In vitro evaluation of dental color stability using various aesthetic restorative materials after immersion in different drinks

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Abstract

Background Currently, the demands for restorations have increased considerably; thus, improvements and modifications have been made in dental composite technologies especially using materials that have been claimed to improve color stability.

Objective This study aimed to determine the effect of various solutions on the color stability of different restorative materials in vitro study.

Methods This study used three types of esthetic restorative materials. The samples comprised 45 discs, including 15 micro-hybrids, 15 nano-hybrids, and 15 glass ionomers). These discs were immersed in various beverages an hour a day for one month at room temperature. The color stability was measured using a spectrophotometer before/after immersion (days 7 and 30).

Results We realized a significant difference in color change with Coca-Cola and tea-milk solution after seven days and 30 days ($p < 0.05$). However, no significant difference was found in the samples immersed in DM after seven days and 30 days ($p > 0.05$). The highest value of lightness (ΔL) and stainability (Δa) was seen in micro-hybrid after 30 days of immersion in tea-milk solution (-12.16 ± 1.74 and 11.4 ± 3.82, respectively), while most samples had a positive Δb value.

Conclusion After one month, the tea-milk solution affected the color stability of all used restorative materials. In addition, micro-hybrid had higher color stability than nano-hybrid and glass ionomer.

Keywords Color stability, Esthetic restoration, Nano-hybrid, Glass ionomer, Micro-hybrid

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Introduction

Generally, there is a significant association between the characteristics of the most negative experiences of dental treatment and increased dental issues, including physical discomfort, fear, anxiety, and pain, especially in children, teenagers, and young adults, which instigates the patients to expect similar suffering during consequent visiting [1].

Today, people complain of common dental issues such as dental caries, cavities, and root canal infections. All these problems are due to bacterial infection of the teeth, which damages the tooth structure [1]. To treat the

affected tooth, dentists recommend the removal of dental caries and filling the cavities with suitable materials. In addition, dental amalgams percolate from the tooth during chewing and affect human health. Compared to previous filling materials, polymer composites are widely used as dental restoration materials due to their superior properties, such as biocompatibility, excellent esthetics, antibacterial and non-toxic properties. In addition, it demonstrates good physical, mechanical, thermal, and tribological properties [2].

Aesthetic restorative materials thoroughly mimic the dental structure as they enhance and maintain natural tooth whitening, transparency, texture, and surface staining stability for an extended period [3]. The initial restorative material first presented to dental work in the early seventies was glass ionomer, widely spread worldwide due to its promising adhesive and fluoride-releasing characteristics [4].

Subsequently, composite resin, hybrid materials, porcelain veers, compomers, and ceramic crowns were developed to overwhelm the disadvantages of glass ionomer and maintain their clinical benefits. Still, they also had some potential drawbacks, including polymerization shrinkage, secondary caries, plaque formation, limited releasing time, and color instability [2, 5].

Additionally, many other types of tooth restoration materials are commonly used; however, their quality, physical, and mechanical features should be high enough not to be easily subjected to color change after a short period, although most have a similar appearance to the tooth substrate. Generally, their disadvantages are color alteration, fracture, poor wearing, leakage, and polymerization shrinkage [6–8].

Moreover, it has been determined that the surface of aesthetic restorative materials is affected by drinks (coffee, tea, and wine), smoking, physiochemical stress, and some foods, which are mainly caused by either absorption or adsorption of coloring substances available in the diet and beverages [9]. On the other hand, superficial degradation on the composite surface produced by diets and drinks reduces its hardness and roughness, which leads to external coloring [10, 11].

Half of all dental restorations fail within ten years [12]; thus, the physical assets and quality of aesthetic restorative materials that are widely used in the dental field can be improved through manipulation of their matrix, size, strength, type, and quantity of filler particles, especially nanocomposite that is used for anterior and posterior teeth restoration [13–15].

Biomaterials have been widely used in dental composite materials or implants and their physical, mechanical, wear, and biocompatibility characteristics must be evaluated for clinical application. Therefore, extensive research has been committed to establishing various scientific methods for customizing the microstructure of dental biomaterials [1].

Moreover, various rechargeable dental nanocomposites with sufficient remineralization ability but with persistent ion release limitation [16] have also been intended and examined by different research groups in other countries for dental restoration with higher dental care than micro-hybrid composites such as nano-hybrid (nanofillers) that have advanced optical and physical features [17–21].

