ORIGINAL ARTICLE

Effect of varnish coating agent application on surface hardness of glass ionomer cement after immersion in carbonated drinks

Natasya Arsanti[1]
Aryo Megantoro[1]
Ratna Meidyawati[1]

[1]Department of Conservative Dentistry, Faculty of Dentistry Universitas Indonesia

* Correspondence:
aryo.megantoro02@ui.ac.id

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ABSTRACT

Introduction: Glass ionomer cement is a material for treating dental caries. The disadvantage of glass ionomer cement is that if it comes into contact with acids before maturation, there will be a decrease in mechanical properties which is indicated by a decrease in surface hardness. Surface hardness has a relationship with aesthetics and resistance to scratches that can cause fractures. Coating agents like varnishes are required for glass ionomer cement to protect them from liquids with low pH level, such as carbonated drinks. Unfortunately many dentists neglected this procedure. The purpose of this research was to analyze effect of coating agent application on surface hardness of glass ionomer cement immersion in carbonated drinks. **Methods:** This research was a laboratory experimental study. Samples consist of 24 glass ionomer cement specimens (GC Fuji IX GP EXTRA). Glass ionomer cement specimens were divided into 4 treatment groups. The first group was not applied with varnish and stored without immersion, the second group was applied with varnish and stored in artificial saliva, the third group was applied with varnish and soaked in carbonated drinks, and the last group was not applied with varnish and was immersed in carbonated drinks. The data that has been collected was processed and analyzed using the computer-based application IBM SPSS Statistics version 23.0. **Results:** There was a significant increase in the surface hardness of glass ionomer cement in all treatment groups. There was a significant difference in the mean surface hardness of glass ionomer cement after immersion in carbonated drinks between the groups that were applied with varnish coating agent and that without application of varnish coating agent. **Conclusion:** The surface hardness of glass ionomer cement restoration which was applied with varnish coating agent has a higher value compared to those not applied with varnish coating agent after immersion on carbonated drinks.

KEYWORDS
carbonated drinks, glass ionomer cement, microhardness test; saliva, varnish coating agent

INTRODUCTION

Glass ionomer cement is a restorative material used in the treatment of dental caries to repair teeth and improve its aesthetics.[1] This material has the advantage that it can bind chemically with dental tissue, is cariostatic, and does not require additional tools such as a light curing unit.[2] However, the disadvantages of glass ionomer cement are that they are less aesthetically pleasing, brittle, and susceptible to solubility.[2] Moisture contamination prior to maturation of the glass ionomer cement will lead to solubility, decreased mechanical and aesthetic properties, and decreased bond strength with the tooth structure.[2,3] Meanwhile, if the glass ionomer cement is dehydrated before maturation, the restoration will change color and form cracks.[1,2] Therefore, coating agent protection is needed to reduce the effects of moisture contamination and dehydration of the restoration during its maturation.[1,2] Maturation of the glass ionomer cement can take up to 7 days with the highest solubility in the first 24 hours.[3]

Contact with acids or acidic solutions prior to maturation of the glass ionomer cement will also cause a decrease in mechanical properties.[4] This acid can be derived from intrinsic factors, like repeated vomiting in patients with bulimia nervosa, GERD, and alcoholics.[5] Extrinsic factors such as consumption of acidic foods and drinks and use of acidic drugs can also cause acidity in the oral cavity.[5,6] Carbonated drinks are one of the ready-to-drink soft drinks that are acidic with a pH of less than 4.[7,8] Globally, this carbonated drink has been consumed by more than 200 million liters in 2013.[9] Another data in Indonesia from Balitbangkes 2014 itself shows in 2014, total consumption of carbonated drinks reach 944 million litres.[10] Riskesdas 2018 also show high percentage of people consuming carbonated drinks that reach more than 80%.[11]

The acidity of the oral cavity due to consumption of acidic drinks can be neutralized by the buffer capacity 1-3 minutes after drinking of acidic drinks.[12,13] However, continuous exposure to acids will cause restoration damage characterized by increased roughness and decreased surface hardness.[3,14,15] A decrease in the surface hardness of the restoration can lead to the formation of cracks which can lead to premature failure of the glass ionomer cement.[15] Therefore, the use of coating agents, like varnishes, emollients, or resins is important to protect glass ionomer cement from acids.[4,16] Tyagi et al[17], states that varnish is the most superior coating agent material in terms

of cost with better protection capabilities than emollients and and has the same protection capability as resin at a higher price. Unfortunately many dentists neglected this procedure. The purpose of this research was to analyze effect of coating agent application on surface hardness of glass ionomer cement immersion in carbonated drinks.

