RESEARCH PAPER

# Comparison Of Watersorption Of Calcium Oxide Nanoparticle Incorporated Gic, Zirconomer And Conventional Class 2 Gic On Subjecting To Thermocycling - An In Vitro Study

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**Abstract**

**Introduction**- Modern adhesives have made it possible to repair rather than replace damaged restorations. Water sorption can make a substance more voluminous, function as a plasticizer, and damage the matrix structure of the substance. The materials used for dental restoration are also subjected to heat stress during routine oral activities. **Materials and method**- Each material was manipulated and proportioned in accordance with the manufacturer's specifications. In total, 15 disc specimens, 5 for each group were created. In a chewing simulator (SD MECHATRONIK CHEWING SIMULATOR. CS - 4.4), samples were put for thermocycling with distilled water. The weight of the samples was taken before thermocycling (W1), and the weight (W2) was taken post thermocycling. All the samples were weighed electronically using a digital weighing scale and pre and post weight was recorded. **Results**- The mean values of water sorption and the standard deviation for groups I, II, and III before thermocycling were 0.312 ± 0.0316, 0.1782 ± 0.0128 and 0.4068 ± 0. ug/mm3 respectively . The mean values of water sorption and the standard deviation for groups I, II, and III post thermocycling were 0.2644 ± 0.0494, 1.7936 ± 0.1463, and 0.3932 ± 0.1181 ug/mm3 respectively. The p value was found to be 0.0018 which is less than <0.05 and hence significant. **Conclusion-** The least watersorption was seen in the glass ionomer cement infused with calcium oxide nanoparticles, followed by ordinary glass ionomer cement and Zirconomer. The differences were statistically significant.

**Keywords:** Glass ionomer cement (GIC), calcium oxide nanoparticles, zirconomer, watersorption

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## Introduction

In recent years, improvements have been made to composite resin formulas. However, composite restorations are still subject to flaws, chipping, and fracturing. A damaged composite restoration had to be replaced in the past [1 2] ; however, this replacement frequently resulted in more tooth structural loss and an expansion of the created cavity.[3] Composite restoration repair is a conservative technique that can lengthen the endurance and lifetime of restorations while keeping the tooth structure intact.[4] Diet related temperature changes in the oral cavity and complex chewing pressures with a significant amount of flexural strains are both put on resin composite restorations.[5 6]

Modern adhesives have made it possible to repair rather than replace damaged restorations. This strategy is conservative and economical since the intact portion of the restoration is left alone, preventing further dental pulp irritation from removal.[7] However, it should be noted that when repairing composite restorations, aging-related changes to composite resins, such as water sorption, chemical degradation, and the leaching of some compounds, may reduce the reactivity of the remaining composite (old composite) and make the repair process

more difficult. In some instances, this may even jeopardize the success of the restored damage. [8 9]
Water sorption can make a substance more voluminous, function as a plasticizer, and damage the matrix structure of the substance. The use of cement with low solubility is much more crucial since there is always a buffer (approximately 40 micrometers) between the teeth and the restoration. Lamination and degradation are two impacts of water sorption that alter the mechanical characteristics. Because the restorative material is so soluble, it loses mass, which has a negative impact on its mechanical qualities. Additionally, it leads to failure at the tooth/restoration interface, which increases the risk of marginal microleakage and undermines the success of the restoration.

The materials used for dental restoration are also subjected to heat stress during routine oral activities like eating and drinking. However, more information is still needed to fully understand how temperature cycling affects the surface roughness of resin composite restorative materials. The surface roughness of resin composite restorative materials may therefore be influenced by temperature cycling, according to the authors of this article. Therefore, this in-vitro study sought to determine how thermocycling affected the surface roughness of several materials utilized in aesthetic restoration techniques.[10]

Glass ionomer cement has recently been replaced in dentistry by a high-strength restorative material called zirconomer (white amalgam), which has been fortified with zirconia fillers. Zirconium oxide, sometimes known as $ZrO_2$, is a substance. It comes in a variety of shapes and is a polycrystalline ceramic without a glassy phase.[11]
The aim of the study was to compare the water sorption of calcium oxide nanoparticle incorporated GIC, zirconomer and conventional class 2 GIC which are subjected to thermocycling.

