

Original Research

Review Study Of The Application Of Nanofield Coatings In Restorative Materials With Base Glass Ionomer: Water Absorption And Solubility Of Restorative Materials

Aida Moeinian¹, Zhila Fahim^{2*}

1. Department Of Operative Dentistry, Faculty Of Dentistry, Tabriz University Of Medical Sciences, Tabriz, Iran

2. Department Of Operative Dentistry, Faculty Of Dentistry, Tabriz University Of Medical Sciences, Tabriz, Iran

***Corresponding Author: Zhila Fahim**, Department Of Operative Dentistry, Faculty Of Dentistry, Tabriz University Of Medical Sciences, Tabriz, Iran. Email: Zhilafahim72@Gmail.Com. Orcid:0000-0001-8813-0114.

Abstract:

Background:

Nanofilled resin-based coatings are a type of surface coating that consists of a resin matrix filled with nanoparticles, which offer several benefits over conventional resin-based coatings. Restorative materials with a base of glass ionomer have become increasingly popular in the field of dentistry over the past few decades. In this study we reviewed the application of nanofield coatings in restorative materials with base glass ionomer.

Methods:

A narrative review.

Results and Conclusion:

There are limited research on impact of nanofield coatings on the water absorption and solubility of restorative materials with a base of glass ionomer, available studies suggest that such coatings may help improve water resistance and durability of these materials. The study by Jafarpour et al. specifically highlights the potential benefits of nanocoatings in reducing solubility and surface roughness of glass ionomer cement. However, more research is needed to fully understand the potential benefits and limitations of nanocoatings for glass ionomer restorations, including their long-term performance and biocompatibility. In evaluating effects of nanofield coatings, it is important to consider characteristics of both coating and material being coated. Overall, advancements in nanotechnology may offer promising solutions for improving performance and longevity of restorative materials in the oral environment.

Keywords: Review, Nanofield, Restorative Materials, Ionomer

Submitted: 18 Jan 2023, Revised: 28 Jan 2023 , Accepted: 5 Feb 2023

Introduction

Nanofield coatings are a type of surface coating that use nanoparticles to enhance the properties of a material (1). One of primary benefits of nanofield coatings is their ability to improve a material's resistance to water and other environmental factors (2). Nanofilled resin-based coatings are a recent development in field of surface coatings, offering superior mechanical and physical properties (3), improved corrosion resistance, and enhanced durability (4). Incorporation of nanoparticles, such as silica, alumina, titanium oxide, and carbon nanotubes, into coating matrix can improve mechanical and thermal properties of coating, while also enhancing its barrier properties against moisture and other corrosive agents (5,6). Synthesis and characterization of these coatings have been widely researched, with effect of nanoparticles on properties of coatings being a major focus. Nanofilled resin-based coatings is another major advantage, with coatings able to be designed to have specific properties such as self-healing (7), anti-fouling, and anti-icing (8). Applications of nanofilled resin-based coatings in dentistry include fabrication of dental composites and adhesives, improving mechanical and bonding properties of restorative materials (9). Restorative materials with a base of glass ionomer, a versatile material that can be used in a variety of dental applications, have also become increasingly popular in dentistry. Glass ionomer restorative materials offer a unique set of benefits, including ability to bond directly to tooth structure, release fluoride, and provide a natural-looking restoration (10). Solubility and water absorption in glass ionomer cements can be evaluated using methods such as gravimetric analysis, microhardness testing, and Fourier transform infrared spectroscopy (11). Development of nanofilled resin-based coatings and use of glass ionomer restorative materials have immense potential in various industrial and dental applications.

Resin-based coatings

In recent years, use of nanotechnology has led to numerous innovations and improvements in various fields of science and technology. One of areas where nanotechnology has shown immense potential is in development of nanofilled resin-based coatings. These coatings have gained significant attention due to their ability to offer superior mechanical and physical properties, as well as improved corrosion resistance and more stability (4).

