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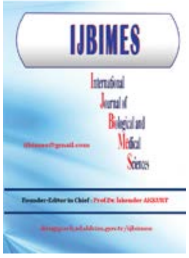

Research Article

Heat Application Dependence of the Vickers Microhardness Behavior of Dental Filling Materials#

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Abstract: The aim of this study is to compare microhardness 24 hours after the initial setting of a glass ionomer material and a resin modified glass ionomer filling material with and without heat application. Twenty cavities were prepared to a depth of 2 mm and diameter of 7 mm on acrylic resin (Meliodent; UK) discs. The groups were as follows; Group1 - Equia without heat application (GC, Japan); Group 2- Equia (GC, Japan); with heat application; Group 3 - Riva LC without heat application (SDI, Australia); Group 4 - Riva LC with heat application (SDI, Australia). A light curing unit was used (GCP CarboLED CL-01; GCP Dental, Netherland) for heat application. Specimens' surfaces were prepared by polishing and microhardness tests were done 24 hours after the initial setting by using Vickers microhardness tester with 9.8 N (1000 gr 15 s dwell time). For Vickers Hardness test one-way analysis of variance (ANOVA) was used to statistically analyze data at the $p < 0:05$ level of significance. Microhardness values were respectively obtained as Group 1=519.525, Group 2=548.518, Group 3=495.296 and Group 4=465.666 MPa. The lowest hardness values were recorded resin modified glass ionomer (Riva LC) with heat and light application. No statistically significant difference ($p<0.05$) was found in the Vickers hardness when heat and light application time were compared. Considering the measured mechanical properties, it is found that heat application increases the microhardness degree of glass ionomer filling material but heat application decreases the microhardness degree of resin modified glass ionomer filling material for the samples which were tested 24 hours after initial setting.

1. INTRODUCTION

Glass ionomer cements (GIC) were first launched in Europe in 1975 [1] and first marketed in the United States in 1977. Since then, the composition of GICs has been modified to improve their mechanical properties, resulting in the many GIC materials available today. Conventional GIC are used by dentists because of their biocompatibility, low cytotoxicity [2], fluoride release, and limited microleakage [3]. However, they also have less-desirable physical and mechanical properties such as poor polishability, susceptibility to dehydration and moisture contamination during initial setting and low fracture toughness and flexural strength [4].

Glass-ionomer cements have certain features that are superior to those of resin-based materials and dental amalgam [5]. These include the following: chemical adhesion to mineralized dental tissues; biological sealing of the cavity interface (including inhibition of bacterial compounds and ability to remineralize dental tissues) [6], and easy use in a variety of clinical settings [5]. The major weakness of GIC is their low fracture toughness. This feature is likely to improve as the material maturates. Incomplete chemical reactions and sensitivity to water during the first stage of the setting reaction of GIC lead to softening and cracking of the cement surface and subsequently to reduction of its wear resistance and fracture toughness [7].

Dental profession now embraces the concept of minimal intervention and conscious effort to practice maximum conservation of tooth structure. This has been very true in case of pediatric and restorative dentistry too where the aesthetically pleasing materials like composite, compomer, and resin-modified glass ionomer cement (RMGIC) have tremendously changed the concept of today's practice. Advantages of resin other than cosmetic include relatively low thermal conductivity, preservation of tooth structure in cavity preparation, and advances in the stability of compositional properties of the material.

RMGIC is an important advancement in glass ionomer technology that has influenced dentistry for children [8]. Resin-modified glass ionomer, which was introduced to decrease sensitivity, decreases initial hardening time and handling difficulties, but substantially increases wear resistance and physical strength of the cement and improve early weak mechanical strength of conventional glass ionomer, while preserving their clinical advantages i.e., esthetics, self-adhesion to dental tissue, fluoride release, and thermal insulation [8].

Recently studies were available which investigated RMGIC and GIC hardness [9]. However, few studies have evaluated the effect of heat and light application on the hardness of the material.

The aim of this in vitro study was to evaluate the Vickers hardness of: Equia,GIC and Riva LC, RMGIC with or without heat application.

2. MATERIAL AND METHODS

Twenty cavities were prepared to a depth of 2 mm and diameter of 7 mm on acrylic resin (Meliodent; UK) discs. Each of the tested material was mixed according to the manufactures instructions and each material was injected into the cavities. A glass plate was used to compress the surface in order to avoid air bubbles. Color shade A2 was selected for all materials. Specimens were showed in figure 1.

Figure 1. *Specimens*

The groups were; Group1 (E) - Equia (GC, Japan); Group 2 (E60) - Equia (GC, Japan); with heat and light application 60sn ; Group 3 (R20) - Riva LC (SDI, Australia) with light application 20sn; Group 4 (R60) - Riva LC (SDI, Australia) with heat and light application 60sn. Materials, codes, descriptions, manufactures, mixing times of materials tested was shown in Table 1.