**Materials and Methods**

The present study was conducted in Saveetha Dental College and Hospital. The glass ionomer cement used were as follows :

Group 1 - GIC mixed with CaO
Group 2 - Zirconomer
Group 3 - Conventional Type 2 GIC

**Preparation of specimen**

Each material was manipulated and proportioned in accordance with the manufacturer's specifications. In total, 15 disc specimens—5 for each group—were created.Petroleum jelly was applied to the interior surfaces of the mold and on top of it, then the mylar strip was laid on a glass slab. The mixing pad was filled with the materials. According to the manufacturer's directions, the powder and liquid were combined, and the mold was slightly overfilled to reduce the amount of air inclusion. To extrude the extra material and create a uniformly smooth specimen surface, a second glass slab was placed on top of the mold, followed by another mylar strip. The mold was then pressed for 30 seconds. The specimens were taken out of the mold an hour or so after mixing, and any extra material was gently ground off by dry, using carbide paper, on both sides. In a chewing simulator (SD MECHATRONIK CHEWING SIMULATOR. CS - 4.4), samples were thermocycler with distilled water for 1,000 cycles at 5 to 55 degrees Celsius with dwell and transfer times of 30 and 10 seconds, respectively. (Figure 1) The weight of the samples was taken before thermocycling (W1), and the weight (W2) was taken post thermocycling. All the samples were weighed electronically using a digital weighing scale and pre and post weight was recorded.

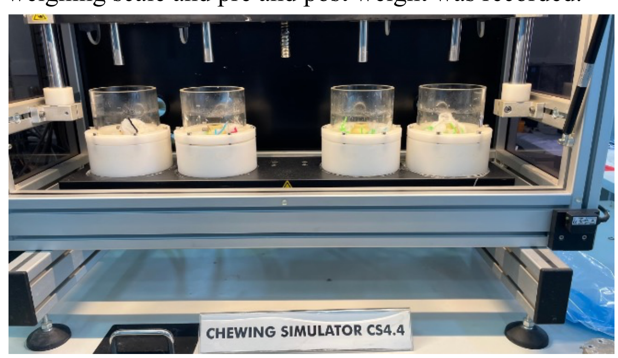


Figure 1 depicts the thermocycler

**Results**

The standard deviation and mean water sorption values for groups I, II, and III prior to thermocycling were 0.312 ± 0.0316, 0.1782 ± 0.0128 and 0.4068 ± 0. ug/mm3 respectively (Table 1 ) . The standard deviation and average water sorption values for groups I, II, and III after thermocycling were 0.2644 ± 0.0494, 1.7936 ± 0.1463, and 0.3932 ± 0.1181 ug/mm3 respectively (Table 2) .

Table 1 represents the mean, Std. deviation, Std. Error and p value for the 3 different materials before thermocycling

| Different Composite Materials | N | Mean | Std. Deviation | Std. Error | P value |
|---|---|---|---|---|---|
| Cao | 5 | 0.312 | 0.0316 | 0.0141 | |
| Zirconomer | 5 | 0.1782 | 0.0128 | 0.0057 | |
| Conventional Class 2 GIC | 5 | 0.4068 | 0.1284 | 0.0574 | |
| | | | | | 0.0018 |

Table 2 represents the mean, Std. deviation, Std. Error and p value for the 3 different materials post thermocycling

| Different Composite Materials | N | Mean | Std. Deviation | Std. Error | P value |
|---|---|---|---|---|---|
| Cao | 5 | 0.2644 | 0.0494 | 0.0221 | |
| Zirconomer | 5 | 1.7936 | 0.1463 | 0.0654 | |
| Conventional Class 2 GIC | 5 | 0.3932 | 0.1181 | 0.0528 | |
| | | | | | 0 |

Before thermocycling, a clear difference in water sorption was observed among the three materials. Conventional Class 2 GIC demonstrated the highest mean water sorption, followed by the calcium oxide nanoparticle incorporated GIC, while Zirconomer showed the lowest value, indicating better initial resistance to moisture uptake. The variation among the groups was statistically significant, confirming that the composition of the material plays an important role in its ability to resist water absorption even before exposure to thermal stress.

After thermocycling, all materials exhibited changes in water sorption, with Zirconomer showing a marked increase, suggesting greater sensitivity to thermal fluctuations. In contrast, the calcium oxide nanoparticle incorporated GIC showed a slight reduction in water sorption, indicating better stability under simulated aging conditions, while conventional Class 2 GIC demonstrated only minimal change. The post-thermocycling differences were also statistically significant, leading to the conclusion that calcium oxide nanoparticle incorporation may improve resistance to water sorption following thermal cycling, thereby potentially enhancing long-term clinical performance.