Resin-based coatings have been widely used in various industries such as automotive, aerospace, marine, and construction, among others (12). They offer excellent protection against corrosion, wear and tear, and environmental damage (13). However, with advancement of technology, there is an increasing demand for higher performance coatings with enhanced properties.

Nanofilled resin-based coatings

Synthesis and characterization of nanofilled resin-based coatings have been subject of extensive research in recent years. Nanofilled resin-based coatings have been developed to meet this demand. These coatings consist of a resin matrix filled with nanoparticles, which offer several benefits over conventional resin-based coatings (13). Use of nanoparticles in these coatings allows for improved mechanical properties, including hardness, tensile strength, and elasticity. In addition, nanoparticles can enhance thermal and electrical conductivity of coating, making them suitable for high-temperature applications (14).

Nanofilled resin-based coatings have also shown promising results in terms of their anti-corrosion properties (15). Wang et al. incorporated nanoplatelets/nano-silica hybrid nanofillers of in coating matrix to enhance barrier properties of coating, preventing penetration of moisture and other corrosive agents. This results in improved corrosion

resistance and durability, making them ideal for use in harsh environments. (16).

In conclusion, development of nanofilled resin-based coatings is a significant advancement in field of coatings technology. These coatings offer several benefits over conventional resin-based coatings, including improved mechanical properties, corrosion resistance, and multifunctionality. With increasing demand for high-performance coatings, nanofilled resin-based coatings have immense potential in various industrial applications (17).

Nanofilled resin-based coatings in dentistry

Nanofilled resin-based coatings have numerous applications in dentistry. They are widely used for restoration of teeth, as they can be easily molded into required shape and size to match natural tooth structure. Use of these coatings has significantly improved quality of dental restorations and increased their longevity (18-20).

One major application of nanofilled resin-based coatings in dentistry is in fabrication of dental composites (21). Dental composites are tooth-colored fillings used to restore teeth that have been damaged by cavities, fractures, or other types of trauma (22). Incorporation of nanofillers into these composites has improved their mechanical properties, such as their strength, wear resistance, and fracture toughness, making them more durable and long-lasting (23).

Furthermore, nanofilled resin-based coatings have been used in development of dental adhesives. Dental adhesives are materials used to bond dental restorations to natural tooth structure. Using of nanofillers in these adhesives has improved their bonding properties, making them more effective in bonding restorative materials to tooth structure (24).

Restorative materials with base glass ionomer

Restorative materials with a base of glass ionomer have become increasingly popular in field of dentistry over past few decades. Glass ionomer is a versatile material that can be used in a variety of dental applications, including as a filling material, a liner or base for cavities, or as a cement for orthodontic brackets (25).

One of primary benefits of glass ionomer restorative materials is their ability to bond directly to tooth structure. This means that they can be used to restore teeth without need for a separate bonding agent, which can save time and simplify restorative process. Additionally, glass ionomer materials have a low coefficient of thermal expansion, which means that they expand and contract at a rate similar to natural tooth structure, reducing risk of cracking or fracturing (25, 26).

Another advantage of glass ionomer restorative materials is their ability to release fluoride over time. Fluoride is a naturally occurring mineral that can help strengthen teeth and prevent tooth decay. By releasing fluoride, glass ionomer restorations can help protect teeth against future decay and promote overall oral health (25, 26).

However, glass ionomer materials do have some limitations. They may not be as strong as other restorative materials, such as composite resins or ceramics, and may not be suitable for restoring teeth in areas of high stress or tension. Additionally, glass ionomer materials can be more sensitive to moisture during setting process, which can affect their strength and longevity (25, 26).

Overall, glass ionomer restorative materials are a versatile and effective option for many dental restorations. With their ability to bond directly to tooth structure, release fluoride, and provide a natural-looking restoration, they offer a unique set of benefits that make them an attractive choice for many dentists and patients.

