

# Nano Glass Ionomers - A Review

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## Abstract

Restorative dentistry deals with materials that are used to fill cavities and prevent the infection of caries from recurrence. We have many restorative materials like amalgam, zinc phosphate, zinc oxide eugenol, GIC. Glass Ionomer Cement (GIC) has been a part of therapeutic dentistry for over three decades. It is one of the dental restorative materials used in dentistry for filling cavities and used as luting cement for the attachment of orthodontic brackets. It is a solid material with satisfactory appearance. It discharges fluoride which has a remineralising effect. It also additionally empowers high quality and rebuilding tendency in restorative dentistry. It is more susceptible to fracture and is more susceptible to fracture as it cannot bear heavy masticatory load. GIC generally lasts for five years and is quite affordable(price) also. Nanotechnology in dentistry has various implications and it tends to improve the existing properties of the materials in numerous ways. When nanoparticles are introduced into GIC, they can help in better adhesive mechanism to teeth so that they can reduce the fracture occurrence as well as the leakages. It also improves the longevity of the restoration, improves the aesthetic appearance and overcomes the surface roughness seen in conventional GIC. Nano particles are small and occupy the space in the matrix which can improve the strength of the material. Nanoparticles improve sustained fluoride release, increase the strength, improve the antibacterial activity, and can be used clinically as an efficient material. The drawbacks of the conventional materials are overcome by the nanotechnology. They play a very important role in dentistry to improve the efficiency of many materials involved in dentistry. This investigation is mainly focussing on the use of nanotechnology in glass ionomer cements dealing with its properties, points of interest and hindrances.

**Keywords:** *Glass ionomer cement, fluoride release, physical properties, antimicrobial effect, aesthetic appearance, properties of cement, nanotechnology.*

## Introduction

Glass ionomer cement is utilised for a wide range of uses in dentistry<sup>1</sup>. They are tooth coloured restorative material which bond chemically to tooth and release fluoride for a longer period. They are also material of choice for restoration in the primary teeth. Their

bonding mechanism can seal and protect the pulp and prevent leakage at the margins which decreases the possibility of failure of restoration. The coefficient of thermal expansion of GIC is similar to dentin in humans so that the marginal leakage possibility is less. When GIC is placed in cervical cavities it is durable also. GIC is available in different shades but still surface finish, variations related to finishing and polishing, surface staining still remain a concern. GIC has changed the restorative approaches, particularly in minimal invasive dentistry. GIC synthetically holds fast to tooth structure through trade of particles which forestall microleakage, secondary caries and pulp contamination<sup>2</sup>. It is ideally utilised since they bond chemically to both enamel and dentin. It is exceptionally biocompatible

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and goes about as a store of fluoride by taking fluoride ions from dentifrices and discharging it after some time<sup>3</sup>. The early conventional glass ionomer materials were technique sensitive, slow setting, opaque when set and can cause premature surface deterioration<sup>4</sup>. Most of these problems are overcome in newer generations of glass ionomer cement<sup>5</sup>. Bioactivity implies cellular growth, proliferation and antibacterial effect. Glass ionomer cement contains bioactive properties due to presence of fluoride and silicate. Each modification in GIC has a significant outcome when considered in relation to effect on final properties<sup>6</sup>. Glass ionomer cement have other uses such as luting agent in crowns and other indirect restorations<sup>7</sup>. High fluoride content gives anti caries effect<sup>8,9</sup>. Tooth coloured restorative material helps in better aesthetic appearance though it has drawbacks viz. being brittle which means it is prone to fracture, poor wear and tear resistance and sensitivity in oral cavity<sup>10</sup>. Nano particles are of the size ranging from 10-20 micrometer. They have better bonding properties because of their occupancy of the space in the material. Their bonding mechanism is micro mechanical interlocking which is because of chemical nature and surface texture. Nano light curing type of GIC is also available for use. They are clinically used for Class 1 temporary restoration and sandwich restoration in type 3 and type 5 along with core build ups. Incorporation of nanoparticles have improved mechanical properties of GIC with enhanced features like elastic modulus and increase in compressive strength. Similar to crystals in enamel, some crystals like nano hydroxyapatite introduced in GIC can favour the remineralisation of enamel<sup>11</sup>. Conventional glass ionomer cement had low flexural and tensile strength and high modulus of elasticity so they were much more prone to fracture. Addition of nano crystal has shown positive impact on compressive, tensile and flexural strength of GIC. It has also improved the chemical stability and water solubility. Glass ionomer cement is considered to be good material for root caries and for sealants. GIC becomes stronger with the progression of reactions more resistant to moisture<sup>12</sup>. When nanoparticles were introduced there was a decrease in working and setting time of the cements. They have better survival rates when compared to conventional GIC<sup>13</sup>. Some particles like nano TiO<sub>2</sub> particles are introduced to show enhanced antibacterial effect<sup>14</sup>. Some particles like zinc oxide when introduced

