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*Original Research*

# Comparative Evaluation of Compressive Strength and Diametral Tensile Strength of Zirconomer with GIC and Amalgam

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***ABSTRACT:***
**Aim:** Present study aimed to comparatively evaluate Compressive strength (CS) and Diametral tensile strength (DTS) of Zirconomer with conventional GIC and Amalgam. **Materials and Methods:** A total of 90 specimens (n=90) were prepared with three materials – Zirconomer, GIC, Amalgam. Compressive strength, diametral tensile strength, and shear bond strength were evaluated after 24 h using Instron Universal Testing Machine. Specimens were submitted to CS and DTS test in each period, namely 1 hour, 24 hours and 7 days. The test was carried out in a universal testing machine with a cross head speed of 1.0mm/min. The maximum load required to fracture the specimen was recorded and calculated. The results obtained were statistically analyzed. **Results:** GIC had the least value of compressive strength and diametral tensile strength when compared to amalgam and Zirconomer at 3 different time interval i.e, after 1hr, 24hr and 7 days showing statistical significant difference at value of P = 0.05. Between amalgam & Zirconomer, Amalgam had better compressive strength and diametral tensile strength compared to Zirconomer at 3 different time interval there was no statistical difference.(P=0.05). **Conclusion:** The present study suggests that the addition of zirconia to the GIC has improved its mechanical properties as amalgam. Hence, zirconomer improved can be used as posterior restorative material.
**Key words:** Compressive strength; diametral tensile strength; glass ionomer cement; shear bond strength; Zirconomer.

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## INTRODUCTION:

The disease of dental caries dates back to ancient times and is the most common disease besetting human race. In spite of various preventive methods, dental caries still presents a colossal challenge to clinicians.[1]

Once dental caries occurs, restoring the carious lesion becomes mandatory. The most widely used material for restoring the deciduous teeth is glass ionomer cement. Glass ionomer cement (GIC) was the one of the first aesthetic restorative materials introduced in the dental arena by Wilson and Kent way back in 1972. It has been shown to be a very useful adjunct to restorative dentistry because of its unique ability to release fluoride, which is mainly responsible for its cariostatic action. Moreover, glass ionomer cement bonds chemically to enamel and dentin, thereby reducing the need for a retentive cavity preparation; thus, also preserving the sound tooth structure following the principle of "Conservation for prevention." [2-4]

Because of these properties, glass ionomer cement is the material of choice in atraumatic restorative treatment (ART). Because atraumatic restorative treatment (ART) is practiced using hand instruments only, there is a possibility of insufficient caries removal; therefore, such kind of cavities require a restorative material with good antibacterial efficacy.

The bygone decade has seen several innovative additions to enhance the properties of GIC whilst simplifying its usage. Unlike the early glass ionomers, these newer systems are easy and more practical to use as a dental restorative and luting material for preschoolers, children and teenagers alike.[2,3]

These newer glass ionomers also claim to address the poor physical properties such as surface crazing and low fracture resistance which had negatively affected its' clinical usage for long.

Zirconia ($ZrO_2$) infused GIC (ZIRCONOMER) is one such recent addition to the GIC family which has been introduced to address all the issues that have plagued the conventional ionomer thus far. However, this newer cement Zirconomer has not been challenged clinically and there is only laboratory-based evidence of it having better mechanical properties and superior esthetics.[4,5] It has also been claimed to have a shear bond strength equivalent to amalgam and a fluoride releasing capacity similar to conventional GIC.[3-5]

Present study aimed to comparatively evaluate Compressive strength (CS) and Diametral tensile strength (DTS) of Zirconomer with conventional GIC and Amalgam.

## MATERIALS AND METHOD:

Ethical clearance for this study was obtained from the Institutional review board before the commencement of study.

