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In vitro comparison of color stability of resin-modified glass ionomer and Cention N bioactive restorative material

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ABSTRACT

Background: This study compared the color stability of resin-modified glass ionomer (RMGI) and Cention N bioactive restorative material following exposure to different coloring solutions.
Materials and Methods: In this *in vitro* experimental study, 12 specimens were fabricated from Cention N and Fuji II LC RMGI and immersed in Turkish coffee, Nescafe, cola, and distilled water as control (n = 3). The color parameters of the specimens were measured after 1, 7, and 28 days of immersion in the respective solutions, and their color change (ΔE) was calculated. Data were analyzed using repeated measures ANOVA Friedman test and two-way ANOVA (alpha = 0.05).
Results: On day 1, the highest and lowest ΔE values were noted in Cention N specimens immersed in Nescafe and Cention N specimens immersed in cola, respectively. On days 7 and 28, the highest and lowest ΔE values were found in RMGI specimens immersed in Nescafe and Cention N specimens immersed in cola, respectively. The effects of the type of material and type of coloring solution and their interaction effect on ΔE of specimens at different time points were statistically significant (P < 0.05).
Conclusion: Within the limitations of this *in vitro* study, the results showed that Fuji II LC RMGI had lower color stability than Cention N in the long term. Nescafe caused the greatest discoloration in Fuji II LC, while Turkish coffee caused the greatest discoloration in Cention N specimens.

Key Words: Bioactive, Cention N, glass ionomer, restorative material

INTRODUCTION

Optimal esthetics is an essential property of dental restorative materials. Thus, tooth-colored restorative materials, such as composite resins, have increased in popularity.[1]

Color stability is a multifactorial parameter that plays a fundamental role in the clinical success of direct tooth-colored restorations.[2] Discoloration of restorations often causes patient dissatisfaction and necessitates restoration replacement, which involves additional costs and further removal of tooth structure.[3] Superficial discoloration of tooth-colored restorations is a major reason for their replacement and may occur due to intrinsic factors related to the composition of restorative materials or extrinsic factors related to the absorption of pigments and staining from foods and drinks. Even the most recent types of composite resins have greater water

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sorption than ceramics due to the resinous nature of their matrix and making them more susceptible to discoloration and staining. [4,5]

Considering the growing use of resin-based dental restorative materials due to their improved esthetics and formulation, easy application, and bonding ability to tooth structure,[6] different tooth-colored direct restorative materials with variable physical and mechanical properties are currently available in the market, including composite resins and glass ionomers (GIs).[7]

Resin-modified GI (RMGI) was developed by the addition of bisphenol A glycidyl dimethacrylate or urethane dimethacrylate and photoinitiators to the conventional GI. Its liquid contains an aqueous solution of polyacrylic acid and hydroxyethyl methacrylate.[8,9] RMGIs have improved properties compared with conventional GI cement but have slightly lower fluoride release.[10,11]

Recently, Ivoclar Vivadent introduced a novel tooth-colored restorative material, namely Cention N, to the market for application in direct restorations with or without an adhesive system. It is radiopaque and is available in A2 shade.[12,13] Its manufacturer claims that it provides excellent esthetics and high strength.[14] Cention N is an alkasite, which is a novel subgroup of composite resins with alkaline fillers, which can release acid-neutralizing ions such as calcium, hydroxide, and fluoride.[13,15,16] It can be used as a bulk-fill restorative material.[17] Cention N contains 78.4% mineral fillers, and its alkaline glass accounts for 24.6% of the final weight of the material, resulting in the release of fluoride, calcium, and hydroxide ions, which can prevent demineralization of the tooth structure in the long term.[18]

Despite the advances in the formulation of restorative materials, their color stability in the dynamic oral environment remains a challenge.[19] The effects of different coloring solutions on the color stability of GI have been the topic of several investigations.[20-23] It has been demonstrated that different coloring foods and drinks can cause discoloration of GI and RMGI and adversely affect their gloss.[22,23] Considering the existing concerns regarding the color stability of fluoride-releasing restorative materials over time[24] and insufficient knowledge about the color stability of bioactive materials such as Cention N, this study aimed to compare the color stability of RMGI and Cention N bioactive restorative material following exposure to different coloring solutions. The null hypothesis of the study was that the color stability of RMGI and Cention N would not be significantly different following exposure to different coloring solutions.