**Discussion**

New tooth-colored restoratives and procedures have been created as a result of both the general decline in dental cavities and patient interest in dental aesthetics. The four basic components of composites are the matrix phase, which contains dimethacrylate resin, the dispersed phase, which is made up of inorganic fillers and tints, the polymerization initiators, which are activated either chemically or by visible light, and the coupling phase, which joins the matrix to the filler particles (Silanes). [12]

In order to have fluoride release properties and bind to enamel and to a smaller extent to dentin, glass ionomer cements were developed as a combination of silicate cements and polycarboxylate cements. Because the physical characteristics of traditional glass ionomer cement can vary greatly depending on the powder-to-liquid ratio, it is important to follow the manufacturer's instructions when mixing.[13] The physicochemical qualities of the material are significantly influenced by its chemical makeup. The performance of the components examined in this research study, when subjected to thermocycling was determined by changes in the composition of the GICs, taking into account sorption. Important aspects of this process include the dimension of the particles introduced to the water, the occurrence of pores, the degree of conversion, the mechanism (chemical or physical) that initiates polymerization, as well as the chain density of the materials. [14] [15] Water absorption is the amount of water that a substance takes up over time per unit of surface area or volume. A restorative material's usefulness as a restorative material is typically reduced as it absorbs water because its characteristics alter. The density of hydrogen bond forming niches with water, which determines the resin's polarity, and the topography of the polymer chain, which is influenced by the cohesive energy density of the polymer network, are the two primary factors that control the rate of water sorption in the polymer chain.[16]

Hygroscopic expansion brought on by water absorption during the initial phases may fill any gaps and reduce interface pressures brought on by polymerization shrinkage. A hygroscopic expansion that is only slightly concerning is one that is close to the amount of polymerization shrinkage. However, on occasion, the coefficient of expansion may exert an outward force on cavity walls when the polymerization shrinkage is greater than the coefficient of expansion, resulting in enamel fracture and cracking.[17] In a previous study [18] zirconomer showed comparatively better physical and mechanical properties compared to resin-modified and conventional GIC in terms of sorption, solubility and microhardness. In actuality, the difference between the gain in water and the dissolution of low-molecular-weight organics is what causes the weight gain in the samples, which indicates the water gain. This is one of the limitations of the experiments in this study when it comes to water sorption. Additionally, the frequent handling of the specimens might have led to slight surface deterioration. As a result, numerical comparisons are not always attainable because this study evaluates the water sorption of three distinct materials from various manufacturers and because there are many variables that affect water uptake. The fact that the current study solely evaluated the materials water sorption is another drawback. However, it has been reported that additional physical characteristics, including fracture toughness, shear strength, and elastic modulus of core materials, correlate with the handling and physical characteristics of materials.[19] [20–29] Although glass ionomer cements are commonly used, further research is needed to characterize how water affects them. More research should be done to determine how saliva affects how long conventional and modified glass ionomer cements last in the therapeutic setting.

**Future scope**

Future investigations could expand this work by evaluating the long-term clinical performance of CaO nanoparticle-incorporated GIC and Zirconomer in vivo, incorporating diverse oral environments such as varying pH levels and microbial challenges. Additionally, exploring synergistic effects with other bioactive nanoparticles or surface modifications might further enhance water sorption resistance and mechanical integrity under extended thermocycling. Comparative studies against emerging restorative materials, coupled with finite element analysis for stress distribution, would provide deeper insights into their translational potential for minimally invasive dentistry.

**Conclusion**

Within the limitations of this in vitro study, it can be concluded that thermocycling significantly influences the water sorption of glass ionomer materials, and this effect varies depending on their composition. Although Zirconomer exhibited the lowest water sorption before thermocycling, it showed a considerable increase after thermal aging. In contrast, the calcium oxide nanoparticle incorporated GIC demonstrated comparatively better stability following thermocycling, with minimal change in water sorption values. Therefore, incorporation of calcium oxide nanoparticles appears to enhance the material's resistance to water uptake under simulated oral conditions, suggesting its potential for improved long-term clinical performance.

**Conflict of interest**

The article has been read and approved by all the contributors and there isn't any conflict of interest.

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