



**EVALUATION OF THE COMPRESSIVE STRENGTH OF RECENT
GLASS IONOMER CEMENTS: A CROSS SECTIONAL
COMPARATIVE STUDY**

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ABSTRACT

The Compressive strength of the restorative materials determines its longevity against masticatory forces. The aim of this study was to compare the compressive strengths of three conventional glass ionomer cements using a Universal testing machine. Three groups of commercially available brands of Glass Ionomer restorative materials were used in this study: (10 samples in each group). Experimental glass ionomer cement (GIC) specimens fabricated using customized cylindrical moulds of dimension 6±1mm (height) × 4±1mm (diameter) were tested for evaluation of compressive strength using Universal Testing Machine (UTM). This was connected to a load measuring cell, which continuously recorded the load applied to the samples at a crosshead speed of 0.75 ± 0.25 mm per 1 minute till the samples fractured.

The samples were statistically analysed using Kolmogorov Smirnov test, One-way ANOVA, and Tukey's post hoc HSD. The results of the study showed that Ketac™ Universal had the highest compressive strength among all the groups tested; Ionofil Molar had the second highest value, and the least value of compressive strength was seen with Fuji IX Extra. A good insight into material endurance was given, but the absolute values of the mechanical properties recorded must be interpreted with respect to the experimental conditions.

Keywords: Compressive strength, Ketac™ Universal, Fuji IX Extra, Ionofil molar, GIC

INTRODUCTION

In the quest for searching a restorative material that chemically adheres to the tooth and has superior mechanical properties; Glass-ionomer cements (GICs) were introduced to dentistry by Wilson and Kent. They possess unique properties such as chemical adhesion to the tooth, low coefficient of thermal expansion, biocompatibility and fluoride ion release that potentially reduces the incidence of caries associated with restorations and sealants [1]. With its diversified applications, several modifications have been imparted with the purpose of enhancing their mechanical properties and expanding their clinical applications [2]. GICs are brittle materials with low tensile strength that are susceptible to crack propagation. The compressive strength of various GICs is an important attribute to know, especially during the masticatory process [3].

Dentists must opt for the relevant material based on the clinical scenario. The selection should be based on a number of factors, such as knowledge of the materials

being used, mechanical properties, biocompatibility, esthetics, and area/ mode of application [4].

Tremendous research has been performed in an attempt to understand their mechanical, chemical and biological properties. However, the commonest method employed to evaluate the strength of these materials is compressive strength testing employing the Universal Testing Machine (UTM).

As it is crucial to have knowledge about the physical and mechanical properties of new products when choosing a restorative material, this in vitro study was aimed at comparing the compressive strength of three conventional glass ionomer cements i.e. Ketac™ Universal, Fuji IX Extra, and Ionofil molar.

MATERIALS AND METHODS

Ethical approval for this study (Protocol No: YEC2/612) was provided by the Yenepoya Ethics Committee 2, Yenepoya (Deemed to be University), Mangalore on 14 January 2021.

Three groups of commercially available brands of Glass Ionomer restorative materials were used in this study: (10 samples in each group)

Group 1: Conventional high viscosity glass ionomer cement – KETAC™ UNIVERSAL GIC (3M ESPE, Germany)

Group 2: Conventional glass ionomer cement - IONOFIL MOLAR GIC (VOCO, Cuxhaven, Germany)

Group 3: Strontium based Conventional high viscosity glass ionomer cement - GOLD LABEL FUJI IX EXTRA GIC (GC Corporation, Tokyo, Japan)

The materials were mixed according to the manufacturer's instructions. Specific

specimen dimensions (6mm x 4mm) were achieved using a metal split mould (**Figure 1**). The insertion of material into the mould was done slowly to adapt the material and avoid bubble formation. The moulds were slightly overfilled with the glass ionomer cement; transparent matrix strip covered with a thin layer of petroleum jelly was placed on the material. Hand pressure was then applied for excess material to be extruded from the top of the mould. The specimens were then stored in glass bottles for five days. Compressive strength tests were conducted with a Universal Testing Machine (**Figure 2**) at a crosshead speed of 0.75 ± 0.25 mm per 1 minute till the samples fractured followed by which statistical analysis was done using the ANOVA tests.

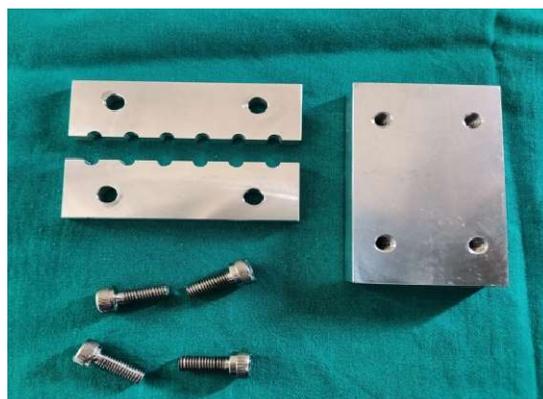


Figure 1: Metal Split mould (6mm X 4mm)



Figure 2: Sample placed in Universal Testing Machine to determine compressive strength

RESULTS:

Based on previous studies, the effect size was calculated and found to be 0.659. Using this effect size, the sample size with power 80% and level of significance 5% for three groups was calculated using G* power software and found to be 27. This was equally divided into 3 groups with 10 samples in each group.