in GIC, the GIC shows increase in anti bacterial activity without modifying mechanical properties and are found to be better alternatives to conventional GIC. Fluoride release from the matrix of GIC helps in antibacterial effect. When compared with conventional GIC, nano modified GIC releases less amount of fluoride from the matrix<sup>15,16</sup>. Even though glass ionomer cements have less chair side time and ease of use, they are also prone to maximum leakage<sup>17</sup>. Restoration of noncarious cervical lesions often poses a challenge to the clinician. Various restorative materials are available and modifications of GIC enhances their properties<sup>18</sup>. Conventional glass ionomers were difficult to manipulate as they are sensitive to moisture imbibition during the early setting reaction. Incorporation of nano technology in dentistry has so many advantages. They are antibacterial in effect and lead to ultimate reduction of periodontal disease. Nowadays even nano technology is introduced in mouthwash and oral hygiene products so that they can reduce caries, dentin permeability<sup>19,20</sup>. Nano hydroxyapatite particles when introduced can also lead to enamel remineralisation effect. Nano glass ionomer cement is said to have many clinical applications and helps in conservation of tooth structure by their adhesive mechanisms<sup>21,22</sup>.

## **Materials and Methods**

The review of literature was done by collecting the articles related to the article. 20 articles were collected from google scholar and pubmed. The articles were searched for using keywords like nano glass ionomers, modifications of GIC, bond strength, polish properties. They were collected from the period of 2000-2020. the inclusion criteria were aesthetic outcome, polish properties and wear resistance. Exclusion criteria includes stress bearing properties.

### **NANOPARTICLES INCORPORATED IN GIC:**

The incorporation of nanoparticles in conventional GIC has led to improved properties. When nano hydroxyapatite particles were introduced they improved the fluoride release, mechanical properties as well as the reduction in bacterial invasion. When titanium oxide was added they improved the mean compressive fracture strength of the material<sup>23</sup>. When silica is introduced it improves the shear bond strength, compressive and flexural strength, they also improve the microhardness

property<sup>24</sup>. When zirconia particles are added, they strengthen the material with reduction in brittleness<sup>25</sup>. Biocompatibility and bioactivity are also improved when niobium pentoxide is added<sup>26</sup>. Barium sulfate was seen to influence the setting and working time of GIC. When titanium oxide was added it improved physical properties.

### FLOURIDE RELEASE

Nano technology increases the longevity of GIC, as the nano glass filler particles are incorporated into them. Nanotechnology increases the mechanical properties and aesthetic outcome of nano glass ionomers to facilitate strong ionic bonding to the tooth. They have improved the stability and sustained fluoride release. Carious lesions are one of the most common problems faced by children. Secondary caries are the recurrence of caries after removal of the existing caries. When there is fluoride release from the restorative material it prevents the emergence of secondary caries. GIC contains fluoride which is clinically cariostatic and acts as a fluoride reservoir. They also undergo remineralisation which is a unique property<sup>18,27</sup>. The fluoride release can remineralise the enamel and can counteract the appearance of secondary caries. Incorporation of nanoparticles have led to sustained release of fluoride<sup>28</sup>. According to another view, fluoride release is initially high but later eventually decreases<sup>29</sup>. When nano GIC was light cured or chemical cured it affected the fluoride release. Addition of CaF particles in nano modified GIC affect the fluoride releasing property<sup>14</sup>. Another study showed that nano hydroxyapatite dentifrice produced better effects along with remineralisation potential<sup>30</sup>. Within the limitations of an in vitro study it was concluded that cumulative release of fluoride was higher in nano glass ionomers, resin modified GIC when compared to resin composite and compomer<sup>31</sup>. Another in vitro study also shows that remineralising effect was additive due to incorporation of zinc reinforced synthetic nano hydroxyapatite on caries like lesion in human teeth<sup>32</sup>. Enamel erosion when prevented we can avoid the occurrence of secondary caries<sup>21,33-35</sup>.

