

Knoop Hardness of Resin-modified Glass-ionomer Cements

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ABSTRACT

The null-hypothesis tested was the indifference in Knoop hardness between a newly launched nanofilled resin-modified glass-ionomer cement (RMGIC): KetacTM N100 (3M/ESPE) – G1 and two commonly used RMGIC: VitremerTM (3M/ESPE) – G2 and Vitro Fill LC® (DFL) – G3. Ten specimens of each material were inserted in PVC molds, stored in paraffin and wet polished. The Knoop hardness was determined with Knoop indentator. On each specimen three indentations were taken in upper surface and three in the lower surface. ANOVA and Tukey post hoc test were conducted ($p=5\%$). The mean Knoop hardness number (and SD) of each group were: G1 – 39.3 (8.8); G2 – 69.9 (16.5) e G3 – 53.5 (3.1). There were significant difference among the mean of the materials' hardness and no significant difference between the upper and lower surfaces of the same specimen. The newly launched glass-ionomer cement with nanotechnology did not achieve comparable Knoop hardness of the others RMGIC tested.

Key words: : Dental Materials. Knoop hardness. Nanotechnology. Resin-modified glass-ionomer cement. Pediatric Dentistry.

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INTRODUCTION

The current concern regarding prevention and oral health promotion encourage dental materials research as oral curative methods are also responsible for health promotion [1]. Glass ionomer cement (GIC) is one of the materials that has been studied and modified since the early 70's [2] in order to spread oral health promotion.

GIC presents some desirable characteristics and advantages over traditional dental materials, such as: chemical setting reaction (acid/base), direct adhesion to tooth structure, biocompatibility, anticariogenic effect due to fluoride release and uptake and thermal expansion coefficient similar to tooth structure [3]. It also has its peculiarities, as it requires a correct mixing proportion and appropriate handling in order to assure good mechanical properties. The hand mixed version is provided in one bottle of powder and one bottle of liquid. The GIC can also be available in capsules, which eliminates dosage and handling problems, although, at a much higher cost. Another possibility is

the two pastes GIC, which makes the dosage and handling steps easier, reducing the possibility of getting mixture too thin or too thick, consistencies commonly obtained with powder/liquid versions.

The most important modification in GIC was the addition of methacrylate groups, which originated the so called resin-modified glass-ionomer cements [4]. The presence of camphoroquinone and tertiary amine in the formula together with the application of light allowed a better controlling of the work and setting time, which are particularly important when used in pediatric dentistry approach [5,6]. Nevertheless, the cement is still based in acid/base setting reaction.

The main objective of restorative dental materials is to re-establish the functions that were lost due to the caries process. It is expected that those materials have good mechanical properties and appropriate aesthetics characteristics. Even presenting relatively lower values for the physical-mechanical properties comparing to resin composites [7,8,9], the GIC had

demonstrated excellent clinical retention in cervical lesions [10, 11].

One relevant mechanical property is the surface hardness. The surface hardness is defined as the micro structural texture, which can be used to predict the material resistance and its capacity to abrade opposite structures [12]. The surface hardness test is also an indirect method to measure the degree of monomer conversion. The relative hardness is considered a good indicator of the degree of conversion (DC) and can be measured on taken the surface hardness on the upper and lower surfaces of disc-shaped specimens with a given thickness [13]. The aim of this *in vitro* study was to access the Knoop hardness of a newly launched nanofilled resin-modified glass-ionomer (KetacTM N100 - 3MESPE) and compare it with a commonly used RMGIC (VitremerTM) and with a low cost RMGIC (Vitro Fil LC[®] - DFL).

MATERIAL AND METHODS

The resin-modified glass-ionomer cements were used according to manufacturer's instructions and are described in table 1.

GROUP	BRAND NAME	MANUFACTURER	SETTING REACTION
1	KETAC TM N100	3M-ESPE (St Paul, MN, USA)	chemical + light cured
2	VITREMER TM	3M-ESPE (St Paul, MN, USA)	chemical + light cured + absence of oxygen
3	VITRO FIL LC [®]	DFL (Rio de Janeiro, RJ, BR)	chemical + light cured

Table 1 – Materials used in study, brand names and setting reaction

The specimens were prepared using PVC molds (2.5 mm height and 7.5 mm diameter), which were slightly overfilled and covered with millar strips. To avoid air bubbles a glass plate was used to compress the surface. The glass ionomer cements were inserted with Centrix[®] Syringe and light cured for 40 seconds, with an halogen

cure unit light (Jetlite 4000 Plus, J Morita USA Inc., USA) with 400 mW/cm² confirmed by radiometer.

Ten specimens of each material were prepared and, after 10 minutes, stored in in paraffin (Liquid Paraffin, Merck KGaA, Darmstadt, DE) for 24 hours, at 37°C [14]. The specimens' surfaces were wet polished with a 1200 grit silicon carbide paper (Buehler, Lake Bluff, IL, USA) until the excesses were removed in both sides (upper and lower). The Knoop hardness test was performed on a hardness test machine (Microhardness Tester HVS – 100 - PANTEC) with 25 g load and 5 s dwell time, making three indentations in each side of the specimen (top and bottom).

The mean of Knoop hardness of the top and bottom surfaces of each specimen were calculated. The overall mean and standard deviation for each specimen were then also calculated.

