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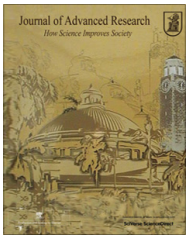

ORIGINAL ARTICLE

Effect of ultrasound application during setting on the mechanical properties of high viscous glass-ionomers used for ART restorations

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ABSTRACT

This study was conducted to evaluate the effect of ultrasound application on the surface microhardness (VHN) and diametral tensile strength (DTS) of three high viscous glass-ionomer restorative materials (HVGIRMs). For each test (VHN and DTS), a total of 180 specimens were prepared from three HVGIRMs (Ketac-Molar Aplicap, Fuji IX GP Fast, and ChemFil Rock). Specimens of each material ($n = 60$) were further subdivided into three subgroups ($n = 20$) according to the setting modality whether ultrasound (20 or 40 s) was applied during setting or not (control). Specimens within each subgroup were then equally divided ($n = 10$) and tested at 24 h or 28 days. For the VHN measurement, five indentations, with a 200 g load and a dwell time for 20 s, were made on the top surface of each specimen. The DTS test was done using Lloyd Testing machine at a cross-head speed of 0.5 mm/min. Ultrasound application had no significant effect on the VHN. Fuji IX GP Fast revealed the highest VHN value, followed by Ketac-Molar Aplicap, and the least was recorded for ChemFil Rock. Fuji IX GP Fast and Ketac-Molar Aplicap VHN values were significantly increased by time. ChemFil Rock recorded the highest DTS value at 24 h and was the only material that showed significant improvement with both US application times. However, this improvement did not sustain till 28 days. The ultrasound did not enhance the surface microhardness, but its positive effect on the diametral tensile strength values was material and time dependent.

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Introduction

Glass-ionomer restorative materials (GIRMs) are acknowledged for their ability to bond to dental structures as well as their capacity for fluoride release and uptake [1,2]. However, like all dental materials, GIRMs have certain drawbacks, chiefly their water sensitivity and insufficient mechanical properties [3]. Thus, attempts were done to overcome the slow setting reactions, in order to decrease the moisture sensitivity as well as to improve the mechanical strength at early stages of the acid-base reaction [4]. Consequently, there have been considerable modifications in the formulations, physical, mechanical and handling properties of this group of materials to enhance their clinical applications. High viscous glass-ionomer restorative materials are one of the results of these improvements. Meanwhile, modifications in clinical application technique were also carried out. Ultrasound (US) is routinely used for setting cement in the building industry and authors

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[5–9] have previously shown that glass-ionomer restorative materials can be command set by a similar process. An external energy source can be conducted through ultrasonic excitation generated from dental scaler [7] which could enhance the materials' physical and mechanical properties.

The reported increase in surface hardness of GIRMs during early setting time after US application could help in the resistance of the material to moisture contamination [4] but, whether this effect remains over time or not, still needs confirmation. Surface hardness property is defined as the resistance of a material to indentation or penetration [10]. Many studies have been done using Vickers hardness (VHN) test to assess the surface hardness of GIRMs [4,11–13]. Moreover, the mechanical strength is an important factor that has to be analyzed for clinical success of dental restorations. The US application could be effective in achieving a homogenous set throughout the bulk of the material enhancing its resistance to force of mastication. The diametral tensile strength test (DTS), which has been used by many researchers [12–14], provides a simple method for indirect measurement of tensile strength of brittle materials such as GIRMs.

Although there is increasing attention concerning the effects of US application during setting, there has been a lack of studies to elucidate its concurrent effect on physical and mechanical properties of HVGIRMs and alteration of these properties with time. The null hypotheses tested were as follows: (1) The US application has no significant effect on either VHN or DTS values of the used HVGIRMs at both testing times. (2) The difference among the tested HVGIRMs has no significant effect on any of the evaluated properties with any setting modality at all testing times. (3) The testing time has no significant effect on the recoded VHN and DTS values of all tested materials with any setting modality.

Material and methods

The three high viscous glass-ionomer restorative materials investigated in this study as well as their composition, manufacturers and lot numbers are listed in Table 1. All specimens were prepared at room temperature (23 ± 1 °C) in a relative humidity of 50 ± 5% in conformance with ISO 9917-1:2003 [15].

Specimen preparation

Mold and base fabrication

A split Teflon mold (2 mm in thickness) was specially fabricated with a central hole of 4 mm in diameter [14]. An accessory Teflon ring with an elevated central button was supplied with the mold to help in specimens' separation from the mold without contamination. A Teflon base with a circular depression corresponding to the external dimension of the mold was also fabricated to support and hold the Teflon mold assembly in position during US application (Fig. 1).

Material insertion

All glass-ionomer capsules of the tested materials were activated and mixed mechanically by an amalgamator (Linea Tec.S.R.L, Montegrosso, Italy) according to the manufacturer's instructions. Thus, Ketac-Molar Aplicap and Fuji IX GP Fast GIRMs were mixed for 10 s with the exception of ChemFil Rock which was mixed for 15 s. Immediately after mixing; the paste was injected into the split Teflon mold until being slightly overfilled. Two polyester strips were used to cover both sides of the mold. A microscope glass slide was hand pressed against the top of the mold to completely pack the material into the mold and to obtain flat and smooth surface.

Specimen grouping

A total of 360 specimens were prepared. The specimens were divided into three groups (n = 120), according to the type of HVGIRMs used. Specimens of each group were further allocated into three subgroups (n = 40) according to different setting modalities; either control (standard setting method) or command set with US application for 20 or 40 s. Specimens of each subgroup were further subdivided into two classes (n = 20) according to the time of testing (24 h and 28 days). Half of the specimens within each class were subjected to surface microhardness measurement and for the other half diametral tensile strength testing was performed.

Preparation of control group specimens (standard setting)

For the control group, specimens were allowed to set under load application of 150 g to ensure an equal pressure was applied for all specimens. Specimens were then incubated at 37 °C for 15 min [16]. Then, specimens were unloaded and left for another one hour under the same conditions [17]. Afterward, specimens were separated from the molds and fine flashes were removed with caution [16]. The specimens were checked with a magnifying lens (10×, Wellpromo.com, magnifying lens, China) for any cracks or air bubbles. Specimens with visible defects were discarded. The specimens' correct dimensions were verified using a digital caliber to an accuracy of 0.01 mm [13] and weighed using a sensitive balance (Kern Precision Balance, Avon Corporation Ltd., India). Each specimen was then stored in a plastic test tube containing 5 ml of de-ionized water, labeled and incubated at 37 °C.

Table 1 Material brand names/manufacturers, compositions and lot numbers of tested glass-ionomer restorative materials.

Material brand names/manufacturers	Composition	Lot number
Ketac-Molar Aplicap (3M ESPE, Sheifeld Germany)	Powder: Alumino-fluoro-silicate glass, Liquid: polycarboxylic acid, tartaric acid and water	404500
Fuji IX GP Fast (GC Company, Tokyo, Japan)	Powder: Alumino-fluoro-silicate glass, Liquid: polycarboxylic acid, tartaric acid and water	1008091
ChemFil Rock (Dentsply, Konstanz, Germany)	Powder: Calcium-aluminum-zinc-fluoro-phosphor-silicate glass, Liquid: polycarboxylic acid, iron oxide pigments, tartaric acid and water	1105001122

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