10.21608/adjc.2023.201359.1281 Advanced Dental Journal
Volume 6 (2024) | Issue 4 | Pages 616 - 621

Original Article

Wear, Microhardness, Water Sorption and Solubility of Conventional Glass Ionomer Cement Modified with Precured Nanofilled Composite

Diaa A. Elmwafy[1], Amr A. Abdelghany[2]
[1] Dental biomaterials Department, Faculty of Dentistry, Benisuef University.
[2]Spectroscopy Department, Physics Research Institute, National Research Center, Cairo.

Email: diaa.zaki@dent.bsu.edu.eg

Submitted: 21-3-2023
Accepted: 27-5-2023

Abstract

Aim: This study aimed to evaluate wear, microhardness, water sorption, and solubility of glassionomer cement modified with precured nanofilled composite.
Subjects and methods: Glass ionomer cement and nanofilled composite were used in this study. Glass ionomer cement was modified with precured nanofilled composite with different concentrations as follows: 0 wt%, 5 wt%, 10 wt%, 15wt% for the groups I, II, III, IV respectively. Wear, microhardness, water sorption, and solubility have been investigated. The data were statistically analyzed by one-way ANOVA and Tukey's HSD analysis at a significant factor of $\alpha = 0.05$.
Results: Regarding wear, water sorption, and solubility, the lowest value was for group IV, while the highest value was for group I. For microhardness,the highest value was for group IV, while the lowest value was for group I.
Conclusions: As the concentration of precured nanofilled composite powder increased in glass ionomer cement, the microhardness have been increased while wear, water sorption and solubility have been decreased.

Keywords: Glass ionomer modified, composite, surface properties

I. INTRODUCTION

Conventional glass ionomer cement (C-GIC) has been commonly used owing to its desirable properties such as chemical bonding with tooth structure, anti-cariogenic properties due to its fluoride release, and its esthetic properties, however, its low mechanical properties such as low wear resistance, low hardness, high sensitivity to moisture and its rapid dehydration, have been a main obstacle for its clinical application, so it is used as filling material in the deciduous teeth and non-stress-bearing areas or as an adhesive.[1-4] Several adjustments have been performed frequently in the powder of GIC to enhance its mechanical properties. These adjustments consists of additives as metal, glass, and various non-reactive particles as fillers.[5,6] In the last years resin modified glass ionomer cement (R-GIC) was introduced. R-GIC has superior mechanical properties such as high wear resistance, high hardness, and high resistance to solubility than C-GIC but it has some disadvantages as polymerization shrinkage, and also a decrease in the amount of fluoride release due to resin content as dental composite.[7] So in this study we attempt to improve the mechanical and physical properties of C-GIC by precured nanofilled composite powder to avoid disadvantages of

polymerization shrinkage and stresses and act only as a filler that contributes to improve properties of C-GIC.

II. SUBJECTS AND METHODS

a.Grouping of specimens and preparartion:

Entire number of 60 disc specimens were constructed from glass ionomer cement (Cemebest, BMS, M Buonarroti, Capannoli PISA, Italy) with 13 mm diameter × 2mm thickness dimensions and were prepared in a Teflon mold and divided into four groups according to modification with precured powder of nanofilled composite (3M ESPE, St. Paul,MN, USA), that were powdered using a NIEOTZ/Photo ball mailing machine adopting zirconium balls with various sizes using 500 rpm for about 2 h**ours**.[8] The powder of precured composite was added to the powder of glass ionomer cement with percentages 0 wt%, 5 wt%, 10 wt%, 15wt% forming four groups, each group consisting of 15 specimens, the four groups are I,II, III, IV respectively. Representative specimens are shown in Figure 1.

b.Scanning Electron Microscopy (SEM)

The surface topography of specimens used and precured powder of nanofilled composite was studied using SEM (JEOL, JSM-6510LV, Japan) conducted at an accelerating voltage of 30 kV. Specimens examination performed at different magnifications as shown in Figure 2

c.Wear

A total number of 20 specimens (5 for each group) were weighed before being subjected to wearing, then they were subjected to wear testing via conventional TNO Tribometer (M/C, England) against carbide abrasive counter-body water as a lubricant. The circumstances of the test were 3 minutes time of wearing, 256 for RPM, and the condition was wet, and the load of wearing was 60 N. After wearing, specimens were weighed again and the weight loss in grams was calculated.[9]

