida, Merck Brasil S.A., São Paulo, SP, Brazil) [9], in a light-proof receptacle, at 37 ± 1° C. This procedure was used to avoid water contamination of the glass ionomer, that could result in lower mechanical properties. In the clinical practice, this protection is made by application of solid vaseline or a dental cavity liner [9].

After 24 hours of storage, each specimen was submitted to the Vickers microhardness test, by means of a microdurometer (Micro Hardness Testers HMV-2 Series Shimadzu, Japan) with a load of 50g, for 10s. After this the specimens were stored in the oily medium again, and re-evaluated one week after their fabrication.

For the Vickers hardness assay, five indentations were made on each test specimen, with one being central and four at the extremities on the surface of the specimens [10,11]. Afterwards the mean value of the indentations was obtained in order to determine the value corresponding to each test specimen.

After collection, the data were tabulated and analyzed in the statistical software SPSS® for Windows, version 18.0 (SPSS Inc., Chicago, USA). For characterization of the sample, descriptive analysis of the data was performed. The Shapiro-Wilk test was used to verify the normality of the variable *hardness*. When normal distribution was found, the Independent Student's-*t* test was used to compare the hardness of an ionomer cement group in two different storage time intervals. Comparison of the immersion times with the different ionomer cement groups was made by means of the Analysis of Variance (ANOVA), and subsequently the post-Tukey test. The level of significance adopted was 95%, and statistical analysis was considered significant when $p<0.05$. The statistical power of this study was 100% between the averages of the three groups by the normal approximation method.

The power of the sample to the T-test and ANOVA was calculated using two different softwares (Epiinfo online version 3 and Action version 3.1). For Epiinfo program, the power was calculated by comparing the difference between the two groups with mean values and standard deviation and 0.05 significance level. For Action program, power was calculated considering as an alternative hypothesis that the mean values of each group are different for equal sample sizes and 0.05 significance level. In all analyzes, we obtained power of 100%.

Results

The results of this study showed that the hardness of all groups increased significantly with time (p <0.001). Group 3 showed the highest hardness compared to the other groups, reinforcing the superiority of material Gold Label 9. The glass ionomer Vitro Molar with modification in the proportion (3 measures of powder to 2 drops of the liquid) (G2) obtained a significant increase of hardness (p < 0.001) when compared to the proportions recommended by the manufacturer (G1) (Table 2)

Table 2. Comparison among hardness mean values of glass ionomer cement groups by polymerization time.

Hardness	Group 1 Mean (SD)	Group 2 Mean (SD)	Group 3 Mean (SD)	P*
24 hours	34.74 (2.55) $^{a, A}$	58.31 (4.19)$^{b, A}$	68.21 (4.37) $^{c, A}$	<0.001
1 week	56.53 (6.33) ^{a,B}	73.76 (6.43) ^{b,B}	91.11 (6.20)^{c,B}	<0.001
P*	<0.001	<0.001	<0.001	

P* statistically significant for Independent Student's-t Test (P≤0.05). Different lower case letters in the same line, and different capital letters in the same column signify significant difference by the Tukey Post Hoc test after ANOVA P≤0.05).

Discussion

The efficacy of Atraumatic Restorative Treatment has been supported by studies that evaluated the clinical success of the restorations [12-15], granting it the nature of definitive treatment [16]. Therefore, it has become an important tool for dental treatment in countries facing a scarcity of resources [17]. The material indicated for ART high viscosity glass ionomer cement [18], which has the characteristics of powder particles of smaller dimensions and lyophilized acid aggregated to powder [19], resulting in a denser glass ionomer cement (GIC) than the conventional type.

The GIC has important characteristics that enable its use in ART, such as bonding to the dental structure, anticariogenic properties by fluoride release, biocompatibility and a thermal expansion coefficient similar to that of the dental structure [20]. However, among the limitations of the material would be the prolonged jellification reaction, sensitivity, dehydration or excessive initial humidity, low resistance to stress and compression, and esthetic problems due to its limited translucence [21]. The mechanical properties of this material may be improved if there were an increase in the powder/liquid ratio, concentration of polyacid, or molecular weight of the polyacid, however, the factor that would limit this improvement would be the change in viscosity and manipulation [22].

In the present study an alteration was made in the powder/liquid ratio, and in fact, in Group 2 (Vitro Molar with modified proportion) a longer time of manipulation was required (40 seconds) so that all the powder would be incorporated into the liquid, when compared with the conventional proportion (20 seconds).

