Effect of Brushing Simulation on the Surface Roughness of Two Different Commercially Available Glass Ionomer Cements - An In Vitro Study

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Authors’ contributions
This work was carried out in collaboration among all authors. Authors SMJ, SBG and SJ designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author SBG managed the analysis of the study. Author SMJ managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Introduction: Glass ionomer cement (GIC) is a restorative material used in dentistry which can also be used as luting cement and for fixing orthodontic appliances. The main components found in GIC are silicon, calcium, sodium and fluoride. In order to improve the toughness of the cement, speed of setting and resistance to wearing, water content of the glass-ionomer cement was replaced by water-soluble polymers or monomer systems. The aim of this study is to evaluate the effect of brushing simulation on the surface roughness of two different commercially available glass ionomer cements.

Materials and Methods: GC gold label and D Tech are commercially available glass ionomer restorative cements chosen for this present study. 5 samples were prepared from each. The samples were checked for pre-surface roughness using a stylus profilometer and then subjected to
brushing. Toothbrush simulator (ZM3.8 SD Mechatronik) with minimum pressure of 3N and a fluoridated toothpaste was used for brushing. Then the post surface roughness was again checked and the results were tabulated and then statistically analyzed using SPSS software.

**Results:** Surface roughness was increased after brushing simulation in both GC gold label and D Tech GIC samples. This difference was statistically not significant (paired student t, p value = 0.763).

**Conclusion:** D-tech GIC samples had less surface roughness after brushing simulation when compared to GC Gold label samples.

**Keywords:** Surface roughness; glass ionomer cement; brushing simulation; stylus profilometer; innovative measurement.

### 1. INTRODUCTION

Glass ionomer cement (GIC) is a restorative material used in dentistry which can also be used as luting cement and for fixing orthodontic appliances. The main components found in GIC are silicon, calcium, sodium and fluoride [1]. Glass ionomer reacts to silicate glass powder and polyacrylic acid [2]. Setting takes place in condensed water solutions, and the final structure includes a considerable volume of unreacted glass that serves as a filler to stabilise the cement [3]. In order to improve the toughness of the cement, speed of setting and resistance to wearing, newer materials in which some of the water content of the glass-ionomer cement was replaced by water-soluble polymers or monomer systems [4]. Since these formulas are proprietary, the precise volume of each ingredient is not generally understood, the impact of these variations is unclear. GIC specimen’s components are dispersed differently between the powder and aqueous phases which have no discernible effect on the final properties of the cement. Glass ionomer cement have low polishability, sensitivity to dryness, and moisture contamination during the early phases of setting, as well as the creation of fractures and gaps. Due to its hydrophilic composition, hydroxyethylmethacrylate in resin modified GIC causes higher water uptake and swelling of the resin matrix, which may degrade the cement’s mechanical qualities [5].

In dental restorations, surface roughness parameter can also determine the quality and the clinical behavior of the used material. Surface roughness is the morphology created by various physical and chemical processes used to modify the surface. Even though, the restorative material used have fluoride which can inhibit the bacterial growth but, the mechanical brushing should be assisted in order get an optimum clean surface of the tooth. Surface roughness is important to determine due to the risk of bacterial adhesion as a biofilm that can create a cavity on the tooth. The most important parameter used to check the surface roughness is Ra (Average roughness) and is measured using a profilometer. Profilometers yield a two-dimensional information, but a scanning electron microscope (SEM) is needed for a detailed analysis [5]. The average roughness obtained can assist clinicians in their treatment decisions. In the previous studies, Effect of brushing on several properties were checked for GIC; color stability [6], bond strength [7] and microleakage [8]. Since GIC was previously checked for the above properties, So in the current study we checked for its pre and post surface roughness after brushing since our oral cavity is exposed to types of brushing.

Glass ionomer cements are primarily used in the prevention of dental caries. It acts as good adhesive material because it forms a tight bond between the internal structures of the tooth and the surrounding environment. Initially glass ionomer cements were recommended for restoring class III and class V cavity preparations and were intended for the cosmetic restoration of anterior teeth [9]. The aim of this study is to evaluate the effect of brushing simulation on the surface roughness of two different commercially available glass ionomer cements.

