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RESEARCH ARTICLE

COMPARITIVE EVALUATION OF COMPRESSIVE STRENGTH AND DIAMETRAL TENSILE STRENGTH OF ZIRCONOMER, KETAC MOLAR AND TYPE IX GIC – AN IN –VITRO STUDY

Dr. Asok Patel, *Dr. Dhanashree Dalal, Dr. Laxmi Lakade, Dr. Preetam Shah, Dr. Sheta Caudhary and Dr. Rahul Lodaya

Bharati Vidyapeeth Deemed Univeristy Dental College and Hospital, India

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*Corresponding author

ABSTRACT

Introduction: The quest for better restorative material still continues which has led to newer materials introduced having better mechanical properties such as better marginal seal, biocompatibility, high compressive and diametral tensile strength in evolution. GIC is no exception to it; a newer class of restorative zirconia reinforced glass ionomer is being evolved. **Aim:** Comparative evaluation of compressive and diametral tensile strength of Zirconomer, Ketac Molar and Type IX GIC. **Method:** These three study groups will be evaluated for compressive strength and diametral tensile strength, by preparing the specimens using cylinder moulds. All these specimens was subjected to the Universal Testing Machine. The data obtained from the study will be compiled, tabulated and analyzed statistically. **Result:** Conventional GIC has higher compressive strength (p=0.805) and tensile strength (p=0.045) followed by Zirconomer and Ketac molar. **Conclusion:** Conventional GIC has better compressive strength and tensile strength followed by Zirconomer and Ketac molar.

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INTRODUCTION

The objective of the use of any restorative material is to substitute the biological, functional and esthetic harmony of the lost tooth structure. Evolution of restorative materials is imperative for better delivery of treatment. Thus the newer materials should exhibit significantly better properties than its predecessors (Chitharanjan Shetty, 2017). GICs were first introduced to the dental field in the 1970s by Wilson and Kent. They tried to combine the advantages of translucency and fluoride release from silicate cement and the advantages of biocompatibility and adhesive properties from polycarboxylate cement. The result was a cement composed of ion-leachable Fluoroaluminosilicate glass in a solution of polyacrylic acid called GIC.GIC are commonly used in restorative and pediatric dentistry for their fluoride release, biocompatibility and ease of use. However, they are susceptible to fracture and exhibit low wear resistance (Chalissery *et al.*, 2016). To overcome the disadvantages of low tensile strength and brittleness of glass ionomer, metal reinforced materials like Miracle Mix and Ketac Silver were introduced. A disadvantage of metal reinforced cement however, is that they are not tooth coloured (Walia *et al.*, 2016). Since glass ionomer cements fail to achieve sufficient hardness, resistance to fracture and have a low abrasion resistance, a newer conventional glass ionomer cement, Ketac Molar, was evolved with improved mechanical properties (Hanan Alzraikat, 2016).Recently, a new material ZIRCONOMER (Zirconia +GIC) has been introduced to combat these disadvantages. It is known to exhibit the strength and durability of amalgam with the protective benefits of glass ionomer, while completely eliminating the hazards of mercury. Amongst the mechanical properties of restorative materials, compressive strength is considered to be a critical indicator of success because high compressive strength is necessary to resist masticatory and parafunctional forces (Hanan Alzraikat, 2016). The compressive strength of a material is defined as the amount of stress required to distort the material in an arbitrary amount. It is calculated by dividing the maximum load by the original cross-sectional area of a specimen (Walia *et al.*, 2016). Diametral tensile strength is also an important property, because many clinical failures are due to tensile stress. The compressive and diametral tensile strengths are clinical tests to determine the mechanical properties of glass ionomers. In light of the concerns associated with the strength of the restorative materials and its physical properties, which play a vital role in durability and resistance of the restoration to fracture due to occlusal load, the aim of this study is to compare the compressive strength and diametral tensile strength of Zirconomer, Ketac Molar and Type IX GIC Extra .

MATERIALS AND METHODS

Sample preparation: A total of 120 specimens were made according to manufacturer's direction for each sample. The mixed materials were placed into cylindrical and disc moulds before it sets. The moulds were then filled to excess and plates were placed above it, followed by slight application of pressure. The excess cement which was extruded was removed.