MATERIALS AND METHODS

This *in vitro* experimental study was conducted on specimens of Cention N (Ivoclar Vivadent, Liechtenstein, Switzerland) and RMGI (GC, Tokyo, Japan). The protocol of the study was approved by the university's ethics committee: IR.ARAKMU.REC.1401.159.

Sample size

The sample size was calculated to be 10 specimens in each group based on a previous study,[25] assuming the mean color change (ΔE) of RMGI to be 0.46, a 95% confidence interval, and a study power of 80%, using Stata Corp LLC, College Station, TX, USA.

To round up, 12 specimens were fabricated from each material for immersion, allowing for 3 specimens in each coloring solution.

Specimen preparation

Cylindrical Teflon molds with a diameter of 6 mm and a height of 3 mm were used for fabricating the specimens. The materials were applied incrementally into the molds. For this purpose, a thin layer of the respective restorative material was initially applied to the mold, compressed with a plastic spatula and light-cured (O-Light, DTE, China) at a light intensity of 2300–2500 mW/cm² from a distance of 1 mm for 20 s. Subsequent layers were applied in the same manner. A glass slab was then placed over the mold to standardize the surface of the specimens.[26] The slab was then removed, and the final increment was light-cured. The specimens were subsequently removed from the molds, and their surfaces were polished using Sof-Lex polishing discs (3M ESPE, St. Paul, MN, USA). They were then coded and stored in distilled water at 37°C for 24 h.

Baseline color assessment

The specimens underwent color assessment using spectrophotometer (Minolta CR; Minolta Co., Osaka, Japan), and their L* (lightness), a* (redness), and b* (yellowness) values were recorded according to the CIE L*a*b* color space.

Immersion in coloring solutions

In each group, the specimens were randomly assigned to four subgroups for immersion in Turkish

coffee (Pendar, Iran), Nescafe (Nestlé), cola (Pendar, Iran), and distilled water as a control (Sabalan, Iran) (n = 3). To standardize the Turkish coffee and Nescafe as aging media, 5 g of the respective powder was dissolved in 100 mL of boiling distilled water according to the manufacturers' instructions. The mixtures were removed from the heat after 3 min and allowed to cool. The specimens were immersed in the respective solutions and underwent color assessment again after 1, 7, and 28 days of immersion.

Secondary color assessment

The specimens were immersed in a cleansing solution composed of 10 mL of soap and 700 mL of distilled water and then rinsed under tap water. Subsequently, they were soaked in distilled water for 1 min. Excess moisture was removed from the surface of the specimens with a paper towel, and they underwent color assessment again after 1, 7, and 28 days, as explained earlier. After measuring the color parameters, the changes in L* (ΔL), a* (Δa), and b* (Δb) were calculated at each time point. The a* parameter indicates redness and greenness; positive values signify a shift toward redness, while negative values indicate a shift toward greenness. The b* parameter indicates blueness and yellowness; positive values signify yellowness, while negative values indicate blueness. The L* parameter indicates lightness and can range from 0 (black) to 100 (white)[27]. The ΔE was calculated using the following formula:

$$\Delta E^*_{ab} = ([\Delta L^*]^2 + [\Delta a^*]^2 + [\Delta b^*]^2)1/2$$

Statistical analysis

Repeated measures ANOVA (for normally distributed data) and the Friedman test (for nonnormally distributed data) were used to analyze the mean Δ E over time based on the type of restorative material and the type of solution. Two-way ANOVA was employed to compare Δ E according to the type of material and type of solution at each time point. All statistical analyses were carried out using SPSS version 24 (SPSS Inc., IL, USA) with a 95% confidence interval.