d.Microhardness

20 specimens (5 for each group) were tested. The test of Vickers hardness was performed for surface hardness measurment via square-based pyramid indenter point. The test was carried out with microhardness tester (Micromet 2001, Model 1600-4981, Buehler, USA) manufactured with 300 g load applied for 15 s at temperature of the room. For every specimen, three indentations of Vickers hardness were done at different points of it. Calculation of the mean hardness was done. [10]

e.Water sorption and solubility

20 specimens (5 for each group) were tested. The specimens were weighed after preparation (M1) on four digits electronic balance. Storage of all specimens in distilled water was carried out for 7 days in eppendorf in a plastic box and were weighed on four digits electronic balance until achievement of constant weight (M2). The specimens were dried by being kept on filter paper then they were put again in the plastic box inside a desicwcator containing calcium chloride at room temperature and then weighed again after removal from the desiccator (M3) on four digits electronic balance. Calculation of specimens volume (V) was done. Calculation of Water sorption (Wsp) and solubility (Wsl) values in $\mu g/mm^3$ for every specimen was done using the following equations:[11]

f.$Wsp=M2-M3/V \quad Wsl=M1-M3/V$

Where Wsp: is water sorption, Wsl: is solubility, M1: is the specimen weight after preparation, M2: is the specimen weight after storage in water, M3: is the specimen weight after removal from the desiccator, V: is the specimen volume.