Methods of water absorption and solubility evaluation

Solubility and water absorption in glass ionomer cements (GICs) are commonly evaluated using various methods (27, 28). One common method involves immersing GIC samples in distilled water for a specific period and then measuring amount of water absorbed by samples or weight loss due to solubility (29). Another method involves using a centrifuge to apply pressure to sample in distilled water to simulate forces experienced by GICs in oral environment (30). Solubility and water absorption of samples can then be measured using same methods as before.

Solubility and water absorption of GICs are important factors to consider in dental restorations as they can affect longevity of restoration. High solubility or water absorption can result in dissolution or degradation of GIC, leading to a loss of retention or marginal breakdown of restoration. Therefore, evaluating these properties can help to identify suitability of GICs for different clinical applications and to optimize their performance in oral environment (28-30).

Nanofield coatings and water absorption and solubility of restorative materials with base glass ionomer

After conducting a search on the given topic, we were collected specific studies that directly address the impact of nanofield coatings on the water absorption and solubility of restorative materials with a base of glass ionomer; while studies were rare.

Many methods have been considered to increase the water sorption/solubility of glass ionomer-Based restorative materials(31). Jafarpour et al. performed an in-vitro laboratory study that investigates the impact of a nanocoating on the solubility and surface roughness of glass ionomer cement. They tried adding nanofilleds to these composites on five glass-ionomer cement (GIC) restorative

materials. Found that their coatings caused decreased water solubility that prevents discolorations (32). The study found that the application of a nanocoating to glass ionomer cement resulted in a significant reduction in solubility and surface roughness compared to uncoated glass ionomer cement. The authors suggest that the nanocoating may help to improve the durability and longevity of glass ionomer restorations by reducing water absorption and surface degradation (32). Overall, this study provides valuable insights into the potential benefits of nanocoatings for glass ionomer restorative materials. However, it is important to note that this study was conducted in a laboratory setting and may not fully reflect the real-world conditions and challenges that can affect the performance of restorations in the oral environment (32).

Bacterial cellulose nanocrystals were added to resin-modified GIC by Moradian et al., to assess its effects on compressive strength, diametral tensile strength, and modulus of elasticity and all these mechanical properties were improved based on their experiments (33). Moghaddasi et al. used G-coat plus in comparison of the non-coated resin composites and found that water solubility improved but the color stability decreased (34). So, while glass ionomer restorative materials that are coated, are known to have relatively high-water absorption and solubility compared to other restorative materials, such as composite resins and ceramics, other factors like discoloration should also be investigated. In addition, while the results of this study are promising, further research is needed to fully understand the potential benefits and limitations of nanocoatings for glass ionomer restorations. Future studies could explore the effects of different types of nanocoatings, as well as their long-term performance and biocompatibility. In summary, while there is no specific research on the effect of nanofield coatings on the water absorption and solubility of glass ionomer

restorative materials, it is possible that such coatings could help improve the water resistance of the material. However, the individual characteristics of both nanofield coatings and glass ionomer materials should be considered when evaluating their effects on water absorption and solubility.

Conclusion

In conclusion, while there is limited research on impact of nanofield coatings on water absorption and solubility of restorative materials with a base of glass ionomer, available studies suggest that such coatings may help improve water resistance and durability of these materials. However, more research is needed to fully understand potential benefits and limitations of nanocoatings for glass ionomer restorations, including their long-term performance and biocompatibility.

