RESEARCH PAPER

Comparison of Surface Roughness of Conventional GIC, Calcium Oxide Nanoparticle Infused GIC and Magnesium Oxide Nanoparticle Infused GIC After Immersion in Carbonated Beverages - An In-Vitro Study

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ABSTRACT

Introduction: Glass ionomer cement also known as man made dentin because the coefficient of thermal expansion is almost similar to that of the dentin when compared. It is of different types, each being used in several branches of dentistry. Its fluoride releasing action, biocompatibility have been advantageous for its wide use. Nano filled GICs is one of the latest developments which contains nano sized powder particles infused in them.

Aim: To compare the surface roughness of conventional GIC, Cao nano particle GIC and Mgo nano particle GIC after immersion in carbonated beverages.

Materials and methods: A total of 4 samples for each material was prepared and their surface roughness was measured with the help of a stylus profilometer before and after its immersion into the carbonated beverages. The Ra (arithmetic mean deviation), Rq (root mean square roughness) and Rz (ten-point height of microscopic unevenness) values were noted.

Result: After the immersion into the beverages the surface roughness decreased in the following order: conventional GIC > MgO nano GIC > CaO nano GIC. Thus conventional GIC was the roughest followed by MgO nano fused GIC and CaO nano fused GIC has the least roughness. (p values for Ra, Rq and Rz for all three groups were 0.535, 0.5612 and 0.4809 respectively) p value was insignificant.

Conclusion: The results showed that the differences in the composition of GIC affect the surface roughness and hardness when subjected to different environments. The most resistant GIC was the one infused with CaO nanoparticles while the least was the conventional GIC.

Keywords: Biocompatibility, Carbonated beverages, Glass ionomer cement, Nano sized particle, Profilometer, Surface roughness, Thermal expansion, innovation, sustainability

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INTRODUCTION :

Comparison of surface roughness of conventional GIC,Calcium oxide nanoparticle infused GIC and magnesium oxide nanoparticle infused GIC after immersion in carbonated beverages-An vitro study.

Glass ionomer cement also known as man made dentin because when compared the coefficient of thermal expansion will be almost similar to that of the dentin.It is of different types, each being used in several branches of dentistry. Its fluoride releasing action, biocompatibility have been advantageous for its wide use.(1)Nano filled GICs is one of the latest developments which contains nano sized powder particles infused in them.(2) Polyacrylic acid, fluoroaluminosilicate glass powder and water together are the basic components of a conventional GIC, many of the compositions mostly contain tartaric acid which extends the working time.(3) The Following factors like setting reaction physical structure and bulk composition helps and determines the property of GIC. Set GICs are composites that contain inorganic glass particles in an insoluble hydrogel matrix.Newly mixed unset GIC will chemically adhere to both bone and metals (4). Nano-modification of conventional GICs are done by incorporating nano-sized fillers to Resin Modified GICs, glass particles are reduced in size, and nano-sized bioceramics are introduces to the glass powder.(5)(6)

Coca-Cola and other beverages with a low pH can dissolve the minerals in teeth and make the surface prone to abrasion. Surface roughness more than 0.2 m substantially promotes plaque maturation, bacterial adhesion, and acidity, raising the risk of dental caries(7). Important factors to consider when predicting the clinical degradation of restorative materials include surface properties and wear resistance of restorations. Dental plaque and germs are built up faster in rough and poorly polished tooth surface , which raises the risk of caries and gingival irritation.(8,9) On the other hand, a highly polished surface reduces it and improves aesthetics and color stability.Bacteria invading and acidic environment significantly increase when the surface roughness which acts on the surface materials se carie increasing the caries risk. Additionally, surface roughness can have a bad impact on marginal integrity and the wear resistance of restoration is also decreased.(10)Using nano-sized apatite increases the mechanical properties of conventional GICs, leading to more fluoride release. Increased fluoride release will help in prevention of secondary carries.(11)

Furthermore, the incorporation of bioactive nanoparticles such as calcium oxide (CaO) and magnesium oxide (MgO) into glass ionomer cements has gained increasing attention due to their potential to enhance both mechanical and biological properties.(12) These nanoparticles not only improve the strength and durability of the material but also contribute to remineralization by releasing essential ions that interact with the surrounding tooth structure. In acidic environments, such as those created by frequent consumption of carbonated beverages, these modified GICs may demonstrate improved resistance to surface degradation compared to conventional formulations.(13) Evaluating their behavior under such erosive challenges is essential to determine their clinical reliability and long-term performance in restorative dentistry.