METHODS

This research was a laboratory experimental study at the Dental Materials Research and Development Laboratory, Faculty of Dentistry, Universitas Indonesia. Samples consisting of 24 glass ionomer cement specimens (GC Fuji IX GP EXTRA) filled in a mold with a diameter of 6 mm and a depth of 3 mm were used as research samples. There are four treatment groups in this study.[18] Six specimens of glass ionomer cement were used in each treatment group.

Petroleum jelly was applied to the inside of the mold.[19] Glass ionomer cement was manipulated according to the manufacturer's instructions using High Speed Mixer HSM3 for 10 seconds, then placed into the mold with capsule applier.[17,18,20] The restoration was covered with a mylar strip, a glass preparation, and a 200 g load for 7 minutes to ensure the initial hardening.[17,20,21] Excess material was removed using scalpel and blade.[17]

The specimens were divided into 4 treatment groups. Group A was not applied with varnish coating agent and was not immersed in artificial saliva or carbonated drinks. Group B was applied with a varnish (TehnoDent GlassyCem Final Varnish) then immersed in artificial saliva during the research. Group C was applied with a varnish, then immersed in carbonated drinks and artificial saliva. Group D was not applied with a varnish, then it will be immersed in carbonated drinks and artificial saliva.

The varnish coating agent was applied to groups B and C by micro brushing the entire surface of the glass ionomer cement, then gently drying it using a chip blower.[17] The specimens were then kept from moisture contamination for 2-3 minutes.[22] Immersion in artificial saliva, Specimens in group A were stored without immersion for 24 hours. Specimens in groups B, C, and D were immersed in artificial saliva for 24 hours.[23] Initial surface hardness test, After 24 hours, each specimen from all groups was measured for surface hardness using a Vickers hardness test for 5 indentations with a minimum distance of 100 µm.[24,25] The load given was 300 gf for 15 seconds.[26] The results of surface hardness were recorded and averaged.[26]

Specimens in group A were stored for 7 days without immersion in artificial saliva and carbonated drinks. Specimens in group B were immersed in artificial saliva for 7 days. The artificial saliva used in group B was changed every day.[27] Specimens in groups C and D were immersed in a carbonated drink (Coca-Cola® Classic) with a pH of 2.37 for 5 minutes.[27,28] Immersion of the specimens in groups C and D was carried out 3 times a day with intervals of 4 hours.[27] The immersion cycle of group C and D in carbonated drinks was repeated for 7 days.[27] Specimens of groups C and D were stored in artificial saliva while not being immersed in carbonated drinks.[27,4] Each specimen was rinsed using distilled water for 120 seconds after immersion.[26]

After 7 days, each specimen was measured for surface hardness using a Vickers hardness test for 5 indentations with a minimum distance of 100 µm.[24,25] The load given was 300 gf for 15 seconds. The results of surface hardness were recorded and averaged.[26]

The data that has been collected was processed and analyzed using the computer-based application IBM SPSS Statistics version 23.0. The One Way ANOVA statistical test with the Post Hoc Bonferroni test was used to see the comparison of the mean surface hardness of glass ionomer cement after 7 days of treatment among all treatment groups. The Paired t-test statistical test was used to see the comparison of the mean surface hardness of glass ionomer cement before and after treatment for 7 days in all treatment groups.

RESULTS

In this study, all treated groups experienced increased surface hardness of glass ionomer cement. In the group without varnish coating agent and without immersion, there was an increase in surface hardness of 15.94 VHN. In the group with the application of varnish coating agent and immersed in artificial saliva, the hardness increase was 9.32 VHN. Whereas in the group that was applied with varnish coating agent and immersed in carbonated drinks and artificial saliva, the surface hardness increased by 9.22 VHN. In the group without varnish coating agent and immersed in carbonated drinks and artificial saliva, the increase in surface hardness was 4.11 VHN.

