ORIGINAL ARTICLE

Biomodification of Glass Ionomer Cement with Seashell Powder for Improved Restorative Strength – An *In Vitro* Study

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ABSTRACT

Background: Glass ionomer cement (GIC) is a tooth-colored bulk placement, intrinsically adhesive restorative material with several other favorable properties including biocompatibility, fluoride release, and a coefficient of thermal expansion compatible with tooth tissues. However, they lack the ideal flexural strength and wear resistance to perform satisfactorily as the posterior tooth restorative material and for carious lesions. **Aims and Objectives:** The aim of the present study was to compare surface microhardness of GIC and seashell-reinforced GIC. **Materials and Methods:** The present study is of quantitative experimental type, in which ten specimens were fabricated and divided equally into two experimental groups: Group 1 (n = 5): Traditional GIC and Group 2: GIC reinforced with 10% Seashell Powder. The micro seashell powder was mixed with the GIC powder at 10% concentration (in weight). After polymerization, the glass ionomer and the reinforced glass ionomer samples were placed in a humidity-free container, where they were stored for 7 days at 37 C. Then, the samples were subjected to Vickers microhardness testing. The structural and superficial analysis of samples was performed through scanning electron microscopy. Hardness was compared and data were analyzed statistically using the Unpaired t-test. **Results:** Seashell-reinforced GIC showed good microhardness values, but compared to traditional GIC, it showed no statistical difference. **Conclusion:** Better materials with improved properties like Seashell reinforced GIC can be used in today's clinical practice. Further studies should be carried out to check other physical properties of this new material.

Key words: Glass ionomer cement, seashell, surface microhardness

INTRODUCTION

For the better part of the past 20 years, dentistry has seen the development of many new all-ceramic materials and restorative techniques fuelled by the desire to capture the ever-elusive esthetic perfection. This has resulted in the fusion of the latest in material science.

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Glass ionomer cement (GIC) was introduced in the 1970s by Wilson and Kent for use as a dental restorative material and adhesive composite for restorations.[1] GIC is popular, because it contains several important properties in an optimal dental restorative material, such as fluoride release, thermal expansion coefficient, and modulus of elasticity that is similar to the dentin, adhesion on both enamel and dentin, and biocompatibility.[2-6]

Although GICs are commonly used as dental cement, they have some disadvantages. The most intractable problem with the conventional GICs is probably their lack of strength and toughness.[7] Most simple and conventional GICs were brittle materials. Therefore, several trials have been devoted to enhancing the physical properties by adding some supporting materials. Several types of GICs modified by specific types of supporting materials have been previously studied.[8-11]

Seashell is one of the natural materials which are not used in dental applications. Seashells are natural ceramics similar to our teeth and bones. Natural ceramic seashells have pearly layers, also known as nacreous layers. They are arranged in layers of calcium carbonate platelets and protein. It consists of 30 more proteins that are held together to provide more strength and toughness. González *et al*. found that the incorporation of seashells increased Young's modulus of the material. Hence, in the present study, seashell material is incorporated into the GIC.[12]

In metallurgy and most other disciplines, the concept that is most generally accepted is that of "Resistance to Indentation." Modern hardness test depends on the "Resistance to Indentation" method. The indentation produced by the machine on the material is useful to calculate the hardness of the material. Micro-hardness is one of the most important physical characteristics for a comparative study of dental materials. Vickers microhardness testing is capable of measuring the hardness in small regions of thin objects.[13] Hence, this was used to evaluate the strength of the materials tested in the present study.

The present experimental study was conducted to comparatively evaluate the surface microhardness of GIC and seashell-reinforced GIC.

MATERIALS AND METHODS

Ethical clearance was obtained. The seashell biomaterial was collected and initially grounded into a fine, homogeneous powder in a mechanical grinder, and then transferred to a Smart dentin grinder to obtain a finer mix by micro sieve [Figure 1]. The present study is of quantitative experimental type, in which ten specimens were fabricated and divided equally into two experimental groups: (n = 5) Group 1: Traditional GIC and Group 2: GIC reinforced with 10% Seashell Powder.