Kolmogorov Smirnov test for checking the normality of data sets was incorporated and

it was found that the data followed normal distribution. Descriptive statistics computing mean and standard deviation was used and statistically analyzed using One-way ANOVA for the comparison of the three groups (**Table 1**). Multiple comparisons were done using Tukey's post hoc HSD. ($P < 0.05$ was considered as significant).

Table 1: Descriptive statistics computing mean and standard deviation

Specimen	Mean (SD)	F value	P value	95% Confidence Interval
Ketac™ Universal	52.26 (14.68)	3.78	0.036*	41.75 to 62.76
Ionofil Molar	46.50 (8.47)			40.44 to 52.57
Fuji IX Extra	35.78 (16.33)			24.09 to 47.47

* $p < 0.05$ – considered significant

DISCUSSION

GICs have a wide range of applications in dentistry [5]. However, they have several key limitations, such as low wear resistance, brittleness, and strength to endure masticatory stresses, in addition to

their distinctiveness. As a result, their application is typically limited to certain indications such as modest restorations in low-stress locations [6]. The strength, wear, resistance to environmental degradation, aesthetics, and viscoelastic property of

materials are all factors in material selection for diverse clinical scenarios. The performance level of the materials is improving in tandem with the yield of the chemical reaction due to the self-curing acid-base reaction of typical GICs. It is critical to have a rapidly increasing performance level in order to reduce the risk of early restorative damage [6].

Universal Testing Machine has been considered a Gold standard for determining compressive strengths of various GICs [1-3, 7-10]. It is proclaimed that the knowledge about compressive strength of a material can give insight into their mechanical integrity. Moreover, the compressive strength results are often used to assess the durability of the material when subjected to masticatory forces [11]. Several clinical trials were carried out to increase bond strength and fluoride release, however, with enhancements in these properties lead to compromising in the mechanical properties [2, 12].

Glass ionomer cements are very technique- and methodology-sensitive, and are even subject to failures during manipulation. Studies suggest the use of smaller specimen dimensions (6 mm x 4 mm) to investigate mechanical properties of glass ionomer cements, according to ISO 7489:1986 specifications, is to reduce the variability that may result when large amounts of material are manipulated [2].

Ionofil molar comprises of aluminofluorosilicate glass, water, pure polyacrylic acid, tartaric acid and pigments. They possess an average particle size of 5micrometer.^[10] GC Fuji IX Extra comprises of powder (Fluoro-aluminosilicate glass, polyacrylic acid powder, iron oxide, titanium dioxide) and liquid (Polyacrylic acid aqueous solution, tartaric acid, water) [7, 9]. Its a bioactive material that restores and protects teeth with minimum intervention and exhibits higher translucency, fluoride release, reactivity and a faster setting time.^[13,14] However, study by Bala *et al* showed that Fuji IX Extra expressed lowest microhardness value in comparison to other conventional GICs like Ionofil Molar etc. [10].

KetacTM Universal GIC comprises of powder (Oxide glass) and liquid (Copolymer of acrylic acid-maleic acid, tartaric acid and water) [7]. It has been designed to save steps for faster procedure and is therefore suitable for treating paediatric and geriatric patients who are more caries prone. The manufacturers claim that, it can be used without preconditioning the cavity and also without a protective coating over the material, thereby reducing chair side time with a simple one step placement procedure. It is mixed by hand to initiate the acid-base setting reaction of the glass ionomer and

renders low stickiness for easy handling [15]. The manufacturers claim that it can be used in high stress bearing areas due to the specially improved filler composition [16]. Powder-liquid ratio, setting reaction, internal structure integrity, voids inside the material, and minute glass particles are all elements that affect the material's compressive strength [17]. All the tested GICs have nearly similar powder-liquid ratios and fast setting reaction [3, 18]. The integrity of the internal microstructure, the existence of voids, and the presence of microscopic glass particles all influenced the strength of these materials [19]. This data is in tandem with our results and proves KU has higher compressive strength as they have denser internal microstructure, fewer and smaller voids, and smaller glass particles. Small glass particles and lesser porosity inside the material structure are associated to hardness values, according to Xie *et al* [20], and the presence of widely dispersed small tightly packed glass particles inside the matrix may be the cause of greater hardness values [19].

The advantage of using Ketac™ Universal is to eliminate pre-conditioning of the dentin while other traditional GICs do require. However, studies reveal that prior conditioning does not interfere with the bond strength of self-cure GICs to the sound dentin of permanent teeth [21] and Fuji IX Extra GIC demonstrated higher

shear bond strengths as compared to Ketac™ Universal [9].

Bresciani *et al* [22] demonstrated that the compressive strength of GICs increase with time i.e. 1 hour had the least while 7 day period showed greater results. The storage time of the specimens in our study was five days, due to the fact that immediately after mixing GICs have weak mechanical properties until they mature [6, 11]. Ketac™ Universal demonstrated better compressive strengths and edge strength than conventional GICs in both normal and repair models [7]. The compressive strength values varied among groups as they are sensitive to variations in cements' structure, the concentration of the reinforcing glass particles, and the presence of voids via air inclusion or inadequate wetting of the powder particles [1].

CONCLUSION

As this is an in vitro study, the oral conditions could not be completely simulated. Within the limitations of this study, a good insight into material endurance was given, but the absolute values of the mechanical properties recorded must be interpreted with respect to the experimental conditions. Considering the results obtained in this study, it can be concluded that Ketac™ Universal has the highest compressive strength among all the groups tested; Ionofil Molar has the second highest value, and the least value of

compressive strength is seen with Fuji IX Extra and the differences are statistically significant.

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