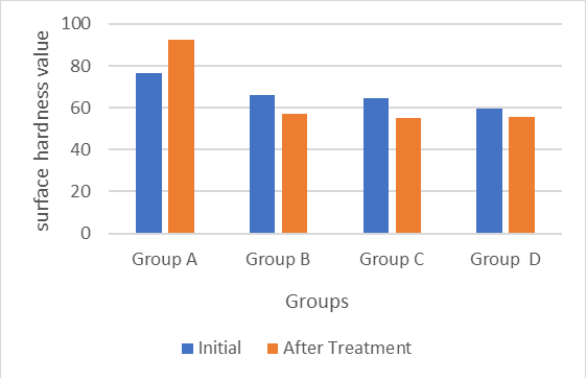

Figure 1. Diagram of the mean surface hardness value of glass ionomer cement initial and after treatment

The surface hardness value of glass ionomer cement before and after treatment in this study can be seen in Figure 1 and Table 1

Table 1. Surface hardness value of glass ionomer cement initial and after treatment

Treatment Group	Mean surface hardness value (VHN) ± SD	
	Initial	After Treatment
A. Without varnish coating agent and without immersion	76.73 ± 1.99	92.67 ± 1.25
B. Varnish coating agent and immersed in artificial saliva	56.97 ± 2.49	66.29 ± 1.68
C. Varnish coating agent and immersed in carbonated drinks and artificial saliva	55.25 ± 2.62	64.47 ± 1.85
D. Without varnish coating agent and immersed in carbonated drinks and artificial saliva	55,54 ± 2,08	59,65 ± 2,77

The increase in surface hardness of glass ionomer cement before and after treatment in all groups had a significant difference based on the results of the Paired t-test statistical test ($p < 0.05$). The results of the Paired t-test statistical test can be seen in Table 2.

Table 2. Comparison of surface hardness values of initial and after treatment glass ionomer cements

Treatment group	Mean surface hardness value (VHN)		p-value
	Initial	After treatment	
A	76.73 (1.99)	92.67 (1.25)	0.001*
B	56.97 (2.49)	66.29 (1.68)	0.001*
C	55.25 (2.62)	64.47 (1.85)	0.001*
D	55.54 (2.08)	59.65 (2.77)	0.015*

*One Way ANOVA ($p < 0.05$ - Statistically significant)

The result of the One Way ANOVA statistical test is that there is a significant difference in the mean surface hardness value of glass ionomer cement after treatment ($p < 0.05$). The results of the One Way ANOVA statistical test can be seen in Table 3.

Table 3. Comparison of mean surface hardness value of glass ionomer cement after treatment of all groups

Treatment Group	Mean (SD)	p-value
A (n=6)	92.67 (1.25)	0.001*
B (n=6)	66.29 (1.68)	
C (n=6)	64.47 (1.85)	
D (n=6)	59.65 (2.77)	

*One Way ANOVA ($p < 0.05$ - Statistically significant)

Based on the Post Hoc Bonferroni statistical test, it shows that there is a significant difference in the mean surface hardness value of glass ionomer cement after treatment, between groups A and B, groups A and C, groups A and D, groups B and D, and groups C and D (p. <0.05). Meanwhile, there was no significant difference in the mean surface hardness value of glass ionomer cement after treatment between groups B and C. The results of the Post Hoc Bonferroni statistical test can be seen in Table 4.

Table 4. Comparison of average surface hardness value of glass ionomer cement after inter-group treatment

Treatment group	p-value
A - B	0.001*
A - C	0.001*
A - D	0.001*
B - C	0.759
B - D	0.001*
C - D	0.002*

*One Way ANOVA (p <0.05 - Statistically significant)

DISCUSSION

The results showed that there was a significant increase in surface hardness values in all treatment groups (table 1). One of the causes of this increase is the maturation process.[12] The cross-linking reaction forms a salt bridge, produces gelation, releases fluoride byproducts, causes hardening, and increases the strength of the restoration over time.[15] The periodic increase in the hardness of glass ionomer cement is in accordance with the study of Moshaverinia, et al[29] which tested the surface hardness of the restoration 24 hours after filling and after 7 days of immersion in distilled water. The hardness of the restoration increased from 40.59 (1.2) VHN to 46.89 (1.01) VHN.[29]

The initial surface hardness value of glass ionomer cement in this study (table 2) is in accordance with research conducted by Soliman, et al.[30] The results of this study indicate that the initial hardness value of glass ionomer cement which is not protected by a coating agent after 24 hours of immersion in distilled water is 55.74 ± 3.7 VHN.[30] Meanwhile, the initial hardness value of glass ionomer cement with coating agent after soaking for 24 hours in distilled water was 53.00 ± 4.19 VHN.[30]

The group without varnish coating agent and without immersion experienced a significant increase in surface hardness of 15.94 VHN from 76.73 VHN to 92.67 VHN (table 2) due to the absence of liquid contamination, namely immersion with artificial saliva or carbonated drinks. This result is in accordance with study of Kamatham that stated liquid contamination before maturation will cause a decrease in the mechanical properties of glass ionomer cement.[31] A decrease in the mechanical properties of glass ionomer cement restorations can be characterized by a reduction in surface hardness.[13] This could be the cause of the initial and after-treatment surface hardness test results on the glass ionomer cement specimens of this group having the highest value compared to other groups.