The mixture of powder and liquid of GIC was performed according to the manufacturer's instructions. The micro shell powder was mixed with the GIC powder at 10% concentration (in weight). After the reaction, the material was placed in silicone molds (8 mm in diameter and 3 mm thick) [Figure 2]. After polymerization, the samples were removed and placed in a humidity-free container, where they were stored for 7 days at 37 C. The samples were, then, mounted in an acrylic mold for them to be subjected to belt grinding (grit papers) to achieve an even surface that facilitates evaluation of surface and microhardness.

Then, the samples were subjected to a Vickers microhardness tester. The load applied was 300 g for 15 s. Four indentations were made on each sample with the Vickers microhardness indenter and an average value for each sample was taken. For the pH measurement, the samples were ground to obtain a homogeneous powder, which was diluted in 20 mL of deionized water. The structural and superficial analysis of samples was performed through scanning electron microscopy.

Statistical Analysis

Hardness was compared and data were analyzed statistically. All collected data were entered into Microsoft Excel and imported to SPSS software (version 21) for statistical analysis. An unpaired t-test was used to compare the two groups. Results were presented as mean, and standard deviation (SD). For the test, $P < 0.05$ is considered statistically significant.

RESULTS

The mean Vickers hardness of the two groups is shown graphically in Graph 1. The present study showed no statistically significant difference between the two experimental groups.

Figure 1: Preparation of seashell reinforced GIC, where seashell biomaterial was collected, initially grounded into a fine homogeneous powder in a mechanical grinder and then transferred to a Smart dentin grinder to obtain a finer mix by micro sieve

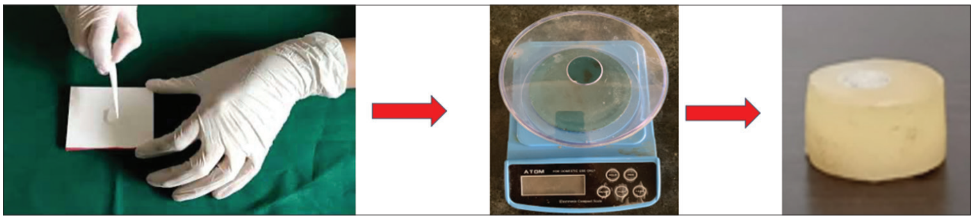
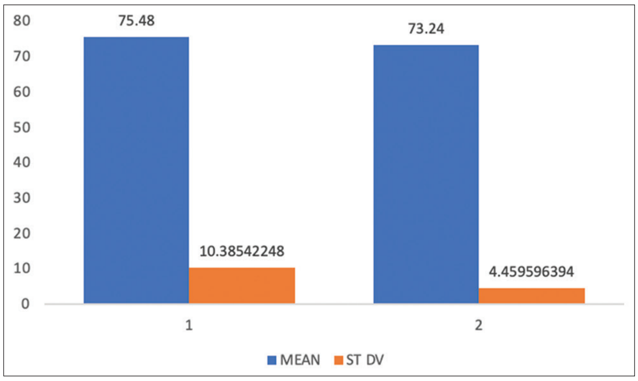


Figure 2: Sample preparation – The micro shell powder was mixed with the glass ionomer cement powder at 10% concentration (in weight). After the reaction, the material was placed in silicone molds (8 mm in diameter and 3 mm thick)



Graph 1: Mean and standard deviation of the two groups showing no statistical significance between the two experimental groups

The pH measurements showed the GIC reinforced with 10% seashell powder with slight alkalinity. In the GIC samples with the shells, the pH values were close to 7.0.

The SEM images of the traditional GIC group showed more regular surface morphology, whereas the seashell-reinforced GIC group showed an irregular surface which demarcates the shell material embedded in the glass ionomer particles, as seen in Figure 3. In addition, the superficial SEM analysis of seashell-reinforced GIC demonstrated that the samples had framework formations in their structures.