These tooth-colored resin-based dental composite materials have been introduced continuously to restore the esthetic and function of human teeth and meet the demands of the ever-increasing human population with increased longevity [22].

Therefore, this study aimed to measure the color stability of micro-hybrid, nano-hybrid, and glass ionomer restorative materials after immersing in tea-milk solution, Coca-Cola, and distilled water (DW), an hour a day for 30 days. The null hypothesis includes no differences in color stability of tested materials following immersing in the selected solution.

Materials and methods
Samples and study design
We prepared 45 disc-shaped samples (10 mm diameter × 3 mm thickness) from different esthetic materials. A package of the tablet has been used with dimensions that match our sample size, including 15 samples from micro-hybrid (Rio Javama-120-45007-Toledo Espana, Spain), 15 samples from nano-hybrid (Itena reflects-75116, France), and 15 samples from glass ionomer; shade A2 (Riva Self Cure, Australia). The samples were invented into a customized plastic container after condensation of their materials. The nanohybrid composite was made up of a micro-sized diameter of (0.3–1 μm) and nanosized diameter (0.02–0.05 μm) fillers while micro-hybrid particle size (0.7–2 μm) fillers. First, micro-hybrid and nano-hybrid samples were light-cured (Light Cure, COXA, DB686, China) for 20 s based on the instruction protocol. Then, all samples were polished with super-snap polishing discs (Nova Twist, Germany) and preserved in DW overnight at 25 °C.

Beverage preparations
We used tea-milk solution (Saadeldeen, Srilanka) and Coca-Cola (Kirkuk, Iraq) as beverages and DW as a control group. Regarding the tea milk preparation, about 4.0 g of dry powdered black tea was added to 0.3 L of boiled water in a small beaker. Then, 0.1 L milk solution and 10 g fine-white sugar were added and left to boil for 5 min. Whereas Coca-Cola was used as a carbonated drink directly without any preparation, the bottle lid was

Faris *et al. BMC Oral Health*   (2023) 23:49

Page 3 of 7

thoroughly tightened to prevent carbonic gas escape. The DW was directly collected from the distillation, while a freshly prepared tea-milk solution with immediately opened Coca-Cola bottles was used daily for the test.

Specimens immersion
Samples of each group (n = 15) were subdivided into three subgroups (n = 5) and were immersed separately in either DW (control), tea-milk solution (treatment I), or Coca-Cola (treatment II) for an hour each day at 37 °C, then took them out with forceps, wiped properly until dryness with clean tissue paper and stored in a sterile place at room temperature for consecutive days. The duration of the study was exactly 30 days.

Color alteration estimation
The specimen's color was tested before exposure (baseline; T0), after 7 days' exposure (T7), and after 30 days of exposure (T30) using a calibrated reflectance spectrophotometer Vita Easy Shade V (Vita, Zahnfabrik, Germany), the new fifth generation of Easy Shade, was used in this study to measure the color changes. This is a more innovative and precise device that, due to the LED technology, is unaffected by ambient conditions and produces objective and reliable measurements. The probe tip illumination diameter is 5 mm. Software version v507k (serial number: H55328, light source: white LED D65) was used.

Briefly, each sample was put on the assessing head of the device and enclosed with the dark lid, then the device was turned on, and the mean color quantity of the sample (ΔL^*, Δa^*, and Δb^*) was automatically obtained. Later on, the color difference (ΔE) was calculated for each specimen. Finally, CIELAB (ΔEab) was used for measuring color differences as follows and analyzed:

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

where L* denotes the lightness of the material, a* indicates a change in hues across the red-green axis, and b* shows the difference in hues across the yellow-blue axis.

Triplicate measurements were done at different sites of each sample to get a valuable average.

Statistical analysis
All material data will be analyzed using a statistical software package (SPSS, Inc., Chicago, USA, version 26). The distribution of the samples according to the type of drink and time of immersion was arranged on tables. The mean value of each material's prevalence of color change was calculated, and then their means were compared using the Chi-square test. The *P* value of < 0.05 was considered significant. ANOVA test is used to show the difference in the material behaviour when exposed to different solutions.