Artificial saliva in this study has a role in increasing the surface hardness of glass ionomer cement.[32] However, initial contact with artificial saliva will dissolve ions, increase restoration roughness, imbibition, and decrease aesthetics.[33] In addition, there can also be a decrease in the mechanical properties of the restoration due to fluid contamination before maturation of the glass ionomer cement.[31] This could be the cause of the lower initial and after-treatment surface hardness test results on the glass ionomer cement specimens in the immersed group compared to the non-immersed group.

The varnish coating agent in this study has an important role in maintaining the surface hardness of the glass ionomer cement because it can protect the outer surface of the restoration[4]. In addition, varnish coating agents can also protect glass ionomer cement from liquid contamination and dehydration.[3] The group with the application of varnish coating agent and immersed in artificial saliva experienced a significant increase in surface hardness of 9.32 VHN from 56.97 VHN to 66.29 VHN. The group that was applied with a varnish coating agent and immersed in carbonated drinks and artificial saliva also experienced a significant increase in surface hardness of 9.22 VHN from 55.25 VHN to 64.47 VHN. This is in accordance with the results of research by Shintome, *et al*[24], namely the group with the application of the varnish coating agent has a higher surface hardness value than the unprotected varnish coating agent after immersing in the liquid (aquades) for 30 days.

The group without application of varnish coating agent and immersed in carbonated drinks and artificial saliva showed a significant increase in surface hardness of the restoration but not as large as the other groups. This increase was 4.11 VHN from 55.54 VHN to 59.65 VHN. In this group, there was no layer that protects it from acids of carbonated drinks. Contact with acids when the glass ionomer cement has not reached the maturation stage will cause a decrease in the mechanical properties of the restoration.[4] This is in accordance with Bajwa's, et al[27] research regarding the surface hardness of various types of aesthetic restorations after immersing in cola. Bajwa's, *et al*[27] obtained results that the glass ionomer cement restoration immersed in cola had a significantly lower surface hardness value compared to the group immersed in artificial saliva. Contact with acids without protection of varnish coating agent caused the increase in surface hardness of glass ionomer cement in this group was the smallest compared to other treatment groups.

The increase in hardness of specimens in the group without the application of varnish coating agent and immersed in carbonated drinks and artificial saliva can be caused by the buffering capacity of the artificial saliva. The buffer capacity of saliva plays an important role in neutralizing acids due to consumption of acidic drinks.[12] Because of the artificial saliva buffer capacity, there was no decrease in the surface hardness of the glass ionomer cement in the specimens of this group. In this study, artificial saliva "Fusayama formula" with a pH of 6.7 was used as an immersion medium.[27]

The results of the One Way ANOVA statistical test with Post Hoc Bonferroni showed that there was a significant difference in the mean surface hardness value of glass ionomer cement after treatment among almost all treatment groups (table 4). The group that did not show a significant difference was the value of surface hardness after treatment between the group applied varnish coating agent and immersed in artificial saliva and the group applied with varnish coating agent and immersed in carbonated drinks and artificial saliva. Based on the results of this statistical test, it can be seen that the ability of the varnish coating agent to protect the glass ionomer cement restoration from acids so that the surface hardness value after treatment in the group that immersed in artificial saliva does not have a significant difference with that immersed in carbonated drinks.

The high value of surface hardness after treatment in the group A compared to other groups could be caused by no moisture contamination of the group without immersion (table 4). Whereas the high value of surface hardness after treatment in group B compared to group D was caused by immersion of carbonated drinks in the group without varnish coating agent protection. Another reason for the high value is because the immersion by artificial saliva in the group with protection of varnish coating agent. Then the surface hardness value after treatment in group C was higher because the varnish coating agent protected from the moisture and stabilized the physical properties compared to group D.