RESULTS

Day 1

On day 1, the highest Δ E was observed in Cention N specimens immersed in Nescafe, while the lowest Δ E was recorded for Cention N specimens immersed in cola [Table 1]. The mean Δ E of Cention N specimens was greater than that of RMGI specimens. ANOVA revealed that the effects of material type (P = 0.718) and coloring solution (P = 0.830) on ΔE were not significant. However, their interaction effect was significant (P = 0.037), indicating that the two materials exhibited different ΔE values after immersion in different coloring solutions for 1 day.

Day 7

On day 7, the highest Δ E was observed in RMGI specimens immersed in Nescafe, while the lowest ΔE was recorded for Cention N specimens immersed in cola. In addition, the mean ΔE of RMGI specimens was greater than that of Cention N specimens [Table 2]. ANOVA revealed significant effects of material type (P = 0.048) and coloring solution (P = 0.001) on Δ E; however, their interaction effect on ΔE was not significant (P = 0.109).

Pairwise comparisons of the effects of coloring solutions on ΔE on day 7 [Table 3] revealed that

Table 1: Mean ΔE of Cention N and resin-modified glass ionomer specimens in different coloring solutions on day 1 (n=3)

Material	Coloring solution	Mean ΔE	SD of ΔE
Cention N	Distilled water	4.05	1.00
	Turkish coffee	7.14	3.77
	Cola	3.26	0.44
	Nescafe	8.59	2.96
	Total	5.76	3.10
RMGI	Distilled water	6.63	0.50
	Turkish coffee	4.19	3.65
	Cola	6.66	2.70
	Nescafe	4.01	2.83
	Total	5.37	2.65

RMGI: Resin-modified glass ionomer; SD: Standard deviation

Table 2: Mean ΔE of Cention N and resin-modified glass ionomer specimens in different coloring solutions on day 7 (n=3)

Material	Coloring solution	Mean ΔE	SD of ΔE
Cention N	Distilled water	3.94	0.94
	Turkish coffee	16.01	0.99
	Cola	4.41	0.97
	Nescafe	9.89	1.71
	Total	8.56	5.21
RMGI	Distilled water	5.47	1.96
	Turkish coffee	13.51	1.57
	Cola	10.43	4.91
	Nescafe	18.46	9.24
	Total	11.97	6.74

RMGI: Resin-modified glass ionomer; SD: Standard deviation

Nescafe caused a significantly greater ΔE than cola ($P = 0.03$) and distilled water ($P = 0.003$). Turkish coffee also resulted in a significantly greater Δ E than cola ($P = 0.023$) and distilled water ($P = 0.002$).

Day 28

On day 28, the highest Δ E was observed in RMGI specimens immersed in Nescafe, while the lowest Δ E was noted in Cention N specimens immersed in cola. In addition, the mean Δ E of RMGI specimens was greater than that of Cention N. Two-way ANOVA revealed significant effects of coloring solution ($P = 0.000$), material type ($P = 0.006$), and their interaction ($P = 0.031$) on Δ E, indicating that the Δ E of the two materials differed across the four coloring solutions [Table 4].

Results of repeated measures ANOVA

The results revealed significant effects of material type ($P = 0.007$), coloring solution ($P = 0.000$), and their interaction ($P = 0.010$) on Δ E, indicating that the Δ E of the two materials varied across different coloring solutions over time.