### STRENGTH PROPERTIES

High mechanical strength is seen in GIC. It is more stable chemically. When more small sized particles are added it makes the material stronger and

tougher. Addition of nFAp particles help in the positive impact of compressive, tensile, and flexural strength to GIC. When MgO nanoparticles were added it showed that they were proved to be a clinically more effective restorative material. Setting time of GIC decreased when macro particles were replaced by nanoparticles. Increase in compressive strength but the effect is being more pronounced when it contains nano glass particles<sup>36</sup>. According to another study cumulative F release decreases when macro particles are replaced by micro particles. Bonding was greatest in nano modified GIC<sup>37</sup>. Mechanical strength was more in nano GIC compared to unmodified GIC. According to another study, the property of improved surface hardness was found when nanoparticles were incorporated into GIC<sup>38</sup>. However, decrease in compressive strength was observed in yet another study after thermal cycling<sup>39</sup>.

### BIOMECHANICAL DEGRADATION

Biodegradation occurs due to many factors like humidity, biofilm, type of material and abrasion. Also undesirable roughening of surface was also observed<sup>40</sup>. There have also been studies which produce contradictory result viz. low roughness values. It has also been reported that nano fillers did not show any influence on roughness and hardness concerning the degradation resistance<sup>41</sup>

### ANTIMICROBIAL ACTIVITY

Anti microbial means the reduction in occurrence of bacteria. The presence of bacteria can lead to caries and destruction of teeth. They determine the stability of teeth. Prevalence of micro leakage is more if they are present<sup>42,43</sup>. It is a very important property when the cement is being used as a luting cement, restorative material because bacteria may still be present in the walls of preparation and can cause infection if microleakage is present after their usage. There have also been contradictory results like more chemical bond strength is seen so there is reduction in leakage. Nano silver incorporation has depicted inhibition halos in an agar plate. According to another study they show that enhanced bactericidal effect. Teratogenicity of nano silver particles is unknown<sup>44,45</sup>.

### PIT AND FISSURE SEALANTS

Dental caries are still a concern. The modern restorative dentistry focuses on natural tooth conservation and minimal invasive dentistry. Atraumatic Restorative Treatment (ART) is one such mechanism in minimal invasive dentistry. In ART, they remove the caries and demineralised tissue with the help of hand instruments. We use GIC as a pit and fissure sealant so that they can seal the fissures at risk for manifestation of caries. Another study has shown lower viscosity and formed a resin tag of sufficient length and the sealant is showing better results when compared to conventional sealant<sup>46,47</sup>. Glass ionomer cement had superior seal property when compared to other restorative materials<sup>48</sup>. Pit and fissure sealants are mostly used for preventing caries formation<sup>49,50</sup>

### AESTHETIC OUTCOME

Glass ionomer cement is a tooth coloured restorative material which can be used anteriorly for aesthetic purposes. They are available in different shades. They do not stain easily and are also affordable to people. They are also durable and can last for about 5 years. They are similar to human dentin so very aesthetic in purpose. They are not much sensitive to water and have better adhesion to the tooth. They can also undergo finishing and polishing almost immediately. When yttrium ions along with aluminium fluoride ions are introduced in the material they show similar chemical and physical properties and produce the uniform surface and improve the aesthetics along with better finishing and polishing property<sup>51</sup>.

### Limitations

Nano glass ionomers are technique sensitive. Conventional GIC are very brittle and fracture prone and not appropriate for their usage in posterior stress bearing areas like molar teeth<sup>52</sup>. Nano GIC have high creep which causes reduction in marginal integrity. Due to lack of studies nano glass ionomers are in the initial stage of use in clinical dentistry. We have to control certain aspects of nanoparticles in GIC, such as correct indication, good isolation, and choice of right material for each situation to be of use without any doubt or apprehension.

### Future Scope

Nanoparticles can be incorporated to improve the

strength of the GIC so that they can be used in posterior stress bearing areas. They can be modified to decrease leakage and improve the marginal integrity. Further research is needed in biochemical stability of glass ionomer cements, supported by both the dentists as well as the industry which is a need of the hour.

### Conclusion

Glass ionomer cement is a tooth coloured restorative material. Introduction of nanotechnology in it will improve the properties. Nano technology is also technique sensitive which is a concern but the pros of introducing the nanoparticles in GIC outweighs the cons of it. Still research is yet to be conducted in nano GIC so that it can overcome the drawbacks.

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**Ethical Clearance:** As it is a review article so it is not required.

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