Comparative Evaluation of Mechanical Properties of Ceramic Reinforced Glass Ionomer Cement and Type IX GIC: An Invitro Study

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Abstract

Background and Objectives: Dental caries is one of the most common problem encountered in pediatric patients. Despite modern advances in prevention of dental caries, many teeth are still lost prematurely leading to loss of function, esthetics, arch length and arch symmetry. Various restorative materials are available for the treatment of dental caries. Physical and mechanical tests were applied to analyze the structural designs of restorative materials. Various researches have been carried out in search of an ideal restorative material.

Hence, the present in-vitro study was done to evaluate and compare the mechanical properties (compressive strength, flexural strength and knoop microhardness) of Ceramic Reinforced Glass Ionomer Cement (Amalgomer CR) and Type IX GIC.

Results: The study showed a statistically significant difference in the compressive strength, flexural strength and knoop microhardness of ceramic reinforced glass ionomer cement (Amalgomer CR) and is superior when compared to Type IX GIC.

Conclusion: The study concluded that the mechanical properties (compressive strength, flexural strength and knoop microhardness) of ceramic reinforced glass ionomer cement (Amalgomer CR) is superior to Type IX GIC.

Keywords: Compressive strength, Flexural strength, Knoop Microhardness, Glass ionomer cement, Amalgomer CR.

Introduction

An ideal restorative material requires minimal cavity preparation, have adequate strength and wear properties, be easy to place with a certain amount of adhesion to tooth structure and not be moisture sensitive during placement and setting.¹ Glass ionomer cement (GIC) seems to meet most of these requirements along with particular advantages like ability to leach fluoride, coefficient of thermal expansion similar to tooth, chemical bonding to enamel and dentin, insolubility in oral fluids at intraoral temperatures, excellent biocompatibility, better esthetics and low moisture sensitivity making it highly appropriate for use in children.²

Physical and mechanical tests were applied to analyze the structural designs of restorative materials. From studies of physical and mechanical behavior, shortcomings of structures and materials were observed. To rectify those shortcomings, the process
of improvement began with the addition of modifiers and studies on various chemical combinations were initiated.\(^3\)

Although GICs were used as the restorative cements in dentistry, they have disadvantages too. Lack of sufficient strength and toughness limited conventional GIC’s use in stress bearing areas.\(^4\) Hence for further improvement in the mechanical properties, a variety of modifiers have been added to conventional GICs and one such material is Amalgomer, which offers the benefits of GIC combined with the strength of amalgam due to ceramic reinforcement in the glass ionomer cement.\(^4,5\)

This tooth-coloured product is proposed by the manufacturer to combine the high strength of a metallic restorative and the esthetics and other advantages of glass ionomers.\(^6\)

In this context, the present study was designed to evaluate and compare the mechanical properties which include compressive strength, flexural strength and Knoop microhardness of Ceramic Reinforced Glass Ionomer Cement (Amalgomer CR) and Type IX GIC.

**Materials and Method**

72 specimens were made by using custom made plexi-glass moulds of different dimensions (Figure 1) according to ISO Standard Specifications (ISO 9917). The mechanical properties of the specimens were evaluated in Raghavendra Spectro Metallurgical Laboratory, Bangalore.

![Fig 1: Custom made plexi-glass moulds](image)

The materials were manipulated according to manufacturer’s instructions and before placing onto the moulds, the walls were coated with petroleum jelly. The mixed cement was then placed by keeping a matrix strip above and below the moulds to achieve a finished surface. After setting, the specimens were removed from the mould and excess was trimmed using Bard Parker blade(#11) and polished with 1200 grit paper. Then the specimens were stored in distilled water at room temperature for 24 hour prior to testing.

In both the groups (Figure 2 & 3);

12 cylindrical specimens of (4 x 6mm) dimension were used to test compressive strength.

12 bar-shaped specimens of (25 x 2 x 2mm) dimension were used to test flexural strength.

12 rectangular specimens of (8 x 4mm) dimension were used to test Knoop microhardness.

**Assessment of Compressive Strength:** 12 cylindrical specimens from each group were placed between the plates of Universal Testing Machine (Model PC-2000, Electronic Tensometer). A compressive load was applied along the long axis at a crosshead speed of 5mm/min until the test specimen fracture. The maximum load applied to fracture the specimen was recorded.