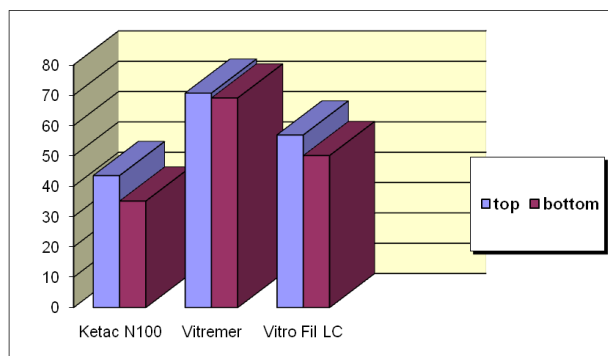
Data was recorded and analyzed by two way ANOVA and Tukey *post-hoc* test, using Med Calc software.

RESULTS

Two way ANOVA showed statistical difference among materials ($p < 0.05$), but not regarding specimen top or bottom ($p > 0.05$). Table 2 summarizes mean and standard deviations and Tukey *post hoc* test value.

Material	Mean KHN	SD	Tukey value (5%)
Ketac TM N100	39.3 ^a	8.8	9.13
Vitremer TM	69.9 ^b	16.5	
Vitro Fil LC [®]	53.5 ^c	13.1	

Table 2 – Knoop hardness number (KHN) means, standard deviations and Tukey test value. Different letters indicate statistically significant difference ($p < 0.05$)



Graph 1 – Mean Knoop hardness number (KHN) regarding lower and upper sides of specimens

DISCUSSION

In vitro studies allow that some variables are controlled and isolated, helping a better understanding of a materials' behavior as well as the forecasting of its performance. Even presenting some limitations, when compared to clinical conditions, *in vitro* studies are necessary to give some behavior ideas of new dental materials [5].

McLean et al. [4] and Ilie and Hickel [15] reported that resin-modified glass-ionomers show less water uptake and loss, as well better mechanical behavior when compared to conventional GIC. However, when compared to high viscous glass-ionomer cements, for Atraumatic Restorative Treatment (ART), the same statement does not apply [16]. The main reasonable explanation for that is based on size and shape of the powder particles, which are in higher number and larger size in glass-ionomer cements indicated to ART than in conventional GIC. This can also explain the reason why high viscous glass-ionomer cement can present some better aesthetics characteristics than resin-modified glass-ionomer cements [17].

The use of surface protection material was not carried out in the present study. The samples were immersed in the oily solution (liquid paraffin), which prevented the possibility of water gain or loss from external sources [14]. As the water from the cement could be lost during the initial setting phase, the material was wrapped and isolated from the environment with polyester strips for 10 minutes, being placed immediately after in the oily medium, remaining there for 24 hours at 37°C.

The polishing with sandpaper (1200 granulation) in politriz is necessary to allow

sufficient superficial smoothness for a clear observation of the indentation, enabling a more reliable measurement. This smoothness can be achieved with the sandpapers in politriz or with diamond paste, which are able to produce well polished surfaces [18].

Swift et al. [19] evaluating the Knoop hardness of resin-modified glass-ionomer, reported that there was no difference between top and bottom of specimen, corroborating to our results. We can assume, therefore, that all the glass ionomer cement used in present research have dual cure, chemical (acid-based reaction) and the light cure reaction. Even when resin-modified glass-ionomer cements are not exposed to light source, the chemical reactions take place [20].

The new nanofilled resin-modified glass-ionomer cement, KetacTM N100 showed the least hardness in our study, and maybe could be indicated to anterior teeth, as they suffer lower masticatory force and, therefore, experience less material wear. According to the manufacturer, KetacTM N100 is indicated for small Class I restorations, Class II and V, sandwich technique, primary teeth restorations and provisional restorations. According to Croll et al. [21], resin-modified glass-ionomer cements could be used as an effective material in primary teeth, in all types of cavities. With the lower hardness results presented by Ketac N100 (mean 39.3 KHN) in the current study, the material does not seem to be appropriate to use in stress bearing areas, being its use restricted to anterior teeth or cervical restorations. It is wise to observe that the material does not comply with the specifications of ADA (American Dental Association), which regulates the number of Knoop hardness of ionomer material indicated for restoration in 48 KHN [12].

The main objective of this study was to evaluate a new brand of resin-modified glass-ionomer cement launched recently in paste-paste version, which is easy to mix by comparing it to glass ionomer cements already available in the dental market. The mixing procedure is always a matter of concern regarding glass-ionomer cements. In general, capsulated versions lead to better mechanical properties [15,22], but are also responsible for an increase in the cost of the cement.

The same is observed in paste-paste versions. Ketac™ N100 has high cost to be used in developing countries, around US\$ 200.00. When compared to Vitremer™, that is from the same manufacturer, the Ketac™ N100 is 200% more expensive and when compared to Vitro Fil LC®, 600% more expensive. This feature probably reduces the use of this material by dentists.

It was logical to hypothesize that the new resin-modified glass-ionomer, with nanoparticules, could deliver better Knoop hardness results, leading to a higher wear resistance [23]. But this was not verified in our results as Ketac™ N100 showed the least hardness values. Due to the results obtained and the fact that the Ketac™ N100 is the first glass ionomer cement with nanotechnology available in the market, therefore, lacking a ample number of dedicated studies, further research and improvements to this material is suggested.

CONCLUSION

Under the conditions and limitations of the current study, it can be concluded that the nanotechnology based resin-modified glass-ionomer cement showed the least Knoop hardness numbers and therefore, should be applied only in non stress bearing areas.

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