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# Effect Of Thermocycling On Surface Roughness Of Two Different Commercially Available Glass Ionomer Cements - An *In Vitro* Study

Research Article

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## Abstract

**Introduction:** Glass ionomer is the commonly used cement in restorative dentistry. Since our oral cavity is subjected to frequent temperature change, that's the reason why we need to study the effect of thermal aging for the surface roughness of glass ionomer cements. The aim of the study is to evaluate the effect of thermocycling on surface roughness of two different commercially available glass ionomer cements.

**Materials and Methods:** Commercially available brands of Glass ionomer cements namely Shofu and D Tech were used for our study. 5 samples were prepared from each GIC. Silicone moulds were prepared with putty impression material to obtain a diameter of about 10 mm and a height of about 2.5 mm and the surface roughness was checked prior to thermocycling and after thermocycling using a stylus profilometer.

**Results:** For shofu GIC, surface roughness values Ra, Rq and Rz prior to thermocycling was more when compared to surface roughness value after thermocycling. This difference of Ra is 0.000, Rq is 0.095 and Rz is 0.077. The Ra value alone is significant and Rz and Rq is not significant. For D tech GIC surface roughness values Ra, Rq and Rz prior to thermocycling was more when compared to surface roughness value after thermocycling.

**Conclusion:** Thermocycling affected the surface roughness property of glass ionomer cements. Thermocycling for 1000 cycles has decreased the surface roughness of both the shofu and D tech brand glass ionomer cements.

**Keywords:** Glass Ionomer Cements; Surface Roughness; Thermocycler; Stylus Profilometer; Innovative Measurement.

## Introduction

Glass ionomer is the most commonly used cement in restorative dentistry. They are made from the product of polymeric acids which are weak and it reacts with powdered simple glasses [1]. Setting happens in condensed water solutions, and the final outcome includes a considerable volume of glass which is not involved in the reaction and that serves as a filler to stabilize the set cement. Basic (ion-leachable) glass, polymeric water-soluble acid, and water are all essential components of a glass-ionomer cement [2]. Since these formulas are proprietary, the precise volume of each ingredient is not generally understood, the impact of these variations is unclear. However, it seems that viewing these specimens with the components which get dispersed differently between the aqueous phases and powder phases has no discernible effect on the final properties [3]. An acid-base reaction is shown to set glass-ionomers in 2–3 minutes, resulting in hard, relatively solid materials of suitable appearance.

Surface roughness is a micromorphology created by various physical processes that change the surface. The surface roughness was the most widely used parameter to be measured with a profilometer is average roughness (Ra). Profilometers provide two-dimensional results, but a scanning electron microscope (SEM) is need-

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ed for a full sized image for a detailed sample. After polishing, an arithmetic average roughness for each material can be estimated to aid clinicians in making treatment decisions [4]. Thermocycling is a technique which is most often done in the laboratory to expose the dental materials and teeth to temperature levels close to the temperature which prevails in the oral cavity to see how varying coefficients of thermal expansion between the filling material and the tooth structure cause harmful effects. Thermal stresses are one of the important factors that influence the bond strength between the repairing or filling materials during these cycles [5].

In the previous studies, the effect of thermocycling on several parameters such as microleakage, shear bond strength and color stability was explored. Since other previous studies did not check the surface roughness for glass ionomer cements, where we checked the pre and post thermocycling surface roughness since our oral cavity is prone to temperature fluctuations. Temperature variations have seldom been backed up by in-vivo tests, and they differ significantly between studies. It is required to justify and standardise the regimen. The aim of the study is to evaluate the effect of thermocycling on surface roughness of two different commercially available glass ionomer cements.

## Materials and Methods

Shofu and D Tech are commercially available glass ionomer restorative cements chosen for this present study. 5 samples were made from each glass ionomer cement (Figure 1). Silicone moulds were prepared in the diameter of 10 mm and height of 2.5 mm. The surface roughness prior to thermocycling of the prepared glass ionomer circular discs were determined using a Stylus profilometer - Mitutoyo SJ 310, 2µm tip/60°angle (Figure 2). The samples were then subjected to Thermocycling with a Thermocycler TC - 4, at temperature 4°C (cold) and 60°C (hot) for 1000 cycles (Figure 3). The dwell time and drain time were set to be 30 seconds and 10 seconds respectively for each cycle. The surface roughness of samples post thermocycling was checked again using the stylus profilometer under the same procedure. The surface roughness value prior and after thermocycling of the glass ionomer materials were obtained and tabulated. The results were then analysed using SPSS software version 22.0 and were graphically represented.