CONCLUSION

The surface hardness of glass ionomer cement restoration which was applied with varnish coating agent has a higher value compared to those not applied with varnish coating agent after immersion on carbonated drinks.

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REFERENCES

1. Anusavice K, Shen C, Rawls H. Phillips' Science of Dental Materials. 12th ed. Saunders. St. Louis: Elsevier; 2013. p. 3, 63–65, 307–308, 320–321, 323.
2. Bonsor S, Pearson G. A clinical guide to applied dental materials. 1st ed. St. Louis: Elsevier Ltd; 2013. p. 286–287, 293–300, 311, 316, 318, 324–5.
3. van Noort R, Barbour ME. Introduction to Dental Materials. 4th ed. Materials in Restorative Dentistry. St. Louis: Elsevier Ltd; 2013. p. 95, 97–103.
4. Ismayanti D, Triaminingsih S, Eriwati YK. The effect of salivary pH on diametral tensile strength of resin modified glass ionomer cement coated with coating agent. J Phys Conf Ser. 2017; 884(1). DOI: 10.1088/1742-6596/884/1/012073
5. Kanzow P, Wegehaupt FJ, Attin T, Wiegand A. Etiology and pathogenesis of dental erosion. Quintessence Int (Berl). 2016; 47(4): 275–8. DOI: 10.3290/j.qi.a35625.
6. Mount GJ, Hume WR, Ngo HC, Wolff MS, editors. Preservation and restoration of tooth structure. 3rd ed. Oxford: John Wiley & Sons Limited; 2016. p. 7–11, 14–15, 44, 141.
7. Ashurst PR. Carbonated Beverages. Reference Module in Food Sciences. Elsevier; 2016. DOI: 10.1016/B978-0-08-100596-5.03240-6 1.
8. Caballero B, Finglas P, Toldrá F. Encyclopedia of Food and Health. Encyclopedia of Food and Health. 2015. p. 2.
9. Abu-Reidah IM. Carbonated beverages. Trends in Non-Alcoholic Beverages. Elsevier Inc.; ISBN 978-0-12-816938-4 2020. p. 1. DOI: 10.1016/C2018-0-01759-4
10. Balitbangkes. Buku Studi Diet Total: Survei Konsumsi Makanan Individu Indonesia 2014. (Trihono, Atmarita, Abas Basuni Jahari DK, ed.). Jakarta: Badan Penelitian dan Pengembangan Kesehatan Kemenkes RI; 2014. p. 1.
11. Kemenkes RI. Laporan Riskesdas 2018. Jakarta; 2018. p.1
12. Torres CRG, editor. Modern Operative Dentistry. 1st ed. São Paulo: Springer Nature Switzerland; 2020. p. 81–2, 309.
13. Xavier AM, Sunny SM, Rai K, Hegde AM. Repeated exposure of acidic beverages on esthetic restorative materials: An in-vitro surface microhardness study. J Clin Exp Dent. 2016; 8(3): e312-7. DOI: 10.4317/jced.52906
14. Adusumilli H, Avula JS, Kakarla P, Bandi S, Mallela GM, Vallabhaneni K. Color stability of esthetic restorative materials used in pediatric dentistry: An in vitro study. J Indian Soc Pedod Prev Dent. 2016; 34(3): 233-7. DOI: 10.4103/0970-4388.186740
15. Sakaguchi R, Ferracane J, Powers J, editors. Craig's Restorative Dental Materials. 14th ed. St. Louis: Elsevier Inc.; 2019. 75–77, 156, 161 p.
16. Kishore G, Sai-Sankar AJ, Pratap-Gowd M, Sridhar M, Pranitha K, Sai-Krishna VS. Comparative evaluation of fluoride releasing ability of various restorative materials after the application of surface coating agents - an in-vitro study. J Clin Diagn Res. 2016; 10(12): ZC38-ZC41. DOI: 10.7860/JCDR/2016/21980.9047
17. Tyagi S, Thomas AM, Sinnappah-Kang ND. A comparative evaluation of resin- and varnish-based surface protective agents on glass ionomer cement - a spectrophotometric analysis. Biomater Investig Dent. 2020; 7(1): 25-30. DOI: 10.1080/26415275.2020.1711760
18. Handoko MW, Tjandrawinata R. Pengaruh Nanofilled Resin Coating terhadap Kekasaran Permukaan Semen Ionomer Kaca. J Mater Kedokt Gigi. 2019; 8(1): 7. DOI: 10.32793/jmkg.v8i1.362
19. Bhatia HP, Singh S, Sood S, Sharma N. A Comparative Evaluation of Sorption, Solubility, and Compressive Strength of Three Different Glass Ionomer Cements in Artificial Saliva: An in vitro Study. Int J Clin Pediatr Dent. 2017; 10(1): 49-54. DOI: 10.5005/jp-journals-10005-1407.
20. Ryu W, Park H, Lee J, Seo H. Effect of Nano-filled Protective Coating on Microhardness and Wear Resistance of Glass-ionomer Cements. J Korean Acad Pedtatric Dent. 2019; 46(2): 226–32. DOI: 10.5933/JKAPD.2019.46.2.226