Table 3: Pairwise comparisons of the effects of coloring solutions on ΔE of specimens on day 7

Compared solutions	Mean difference	SD of mean difference	*P*
Nescafe			
Turkish coffee	0.58	2.25	0.99
Cola	6.75	2.25	0.03
Distilled water	9.47	2.25	0.003
Turkish coffee			
Cola	7.34	2.25	0.023
Distilled water	10.05	2.25	0.002
Cola			
Distilled water	2.7	2.25	0.63

SD: Standard deviation

Table 4: Mean ΔE of Cention N and resin-modified glass ionomer specimens in different coloring solutions on day 28 (*n*=3)

Material	Coloring solution	Mean ΔE	SD of ΔE
Cention N	Distilled water	6.54	3.18
	Turkish coffee	21.70	5.04
	Cola	5.56	3.34
	Nescafe	16.02	3.07
	Total	12.45	7.71
RMGI	Distilled water	7.67	1.12
	Turkish coffee	20.05	3.33
	Cola	14.44	4.60
	Nescafe	25.67	3.17
	Total	16.96	7.51

RMGI: Resin-modified glass ionomer; SD: Standard deviation

DISCUSSION

This study compared the color stability of RMGI and Cention N bioactive restorative materials following exposure to different coloring solutions. The null hypothesis was that the color stability of RMGI and Cention N would not differ significantly after exposure to these solutions.

On day 1, the highest ΔE value was observed in Cention N specimens immersed in Nescafe, while the lowest ΔE was recorded in Cention N specimens immersed in cola. The mean ΔE of Cention N specimens was greater than that of RMGI specimens. Intrinsic factors affecting the ΔE of composite resins include the type of resin matrix, as well as the type, size, and volume of mineral fillers. Furthermore, surface degradation and roughness of restorative materials also influence their ΔE. Surface degradation of GIs can occur due to increased ionic exchange of fluoride on the specimen surface following exposure to acidic or neutral pH drinks. The greater ΔE of Cention N specimens compared with RMGI on day 1 may be attributed to their higher surface roughness or distinct chemical composition. In addition, since all specimens were polished uniformly, this difference may result from variances in the polishability of Cention N and RMGI.

On days 7 and 28, the highest ΔE values were found in RMGI specimens immersed in Nescafe and the lowest in Cention N specimens immersed in cola. The mean ΔE of RMGI specimens exceeded that of Cention N specimens, and the ΔE of RMGI specimens increased over time compared to that of Cention N specimens. Considering the differences in surface roughness between RMGI and Cention N and the direct effect of surface roughness on the ΔE of restorative materials, it can be concluded that surface degradation of RMGI increased over time compared with Cention N.

Repeated measures ANOVA indicated that the effects of material type, coloring solution, and their interaction on the ΔE of specimens at different time points were statistically significant. Therefore, the null hypothesis of the study was rejected.

Kurinji Amalavathy *et al.*[28] compared the effects of different coloring solutions on color stability and nanohardness of Equia Forte Fil (coated with Equia Forte Coat) GI and Cention N (noncoated) specimens. They found that the GI demonstrated higher color stability than Cention N following immersion in

coloring solutions. Equia Forte Fil is a fluoride-releasing hybrid glass that was resin-coated in their study. In the Equia Forte Fil group, the highest ΔE was recorded after immersion in coffee, while the highest ΔE in the Cention N group occurred after immersion in tea.[28]

In contrast, the present study showed that Cention N generally had higher color stability than Fuji II LC RMGI; the highest ΔE in the Cention N group was observed after immersion in Turkish coffee, while the highest ΔE in the Fuji II LC group occurred following immersion in Nescafe. Cention N demonstrated higher susceptibility to staining on day 1 compared with RMGI; however, RMGI showed greater staining on days 7 and 28. The increased ΔE over time suggests a higher possibility of surface degradation of RMGI specimens. This phenomenon in RMGI may be due to increased ionic exchange of fluoride following exposure to the acidic or neutral pH of drinks.[28] The greater surface degradation of RMGI over time likely accounts for its increased susceptibility to staining compared with Cention N specimens.