A total of 90 specimens (n=90) were prepared with three materials –Zirconomer, GIC, Amalgam.

| Total number of specimens (n=90) | | |
|---|---|---|
| **Materials** | **Compressive strength (CS) n= 45** | **Diametral tensile strength (DTS) n= 45** |
| **GIC** | 15 | 15 |
| **Amalgam** | 15 | 15 |
| **Zirconomer** | 15 | 15 |

**Evaluation of compressive strength (CS) and diametral tensile strength (DTS):**

All the three materials were mixed and prepared according to manufacturers direction. According to ADA specification For CS cylinders were made of 6mm diameter x 12mm height. For DTS disks were of 6mm diameter x 3mm height. Specimens were stored in deionized water at 37º C and 100% of humidity in a stove until testing. Specimens were submitted to CS and DTS test in each period, namely 1 hour, 24 hours and 7 days.

The test was carried out in a universal testing machine with a cross head speed of 1.0mm/min. The maximum load required to fracture the specimen was recorded and calculated. The sample was placed with the flat ends between the plate of the apparatus and the load is applied along long axis of specimen.

**STATISTICAL ANALYSIS:** Two- way Analysis of variance (ANOVA) was computed to determine whether statistical difference existed between the materials. Post hoc test was used to compare the strength among the two materials. (P=0.05)

## RESULTS

On comparing the compressive strength and diametral tensile strength it was seen that GIC had the least value when compared to amalgam and Zirconomer at 3 different time interval i.e, after 1hr, 24hr and 7 days showing statistical significant difference at value of P = 0.05. Between amalgam & Zirconomer, Amalgam had better compressive strength and diametral tensile strength compared to Zirconomer at 3 different time interval there was no statistical difference.(P=0.05) [Table 1 and 2]

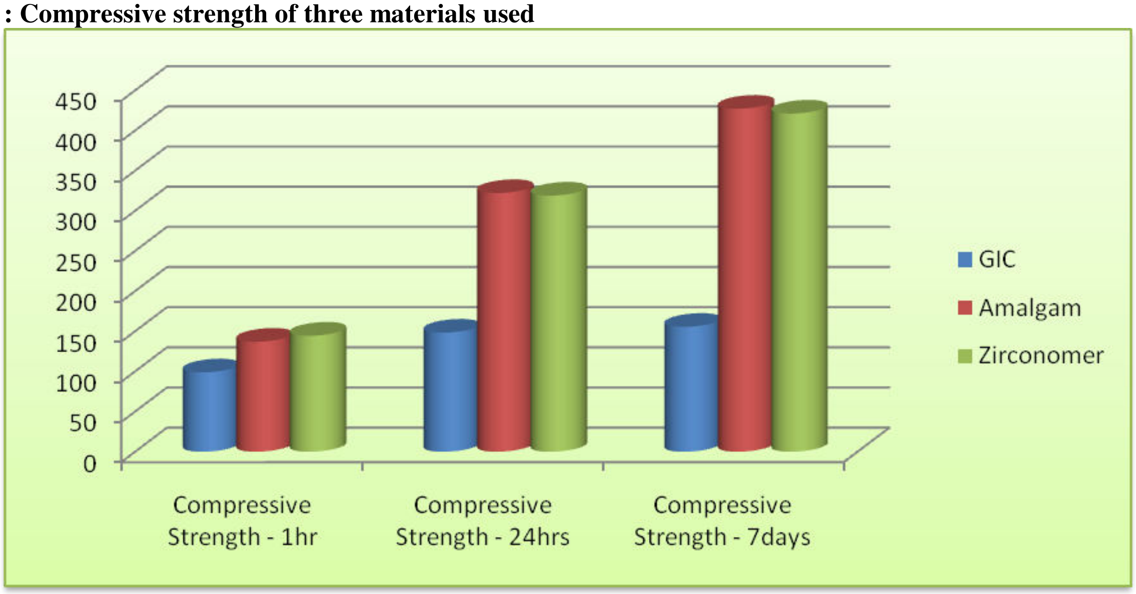
**Table I : Showing Compressive Strength of three materials**

