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A Comparative Evaluation of Shear Bond Strength of a Zirconia-reinforced Glass-ionomer and a Resin modified Glass-ionomer Restorative Material

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ABSTRACT— Introduction: Glass ionomer cements (GICs) are self-adhesive restorative materials composed of fluoro-alumino-silicate glass and polyacrylicacid, offering good adhesive bonds to teeth. However, their poor mechanical properties limit their use. To address this, resin-modified GICs were introduced, with Zirconomer Improved being a recent advancement that improves both mechanical strength and aesthetics. Flexural and shear bond strength are key indicators of ideal restorative material performance. **Aim:** To evaluate the flexural and shear bond strengths of Zirconomer Improved and compare them with those of the resin-modified glass ionomer cement (Fuji II LC). **Materials and Methods:** In this study, 36 specimens were prepared. For the flexural strength test, 18 specimens were mixed and placed in Teflon molds, with 9 specimens for Group I(Zirconomer Improved) and 9 for Group II (Fuji II LC). For the shear bond strength test, 18 molars had their occlusal surfaces ground flat, and cylinders of each material (n = 9) were bonded according to the manufacturers' instructions. All specimens were thermocycled before testing on a universal testing machine. Results: Fuji II LC exhibited significantly higher shear bond strength values compared to Zirconomer Improved specimens. **Conclusions:** In this in vitro study, GIC Fuji II LC consistently outperformed Zirconomer Improved.

Key words: Zirconia- reinforced Glass-ionomer, Resin-modified Glass-ionomer and Shearbond strength**.**

1. Introduction: Glass-ionomer cements (GICs) are self-adhesive restorative materials made of fluoro-alumino silicate glass and polyacrylic acid, offering strong adhesion to tooth structure. However, their poor mechanical properties limit their use. To address this, resin-modified GICs were developed, enhancing both mechanical and aesthetic properties. Zirconomer Improved, a zirconia- reinforced GIC, was introduced as a durable, tooth-colored, self-adhesive material for posterior bulk- fill restorations. Its high-strength glass and polyalkenoic acid components are specially processed to provide superior mechanical and handling qualities. **(Prabhakar *et al.* 2010)** The glass component of this high-strength restorative material is micronized to optimize particle size and improve its properties. Zirconomer Improved contains zirconium oxide (ZrO_2), glass powder, polyacrylic acid

(20%-50%), tartaric acid (1%-10%), and de ionized water. The zirconium oxide, sourced from baddeleyite (ZrO2), contains 96.5%-98.5% zirconia and includes nano-sized zirconia fillers, enhancing handling and aesthetic qualities. **(Shofu 1922)** The uniform incorporation of zirconia particles in the glass enhances the material's strength, improving its resistance to occlusal loads and ensuring long-term durability. Zirconomer and Zirconomer Improved are innovative restorative materials, produced using advanced techniques, offering strength comparable to amalgam while addressing its limitations. **(Patel *et al.* 2015).**

Flexural strength, the maximum stress a material can endure before failure under load, is particularly important in areas subject to heavy masticatory forces in clinical settings. **(El-Askary*et al.*,2017).**

Shear bond strength (SBS) is the maximum load an adhesive bond can withstand before failure or fracture. **(Mohanty*et al* 2017)** This property is used to evaluate the bond strength of restorative materials to tooth structure or other materials. To replicate the challenges of the oral environment, aging protocols such as thermal cycling, immersion in fluids (water, coffee, ethanol), and mechanical brushing are used to simulate the intraoral conditions that significantly affect restorative materials. **(Gale *et al* 1999)**.

To date, no studies have compared the restorative materials mentioned. Therefore, this study aimed to evaluate and compare the flexural strength and shear bond strength of a zirconia-reinforced glass ionomer and a resin-based glass ionomer.

2. **Materials and methods**:

Materials used in this study are represented in table 1 and figure 1

Table(1):Materials'tradename,Description,CompositionandManufacturers,Lot number.

Materials	**Composition**	**Batch/lotNo.**	**Manufacturer**
Zirconomer Improved	Powder: Fluoroaluminosilicate glass, zirconiumoxide (ZrO2), pigment Liquid: Polyacrylic acid, tartaric acid	Lot 02210480	ShofuDental,Tokyo, Japan.
Fuji II LC capsule	Liquid: Polyacrylic acid (20-25%), 2-Hydroxyethylmethacrylate (30-35%), Proprietary ingredient(5-15%),2,2,4- Powder: Trimethylhexamethylene decarbonate(1-5%),	A32302132	GCCorporation Tokyo, Japan.

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	Fluoroaluminosilicate glass(95-100%).		