Results
In the present study and after processing the samples in different solutions, the color change was measured on the first day (baseline), the seventh day, and then after 30 days using a spectrophotometer (Table 1).

Our results showed a significant difference in the specimen's color change with the Coca-Cola and tea-milk solution ($p = 0.004$ and 0.001, respectively) after seven days and ($p = 0.003$ and $p = 0.005$, respectively) after 30 days. However, no significant difference was seen in the samples immersed in DM after seven days ($p = 0.859$) and 30 days ($p = 0.366$) (Tables 2 and 3).

Regarding sample ΔL (lightness), positive ΔL designates lighter samples, while negative ΔL designates darker samples after immersion. In this study, the result shows that the lightness (ΔL value) of all specimens became negative (darken) in the tea-milk solution, and there was less change in DW and variable values in Coca-Cola (Tables 3, 4 and 5). The highest value was observed in micro-hybrid 1-month post-immersion in tea-milk solution (-12.16 ± 1.74) (Table 4).

Moreover, negative Δa specify turning to green color, while positive Δa specify turning to red. Our samples showed positive Δa value for all specimens (Tables 4, 5 and 6) except for nano-hybrid specimens after seven days in tea-milk solution (-0.76 ± 0.56) (Table 3). The highest

Table 1 The mean value of color change (ΔE) of the studied samples after their immersion in different solutions

Material	Color change (Mean ± SD)					
	Distilled water		Coca-Cola		Tea	
	Day 7	Day 30	Day 7	Day 30	Day 7	Day 30
Micro-hybrid	3.25 ± 3.37	3.33 ± 1.09	1.42 ± 1.08	7.64 ± 3.59	13.57 ± 2.63	19.94 ± 2.74
Nano-hybrid	3.6 ± 0.53	6.32 ± 4.41	5.83 ± 1.12	12.19 ± 2.39	8.95 ± 1.65	15.7 ± 1.55
Glass-ionomer	4.38 ± 4.6	6.87 ± 5.38	7.7 ± 3.82	4.91 ± 1.48	7.48 ± 1.72	11.99 ± 4.25

Table 2 ANOVA test shows color change after 7 days' immersion in different solutions

Material	Difference	Sum of squares	df	Mean square	F	P-value
Distilled water	Between groups	3.378	2	1.689	0.154	0.859
	Within groups	131.482	12	10.957		
	Total	134.859	14			
Coca-Cola	Between groups	104.093	2	52.047	9.183	0.004*
	Within groups	68.016	12	5.668		
	Total	172.109	14			
Tea	Between groups	100.838	2	50.419	11.973	0.001*
	Within groups	50.534	12	4.211		
	Total	151.372	14			

*Significant difference

Table 3 ANOVA test shows color change after 30 days' immersion in different solutions

Material	Difference	Sum of squares	df	Mean square	F	P-value
Distilled water	Between groups	36.165	2	18.083	1.094	0.366
	Within groups	198.337	12	16.528		
	Total	234.502	14			
Coca-Cola	Between groups	135.311	2	67.655	9.761	0.003*
	Within groups	83.177	12	6.931		
	Total	218.488	14			
Tea	Between groups	158.007	2	79.004	8.465	0.005*
	Within groups	112.000	12	9.333		
	Total	270.008	14			

*Significant difference

Table 4 Mean values of color change of different filling materials after exposure to tea

Time-line	Micro-hybrid			Nano-hybrid			Glass-ionomer		
	ΔL	Δa	Δb	ΔL	Δa	Δb	ΔL	Δa	Δb
Day 7	−7.28±1.09	8.9±2.68	6.28±3.76	−6.34±1.02	−0.76±0.56	5.84±2.82	−6.84±1.23	1.92±1.92	−0.18±2.15
Day 30	−12.16±1.74	11.4±3.82	9.94±4.0	−9.2±1.2	5.0±3.75	10.78±3.55	−10.96±4.22	4.48±1.65	−0.5±1.3

Table 5 Mean values of color change of different filling materials after exposure to distilled water

Time-line	Micro-hybrid			Nano-hybrid			Glass-ionomer		
	ΔL	Δa	Δb	ΔL	Δa	Δb	ΔL	Δa	Δb
Day 7	−5.0±2.68	0.78±0.44	−0.8±3.92	1.02±0.3	0.92±0.08	3.3±0.55	0.54±6.31	0.02±0.69	−0.12±2.13
Day 30	1.24±2.15	2.2±0.47	0.88±1.13	−2.2±6.44	2.18±1.33	2.4±2.65	0.54±6.31	0.02±0.69	−0.12±2.13