**Assessment of Flexural Strength:** 12 bar-shaped specimens from each group were subjected to 3-point bending test on Universal Testing Machine (Model PC-2000, Electronic Tensometer) at a crosshead speed of 5mm/min. The maximum load applied to fracture the specimen was recorded.

**Assessment of Knoop Microhardness:** 12 rectangular specimens from each group were subjected to micro-indentation hardness test in Microhardness Tester (Matsuzawa, Japan/MMT-X7A), where a diamond-intenter was pressed onto the surface of the specimens under a load of 100g with a 10sec dwell time. After the load was removed, measurements of the major axis of the diamond marked by the intenter on the surface of test specimens were made and used for determining the Knoop microhardness.

The values obtained were tabulated and fed in Statistical Package for Social Sciences software (SPSS version 23) for statistical analysis.

**Specimens:**

![Fig 2: Specimens of Amalgomer CR](image)
Findings: Table 1 shows the mean and standard deviations of the mechanical properties of Amalgomer CR and Type IX GIC.

Table 1: Mean Compressive Strength, Flexural Strength and Knoop Microhardness of Amalgomer CR and Type IX GIC

<table>
<thead>
<tr>
<th>Parameters Tested</th>
<th>Materials</th>
<th>N</th>
<th>Mean</th>
<th>Standard deviation</th>
<th>T</th>
<th>Significant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compressive strength</td>
<td>Amalgomer CR</td>
<td>12</td>
<td>140.1534</td>
<td>1.47761</td>
<td>13.258</td>
<td>0.000 (HS)</td>
</tr>
<tr>
<td></td>
<td>Type IX GIC</td>
<td>12</td>
<td>101.5079</td>
<td>9.98895</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flexural strength</td>
<td>Amalgomer CR</td>
<td>12</td>
<td>53.2904</td>
<td>2.55654</td>
<td>26.538</td>
<td>0.004 (HS)</td>
</tr>
<tr>
<td></td>
<td>Type IX GIC</td>
<td>12</td>
<td>31.7092</td>
<td>1.18312</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Knoop microhardness</td>
<td>Amalgomer CR</td>
<td>12</td>
<td>101.4000</td>
<td>2.44838</td>
<td>45.109</td>
<td>0.003 (HS)</td>
</tr>
<tr>
<td></td>
<td>Type IX GIC</td>
<td>12</td>
<td>67.7333</td>
<td>0.83048</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

p value ≤ 0.05 is Significant, NS – Not Significant, HS – Highly Significant, T - Student T Test, N – Number of Specimens Tested

Discussion

The efficiency of the restorative material to withstand the functional forces is an important requirement for its longevity. Among the mechanical properties, compressive strength and flexural strength are the widely used properties in evaluating the clinical performance of the restorative materials.

Compressive strength is often used as a measure to evaluate the ability of the material to withstand the masticatory force. Flexural strength is used to evaluate the strength of the material and the amount of distortion expected under bending stress. The specimens were subjected to 3-point bending test because it is considered as a representation of the clinical situation as the forces exerted by the opposing cusp. Microhardness can be defined as the resistance of a material to indentation or penetration. Surface hardness tests appears to be appropriate for evaluating the degradation and durability of dental materials.

Mean compressive strength of Amalgomer CR was found to be 140.1534Mpa and for Type IX GIC the mean value was 101.5079Mpa with a p-value of 0.000, which was statistically significant.

Mean flexural strength of Amalgomer CR was 53.2904Mpa whereas for Type IX GIC the mean value was 31.7092Mpa which was statistically significant with a p-value of 0.004.

The mean knoop microhardness of Amalgomer CR was found to be 101.4000Mpa whereas for Type IX GIC the mean value was 67.7333Mpa with a p-value of 0.003, which was statistically significant.

Various restorative materials have been used since years to preserve the lost tooth structure and maintain form, function and esthetics. Dental amalgam has served as an excellent and versatile restorative material for many years. However, it has many drawbacks like lack of esthetics and the unavoidable use of mercury. This lead to the search of more improved materials and the most commonly used restorative material is GIC because of their fluoride release, biocompatibility and ease of use. However, some deficiencies like moisture sensitivity, short working time, long setting and maturation time, low fracture toughness and poor wear resistance have limited their use to areas which are not subjected to high masticatory stresses.