In addition, Majeti *et al*.[29] assessed the color stability of Solare Sculpt composite resin and Cention N following exposure to coffee, green tea, and diet cola. They reported that Cention N exhibited a greater ΔE, with coffee causing the most significant discoloration in the specimens. Similarly, the present results revealed that Nescafe caused the greatest ΔE.

This study utilized an *in vitro* design, and the dynamic oral environment cannot be accurately simulated *in vitro*. In addition, the color stability of the materials was evaluated over a short period. Only three coloring solutions were assessed, whereas restorative materials are typically exposed to a wide range of coloring foods and drinks in the oral cavity. Furthermore, only two restorative materials were compared in this study.

Therefore, future studies should explore other restorative materials immersed in various coloring solutions over a longer duration, with improved simulation of clinical conditions. Scanning electron microscopic assessment of the surfaces of the specimens is also recommended for future studies to compare their surface properties. Clinical studies are necessary to obtain more generalizable results.

CONCLUSION

Within the limitations of this *in vitro* study, the results indicated that Fuji II LC RMGI had lower color stability than Cention N over the long term. Nescafe caused the greatest discoloration in Fuji II LC specimens, while Turkish coffee resulted in the most significant discoloration in Cention N specimens.

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Conflicts of interest
The authors of this manuscript declare that they have no conflicts of interest, real or perceived, financial or non-financial in this article.

REFERENCES

1. Singla MG, Wahi P. Comparative evaluation of shear bond strength of biodentine, endocem mineral trioxide aggregate, and TheraCal LC to resin composite using a universal adhesive: An *in vitro* study. Endodontology 2020;32:14-9.
2. Alizadeh Oskoee P, Savadi Oskoee S, Pournaghi-Azar F, Dibazar S, Esmaeili M. Pre-heating of low-shrinkage composite resins: Effects on color stability and surface roughness. Front Dent 2022;19:26.
3. Korać S, Ajanović M, Džanković A, Konjhodžić A, Hasić-Branković L, Gavranović-Glamoč A, *et al.* Color stability of dental composites after immersion in beverages and performed whitening procedures. Acta Stomatol Croat 2022;56:22-32.
4. Paolone G, Formiga S, De Palma F, Abbruzzese L, Chirico L, Scolavino S, *et al.* Color stability of resin-based composites: Staining procedures with liquids-a narrative review. J Esthet Restor Dent 2022;34:865-87.
5. Elwardani G, Sharaf AA, Mahmoud A. Evaluation of colour change and surface roughness of two resin-based composites when exposed to beverages commonly used by children: An *in-vitro* study. Eur Arch Paediatr Dent 2019;20:267-76.
6. Erdemir U, Yildiz E, Eren MM, Ozel S. Surface hardness evaluation of different composite resin materials: Influence of sports and energy drinks immersion after a short-term period. J Appl Oral Sci 2013;21:124-31.
7. Nowaiser A. Comparison between polyacid-modified composite resin and conventional composite resin used for primary molars restoration. J Dent Oral Care Med 2017;3:204.
8. Moodley D, Grobler SR. Compomers: Adhesion and setting reactions. SADJ 2003;58:21, 24-8.
9. Bilić-Prcić M, Rajić VB, Ivanišević A, Pilipović A, Gurgan S, Miletić I. Mechanical properties of glass ionomer cements after incorporation of marine derived porous cuttlefish bone hydroxyapatite. Materials (Basel) 2020;13:3542.
10. Nicholson JW. Maturation processes in glass-ionomer dental cements. Acta Biomater Odontol Scand 2018;4:63-71.
11. Rêgo HM, Butler S, Santos MJ. Evaluation of the mechanical properties of three resin-modified glass-ionomer materials. Biomed Res Int 2022;2022:4690656.
12. Firouzmandi M, Alavi AA, Jafarpour D, Sadatsharifee S. Fracture strength and marginal adaptation of conservative and extended MOD cavities restored with cention N. Int J Dent 2021;2021:5599042.