References

1. Capek I, Capek I. Nanofield. Noble Metal Nanoparticles: Preparation, Composite Nanostructures, Biodecoration and Collective Properties. 2017:1-23.
2. Makhlouf AS. Current and advanced coating technologies for industrial applications. In Nanocoatings and ultra-thin films 2011 Jan 1 (pp. 3-23). Woodhead Publishing.
3. Curtis AR, Shortall AC, Marquis PM, Palin WM. Water uptake and strength characteristics of a nanofilled resin-based composite. Journal of dentistry. 2008 Mar 1;36(3):186-93.
4. Ma IW, Sh A, Ramesh K, Vengadaesvaran B, Ramesh S, Arof AK. Anticorrosion properties of epoxy-nanochitosan nanocomposite coating. Progress in Organic Coatings. 2017 Dec 1;113:74-81.
5. Esfahani MR, Tyler JL, Stretz HA, Wells MJ. Effects of a dual nanofiller, nano-TiO₂ and MWCNT, for polysulfone-based nanocomposite membranes for water purification. Desalination. 2015 Sep 15;372:47-56.
6. Kumar V, Kumar A, Han SS, Park SS. RTV silicone rubber composites reinforced with carbon nanotubes, titanium-di-oxide and their hybrid: Mechanical and piezoelectric actuation performance. Nano Materials Science. 2021 Sep 1;3(3):233-40.
7. Wang T, Wang W, Feng H, Sun T, Ma C, Cao L, Qin X, Lei Y, Piao J, Feng C, Cheng Q. Photothermal nanofiller-based polydimethylsiloxane anticorrosion coating with multiple cyclic self-healing and long-term self-healing performance. Chemical Engineering Journal. 2022 Oct 15;446:137077.
8. Liu C, Yan B, Sun J, Dong X, Zheng J, Duan J, Hou B. Cu@C core-shell nanoparticles modified polydimethylsiloxane-based coatings with improved static antifouling performance. Progress in Organic Coatings. 2022 Oct 1;171:107026.
9. Elgendy H, Maia RR, Skiff F, Denehy G, Qian F. Comparison of light propagation in dental tissues and nano-filled resin-based composite. Clinical Oral Investigations. 2019 Jan 29;23:423-33.
10. Sidhu SK, Nicholson JW. A review of glass-ionomer cements for clinical dentistry. Journal of functional biomaterials. 2016 Jun 28;7(3):16.
11. El-Safty SM, El-Wakiel N, El-Oleimy G, Gaber M, El-Sayed YS. Microhardness and Fluoride Release of Glass Ionomer Cement Modified with a Novel Al³⁺ Complex to Enhance Its Antimicrobial Activity. International Journal of Biomaterials. 2021 Oct 23;2021.
12. Dorieh A, Pour MF, Movahed SG, Pizzi A, Selakjani PP, Kiamahalleh MV, Hatefnia H, Shahavi MH, Aghaei R. A review of recent progress in melamine-formaldehyde resin based nanocomposites as coating