DISCUSSION

The continued use of GIC as a restorative material, in dry mouth, for geriatric patients, pediatric patients, and cervical and root caries demands its improved properties. The present study investigated the possibility of modifying GIC with seashells to improve its properties. The advantage of using type II GIC in the present study is that it is widely used, improved properties are adherent, translucent and release fluoride, which acts as an anti-cariogenic.

GIC originates from the neutralizing reaction between a basis of aluminium silicate glass powder, calcium, sodium fluoride and phosphate ions, and a solution of polyacids, which is generally formed by homopolymers of acrylic acid or copolymers of acrylic acid and other unsaturated acids. The neutralizing reaction consists of the following stages:

a. Decomposition of glass components and leaching of metallic ions,
b. Migration of these ions into the liquid phase,
c. Configuration of the polyacid due to the interaction with metallic ions, and
d. Hardening of the GIC.

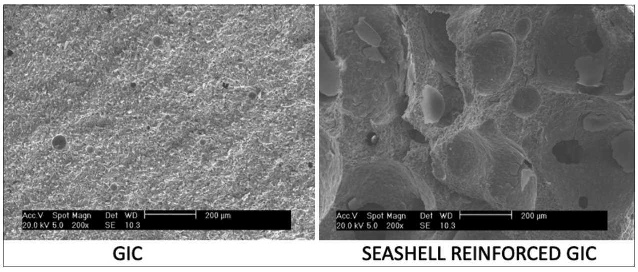


Figure 3: SEM Images of Group 1 and Group 2. The traditional GIC group shows more regular surface morphology, whereas the seashell reinforced GIC group shows an irregular surface which demarcates the shell material embedded in the glass ionomer particles

Once hardened, GICs may be considered composites of aluminium silicate glass and an inorganic bonding matrix.[14]

The survival rate of GIC restorations for multi-surface lesions is still not satisfactory.[15] Modified GICs due to the diversity of composition are expected to undergo significant variations in their complex setting reactions and cement properties.[16]

Microhardness is a physical property value in comparing restorative materials. It gives indications of long-term durability and clinical performance parameters such as resistance and wear.[17,18] For microhardness testing, hardness is measured on a microscopic scale.

Microhardness is one of the most important physical characteristics for the comparative study of dental materials.[19] The importance of the microhardness test lies in the fact that it throws light on the mechanical properties of a material. Hardness is the resistance of a material to plastic deformity typically measured under an indentation load. There are various tests to check hardness such as Brinell, Rockwell, Shore, Vickers, and Knoop. The most commonly used macro hardness test is Brinell and Rockwell. Vickers and Knoop are the most commonly used microhardness test in dentistry. Both Vickers and Knoop test employ loads <9.8 N. The resulting indentation is small and is limited to a depth of 19 μm. Hence, they are capable of measuring the hardness in small regions of thin objects. Vickers and Knoop hardness tests seem to be the preferred choice of test among the majority of the investigators.[20-23]

The present study results follow the previous studies by Karthick *et al.*, who proved increased hardness by incorporating seashell material.[24]

The present study demonstrated that the addition of seashells to the GIC powder resulted in the formation of a framework in the samples of GIC which following the study conducted by Giacomelli *et al.*[14]

An increase in the pH of the samples with seashells was seen. The pH of the GIC samples with the shells presented values close to neutral (pH = 7). Because the physiological pH varies between 7.3 and 7.4, it may concluded that the samples will adapt to the physiologic environment; however, more tests are needed to confirm this.[14]

The results of the present study are following the previous studies performed by Giacomelli *et al.* which showed an increase in PH by incorporating seashell material.[14]

CONCLUSION

Adding seashell powder to GIC could modify the material structure and help improve a few properties. From the inferences of this study, further research *in vivo* conditions may throw light on real-life scenarios. More research on the stability of these formulations, their shelf life, working times, bioactivity, compatibility, cellular cytotoxicity tests, and the exact composition of these types of cement at an ultrastructural level has to be evaluated in the future.

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