## Results

From the results analysed, the Ra, Rq and Rz value of Shofu and Dtech for Pre and Post surface roughness was obtained (Table 1). From the raw data we can conclude that Shofu had less surface roughness prior and after thermocycling. The difference of Ra, Rq and Rz value of surface roughness prior to thermocycling and after thermocycling was analysed and both the glass ionomer cements that is shofu and Dtech did not show much deviation after thermocycling. The independent paired t test was done for Shofu and Dtech surface roughness value for both prior and after thermocycling using SPSS statistics version 22.0. This difference of Ra is 0.000, Rq is 0.095 and Rz is 0.077. The Ra value alone is significant and Rz and Rq is not significant (Table 2). Bar graph depicts the association between surface roughness parameter Ra of Shofu before and after subjecting it to thermocycling (Figure 1). For shofu GIC, surface roughness values Ra, Rq and Rz prior to thermocycling was more when compared to surface roughness value after thermocycling. This difference was statistically not

**Figure 1. Represents the 10 discs prepared from commercially available Glass ionomer cements.**

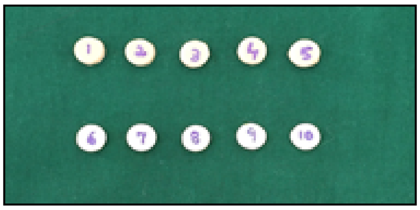


**Figure 2. Represents the Stylus profilometer - Mitutoyo SJ 310, 2µm tip/60°angle, device was moved physically on the surface of the GIC disc material to obtain the values of surface roughness.**


**Figure 3. Represents the Thermocycler TC - 4, at temperature 4°C (cold) and 60°C (hot) for 1000 cycles.**

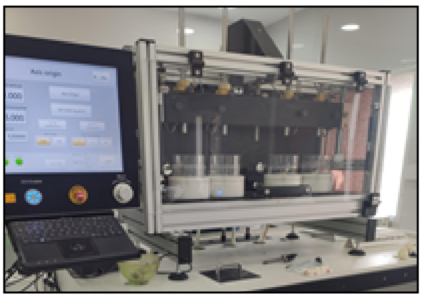


**Table 1. This table represents the Ra, Rq, Rz values of GIC before and after thermocycling.**

| Samples | Surface roughness value prior to thermocycling | | | Surface roughness value after thermocycling | | |
|---|---|---|---|---|---|---|
| | **Ra** | **Rq** | **Rz** | **Ra** | **Rq** | **Rz** |
| Shofu 1 | 0.005 | 0.007 | 0.06 | 0.004 | 0.005 | 0.046 |
| Shofu 2 | 0.005 | 0.007 | 0.061 | 0.004 | 0.005 | 0.041 |
| Shofu 3 | 0.005 | 0.007 | 0.072 | 0.004 | 0.005 | 0.046 |
| Shofu 4 | 0.005 | 0.006 | 0.059 | 0.004 | 0.005 | 0.045 |
| Shofu 5 | 0.005 | 0.007 | 0.059 | 0.004 | 0.005 | 0.042 |
| Dtech 1 | 0.007 | 0.005 | 0.06 | 0.004 | 0.005 | 0.044 |
| Dtech 2 | 0.007 | 0.006 | 0.061 | 0.004 | 0.005 | 0.044 |
| Dtech 3 | 0.005 | 0.007 | 0.064 | 0.004 | 0.005 | 0.048 |
| Dtech 4 | 0.005 | 0.007 | 0.062 | 0.004 | 0.005 | 0.044 |
| Dtech 5 | 0.005 | 0.007 | 0.06 | 0.004 | 0.005 | 0.047 |

**Table 2. Significance testing on surface roughness between groups before and after thermocycling.**

| Groups | | N | Mean | Std. Deviation | Sig |
|---|---|---|---|---|---|
| Mean diff Ra | SHOFU | 5 | .00100 | 0.000000 | 0.000* |
| | D-TECH | 5 | .00180 | .001095 | |
| Mean diff Rq | SHOFU | 5 | -.00180 | .000447 | 0.095 |
| | D-TECH | 5 | -.00140 | .000894 | |
| Mean diff Rz | SHOFU | 5 | -.01820 | .005020 | 0.077 |
| | D-TECH | 5 | -.01600 | .001871 | |