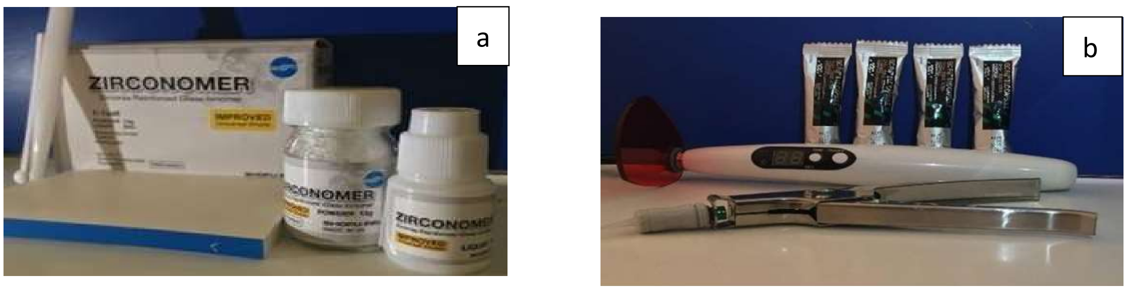

Figure1. a)ZIRCONOMER IMPROVED (Zirconia-reinforced glass-ionomer)P:Lform,**b)** FujiIILC Capsules(Resin-modified glass ionomer) Capsules and applicatorgun.

Methods

Shearbond Strength:

Collection and Storage of Teeth:

Eighteen permanent upper molar teeth were collected, washed under running water to clean from blood, and an ultrasonic sc alert or remove adherent tissues. The teeth were examined according to the set inclusion and exclusion criteria:

Inclusion Criteria: Plain, unrestored teeth.

Exclusion Criteria: Hypoplastic and cracked teeth.

Selected teeth were stored in buffered saline plus 0.5% for one month before testing. Eighteen teeth were randomly divided into two groups (Nine teeth/per group) as shown in (fig. **2**).

Figure2. Teeth stored in buffered saline plus 0.5% for a month before testing.

Teeth Preparation

The occlusal surfaces of the selected 18 molars were ground flat, and cylinders of both restorative materials (n = 9/grp) were prepared in a jig and bonded to the flat occlusal surface according to manufacturers' instructions. (**fig.3**)
Using a low-speed hand piece, and a diamond disc, the occlusal surfaces of each tooth were flattened, to obtain a uniform dentin surface. Each tooth was embedded in one block as shown in(**fig. 3**).
The occlusal surfaces of the teeth were transversally sectioned by diamond discs(DandZ, Germany) under water cooling exposing the flat superficial dentin in(**fig.4)**. The exposed dentin surfaces of all teeth were wet-ground using 600-grit silicon carbide abrasive paper to create a homogeneous surface. Next, the dentin was conditioned with cavity conditioner (GC, Tokyo, Japan) applied with a microbrush for 10 seconds, followed by rinsing with distilled water for 20 seconds and drying with cotton pellets.

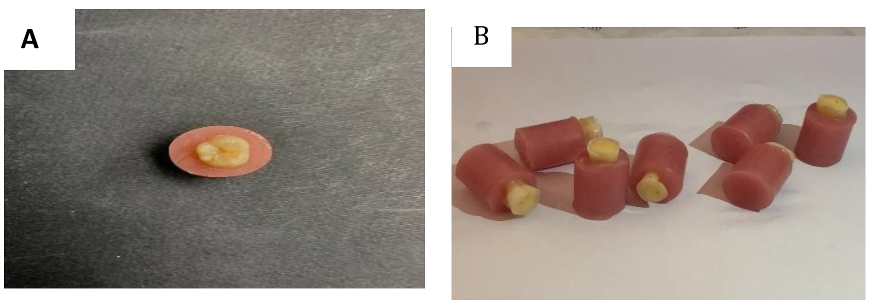

Figure3. Teeth embedded in acrylic resin blocks

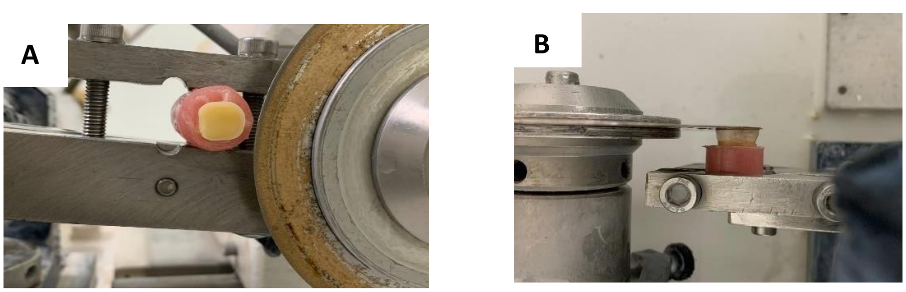

Figure4.The occlusal surfaces of the teeth were transversally sectioned under water cooling to expose the flat superficial dentin.