Figure 1: A: Group I, B: Group II., C:Group III ., D: GroupIV

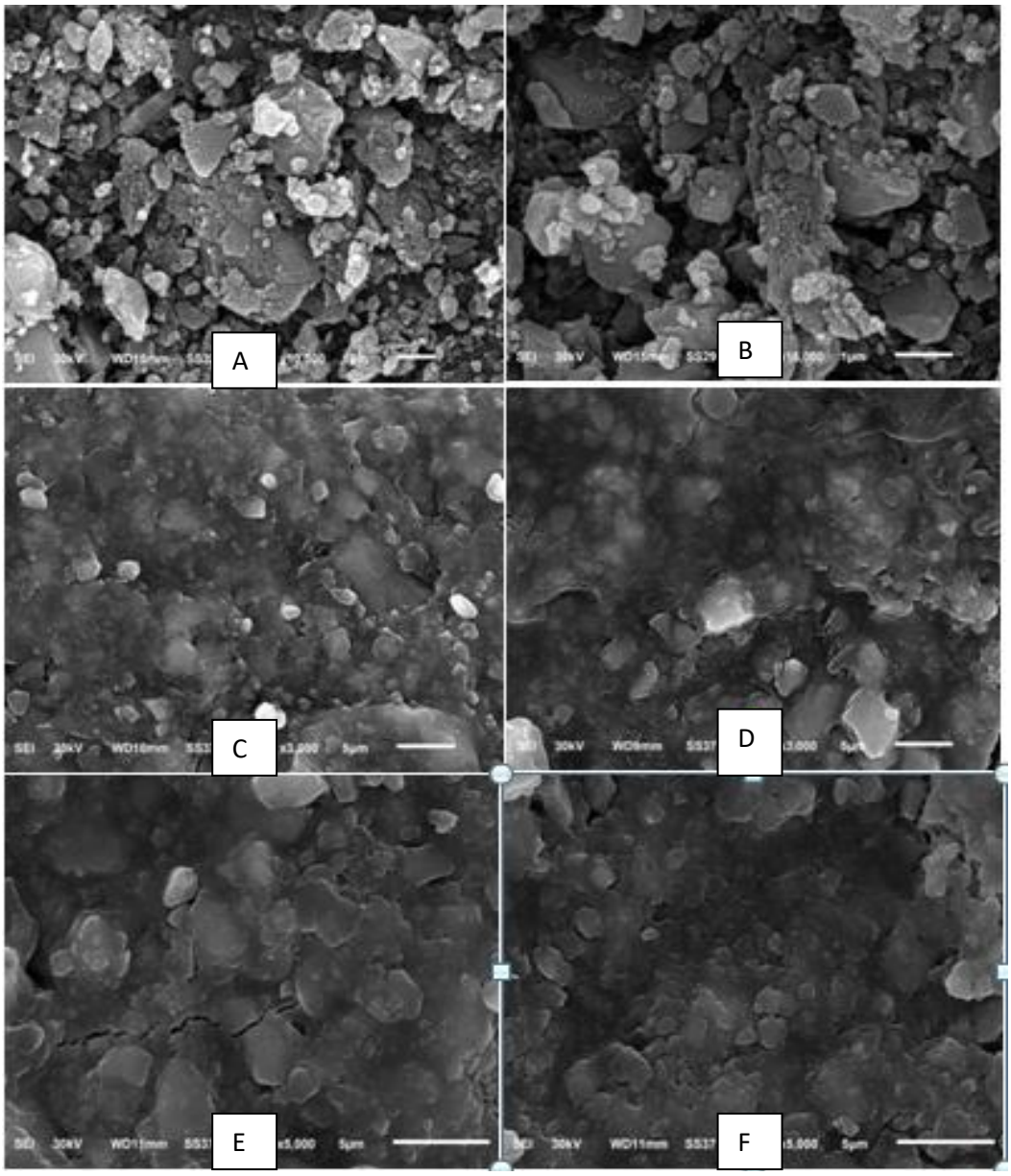

Figure 2: A& B: Scanning electron micrograph of precured powder of nanofilled composite resin at magnification 10, 15 kx respectively. C:Scanning electron micrograph of group I. D: Scanning electron micrograph of group II., E: Scanning electron micrograph of group III., F: Scanning electron micrograph of group IV.

g.Statistical Analysis

It was done via statistical package for the social sciences (SPSS) version 20. All data were performed by one-way ANOVA and Tukey"s HSD test for pairwise comparison with a significant factor of $\alpha = 0.05$.

III. RESULTS

Concerning wear test, Table 1 revealed that there was a significant difference among all groups, the highest value was for group I, while the lowest value was for group IV. For microhardness test, as illustrated in Table 2 there was a significant difference among all groups, the highest value was for group IV, while the lowest value was for group I. Concerning water sorption as shown in Table 3 there was a significant difference between all groups except between group III and group IV there was no significant difference, the highest value was for group I, while the lowest value was for group IV. For solubility as shown in Table 4 there was a significant difference among all groups, the highest value was for group I, while the lowest was for group IV.

IV. DISCUSSION

Wear is the loss of material resulting from the contact of two or more materials, while hardness is the resistance to scratching and indentation hardness.[12] The material with high hardness has lower wear giving high surface quality.[11] Wear can produce particles that can elicit an inflammatory response. The process of wear can also produce shape changes that can influence function.[12] Water sorption is the water amount adsorbed to the surface and absorbed into the material body, which can lead to an increase in the material volume as it can function as a plasticizer and lead to material structure deterioration as margin contours breakage and stains are observed that results in restoration failure.[13,14] Solubility is an additional factor of concern since it influences the biocompatibility, degradation rate and loss of integrity of margins affecting prognosis of restorations.[13,14] Consequently, water sorption and solubility results in dimensional changes that cause failure of the restoration.[14] In our study, micro hardness and wear has been increased by increasing precured nanofilled composite concentration in glass ionomer cement, this is in agreement with **Rahman et al**[15] who have concluded that the microhardness of nano hydroxyapetite silica glass ionmer cement using unlike formulations by wt % of SiO_2, hydroxyapetite silica nanocomposite addition improves the glass ionomer cement hardness.[15] **Moheet et al** have studied the mechanical properties of nano-hydroxyapatite-silica added glass ionomer cement and it was found that the addition of nano-HA-silica to conventional GIC significantly enhanced the mechanical properties of the material including surface hardness.[16] **Felemban and Ebrahim** have studied addition of silica fillers to resin modified glass ionomer cement to evaluate some mechanical and physical properties,[17] and it was revelaed that silica addition to resin modified glass ionomer cement have improved the mechanical properties and increase water sorption rates but reduced solubility.[17] In another study, Vickers hardness of GIC powder after incorporation of nano-zirconia-silica was tested ant it have found that Vickers hardness was improved at lower wt% (1–5%) and reduced as the concentration of the nano-Zr-Si-HA powder was increased in GIC powder. Highest Vickers hardness was for 5 wt % nano-Zr-Si-HA-added GIC.[18]

V. *CONCLUSIONS:*

As the concentration of precured nanofilled composite powder increased in glass ionomer cement, the microhardness have been increased while wear, water sorption and solubility have been decreased.

Conflict of Interest:

The authors declare no conflict of interest.

Funding:

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors

Table 1: Means and standard deviations (SD) of wear (g)

Subgroups	Mean	SD	F value
Group I	0.0935[a]	0.0016	867
Group II	0.0746[b]	0.0017	
Group III	0.0462[c]	0.0027	
Group IV	0.0350[d]	0.0019	

Means in one column with unsimilar superscript small letter are significantly different (P <0.05).

Table 2: Means and standard deviations (SD) of microhardness (HV)

Subgroups	Mean	SD	F value
Group I	34.22[a]	0.35	689
Group II	36.36[b]	0.25	
Group III	39.42[c]	0.33	
Group IV	42.32[d]	0.22	

Means in one column with unsimilar superscript small letter are significantly different (P <0.05).