If appropriate oral hygiene is practiced and fluoride is regularly administered, teeth will remain healthy even if sugary liquids are consumed often(14). According to a study by (15) done in Sudan, the increase in economic activity is likely to have increased sugar consumption. According to each person's frequency of consumption, a workable plan for the prevention of caries may one day be offered, underscoring the significance of implementing dietary habit-controlling oral health promotion programmes.

When the tooth enamel, the outermost layer of protection on our teeth, comes into contact with the acids in soft drinks, erosion occurs. They have the effect of making the enamel's surface less firm.(16)Soft drinks, on the other hand, can also affect the dentin layer beneath and even composite fillings. Your teeth's damaged enamel may lead to cavities. (17)Cavities, often known as caries, eventually develop in those who regularly drink soft drinks. When dental hygiene is neglected, the teeth might suffer serious harm.(18) Despite the fact that early detection and diagnosis are crucial for prevention, there are currently no in vivo diagnostic tools that can quantify the activity of dental erosion. (19)Changes in enamel surface roughness could be a potential indicator of early erosion, hence it is important to compare the surface roughness,the main aim of this study is to compare the surface roughness of conventional GIC,Cao and Mgo nano GIC after immersion in carbonated beverages.

MATERIALS AND METHODS :

A total of 12 samples, 4 samples for each material was prepared and the surface roughness was measured using a stylus profilometer(figure 1) after its immersion into the carbonated beverages. The Ra(the arithmetic mean deviation), Rq(the root mean square roughness) and Rz(

the ten-point height of microscopic unevenness) values were noted.

Group 1- Conventional GIC
Group 2- Magnesium oxide nanoparticle infused GIC
Group 3- Calcium oxide nanoparticle infused GIC

MgO preparation: To 0.2 M of magnesium nitrate in 250 ml and 1 M of NaOH in 250 ml each after magnetic stirring for 45 mins add NaOH drop by drop to magnesium nitrate solution ,maintaining it in room temperature and constantly stirring a precipitate is formed. After filtration and drying magnesium oxide is collected.

CaO preparation: CaO nanoparticles were derived from molluscal sea-shells by calcination of the calcium carbonate from the molluscan shells.

Sample preparation:

The sample was done by mixing GIC powder and liquid according to the manufacturer's-recommended ratio on a glass slab using a mixing spatula. Firstly the mixture was poured into the cylindrical metal mold (9.5x1mm). Excess material was removed using a glass slide. After setting the GIC cylinder was removed from the metal mold. Each sample was measured using a digital vernier caliper. A total of 12 samples were prepared.

RESULTS:

The detailed mean values and corresponding p-values for Ra, Rq, and Rz are presented in Table 1.The surface roughness of three groups conventional Glass Ionomer Cement (GIC), MgO nanoparticle-infused GIC, and CaO nanoparticle-infused GIC was evaluated using three parameters: average surface roughness (Ra), root mean square roughness (Rq), and ten-point height of microscopic unevenness (Rz).

The mean values of all three surface roughness parameters demonstrated a consistent trend across the groups. Conventional GIC exhibited the highest surface roughness values, followed by MgO nanoparticle-infused GIC, while CaO nanoparticle-infused GIC showed the lowest surface roughness. This pattern was observed for all measured parameters (Ra, Rq, and Rz), indicating improved surface smoothness with nanoparticle incorporation.

One-way ANOVA was performed to compare the surface roughness among the three groups. The analysis revealed that the differences in mean surface roughness values between the groups were statistically insignificant ($p > 0.05$) for all three parameters.