***Independent sample t test was used and p value of less than or equal to 0.05 is considered to be statistically significant.**

**Figure 1. Bar graph depicts the association between surface roughness parameter Ra of Shofu before and after subjecting it to thermocycling. X axis represents the Shofu brand GIC and the Y axis represents the mean value of surface roughness parameter Ra prior and after thermocycling of Shofu. Dark green represents the surface roughness of Shofu GIC prior to themocycling and Dark blue represents the surface roughness of Shofu GIC after themocycling. The surface roughness parameter Ra has reduced after thermocycling for shofu GIC.**

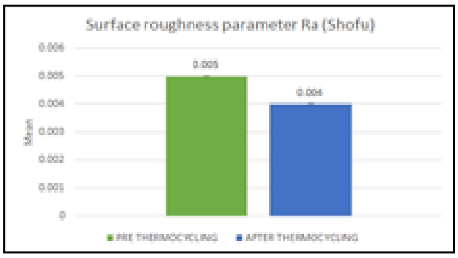



**Figure 2. Bar graph depicts the association between surface roughness parameter Rq of Shofu before and after subjecting it to thermocycling. X axis represents the Shofu brand GIC and the Y axis represents the mean value of surface roughness parameter Rq prior and after thermocycling of Shofu. Dark green represents the surface roughness of Shofu GIC prior to themocycling and Dark blue represents the surface roughness of Shofu GIC after themocycling. The surface roughness parameter Rq has reduced after thermocycling for shofu GIC.**

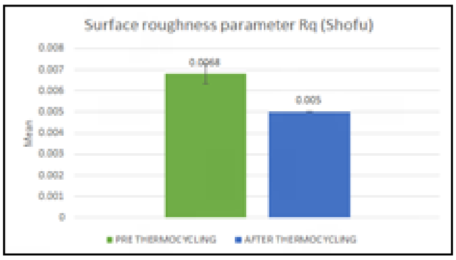


**Figure 3. Bar graph depicts the association between surface roughness parameter Rz of Shofu before and after subjecting it to thermocycling. X axis represents the Shofu brand GIC and the Y axis represents the mean value of surface roughness parameter Rz prior and after thermocycling of Shofu. Dark green represents the surface roughness of Shofu GIC prior to themocycling and Dark blue represents the surface roughness of Shofu GIC after themocycling. The surface roughness parameter Rz has reduced after thermocycling for shofu GIC.**

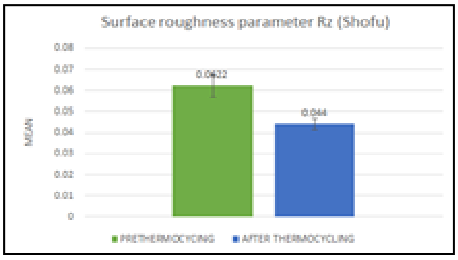



**Figure 4. Bar graph depicts the association between surface roughness parameter Ra of D-Tech before and after subjecting it to thermocycling. X axis represents the D-Tech brand GIC and the Y axis represents the mean value of surface roughness parameter Ra prior and after thermocycling of D-Tech. Dark green represents the surface roughness of Shofu GIC prior to themocycling and Dark blue represents the surface roughness of D-Tech GIC after themocycling. The surface roughness parameter Ra has reduced after thermocycling for D-Tech GIC.**

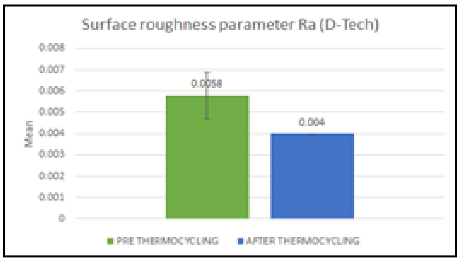



**Figure 5. Bar graph depicts the association between surface roughness parameter Rq of D-Tech before and after subjecting it to thermocycling. X axis represents the D-Tech brand GIC and the Y axis represents the mean value of surface roughness parameter Rq prior and after thermocycling of D-Tech. Dark green represents the surface roughness of D-Tech GIC prior to thermocycling and Dark blue represents the surface roughness of D-Tech GIC after themocycling. The surface roughness parameter Rq has reduced after thermocycling for D-Tech GIC.**