21. Nadia AA, Eriwati YK, Damiyanti M. The effect of CPP-ACP paste on the surface hardness of glass ionomer cement when immersed in orange juice. J Phys Conf Ser. 2017; 884(1). DOI: 10.1088/1742-6596/884/1/012004
22. Klaisiri A, Krajangta N, Yang L. Effect of Different Surface Protection Materials on Microhardness of a Resin- Modified Glass-Ionomer Cement. Songklanakarin Dent J. 2018; 6(2): 12–9.
23. Firdausy MD. Surface Deterioration of Gic Type Ii Based on Its Expiration Date After Immersion in Carbonated Drink. ODONTO Dent J. 2019; 6(2): 99. DOI: 10.30659/odj.6.2.99-106
24. Jose A, Thomas AM. A Comparative Evaluation of the Microhardness of Glass Ionomer Cements Modified with Chitosan and Chlorhexidine. J Int Oral Heal. 2019; 11(6):376–83. DOI: 10.4103/jioh.jioh_68_19
25. Dionysopoulos D, Tolidis K, Sfeikos T, Karanasiou C, Parisi X. Evaluation of Surface Microhardness and Abrasion Resistance of Two Dental Glass Ionomer Cement Materials after Radiant Heat Treatment. Adv Mater Sci Eng. 2017; 2017. DOI: 10.1155/2017/5824562
26. Abdel Hamid DM, Mahmoud GM, El-Sharkawy FM, Abou Auf EA. Effect of surface protection, staining beverages and aging on the color stability and hardness of recently introduced uncoated glass ionomer restorative material. Futur Dent J. 2018; 4(2): 288–96.
27. Bajwa N, Pathak A, Jingarwar M. Quantitative assessment of surface microhardness of esthetic restorative materials after exposure to different immersion regimes in a cola drink: An in vitro study. Saint's Int Dent J. 2016; 2(1): 11. DOI: 10.4103/2454-3160.202122
28. Reddy A, Norris DF, Momeni SS, Waldo B, Ruby JD. The pH of beverages in the United States. J Am Dent Assoc. 2016; 147(4): 255-63. DOI: 10.1016/j.adaj.2015.10.019.
29. Moshaverinia M, Borzabadi-Farahani A, Sameni A, Moshaverinia A, Ansari S. Effects of incorporation of nano-fluorapatite particles on microhardness, fluoride releasing properties, and biocompatibility of a conventional glass ionomer cement (GIC). Dent Mater J. 2016; 35(5): 817-21. DOI: 10.4012/dmj.2015-437
30. Soliman TA, Othman MS. Mechanical Properties Of The New Ketac™ Universal Glass Ionomer Restorative Material: Effect Of Resin Coating. Egypt Dent J. 2017;63(1):1027–35. DOI: 10.21608/edj.2017.75257
31. Kamatham R, Reddy S. Surface coatings on glass ionomer restorations in Pediatric dentistry-Worthy or not. J Indian Soc Pedod Prev Dent. 2013;31(4):229–33. DOI: 10.4103/0970-4388.121818.
32. Okada K, Tosaki S, Hirota K, Hume WR. Surface hardness change of restorative filling materials stored in saliva. Dent Mater. 2001;17(1):34–9. DOI: 10.1016/s0109-5641(00)00053-1.
33. Shidu SK, editor. Glass Ionomers in Dentistry. 1st Ed. London: Springer International Publishing Switzerland; 2016. p. 16–17, 34, 37.
34. Shintome LK, Nagayassu MP, Di Nicoló R, Myaki SI. Microhardness of glass ionomer cements indicated for the ART technique according to surface protection treatment and storage time. Braz Oral Res. 2019;23(4):439–45.