Vitro Molar was included in this study because it is a low cost material frequently used in Brazilian public health. As Vitro Molar´s performance is worse than Gold Label 9, probably because of the powder to liquid ratio, we decided to test Vitro Molar with 50% more powder than liquid in order to improve its properties [5]. Gold Label 9 was used as the control group in this study, as it was developed for the specific use in ART and because of its good performance [8,11,24-26].

Microhardness is an important property for dental materials, and the concept is linked to the resistance of a material to indentation/penetration [23]. Surface hardness tests may be applied to evaluate the degradation and durability of dental materials, to observe the effect of storage mediums on the surface, as indicative of resistance to wear and durability, and also to monitor the hardening process of cements [5]. From the results of the present study, the Gold Label 9 Group (Fuji IX) presented the best performance among the cements studied, with data similar to those found in the literature [8,11,24-26]. As observed in Table 1, Gold Label 9 obtained the best hardness mean values and alteration in the powder/liquid ratio of Vitro Molar resulted in a significant increase in surface hardness both after one day and after one week. The data observed after the 24-hour analysis of Group 1 (Table 1) are similar to those found in other study [5], who pointed out Vitro Molar as having the worst performance among the GICs evaluated, and Gold Label 9 as having the best results. This statistically significant difference could be attributed to the type of material; Gold Label 9 is a high viscosity GIC, with a higher powder/liquid ratio, and shorter setting time [22,25], resulting in better mechanical characteristics and a good clinical repercussion, as was observed in another study [27], in which the success rate of restorations and sealants, by the ART technique, using high viscosity GICs was higher than those of the conventional types.

After 7 days of storage the microhardness of Vitro Molar increased from 34.7 VH to 56.53 VH, a behavior which has also been observed in other studies [8,25]. The time interval of measurements (after one day and after one week) was chosen because it was the period with the most elevated increase in hardness, as was observed in a previous study [25].

Another study [23] evaluated the microhardness of four GICs and a composite resin, and observed hardness values similar to those of the present study for Group 1 (corresponding to Vitro Molar 1:1), however, the hardness values with regard to Gold Label 9 (Fuji IX) were statistically different. In the present study, Gold Label 9 obtained the best performance, and in the previously cited study, it obtained a value close to that of Vitro Molar, and did not obtain a statistically significant increase in hardness after one week. This is attributed to the fact that the setting process of materials is still in the course of occurring, and as Fuji IX has particles with a smaller mean size, the setting process would be faster.

In another study [9] difference was found between the hardness of high viscosity ionomer cements and that of the conventional types, a fact that was justified by the large discrepancy in the microhardness values of each test specimen and by the inclusion of the indentations with bubbles and roughness, common to glass ionomer cements. In the present study no discrepancy in the values was observed, probably due to the larger number of indentations per test specimen, in addition to the fact that indentations with bubbles had been discarded due to the difficulty of visualization, which may lead to some imprecise readouts. In the previously cited study, Vitro Molar was considered a high viscosity GIC, but it presented a hardness value similar to that of the conventional type.

There is an inverse relationship of proportionality between the consistency of the glass ionomer cement and the powder/liquid ratio. In the present study, the reduction in the consistency of Vitro Molar with the increase in the powder/liquid ratio was shown to be beneficial because, when the material is manipulated in accordance with the manufacturer's specifications, its fluidity makes the material difficult to insert in the cavity [22].

Based on the results here described, the modification in the proportion of GIC used in ART was shown to be positive with reference to surface hardness. Further studies are necessary, in order to serve as a basis for the clinical practice of increasing the powder/liquid ratio of Vitro Molar in the ART technique, seeing that other properties must also be evaluated, such as surface roughness, flexural strength and bond strength.

Conclusion

The increase in the powder/liquid ratio resulted in a significant increase in surface hardness of the conventional Vitro Molar glass ionomer cement. The surface hardness of Gold Label 9 ionomer cement was statistically higher than that of the conventional and modified Vitro Molar cement, both at 24 hours and after 7 days.

Acknowledgements

The authors thank the “Institute” for making available the physical space and equipment necessary for conducting the study. They also thank the “University” for the Voluntary Scientific Initiation (VSI) Program that made it possible to develop and conduct this study.

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