Table 3: Means and standard deviations (SD) of watersorption (μg/mm^2)

Subgroups	Mean	SD	F value
Group I	0.0032[a]	0.0001	76
Group II	0.0029[b]	0.0001	
Group III	0.0024[c]	0.0001	
Group IV	0.0022[c]	0.0001	

Means in one column with unsimilar superscript small letter are significantly different (P <0.05).

Table 4: Means and standard deviations (SD) of solubility (μg/mm^2)

Subgroups	Mean	SD	F value
Group I	0.0024[a]	0.0002	71
Group II	0.0018[b]	0.0002	
Group III	0.0014[c]	0.0002	
Group IV	0.0008[d]	0.0001	

Means in one column with unsimilar superscript small letter are not significantly different (P >0.05).

VI. REFRENCES

1. Khurshid Z, Zafar M, Qasim S, Shahab S, Naseem M, AbuReqaiba A. Advances in nanotechnology for restorative dentistry. Materials 2015;8:717–31.
2. Najeeb S, Khurshid Z, Zafar MS, et al. Modifications in glass ionomer cements: nano-sized fillers and bioactive nanoce ramics. Int J MolSci2016;17:E1134
3. Ching HS, Luddin N, Kannan TP, Ab Rahman I, Abdul Ghani NR. Modification of glass ionomer cements on their physical-mechanical and antimicrobial properties. J Esthet Restor Dent 2018; 30: 557–571.
4. Berg JH, Croll TP. Glass ionomer restorative cement systems: an update. Pediatr Dent 2015;37:116–124.
5. Elsaka SE, Hamouda IM, Swain MV. Titanium dioxide nanoparticles addition to a conventional glass-ionomer restorative: influence on physical and antibacterial properties. J Dent 2011;39:589–598
6. Kobayashi M, Kon M, Asaoka K, Miyai K. Strengthening of glass-ionomer cement by compounding short glass-fibers. J Dent Res 2000;79:539–539.
7. Alatawi RA, Elsayed NH, Mohamed WS Influence of hydroxyapatite nano-particles on the properties of glass ionomer cement. J mater res technol.2019;8:344–349.
8. Menazea AA, Abdelghany, AM., Hakeem NA, Osman WH, & Abd El-kader FH. Precipitation of silver nanoparticles in borate glasses by 1064 nm Nd: YAG nanosecond laser pulses: characterization and dielectric studies. Journal of Electronic Materials. 2020;49:826-832.
9. Hammouda IM. Effect of light-curing method on wear and hardness ofcomposite resin. J Mech Behav Biomed Mater 2010; 3:216–22.
10. Gungor H, Gundogdu M, MAlkurt. Effect of polymerization cycles on flexural strengths and microhardness of different denture base materials. Dental Materials Journal 2017;36:168–173.
11. Gerdolle DA, Mortier E, Jacquot B, et al. Water sorption and water solubility of current luting cements: An in vitro study. Quintessence Int 2008;39;107–114.
12. Sakaguchi RL Ferracane J, Powers J. Craig's Restorative Dental Materials. 14th ed. St. Louis: Mosby Co.; 2019. p. 45.
13. Heshmat H, Banava S, Zarandi P, et al. In-vitro evaluation of watersorption and solubility of G-Cemand Fuji Cem in water and acid. J Islamic Dent Assoc Iran 2013;25;249–254.
14. Cattani-Lorente MA, Dupuis V, Payan J, et al. Effect of water on the physical properties of resin-modified glass ionomer cements. DentMater 1999;15:71–78.
15. Rahman IA, Masudi SAM, Luddin N, Shiekh RA. One-pot synthesis of hydroxyapatite–silica nanopowder composite for hardness enhancement of glass ionomer cement (GIC) Bull Mater Sci2014;37:213–219
16. Moheet IA, Luddin N, Ab Rahman I, Masudi SaM, Kannan TP, AbdGhani NR. Evaluation of mechanical properties and bond strength of nano-hydroxyapatite-silica added glass ionomer cement. Ceram Int 2018;44: 9899–9906.
17. Felemban NH, Ebrahim MI. Effects of adding silica particles on certain properties of resin-modified glass-ionomer cement. Eur J Dent 2016;10:225–229 .
18. Rahman I, Ghazali NAM, Bakar WZ, Masudi SM. Modification of glass ionomer cement by incorporating nanozirconia-hydroxyapatite-silica nano-powder composite by the one-pot technique for hardness and aesthetics improvement. Ceram Int 2017;43:13247–13253.