| | | N | Mean | Std. Deviation | Sig |
|---|---|---|---|---|---|
| **Compressive_ 1hr** | **GIC** | 05 | 98.8170 | .98312 | 0.000 |
| | **Amalgam** | 05 | 136.9820 | .83472 | |
| | **Zirconomer** | 05 | 134.4750 | 1.39726 | |
| **Compressive_ 24hrs** | **GIC** | 05 | 148.2750 | .42356 | 0.000 |
| | **Amalgam** | 05 | 322.0950 | .80336 | |
| | **Zirconomer** | 05 | 318.9640 | 1.04521 | |
| **Compressive_ 7days** | **GIC** | 05 | 155.5000 | .99714 | 0.000 |
| | **Amalgam** | 05 | 427.1600 | 1.48537 | |
| | **Zirconomer** | 05 | 421.1280 | 1.40520 | |

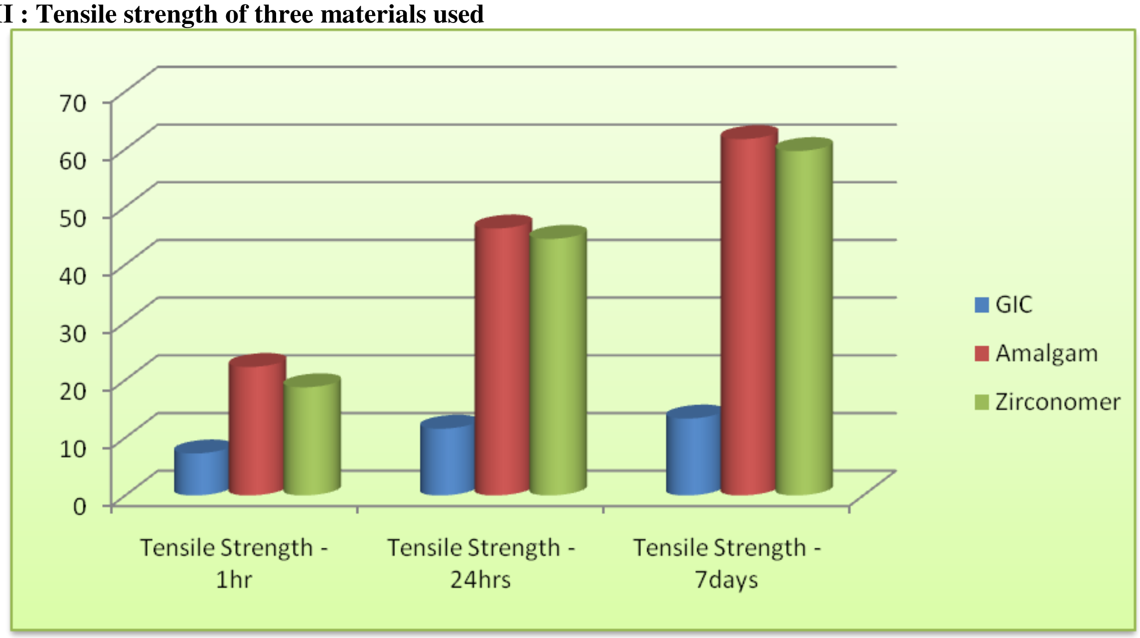
**Table II : Showing Tensile Strength of three materials**

| | | N | Mean | Std. Deviation | Sig |
|---|---|---|---|---|---|
| **Tensile_1hr** | **GIC** | 05 | 7.2630 | .32166 | 0.000 |
| | **Amalgam** | 05 | 22.2540 | .87312 | |
| | **Zirconomer** | 05 | 18.7340 | .70141 | |
| **Tensile_24hrs** | **GIC** | 05 | 11.5500 | .42311 | 0.000 |
| | **Amalgam** | 05 | 46.2540 | 1.88732 | |
| | **Zirconomer** | 05 | 44.4520 | 1.45304 | |
| **Tensile_7days** | **GIC** | 05 | 13.3170 | .67337 | 0.000 |
| | **Amalgam** | 05 | 61.7480 | 1.01608 | |
| | **Zirconomer** | 05 | 59.6740 | .68378 | |