DISCUSSIONS:

The comparison between all 3 groups indicated that there is a difference in the mean surface roughness. ONE-WAY ANOVA was performed between the three groups and the results suggested that there is a characteristic decrease in surface roughness for the length of the measurement performed(Ra) as conventional GIC > MgO nano GIC > CaO nano GIC. While the root mean square roughness(Rq) decreases in the order of conventional GIC > MgO nano GIC> CaO nano GICand the ten-point height of microscopic unevenness (Rz) also follows the order conventional GIC > MgO nano GIC > CaO nano GIC. The mean value and p value for the three groups comparing all 3 parameters is given in table 1.(p value>0.05 for all the groups, so insignificant)

This study aims to evaluate the surface roughness of different types of GIC after its immersion in soft drinks. Carbonated beverages in those who consume it is one of the causes of changes in the surface roughness of tooth enamel and the surface of various restorative materials.(20,21))(22)Increased surface roughness will later lead to bacterial colonization in the form of plaque attached to the restorative material which will further lead to secondary caries and periodontal inflammation.(23)(24) In this study we observed that conventional GIC was more prone to surface irregularities after the effect of carbonated beverages on it than the other two nanoparticle infused GICs similar to the study done by korte et al where they have reported severe erosion of surface with conventional GICs due to the action of orange and apple juice extract for 3–6 months.The longevity of the restoration mainly depends upon the physical, chemical and mechanical properties.(23,25,26).Our research team with the most advanced research facilities have published few high quality research papers.(27–36)

Conventional GIC and Resin-Modified GIC and their surface roughness after attack by acid beverages was analyzed by nica et al. For both studied materials, there was a significant increase in surface roughness that was observed after 7th and 14th day of submersion in acidic beverages as a result of the acid attack both on the organic and inorganic fraction similar to our study where the surface roughness was more for conventional GIC after immersion than the other 2 variants(23,25,26,37).Similarly the study done by Abrar et al suggested Hybridization both the resin modified-glass ionomer cement (RMGIC) and bioactive glass (BAG) will have higher mechanical strength and resistance to disintegration.(38)

Another possible explanation for the improved surface characteristics of nanoparticle-modified GICs could be attributed to the enhanced packing density and reduced interparticle spacing achieved by the incorporation of nano-sized fillers. These nano-fillers occupy the voids between larger glass particles, resulting in a more homogeneous and compact matrix that is less susceptible to acid dissolution and surface degradation. Additionally, the presence of CaO and MgO nanoparticles may contribute to the buffering capacity of the material, thereby neutralizing the acidic challenge posed by carbonated beverages to some extent. This could further minimize ion leaching and structural breakdown of the cement matrix. Hence, the synergistic effect of improved microstructure and potential chemical resistance offered by these nanoparticles may be responsible for the comparatively smoother surface observed in nano-modified GICs in this study.

In the present study we observe that nanoparticle infused GICs showed better resistance to attack of surface by carbonated beverages than the conventional GIC similar to the study done by kim DA et al where the authors concluded that prepared GICs have high flexural strength ($p<0.05$) and comparable modulus(38,39) . The modified cements showed a significant increase in the cell viability for rDPSCs in carbonated beverages. The experimental GICs infused with MaO or ZnO are bioactive dental materials. The limitations of this study is its small sample size, in the future with increase in sample size and in vivo studying will help us obtain a more significant and accurate result.

CONCLUSION:

The results showed that the differences in the composition of GIC affect the surface roughness and hardness when subjected to different environments. The most resistant GIC was the one infused with CaO nanoparticles while the least was the conventional GIC. The addition of nanoparticles in GIC reduces microscopic voids,leading to improvements in its properties.

TABLES:

PARAMETERS	MEAN VALUE (conventional GIC)	MEAN VALUE (MgO nano GIC)	MEAN VALUE (CaO nano GIC)	P VALUE
Ra	1.56525	1.4995	0.9415	0.535
Rq	1.99375	1.6205	1.30225	0.5612
Rz	199.455	9.268	8.1815	0.4809

Table 1: The above table represents the mean values and p values

FIGURES:

Figure 1: This picture represents a stylus profilometer

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CONFLICT OF INTEREST:

The author declares that there was no conflict of interest in the present study.

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