- materials. *Progress in Organic Coatings*. 2022 Apr 1;165:106768.
13. Moghimi M, Jafarpour D, Ferroz R, Bagheri R. Protective effect of a nanofilled resin-based coating on wear resistance of glass ionomer cement restorative materials. *BMC Oral Health*. 2022 Jul 30;22(1):317.
 14. Khalid I, Anggani HS, Ismah N. Differences in Enamel Surface Roughness Changes after Debonding Using Resin Infiltration System and Nano-Filled Resin Coating. *Journal of International Dental and Medical Research*. 2019;12(1):95-100.
 15. Tiwari S, Srivastava K, Gehlot CL, Srivastava D. Epoxy/fly ash from thermal power plant/nanofiller nanocomposite: studies on mechanical and thermal properties: a review. *Int. J. Waste Resour*. 2020;10:1-6.
 16. Wang X, Lin Z. Robust, hydrophobic anti-corrosion coating prepared by PDMS modified epoxy composite with graphite nanoplatelets/nano-silica hybrid nanofillers. *Surface and Coatings Technology*. 2021 Sep 15;421:127440.
 17. Jafarpur D, Bagheri R. Evaluation of the effect of nanofilled resin-based coatings on water sorption and solubility of glass ionomer restorations. *Journal of Dental Medicine*. 2019 Mar 10;31(4):208-14.
 18. Basso M. Teeth restoration using a high-viscosity glass ionomer cement: The Equia® system. *Journal of Minimum Intervention in Dentistry*. 2011 Jan 1;4(3):74-6.
 19. Mohammadi N, Bagheri R, Borazjani LV. Effect of the resin-based adhesive coating on the shear punch strength of Aesthetic restorative materials. *Dental Hypotheses*. 2021 Oct 1;12(4):189.
 20. Jandt KD, Sigusch BW. Future perspectives of resin-based dental materials. *Dental materials*. 2009 Aug 1;25(8):1001-6.
 21. Shatat F. The effect of resin based coatings on fluoride release of glass ionomer cement, an in vitro study. *Magister Scientiae Dentium - MSc(Dent) (Paediatric Dentistry)*.
<http://hdl.handle.net/11394/6399>
 22. Ferracane JL. Current trends in dental composites. *Critical Reviews in Oral Biology & Medicine*. 1995 Oct;6(4):302-18.
 23. Montoya C, Jain A, Londoño JJ, Correa S, Lelkes PI, Melo MA, Orrego S. Multifunctional dental composite with piezoelectric nanofillers for combined antibacterial and mineralization effects. *ACS Applied Materials & Interfaces*. 2021 Sep 8;13(37):43868-79.
 24. da Cruz LB, Oliveira MT, Saraceni CH, Lima AF. The influence of nanofillers on the properties of ethanol-solvated and non-solvated dental adhesives. *Restorative Dentistry & Endodontics*. 2019 Aug 1;44(3).
 25. Sidhu SK. Glass-ionomer cement restorative materials: a sticky subject?. *Australian dental journal*. 2011 Jun;56:23-30.
 26. Tay FR, Pashley EL, Huang C, Hashimoto M, Sano H, Smales RJ, Pashley DH. The glass-ionomer phase in resin-based restorative materials. *Journal of Dental Research*. 2001 Sep;80(9):1808-12.
 27. Kanchanasavita W, Anstice HM, Pearson GJ. Water sorption characteristics of resin-modified glass-ionomer cements. *Biomaterials*. 1997 Jan 1;18(4):343-9.
 28. Crisp S, Lewis BG, Wilson AD. Characterization of glass-ionomer cements: 6. A study of erosion and water absorption in both neutral and acidic media. *Journal of Dentistry*. 1980 Jan 1;8(1):68-74.
 29. Gemalmaz D, Yoruc B, Ozcan M, Alkumru HN. Effect of early water contact on solubility of glass ionomer luting cements. *The Journal of prosthetic dentistry*. 1998 Oct 1;80(4):474-8.
 30. Moheet IA, Luddin N, Ab Rahman I, Masudi SA, Kannan TP, Abd Ghani NR.

- Novel nano-hydroxyapatite-silica-added glass ionomer cement for dental application: Evaluation of surface roughness and sol-sorption. *Polymers and Polymer Composites*. 2020 Jun;28(5):299-308.
31. Savas S, Colgecen O, Yasa B, Kucukyilmaz E. Color stability, roughness, and water sorption/solubility of glass ionomer-Based restorative materials. *Nigerian journal of clinical practice*. 2019 Jun 1;22(6):824-32.
32. Jafarpour D, Mese A, Ferroz M, Bagheri R. The effects of nanofilled resin-based coatings on the physical properties of glass ionomer cement restorative materials. *Journal of dentistry*. 2019 Oct 1;89:103177.
33. Moradian M, Abadi MN, Jafarpour D, Saadat M. Effects of bacterial cellulose nanocrystals on the mechanical properties of resin-modified glass ionomer cements. *European Journal of Dentistry*. 2021 May;15(02):197-201.
34. Moghaddasi N, Tavallali M, Jafarpour D, Ferroz R, Bagheri R. The effect of nanofilled resin-base coating on the mechanical and physical properties of resin composites. *European Journal of Dentistry*. 2021 May;15(02):202-9.