Table 6 Mean values of color changes of different filling materials after exposure to Coca-Cola

Time-line	Micro-hybrid			Nano-hybrid			Glass-ionomer		
	ΔL	Δa	Δb	ΔL	Δa	Δb	ΔL	Δa	Δb
Day 7	−0.08±1.48	0.34±0.64	−0.68±0.6	−0.14±0.33	0.66±0.05	5.78±1.14	−6.86±3.05	2.2±0.85	2.38±2.58
Day 30	1.92±8.36	2.4±1.07	0.44±1.69	5.66±8.02	1.3±3.22	7.6±1.52	−0.12±2.13	2.04±0.9	1.3±2.81

Faris *et al. BMC Oral Health*   (2023) 23:49

Page 5 of 7

value has been recorded by micro-hybrid composite in tea-milk solution after 30 days (11.4±3.82) (Table 4).

Finally, positive Δb means a change to yellow color, and negative Δb implies a change to blue color. Most of our samples had a positive Δb value (Tables 4, 5 and 6), except for micro-hybrid in DW (−0.8±3.92) after seven days and glass ionomer after 7 and 30 days (−0.12±2.13) (Table 5) with micro-hybrid in Coca-Cola (−0.68±0.6) after seven days (Table 6). Collectively, duration of time, material type, and solution type have a statistically significant effect on ΔE.

Discussion

Used dental restorative materials are vulnerable to various adverse effects in the oral cavity, such as the impact of acidity of different diets and drinks. Moreover, the high frequency of dental problems claims the essential outlook on the degradation capacity of restorative materials to protect their quality [6, 23].

We used 3 different solutions to check the color stability of 3 restorative materials that are widely used in dental practice nowadays and realized that DM presented no noticeable color changes in the materials. In comparison, the tea solution developed significant color changes in the composites. These findings are similar to those found in Saudi Arabia [24] and Turkey [25], which found that tea was the most staining solution, while DW did not alter the colors of the composites. These outcomes approve that water absorption by itself does not change the composite stainability to a substantial level [26].

Rather than using DW as an immersion medium, Tanthanuch et al. [6] in Singapore reported a clinically perceptible color alteration (ΔE > 3.3) for various composites immersed in tea, wine, and coffee. However, Falkensammer et al., 2013 demonstrated that red wine was a more potent discoloration agent than black tea (ΔE > 5.5) for nano-hybrid and micro-hybrid materials [27], and Majeti et al. [28] stated that diet coke was more potent discoloration medium than green tea, but less potent than coffee.

On the other hand, the color change in used materials increased substantially over time, especially for tea and Coca-Cola, which agreed with results found by other authors who indicated that the degree of change in the used restorative materials becomes greater with duration and frequency of interaction with the beverages, so a decrease in the amount and frequency of beverage intake was recommended [4].

Furthermore, we found that nano-hybrid presented higher color changes than micro-hybrid, which is in line with the outcomes of research in Saudi Arabia, which mentioned that nano-hybrid had a higher ΔE value and discoloration with less color stability despite having a higher degree of conversion compared to micro-hybrid, especially when immersed into coffee rather than tea or Coca-Cola [17]. However, Poggio et al. [29] in Italy excluded that there is no significant difference in discoloration ability between micro-hybrid and nano-hybrid composites in tea, and both increased staining. Silva et al. [30] showed that the Filtek Z350XT significantly stained higher than all other tested composites. Whereas Garcia et al. [31] reported that the color of restorative material changes with time, regardless of immersion solution (saliva, coke, or tea).

Generally, it has been stated that these outcomes can occur as nanomaterials have smaller particle sizes with a smoother surface that retains fewer surface stains [25]. Furthermore, it was suggested that any composite that can absorb water could also absorb other fluids, resulting in discoloration and reduction of its powered features due to polymer matrix degradation [32].

Another study demonstrated more discoloration of a nano-filled composite than a micro-hybrid which could be due to the composition of the resin matrix, as resin matrix also has a major effect on the color stability of composite resin. The conversion rate and chemical characteristics of the resin matrix modulate the discoloration. The composite resin contains TEGDMA in its composition. Therefore, it releases more monomers in the aqueous media than Bis-GMA- and UDMA-based composite resin, resulting in more remarkable color alteration [33].