### 2. MATERIALS AND METHODS

GC gold label and D Tech are commercially available glass ionomer restorative cements chosen for this present study (Figs. 1 and 2). 5 samples were prepared from each glass ionomer cement. The surface roughness prior to brushing of the prepared glass ionomer circular discs were determined using a Stylus profilometer (Mitutoyo SJ 310), 2μm tip/60°angle, the device was moved physically on the surface of the GIC disc material to obtain the values prior to brushing surface roughness (Fig. 3). After obtaining the surface roughness value prior to brushing the
GIC discs were kept in the brushing stimulator. Toothbrush simulator (ZM3.8 SD Mechatronik) with minimum pressure of 3N and a fluoridated toothpaste was used for brushing. The surface roughness value after brushing was then determined 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.

Fig. 1. Represents the 5 discs prepared from D-tech glass ionomer cement

Fig. 2. Represents the 5 discs prepared from GC gold label glass ionomer cement

Fig. 3. Stylus profilometer - Mitutoyo SJ 310 used to obtain the values of surface roughness
3. RESULTS AND DISCUSSION

From the results analysed, the Ra, Rq and Rz value of GC Gold label and D-tech for Pre and Post surface roughness was obtained (Table 1). From the raw data we can conclude that D-tech had less surface roughness prior and after brushing. The paired student t test was done for GC Gold label and D-tech surface roughness value for both prior and after brushing using SPSS statistics version 22.0. Paired student t test was done and the Rz values prior and after brushing for the samples GC Gold Label and D tech showed a significance of 0.763 (>0.05). Hence, statistically insignificant (Table 2). Only the five highest peaks and the five deepest valleys are averaged in Rz. As a result, extremes have a significantly larger impact on the ultimate rating. Surface roughness was increased after brushing simulation (Figs. 4 and 5).

Our team has extensive knowledge and research experience that has translated into high quality publications [10–19,20–23,24–28,29]. The maintenance of the smooth surface of GIC is completely based on its composition. The present study evaluated the effect of brushing simulation on surface roughness of glass ionomer cements. The surface roughness of amalgam, posterior composite, microfilled composite, glass ionomer cement and porcelain was evaluated in another study, where the values of Ra were assessed between the baseline for 14 days and minor variations were seen. There were no statistically significant differences for any material [9]. The profilometric measurements and the scanning electron microscopic evaluation showed that most of the material’s surface roughness was significantly increased after sonic instrumentation but after polishing the materials, the roughness values decreased [30]. In a study conducted by Roulet, almost all pastes roughened the surfaces of dental restorative materials and only a few pastes smoothened the surfaces of dental hard tissues [31].

In a study conducted by Catrise, the surface roughness of composite resin was checked using mouthwashes and concluded that although mouthwashes had an effect on the surface roughness of restorative material, it did not seem to be relevant in a short period of time [32]. A rougher surface will also be achieved by using a matrix and completing the surface with an abrasive strip. The consequence of completing the reconstruction with the matrix obtained is a polymer-rich, relatively unstable GIC [33]. Polishing and finishing cannot always be done during teeth reconstruction in uncooperative patients, this is for patients with special care such ws paediatric patients. GICs received high surface roughness values, but microbiological studies showed no variations as compared to healthy teeth. This is due to the antibacterial activity of the fluoride content in these materials [34]. Bulaha et al. in their study reported that a total of 100 specimens were prepared and classified into two categories: EF and Zl. Before and after virtual brushing of the specimens with water and Colgate, Surface roughness (Ra) was measured for EF and Zl and had statistically meaningful variations in their mean values [35]. This study reported that Super-snap abrasive discs produced a smoother surface than the Astropol and Astrobrush silicone polishers for composite and ormocer-based restorative materials, but the results would be valid clinically for readily accessible and flat surfaces [36].