Table 1: *Materials, codes, descriptions, manufactures, mixing times and heat and light application time of materials tested*

Material and group	Code	Description	Manufacturer	Mixing time(s)	Heat and light application time (s)
Group 1 EQUIA	E	Glass ionomer cement	GC Europe	10	0
Group 2 EQUIA	E60	Glass ionomer cement	GC Europe	10	60
Group 3 Riva LC	R20	Resin modified glass ionomer cement	SDI, Australia	10	20
Group 4 Riva LC	R60	Resin modified glass ionomer cement	SDI, Australia	10	60

For heat application a light curing unit was used (GCP CarboLED CL-01; GCP Dental, Netherland) .The CarboLED Lamp is a heat-curing lamp that brings out high-energy hardening (curing). The lamp has no need of an internal ventilator (self-cooling). The temperature of the lamp reaches between 50-65 ˚C within 60 seconds. The power of the curing unit was measured using a radiometer (Demetron; Kerr) to ensure that light output exceeded 400 mW/cm2.

Specimens were maintained in 100% relative humidity at 37°C for 20 min [10,11] and embedded in acrylic resin (Varidur; High Performance Mounting Kit; Buehler, Lake Bluff, IL, USA) to facilitate mounting in the testing devices. All specimen surfaces were wet-polished using a sequence of 600, 1200, 2400 grit silicon carbide paper [12], then immersed in distilled water at 37°C for 24 h [11, 13] for microhardness tests. After the polishing procedure microhardness tests were done 24 hours after initial setting by using Vickers microhardness device with 9.8 N. Three indentations were made at the surface periphery of each specimen with a Vickers diamond indenter under a 1000grf load and a dwell time of 15 s, using a microhardness tester (FM 700e type D, Future tech corp., Japan).

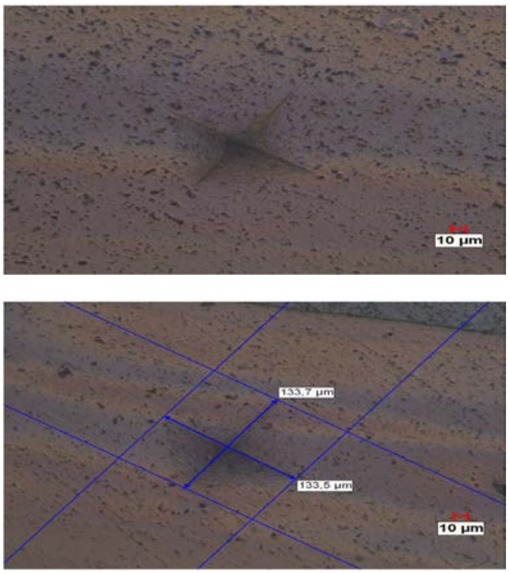

***Figure 2**. Microscopic image of specimens*

The average of the three measurements was recorded as the microhardness value for the each specimen. Photomicrographs are shown in figure 2.

The Vickers microhardness values (i.e., H_V) were calculated using the standard formula:

$$H_V = 1.8544 \frac{P}{d^2} \quad (1)$$

where P is the applied test load in N, d is the average of two indentation diagonal lengths in µm, and 1.8544 is the geometrical constant of the diamond pyramid.

The mean Vickers microhardness data was assessed by two-way ANOVA and Tukey's post-hoc tests (α =0.05).

3. RESULTS AND DISCUSSIONS

The mean and standard deviations for the Vickers microhardness test on the four groups are presented in Table 2. The data analysis showed no statistically significant differences (p<0.05) between the measurements after 24 h in all groups. According to Vickers microhardness evaluation, all Equia groups were harder than the Riva groups. The E60 system showed the highest mean scores followed by E while the R20 and R60 had the lowest mean test scores. The minimum microhardness values were recorded resin modified glass ionomer (Riva LC) with heat and light application. No statistically significant difference (p<0.05) was found in the Vickers