It is difficult to explain which dental formulation is more crucial than others. But it can be solved after determining the weight criteria of different material performances and evaluating the ranking of the alternative dental composite [34, 35].

Regarding the study's limitations, we did not use saliva as an immersion medium due to infection control considerations. Additionally, the prepared discs did not look like a restoration from the geometrical perspective, but our results can be used to formulate designs for clinical experiments.

Conclusions

Within the limitation of our study, we concluded that all materials used for this thesis showed undesirable color alteration after immersion in the tea-milk solution for one month. However, we realized that all used solutions (tea-milk solution, Coca-Cola, and distilled water) impacted on color stability of used restorative materials; but within a clinically acceptable range. Additionally, we found that micro-hybrid composite had high color stability compared to nano-hybrid and glass ionomer. Further study under the different conditions with other different

Faris *et al. BMC Oral Health*   (2023) 23:49

Page 6 of 7

esthetic restorative materials can be done in the future for better results.

Author contributions
Conceptualization and research work: TMF and RHA; Data analysis and validity: MAM and GAM; Resources and supervision: SSG. All authors participated in writing the original manuscript. All authors read and approved the final manuscript.

Availability of data and materials
The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent for participation
Not applicable.

Consent for publication
Not applicable.

Competing interests
There is no competing interests in this research.