The three experimental groups will be

- Zirconia reinforced glass ionomer (Zirconomer, Shofu Inc. Japan)
- Ketac Molar (3M ESPE)
- Reinforced glass ionomer cement, (Fuji 1X Extra, GC Corp, Japan)

Compressive strength testing

Thirty specimens (n=10) for compressive strength were prepared using cylinder moulds	
Dimensions :	6.0 mm diameter × 12.0 mm height

↓

Compressive strength testing was carried out using universal testing machine	
Crosshead speed	1.0 mm/min

↓

Samples were placed with the flat ends between the plantens of the apparatus so that load will be applied in the long axis of the specimens the maximum load apply to fracture the specimens were recorded	
Formula	$C=4P/\pi D^2$

Where P is the maximum applied load (N), D is the measured diameter of the sample (mm)

Diametral tensile strength testing

Ninety specimens (n=30) for diametral tensile testing was prepared using cylinder moulds	
Dimensions:	6.0 mm diameter × 3.0 mm height

↓

Diametral tensile strength was determined using universal testing machine	
Crosshead speed	1.0 mm/ min

↓

Samples were placed with the flat ends perpendicular to the platens of the apparatus so that the load is applied to the diameter of the specimens and the maximum load applied to fracture the specimens were recorded	
Formula	$T=2P/\pi DL$

Where P is the maximum load applied (N), D is the measured mean diameter of the sample (mm), L is the measured length of the sample (mm).

Statistical analysis: The data obtained was statistically analysed and mean value with its standard deviation was calculated for each core material. ANOVA test was computed to determine whether statistically significant difference existed among core materials. Tukey's post hoc test was used to determine which core materials were statistically significant from one another.

RESULTS

There was no significant difference among the three materials for the compressive strength. The Ketac molar had a compressive strength significantly lower compared with zirconomer and type IX GIC (Table 1). Even though type IX GIC expressed slightly higher values to zirconomer, it was not significant (Table 2). The possible reasons to explain this results could be according to Wilson, Increase in the alumina content is responsible for the compressive strength. Secondly, Incorporation of fluorocomplex salt especially Aluminium fluoride is responsible for the increase in strength (Channensanon *et al.*) (Graph 1).

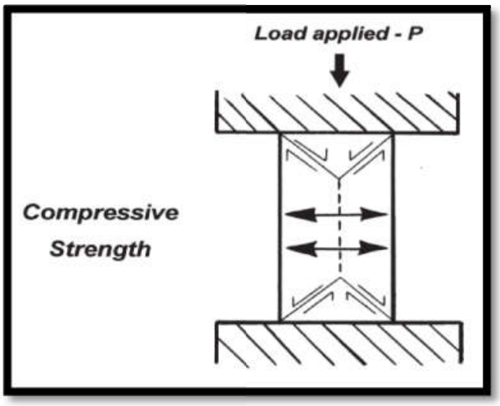


Figure 1. Schematic illustration of Compressive Strength adapted from Darvell (2000) 2000

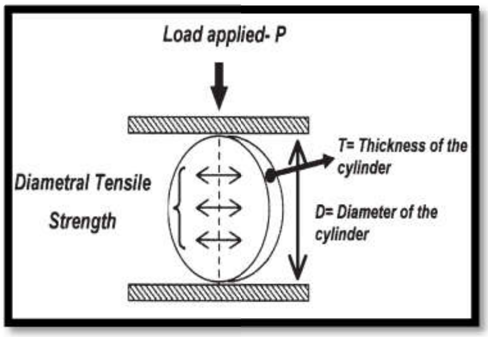
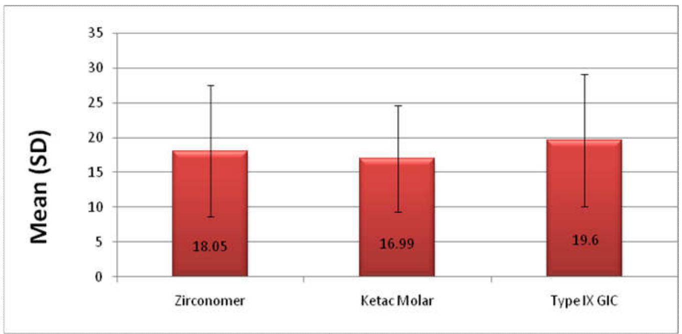
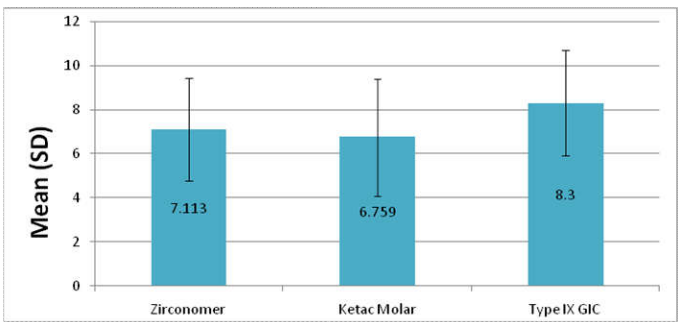


Figure 2. Schematic illustration of Diametral Tensile Strength adapted from Darvell 2000