2.1.3. Specimen Preparation
2.1.4 Shearbond strength(SBS) Test
The teeth were mounted in blocks to facilitate their accurate placement in the universal testing machine, without any risk of slippage upon shear loading. The specimens were tested in a shear mode (knife edge testing apparatus, atcross head speed of 1.0mm/minuntilde bonding

of the cylinder tubes). (**fig.8**) The sample cylinder tube was kept in line with the center of the load, and the blade was moved parallel to the load direction and to the bonded surface, maintaining as hear stress at the bonding interface. The SBS values were calculated by dividing the load at failure (Newton) by the area of the cylindrical cross-section. (**Takada *et al* 2015).**

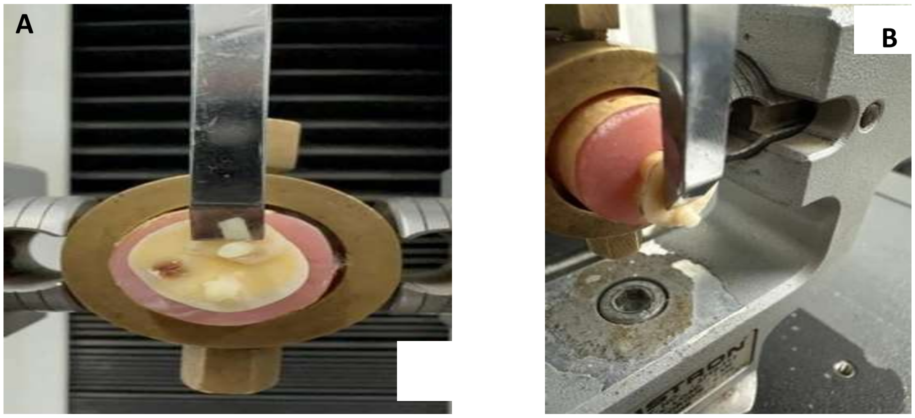

Figure8. The cylindrical tube specimens tested in shear mode using a knife edge testing apparatus, top view (A), and side view (B).

Results:
The Shear Bond Strength values of FUJI II LC and ZIRCONOMER Improved (MPa) are presented in Table (2). Statistical analysis showed significant difference between both groups using independent sample T-test at pvalue<0.05(T=4.45,p<0.001). The high mean values were recorded for FUJI II LC group(12.86±2.63MPa) than ZIRCONOMER Improved group(8.23±1.98MPa) (**Table2and fig,9**).

Table2.ShearBondStrengthofFUJIIILCandZIRCONOMERImproved

Groups	Mean MPa	SD	Mean Difference (%change)	95%Confidence Interval ofthe Difference		t	Sig.(2-tailed)
				Lower	Upper		
FUJI II LC	12.86	2.63	4.64 (36.0%)	2.45	6.82	4.45	<0.001**
ZIRCONOMER Improved	8.23	1.98					

***,**;meanssignificantdifferenceusingindependentT-testp<0.05andp<0.01**

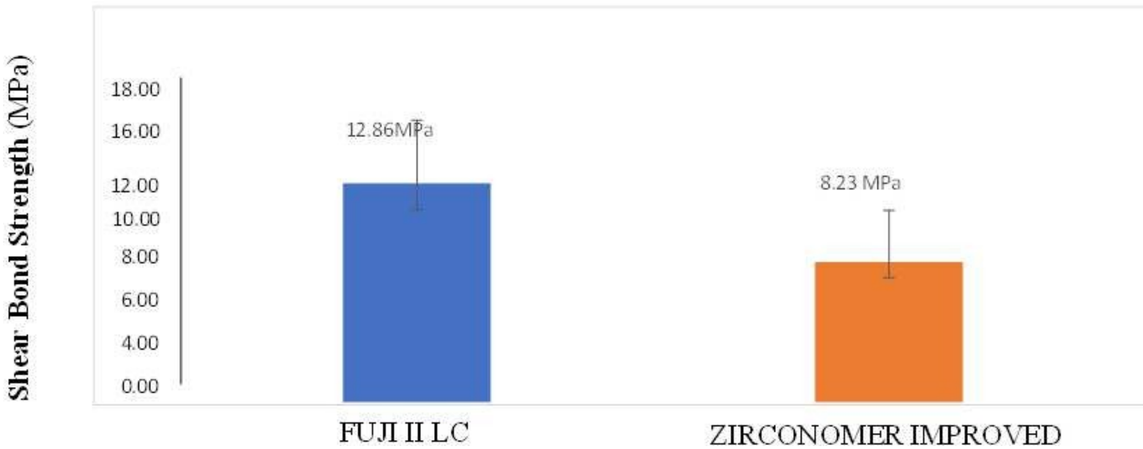

Figure9. ShearBond Strength of Fuji II LC and Zirconomer Improved (MPa)