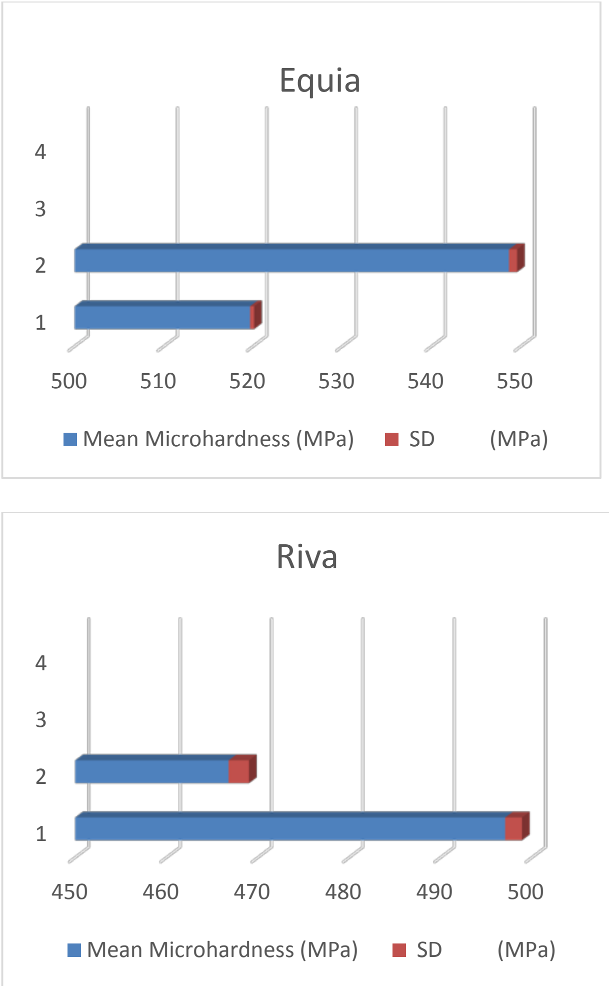

***Figure 3:** Mean Microhardness and Standard deviations (SD) scores in MPa of all groups*

hardness when heat and light application time were compared (Figure 3). In vitro studies allow the analysis of selected variables for a better understanding of materials' behavior as well as the forecasting of its performance. Even when presenting some limitations, compared to clinical conditions, in vitro studies are necessary to provide important data of new dental materials. GICs are clinically attractive dental materials and the requirement to strengthen these cements has led to an increasing research effort into reinforcement and strengthening concepts. The present study analyzed the effect of heat on the mechanical behavior of a glass ionomer cement. In addition, the mechanical properties were compared to well-known resin modified glass ionomer cement. In all materials the top surfaces of the cements were examined.

Ongoing developments have led to improved GICs. Manufacturers added silver (Ketac Silver, 3 M ESPE, Seefeld, Germany) [14], resin-modified GICs were introduced [15], the viscosity was increased by reducing filler size (Ketac Molar, 3 M ESPE, Seefeld, Germany) [14], and heat application was suggested [16,17]. Heat application is supposed to accelerate the slow setting reaction [17] and thus, skipping over the initial sensitive period before exposure to saliva occurs [15, 17]. The heat energy can be supplied by the use of a high-energy LED, halogen lamp or ultrasonic excitation [19]. The compressive strength of GICs (e.g. Fuji IX GP Fast, GC Europe N.V., Leuven, Belgium) was affected by heat application [20]. At early setting stage, a significant increase in the compressive strength was measured compared to the standard setting reaction of the material (for ultrasonic excitation, 65 % increase in strength after 15 min and 21 % after 1 day; for heat application, 130 % after 15 min and 24 % after 1 day) [20]. An obvious relationship between temperature of the GIC samples (70 °C) and their compressive strength was observed [20]. In our study, heat application increases the hardness degree of glass ionomer filling material but it is not statistically significant.

Woolford assumed that heat application is supposed to accelerate the matrix-forming reaction of the cement and so at initial stage, the setting reaction will result in a more advanced and greater surface hardness. [19]

During the last few years concerns have been raised regarding the biocompatibility of the RMGICs. Filling and sealing material including RMGICs often contains the toxic (co) monomers hydroxyethylmethacrylate (HEMA), triethyleneglyc oldimethacrylate (TEGDMA), urethanedimethacryl ate (UDMA) and bisglycidylmethacrylate (BisGMA) [21]. The resin (co)monomers may be released from restorative dental materials and can diffuse into the pulp, the gingiva, the saliva and the circulating blood [21]. Numerous cytotoxic responses to dental composite resins have been described [22]. It can lead to a variety of adverse biological effects in the patient, from persistent inflammation to sensitization and potential allergic reactions [23]. There are potential problems of long-term exposure to HEMA in particular for dental personel [23]. Besides contact dermatitis and other immunological responses, HEMA is volatile and its vapor can be readily inhaled, causing adverse reactions in the respiratory system [23]. One advantage of GCP is that it is biocompatible and monomer free compared to RMGICs. Besides, RMGICs are considered to produce an exothermic setting reaction and thus, a greater temperature rise than GICs [24]. Clinically, RMGICs and cGICs are used in similar indications. Due to the rapid set, RMGICs are more attractive in patients with low compliance like children [8]. On the other hand, the higher fluoride release is one major argument for the use of GICs in high caries risk patients [25].

4. CONCLUSIONS

Considering the measured mechanical properties, heat application increases the hardness degree of glass ionomer filling material but heat application decreases the hardness degree of resin modified glass ionomer filling material 24 hours after initial setting.

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