The physical and mechanical properties of GICs were further improved when a resin portion was added to the original GIC which yielded a hybrid material, i.e., resin modified glass ionomer cement (RMGIC) which was developed to overcome the problems of moisture sensitivity and low initial mechanical strength.
that were typical for conventional glass ionomers and have the advantage of longer working time, less sensitivity to water during setting.\textsuperscript{16,17}

A new generation of glass ionomer, GC Fuji IX, was developed especially for Geriatric and Pediatric patients in late 1990s. It is said to possess high strength, wear resistance, chemical adhesion to tooth, fluoride release, radiopacity, and less sensitivity to saliva.\textsuperscript{18} Last few decades have witnessed efforts increasingly directed towards modifications of the older materials with the addition of various modifiers which were proven to be beneficial.\textsuperscript{4} One such modification made was the incorporation of ceramic particles to GIC. According to Williams et al reinforced materials were significantly stronger than other materials.\textsuperscript{19}

In this context, the present study was done to evaluate and compare the mechanical properties of ceramic reinforced glass ionomer cement (Amalgomer CR) and Type IX GIC by fabricating specimens where were then subjected to subsequent mechanical testing.

The specimens made in the study, failed to have a smooth surface even after placing the mylar strip. It could be due to the irregular surface of the fabricated customized mould. Finishing and polishing of restorative materials always pose a difficulty because particles and matrix differ in hardness and thus cannot be abraded uniformly.\textsuperscript{20,21} For a finishing system to be effective, the cutting particles should be harder than the filler materials. Otherwise, the polishing agent will only remove the matrix and leave the particles protruding from the surface.\textsuperscript{21} GICs’ surface hardness can be affected by the polishing process because it involves polishing of the glass particles and abrasion of the matrix which inturn can compromise the mechanical properties.\textsuperscript{22} Considering this, only gross finishing of the specimens were done.

Once the material is set, they were removed from the mould and immersed in distilled water for 24 hours. Mckenzie et al reported that the physico-mechanical properties of conventional and resin-modified GICs were not significantly different comparing storage in water or saliva upto 1 year. Therefore, water was considered as an acceptable storage medium for the in-vitro analysis of GIC’s properties.\textsuperscript{23} The specimens were then subjected to mechanical testing in the laboratory.

From the results obtained, the mean compressive strength and flexural strength of Amalgomer CR was found to be higher than Type IX GIC which was statistically significant with a p-value less than 0.05. This increase was attributed to the ceramic reinforcement where the ceramic filler in the powder component would react partially with the matrix and forms an altered polysalt matrix thereby enhancing the all round strength of the cement.\textsuperscript{4,5}

The knoop microhardness of Amalgomer CR was higher than Type IX GIC, with a p-value less than 0.05, this increase in microhardness could also be a result of the ceramic reinforcement and due to the improvization inmicronization and treatment of the main glass components, fluoro alumino silico phosphate glass and polyalkenoic acids.\textsuperscript{1} Hence from the present study it was shown that the mechanical properties of Ceramic Reinforced Glass Ionomer Cement (Amalgomer CR) is statistically significant than Type IX GIC with a p-value less than 0.05.

Within the limitations of the present study, Ceramic Reinforced Glass Ionomer Cement (Amalgomer CR) showed superior mechanical properties in terms of compressive strength, flexural strength and knoop microhardness owing to the homogeneous incorporation of ceramic particles in the glass component which further reinforces the material with high strength, lasting durability and high tolerance to occlusal load thereby ensuring it as a restorative material with promising results to be used in pediatric dentistry.

\section*{Conclusion}

The study concludes that mechanical properties of Ceramic Reinforced Glass Ionomer Cement (Amalgomer CR) is superior to Type IX GIC. However, further in-vivo research with more parameters are needed to evaluate the efficiency of ceramic reinforced glass ionomer cement in real environmental circumstances.

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\section*{Ethical Clearance:} All the clinical procedures were carried out following the protocols approved by the Ethics and Review Committee of Sri Siddhartha Dental College and Hospital, Tumkur (IEC 02/2017).
References


21. Wilder AD Jr, Swift EJ Jr, May KN Jr, Thompson JY, Mc- Dougal RA. Effect of finishing technique on the microleakage and surface texture of resi-