Graph 1. The compressive strength of the three materials tested



Graph 2. The diametral strength of the three materials tested

Table 1. Comparison of Diametral tensile strength in terms of {Mean (SD)} among all the 3 groups using ANOVA test

Group	N	Mean	Std. Deviation	F value	P value
Zirconomer	30	7.113	2.331	3.219	0.045*
Ketac Molar	30	6.759	2.656		
Type IX GIC	30	8.300	2.391		
Total	90	7.391	2.524		

Table 2. Tukey's post hoc analysis

	Zirconomer	Ketac Molar	Type IX GIC
Zirconomer	-	0.844	0.155
Ketac Molar	0.844	-	0.046*
Type IX GIC	0.155	0.046*	-

Table 3. Comparison of compressive strength in terms of {Mean (SD)} among all the 3 groups using ANOVA test

Group	N	Mean	Std. Deviation	F value	P value
Zirconomer	10	18.05	9.425	0.219	0.805
Ketac Molar	10	16.99	7.644		
Type IX GIC	10	19.60	9.448		
Total	30	18.21	8.637		

Table 4 .Tukey's post hoc analysis

	Zirconomer	Ketac Molar	Type IX GIC
Zirconomer	-	0.962	0.919
Ketac Molar	0.962	-	0.790
Type IX GIC	0.919	0.790	-

In DTS, no statistically significant difference on serves between three groups .To explain, the possibility could be due to alteration in powder / liquid ratio. According to Fonseca *et al*, the ratio of powder and liquid is directly proportional to diametral tensile strength of GICs (Graph 2).

DISCUSSION

The availability of variety of restorative materials in the field of dentistry results in continual scrutiny of the properties of the material. This is to ensure the right choice of the material for clinical purposes which would adhere optimally to the tooth structure and which can withstand the masticatory forces (Mali *et al*., 2006). The resistance to fracture within a restorative material is specified by a fracture stress, which is often referred to as the strength of the material (Yap *et al*., 2003). Two mechanical strength tests (Compressive and Diametral Tensile) were used in this study. The compressive strength (CS) is an important property in restorative materials, particularly in the process of mastication. This test is more suitable to compare brittle materials, which show relatively low result when subject to tension (Naasan, 1998). 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 (Wang 2003). Compressive strength testing is commonly used as a measure by which clinicians and researchers predict the performance of a restorative material in oral environment. The compressive strength of a material is defined as the amount of stress required to distort the material in an arbitrary amount. It is calculated by dividing the maximum load by the original cross-sectional area of a specimen (Walia *et al*., 2016). The diametral tensile strength (DTS) is a critical requirement, because many clinical failures are due to tensile stress (McKinney, 1987). As it is not possible to measure the tensile strength of brittle materials like Glass Ionomer Cements (GICs) directly, the British Standards Institution adopted the diametral tensile strength test (British Standards Institution, 1981). In this test, a compressive force is applied to a cylindrical specimen across the diameter by compression plates. While the stresses in the contact regions are indeterminate, there is evidence of a compressive component that hinders the propagation of the tensile crack (Darvell, 2000). Large shear stresses that exist locally under the contact area may also induce a shear failure before tensile failure at the center of the specimen (Craig, 1997). For all cements, CS values were much higher than DTS values. Compressive strength was about 8-13 times greater than DTS. This may be explained because cohesion between the materials is identical in both compressive and diametral tensile strength tests, but the direction of forces is reversed (Yap *et al*., 2003). Ketac Molar had the lowest value for compressive strength as compared to the other study groups. The reason for the low score of compressive strength for Ketac Molar is due to the poor mechanical properties, such as low fracture strength, toughness, and higher occlusal wear rate as studied by Lohbauer (Walia *et al*., 2016). To overcome the shortcomings of GIC, researchers have formulated GICs with improved handling properties, resistance to surface wear and fracture. Zirconomer is a ceramic and zirconia reinforced glass ionomer cement. It exhibits the strength of amalgam and at the same time maintain the fluoride releasing capacity of GICs. Fujii IX Extra GC is the latest addition to the glass ionomers that offer unsurpassed wear resistance, compressive strength, and durability. This product contains glass filler, Smart Glass. Addition of this filler provides higher translucency, reactivity and a faster setting time (Mali, 2006).

Conclusion

The present study revealed maximum mean value score of compressive strength and diametral tensile strength to be higher for type IX GIC followed by zirconomer and ketac molar .The results could be variable due to-Different mixing methods of the cements ,variable sample dimensions, variable sample size and testing methods. Within the limitation of the present study, the results obtained may not be correlated with the clinical situations thus to provide relevant information regarding the restorative material, Large sample size and in vivo conditions can be taken into considerations to substantiate with the present results.

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