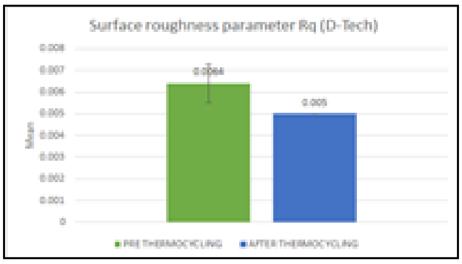
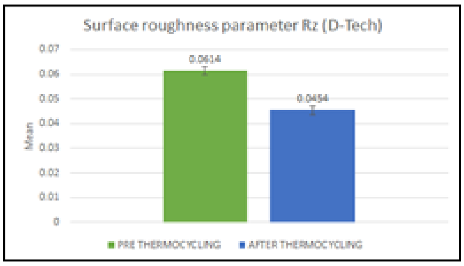



**Figure 6. Bar graph depicts the association between surface roughness parameter Rz of D-Tech before and after subjecting it to thermocycling. X axis represents the D-Tech brand GIC and the Y axis represents the mean value of surface roughness parameter Rz prior and after thermocycling of D-Tech. Dark green represents the surface roughness of D-Tech GIC prior to thermocycling and Dark blue represents the surface roughness of D-Tech GIC after themocycling. The surface roughness parameter Rz has reduced after thermocycling for D-Tech GIC.**




significant (Figure 4). Bar graph depicts the association between surface roughness parameter Rq of Shofu before and after subjecting it to thermocycling (Figure 2). Bar graph depicts the association between surface roughness parameter Rz of Shofu before and after subjecting it to thermocycling (Figure 3). Bar graph depicts the association between surface roughness parameter Ra of D-Tech before and after subjecting it to thermocycling (Figure 4). Bar graph depicts the association between surface roughness parameter Rq of D-Tech before and after subjecting it to thermocycling (Figure 5).Bar graph depicts the association between surface roughness parameter Rz of D-Tech before and after subjecting it to thermocycling (Figure 6).

## Discussion

Our team has extensive knowledge and research experience that has translated into high quality publications [6-25]. For more than two decades, glass ionomer cements have been utilized in restorative dentistry. They are favoured in clinical dentistry over other products because the glass component of the GIC releases fluoride, chemical adherence to dentin and enamel, biocompatibility, its flexibility and coefficient of thermal expansion equivalent to that of tooth structure [26]. GIC materials surface roughness has a number of clinical effects, and improvements in surface roughness are often used as an indicator of material wear. The physical properties such as compressive strength, fracture, resilience, microhardness, abrasion resistance, and surface and surface roughness are influenced by the particle size and composition of GICs [27].

The surface roughness of GICs is dependent partly on their particle size range [28]. In the previous studies done by Glady S et al, on gel phase formation at resin-modified glass-ionomer/tooth interfaces, observed a surface roughness of less than 0.2 for resin-modified glass-ionomers [29]. In another study performed by Rios et al, the results obtained in his study were GICs received high surface roughness values when compared to other restorative materials, but microbiological studies showed no difference from GIC and other restorative materials [30].

Few limitations of the study were less sample size, and the study might have included more than two glass ionomer cements to have a better option of a good commercially available GIC material. Only the surface roughness was detected, there could have been more parameters to the study. The thermocycling process included only 1000 cycles which could be increased to check a more efficient and significant difference between the two GIC materials. According to this study, the two different commercially available brands of glass ionomer cement materials used were Dtech and Shofu, it was found that the thermocycling did have its effect on the surface roughness. Shofu was identified to be more effective and compatible because its surface roughness seemed to be less when compared to Dtech before thermocycling. But after thermocycling both Dtech and Shofu did not show much deviation and shofu showed less surface roughness even after thermocycling.

## Conclusion

Thermocycling affected the surface roughness property of glass ionomer cements. Thermocycling for 1000 cycles has decreased the surface roughness of both the shofu and D tech brand glass ionomer cements.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