**Graph I : Compressive strength of three materials used**




**Graph II : Tensile strength of three materials used**



## DISCUSSION:

In the past decade, manufacturers always worked assiduously to produce GIC systems that overcome the 3 chief disadvantages of this class of materials: (1) Difficult handling properties, (2) poor resistance to surface wear, and (3) poor resistance to fracture. They have produced products that are improved to the point that these major disadvantages have either been eliminated or reduced to acceptable levels. Amalgam has certain drawbacks of Post-operative tooth sensitivity, Susceptibility to fracture restored tooth, Microleakage and Secondary caries.[4-7]

The fascination for research on metal free restorations has risen considerably in the past 20 years. The introduction of $ZrO_2$ as a metal free, "ALL" ceramic option opened a new horizon for restorative dentistry with unlimited possibilities and virtually no limitations. $ZrO_2$ is alluring due to its good mechanical properties, aesthetics and low plaque accumulation. It was introduced by Martin Heinrich Klaproth in 1789. This material is a non cytotoxic metal oxide, is insoluble in water and has no potential for bacterial adhesion. In addition, it has radiopaque properties and exhibits low corrosion. These elements of $ZrO_2$ led to the formulation of $ZrO_2$ infused GIC to enhance the strength and aesthetics of GICs. Zirconomer (a white amalgam) or Zirconia reinforced GIC is developed to exhibit the strength i.e, consistent with amalgam through a rigorous manufacturing technique. The homogenous incorporation of Zirconia particles in the glass component further reinforces the material for lasting durability & high tolerance to occlusal load.[3-7]

Two mechanical strength tests Compressive and Diametral Tensile were used in this study. To test compressive strength of a material two axial sets of force are applied to a sample in an opposite direction, in order to approximate the molecular structure of the material. The diametral tensile strength (DTS) is a critical requirement, because many clinical failures are due to tensile stress.

On comparing the CS and DTS it was seen that GIC had the least value(CS=98.825±0.98, 148.2±0.42, 155.50 ±0.99; DTS= 7.2630 ± 0.32, 11.5 ±0.42, 13.31 ± 0.67) when compared to amalgam and Zirconomer at 3 different time interval i.e, after 1hr, 24hr and 7 days respectively showing statistical significant difference at value of P = 0.05.

Between amalgam & Zirconomer, Amalgam had better CS (427.16 ± 1.48) & DTS (61.7 ±1.0) compared to Zirconomer (CS= 421.1 ±1.4,DTS= 59.6 ±68) at 3 different time interval but there was no statistical difference.

Zirconomer improved the mechanical properties of the restoration by reinforcing structural integrity of the restoration & can be used in load bearing areas i.e, as posterior restorations.[4]

Upadhyay et al.[8] showed that nano-ionomer containing silica and zirconia fillers revealed the least microleakage. Gorseta et al.[9] witnessed least microleakage for nano-ionomers as observed with conventional glass ionomer cements and accentuated the efficacy of nano-ionomer cements.

A study conducted by Patel et al. used extracted molars with Class I restorations to evaluate and compare microleakage with the dye penetration method. They concluded that the Zirconomer group exhibited maximum microleakage when compared with the amalgam group.[10]

The combination of strength, durability and fluoride release deemed with chemical bonding makes it ideal for posterior restorations in patients with high caries incidence as well as case where strong structural cores and bases are required.[11]

In a study conducted by Gu et al., where amalgam alloy in miracle mix was replaced by yttria stabilized ZrO2 particles, mechanical properties of ZrO2 infused miracle mix were found to improve with increased soaking time and tensile strength was found to be greater than the amalgamated miracle mix.[12]

In another study by Gu et al. on the effect of incorporation hydroxyapatite (HA)/ZrO2 particles, there was a uniform distribution of these particles in the GIC matrix and mechanical properties were found to be better than HA GICs. They also observed the deterioration of mechanical properties with an increase in HA/ZrO2 content in the GIC above 12 vol%.[12]

## CONCLUSION:

Authors found that the addition of zirconia to the GIC has improved its mechanical properties as amalgam. Hence, zirconomer improved can be used as posterior restorative material.

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