Table 1. This table represents the Ra, Rq and Rz value of Pre and Post surface roughness

<table>
<thead>
<tr>
<th>Samples</th>
<th>Surface roughness value prior to brushing</th>
<th>Surface roughness value after brushing</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ra</td>
<td>Rq</td>
</tr>
<tr>
<td>GC Gold label - 1</td>
<td>0.003</td>
<td>0.004</td>
</tr>
<tr>
<td>GC Gold label - 2</td>
<td>0.003</td>
<td>0.004</td>
</tr>
<tr>
<td>GC Gold label – 3</td>
<td>0.003</td>
<td>0.004</td>
</tr>
<tr>
<td>GC Gold label – 4</td>
<td>0.003</td>
<td>0.004</td>
</tr>
<tr>
<td>D-tech - 1</td>
<td>0.003</td>
<td>0.004</td>
</tr>
<tr>
<td>D-tech – 2</td>
<td>0.003</td>
<td>0.004</td>
</tr>
<tr>
<td>D-tech – 3</td>
<td>0.003</td>
<td>0.004</td>
</tr>
<tr>
<td>D-tech – 4</td>
<td>0.003</td>
<td>0.004</td>
</tr>
</tbody>
</table>
Table 2. Significance testing of surface roughness parameter between two different GICs

<table>
<thead>
<tr>
<th>Groups</th>
<th>N</th>
<th>Mean</th>
<th>STD. deviation</th>
<th>STD. error mean</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meandiff</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ra Gold Label</td>
<td>4</td>
<td>0.0000</td>
<td>0.0000a</td>
<td>0.00000</td>
<td>Nil</td>
</tr>
<tr>
<td>Rq Gold Label</td>
<td>4</td>
<td>0.0000</td>
<td>0.0000a</td>
<td>0.00000</td>
<td>Nil</td>
</tr>
<tr>
<td>Rz Gold Label</td>
<td>4</td>
<td>-0.00275</td>
<td>0.001708</td>
<td>0.000854</td>
<td>0.763</td>
</tr>
<tr>
<td>Meandiff</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ra D tech</td>
<td>4</td>
<td>0.0000</td>
<td>0.0000a</td>
<td>0.00000</td>
<td>Nil</td>
</tr>
<tr>
<td>Rq D tech</td>
<td>4</td>
<td>0.0000</td>
<td>0.0000a</td>
<td>0.00000</td>
<td>Nil</td>
</tr>
<tr>
<td>Rz D tech</td>
<td>4</td>
<td>-0.002160</td>
<td>0.002160</td>
<td>0.001080</td>
<td></td>
</tr>
</tbody>
</table>

Paired student t test were used. P value of <0.05 is considered significant.

Fig. 4. Bar graph depicts the association between surface roughness of GC Gold label before and after subjecting it to brushing. X axis represents the GC gold label sample and the Y axis represents the mean value of surface roughness prior and after brushing. Blue denotes Ra, Orange denotes Rq and grey denotes Rz for surface roughness of Dtech prior and after brushing. Surface roughness was increased after brushing simulation.

Fig. 5. Bar graph depicts the association between surface roughness of D-tech before and after subjecting it to brushing. X axis represents the D-tech sample and the Y axis represents the mean value of surface roughness prior and after brushing. Blue denotes Ra, Orange denotes Rq and grey denotes Rz for surface roughness of Dtech prior and after brushing. Surface roughness was increased after brushing simulation.
According to the present study, the two different glass ionomer cement materials used were GC Gold label and Dtech. It was found that the brushing did affect the surface roughness and D-tech GIC was found to be more effective because of the less surface roughness after brushing simulation. So, D-tech GIC is a better option for commercially available glass ionomer restorative material. 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 like diametral tensile strength and flexural strength to the study.

4. CONCLUSION
Brushing simulation with a fluoridated toothpaste has increased the surface roughness of glass ionomer cement material. D-tech GIC samples had less surface roughness after brushing simulation when compared to GC Gold label samples.

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CONSENT
It is not applicable.

ETHICAL APPROVAL
It is not applicable.

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COMPETING INTERESTS
Authors have declared that no competing interests exist.

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