Discussion:

The shear bond strength (SBS) values, revealed the highest for FUJI II LC compared to ZIRCONOMER IMPROVED, being in accordance with **Tedesco,*et al* 2015** who evaluated the influence of dentin depths and location on the SBS of high-viscosity ZIRCONOMER IMPROVED (P/L). Due to the dual bonding mechanism (chemical bonding and mechanical bonding) of FUJI II LC, the material performed best in dentin. This could be related to the high amount of calcium available in the dentinal area to interact with carboxyl groups, being in accordance with **Yamakami , *et al* 2018.** And **Hong *et al* 2003.** Resin modified GIC FUJI II LC also demonstrated pulpal pressure that had a stronger influence on SBS than regional differences of substrate**(Pereira,et*al*2000).** A possible explanation for this is the more hydrophilic nature of bonded materials, which imparts a lower sensitivity of SBS to dentin depth**(Sirisha,*etal*2014)**. On the other hand, using extracted teeth in this study eliminated pulpal pressure and moisture arising from pulp chamber. Therefore, it could be expected that after conditioning and drying of the dentin surface, the amount of moisture has been reduced. Thus, differences in the hydraulic conductance and moisture of dentin were non-contributing factors. Therefore, the slight decrease in SBS of ZIRCONOMER IMPROVED compared to FUJI II LC to dentin may be due to lower amount of inter tubular dentin and subsequently lowered amount of calcium available.

Specimens were thermocycled (500 cycles) and stored in distilled water for one week **(Tedesco,et*al*2015).**They reported higher SBS values in dentin, both for FUJI II LC GIC in contrast with our results. These different findings could be related to differences in operated methodology and materials. Likewise, they utilized different protocols for obtained deep and superficial dentin, which may vary in dentin depth.

In laboratory studies, thermalcycling(TC) is a frequently used aging procedure for matching temperature fluctuations that occur intraorally. The thermal cycling regimen differs significantly among experimental studies regarding the number of cycles, the temperature of water baths, dwelling time in each bath and transfer time. **(Gale, *et al* 1999) (Morresi, et*al***

2014). They observed a significant decline in the mechanical properties of materials.
According to the literature, thermocycled FUJI II LC showed significant difference to non-thermocycled groups. This might be due to the increased moisture sensitivity of glass ionomers. **Cattani -Lorente et al., 1999** studied the effect of water on physico-mechanical properties of RMGIC and demonstrated rather high amounts of absorbed water. A correlation was established between the decrease in their physical and mechanical properties and the water uptake. Therefore, water along with high temperature difference during thermocycling caused a relative decrease in fracture toughness values and mechanical properties of Fuji II LC, the RMGIC.

A study conducted by **Sharafeddin et al. in 2017** showed reduced mechanical properties of ZIRCONOMER IMPROVED after thermocycling. This is most probably due to itsself-curingnature, and therefore being chemically similar to glass ionomers, which show more dissolution in water. However, this contradicts a study conducted by **Guetal.2005** who stated that Zirconomer Improved is resistant to dissolution after complete settings, explaining the lower surface hardness of Zirconomer Improved throughout the study (**Gu etal.2005)**. Moreover, the significant degradation Zirconomer Improved after thermocycling could be related to its possibly higher percentage of porosity, which would act as a reservoir for water within the structure of material, being retained and transported through the restorative structure. **(Aws *et al.* 2018)**(**Al-Khadim Aws *et al* 2018)** Also, the presence of zirconia/silica fillers, as well as zinc and glass fillers, made the material more susceptible to hydrous attack (**Sultana et al 2013).**

As Zirconomer Improved is a new material, and only a few studies have assessed its properties; more research work needs tobe conducted to have a better vision of this new material. To confirm these results, further studies are required using different ZIRCONOMER IMPROVED to the different tooth substrates and other methods that simulate degradation of the bonding interface. These should include pH cycling and mechanical loading, as well as long-term clinical trials.

Conclusions

Within the limitations of this *in vitro* study, the following could be concluded:

1. FUJI II LC yielded significantly higher Shear Bond Strength values to dentin compared toZirconomer IMPROVED.
2. Still,furtherstudiesarerequiredtoproveitsperformanceina clinicalscenario.

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