13. Mazumdar P, Das A, Das UK. Comparative evaluation of microleakage of three different direct restorative materials (silver amalgam, glass ionomer cement, cention N), in class II restorations using stereomicroscope: An *in vitro* study. Indian J Dent Res 2019;30:277-81.
14. Kini A, Shetty S, Bhat R, Shetty P. Microleakage evaluation of an alkasite restorative material: An *in vitro* dye penetration study. J Contemp Dent Pract 2019;20:1315-8.
15. Samanta S, Das UK, Mitra A. Comparison of microleakage in class V cavity restored with flowable composite resin, glass ionomer cement and cention N. Imp J Interdiscip Res 2017;3:180-3.
16. Hotwani K, Thosar N, Baliga S. Comparative *in vitro* assessment of color stability of hybrid esthetic restorative materials against various children's beverages. J Conserv Dent 2014;17:70-4.
17. Naz F, Samad Khan A, Kader MA, Al Gelban LO, Mousa NM, Asiri RS, *et al.* Comparative evaluation of mechanical and physical properties of a new bulk-fill alkasite with conventional restorative materials. Saudi Dent J 2021;33:666-73.
18. Meshram P, Meshram V, Palve D, Patil S, Gade V, Raut A. Comparative evaluation of microleakage around class V cavities restored with alkasite restorative material with and without bonding agent and flowable composite resin: An *in vitro* study. Indian J Dent Res 2019;30:403-7.
19. Ahmed KI, Sajjan G. Color stability of ionomer and resin composite restoratives in various environmental solutions: An *in vitro* reflection spectrophotometric study. J Conserv Dent 2005;8:45-51.
20. Hashemikamangar SS, Hoseinpour F, Kiomarsi N, Dehaki MG, Kharazifard MJ. Effect of an optical whitening toothpaste on color stability of tooth-colored restorative materials. Eur J Dent 2020;14:85-91.
21. Pani SC, Aljammaz MT, Alrugi AM, Aljumaah AM, Alkahtani YM, AlKhuraif A. Color stability of glass ionomer cement after reinforced with two different nanoparticles. Int J Dent 2020;2020:7808535.
22. 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. Future Dent J 2018;4:288-96.
23. Bindal P, Bindal U, Dabbagh A, Ramanathan A, Ginjupalli K. Comparative effects of turmeric, coffee, and chew-able tobacco on the color stability of tooth-colored restorative materials. Open J Dent Oral Med 2015;3:59-67.
24. Poggio C, Ceci M, Beltrami R, Mirando M, Wassim J, Colombo M. Color stability of esthetic restorative materials: A spectrophotometric analysis. Acta Biomater Odontol Scand 2016;2:95-101.
25. Prabhakar A, Pattanshetti K, Sugandhan S. A comparative study of color stability and fluoride release from glass ionomer cements combined with chlorhexidine. Int J Clin Pediatr Dent 2013;6:26-9.
26. Haque SW, Muliya VS, Somayaji K, Pentapati KC. Effect of different herbal tea preparations on the color stability of glass ionomer cements. Clin Cosmet Investig Dent 2021;13:121-5.
27. Huang W, Ren L, Cheng Y, Xu M, Luo W, Zhan D, *et al.* Evaluation of the color stability, water sorption, and solubility of current resin composites. Materials (Basel) 2022;15:6710.
28. Kurinji Amalavathy R, Sahoo HS, Shivanna S, Lingaraj J, Aravinthan S. Staining effect of various beverages on and surface Nano-hardness of a resin coated and a non-coated fluoride releasing tooth-coloured restorative material: An *in-vitro* study. Heliyon 2020;6:e04345.
29. Majeti C, Ravi R, Kambhampati B, Borugadda R, Athkuri S, Kakani AK. Evaluation of the color stability of two different posterior tooth colored restorative materials. F1000Res 2020;9:1251.