References
1. Yadav R, Meena A, Patnaik A. Biomaterials for dental composite applications: a comprehensive review of physical, chemical, mechanical, thermal, tribological, and biological properties. Polym Adv Technol. 2022;33(6):1762–81.
2. Yadav R, Kumar M. Dental restorative composite materials: a review. J Oral Biosci. 2019;61(2):78–83.
3. Pratap B, Gupta RK, Bhardwaj B, Nag M. Resin based restorative dental materials: characteristics and future perspectives. Jpn Dental Sci Rev. 2019;55(1):126–38.
4. Choi J-W, Lee M-J, Oh S-H, Kim K-M. Changes in the physical properties and color stability of aesthetic restorative materials caused by various beverages. Dent Mater J. 2019;38(1):33–40.
5. Yap A, Mok B. Surface finish of a new hybrid aesthetic restorative material. Oper Dent. 2002;27(2):161–6.
6. Tanthanuch S, Kukiattrakoon B, Eiam-O-Pas K, Pokawattana K, Pamanee N, Thongkamkaew W, et al. Surface changes of various bulk-fill resin-based composites after exposure to different food-simulating liquid and beverages. J Esthet Restor Dent. 2018;30(2):126–35.
7. Yadav R, Kumar M. Investigation of the physical, mechanical and thermal properties of nano and microsized particulate-filled dental composite material. J Compos Mater. 2020;54(19):2623–33.
8. Yadav R, Lee H, Lee J-H, Singh RK, Lee H-H. A comprehensive review: physical, mechanical, and tribological characterization of dental resin composite materials. Tribol Int. 2022;179:108102.
9. Correr GM, Bruschi Alonso RC, Baratto-Filho F, Correr-Sobrinho L, Sinhoreti MAC, Puppin-Rontani RM. In vitro long-term degradation of aesthetic restorative materials in food-simulating media. Acta Odontol Scand. 2012;70(2):101–8.
10. Hamouda IM. Effects of various beverages on hardness, roughness, and solubility of esthetic restorative materials. J Esthet Restor Dent. 2011;23(5):315–22.
11. Yadav R. Analytic hierarchy process-technique for order preference by similarity to ideal solution: a multi criteria decision-making technique to select the best dental restorative composite materials. Polym Compos. 2021;42(12):6867–77.
12. Browning W, Dennison J. A survey of failure modes in composite resin restorations. Oper Dent. 1996;21:160–6.
13. Erdemir U, Yıldız E, Eren MM. Effects of sports drinks on color stability of nanofilled and microhybrid composites after long-term immersion. J Dent. 2012;40:e55–63.
14. Yadav R, Meena A. Comparative investigation of tribological behavior of hybrid dental restorative composite materials. Ceram Int. 2022;48(5):6698–706.
15. Yadav R. Fabrication, characterization, and optimization selection of ceramic particulate reinforced dental restorative composite materials. Polym Polym Compos. 2022;30:09673911211062755.
16. Mitwalli H, AlSahafi R, Alhussein A, Oates TW, Melo MAS, Xu HH, et al. Novel rechargeable calcium fluoride dental nanocomposites. Dent Mater. 2022;38(2):397–408.
17. Al-Kheraif AAA, Qasim SSB, Ramakrishnaiah R, ur Rehman I. Effect of different beverages on the color stability and degree of conversion of nano and microhybrid composites. Dent Mater J. 2013;32(2):326–31.
18. Angerame D, De Biasi M. Do nanofilled/nanohybrid composites allow for better clinical performance of direct restorations than traditional microhybrid composites? A systematic review. Oper Dent. 2018;43(4):E191–209.
19. Yadav R, Meena A. Comparative study of thermo-mechanical and thermogravimetric characterization of hybrid dental restorative composite materials. Proc Inst Mech Eng Part L: J Mater Des Appl. 2022;236(5):1122–9.
20. Yadav R, Meena A, Patnaik A. Tribological behavior of zinc oxide-hydroxyapatite particulates filled dental restorative composite materials. Polym Compos. 2022;43:3029–40.
21. Yadav R, Meena A. Effect of aluminium oxide, titanium oxide, hydroxyapatite filled dental restorative composite materials on physico-mechanical properties. Ceram Int. 2022;48(14):20306–14.
22. Meena A, Bisht D, Yadav R, Saini S, Dangayach GS, Patnaik A, et al. Fabrication and characterization of micro alumina zirconia particulate filled dental restorative composite materials. Polym Compos. 2022;43(3):1526–35.
23. Fatima N, Abidi SYA, Jat SA. Effect of different tetra pack juices on microhardness of direct tooth colored-restorative materials. Saudi Dent J. 2013;25(1):29–32.
24. Bahbishi N, Mzain W, Badeeb B, Nassar HMJM. Color stability and microhardness of bulk-fill composite materials after exposure to common beverages. Materials. 2020;13(3):787.
25. Tekçe N, Tuncer S, Demirci M, Serim ME, Baydemir C. The effect of different drinks on the color stability of different restorative materials after one month. Restor Dent Endod. 2015;40(4):255–61.
26. Al-Wahab Z. An evaluation of the effect of different drinks on the color change of composan ceram composite resin (in vitro study). Mustansiria Dent J. 2009;6(1):14–9.
27. Falkensammer F, Arnetzl GV, Wildburger A, Freudenthaler J. Color stability of different composite resin materials. J Prosthet Dent. 2013;109(6):378–83.
28. 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. F1000 Res. 2020;9(1251):1251.
29. Poggio C, Beltrami R, Scribante A, Colombo M, Chiesa M. Surface discoloration of composite resins: effects of staining and bleaching. Dent Res J. 2012;9(5):567.
30. Silva TMD, Sales ALLS, Pucci CR, Borges AB, Torres CRG. The combined effect of food-simulating solutions, brushing and staining on color stability of composite resins. Acta Biomater Odontol Scand. 2017;3(1):1–7.
31. Garcia PPNS, Rodrigues Neto E, Santos PAD, Campos JÁDB, Dibb RGP. Influence of surface sealant on the translucency of composite resin: effect of immersion time and immersion media. Mater Res. 2008;11:193–9.
32. Soares-Geraldo D, Scaramucci T, Steagall-Jr W, Braga SRM, Sobral MAP. Interaction between staining and degradation of a composite resin in contact with colored foods. Braz Oral Res. 2011;25:369–75.

33. Muhittin U, Burak TU, Kam HO. Color stability of microhybrid and nanofilled composite resins: effect of surface sealant agents containing different filler content. J Contemp Dent Pract. 2019;20(9):1045–50.
34. Yadav R, Lee HH. Ranking and selection of dental restorative composite materials using FAHP-FTOPSIS technique: an application of multi criteria decision making technique. J Mech Behav Biomed Mater. 2022;132:105298.
35. Yadav R, Lee HH. Fabrication, characterization, and selection using FAHP-TOPSIS technique of zirconia, titanium oxide, and marble dust powder filled dental restorative composite materials. Polym Adv Technol. 2022;33(10):3286–95.

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