Effect of Acidic Beverage on Color Stability, Microhardness, Surface Roughness and Solubility of Different Novice Restorative Materials: An in Vitro Study

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ABSTRACT

Background

Resin-based restorative materials are continuously exposed to chemical challenges in the oral environment. Frequent consumption of acidic beverages may compromise their esthetic appearance and mechanical performance through degradation of the resin matrix and filler–matrix interface. Although several contemporary restorative materials have been introduced with improved optical and mechanical characteristics, comparative evidence regarding their resistance to acidic degradation remains limited.

Objective

To evaluate and compare the effect of acidic beverage exposure on color stability, surface microhardness, surface roughness, and solubility of four contemporary resin-based restorative materials: Vittra APS Unique, Neo Spectra™ ST, Beautifil II LS, and Palfique Omnichroma.

Materials and Methods

This in vitro experimental study was performed using sixty standardized disc-shaped specimens (n = 15/group) fabricated from four commercially available restorative materials. Following polymerization and finishing, the specimens were subjected to cyclic immersion in Coca-Cola, with storage in artificial saliva between immersion cycles to simulate the oral environment.

Color stability was assessed using a spectrophotometer based on CIE Lab* coordinates. Surface microhardness was measured using a Vickers hardness tester, surface roughness was evaluated with a contact profilometer, and solubility was determined using a precision analytical balance according to standardized procedures. Statistical analysis was performed using one-way analysis of variance followed by appropriate post hoc comparisons, with statistical significance established at $p < 0.05$.

Results

Significant differences were observed among the restorative materials for color stability, surface microhardness, and solubility ($p < 0.05$), whereas surface roughness did not differ significantly among the groups ($p > 0.05$). Neo Spectra™ ST demonstrated superior color stability and the lowest solubility following acidic exposure. Beautifil II LS exhibited the highest surface microhardness, while Palfique Omnichroma showed the lowest hardness values together with the greatest solubility. Vittra APS Unique demonstrated intermediate performance across the evaluated parameters.

Conclusion

Acidic beverage exposure adversely affected the esthetic and mechanical properties of all evaluated restorative materials. Among the tested composites, Neo Spectra™ ST demonstrated the most balanced overall performance under acidic conditions, whereas Beautifil II LS exhibited superior hardness retention. Vittra APS Unique and Palfique Omnichroma showed comparatively greater susceptibility to acidic degradation. These findings may assist clinicians in selecting restorative materials for patients with frequent consumption of acidic beverages.

Keywords: Acidic beverages; Resin-based composites; Color stability; Surface microhardness; Surface roughness; Solubility; Neo Spectra ST; Omnichroma.

INTRODUCTION

Resin-based composites (RBCs) have become widely used for direct esthetic restorations because of their favorable mechanical properties, esthetics, and conservative tooth preparation requirements.[1,2] Continuous developments in resin chemistry and filler technology have produced contemporary materials with improved polymerization, optical blending, wear resistance and polish retention.[3]

The long-term performance of these materials depends not only on their intrinsic composition but also on their resistance to the oral chemical environment.[☐] Dietary acidic beverages such as carbonated drinks, fruit juices, and sports drinks may soften the resin matrix, increase water sorption, and weaken the filler–matrix interface.[5,6] Repeated acidic exposure may therefore result in discoloration, reduced hardness, increased roughness, and greater solubility.[6,7]

Color stability is clinically important because discoloration affects patient satisfaction, particularly in anterior restorations.[☐] Surface microhardness reflects resistance to wear and deformation, whereas surface roughness influences plaque accumulation and gloss retention.[9,1☐] Solubility indicates chemical degradation and possible leaching of resin components.[11]

Previous studies have reported that acidic and staining beverages adversely affect resin composites, but most evaluated conventional composites or limited parameters.[10,12] Evidence comparing newer materials such as universal shade composites, nanohybrid composites, and giomer-based systems under the same acidic challenge remains limited.[13,1☐]

This study was therefore designed to comparatively evaluate the influence of an acidic beverage on four contemporary resin-based restorative materials—Vittra APS Unique, (Group 1) Neo Spectra™ ST, (Group 2) Beautifil II LS, (Group 3) and Palfique Omnichroma (Group 4) by simultaneously assessing color stability, surface microhardness, surface roughness, and solubility. It was hypothesized that acidic beverage exposure would adversely affect all evaluated restorative materials, with the magnitude of degradation varying according to their material composition and structural characteristics.

MATERIALS AND METHODOLOGY

Restorative Materials

Four commercially available restorative materials were evaluated:

- **Group I:** Vittra APS Unique
- **Group II:** Neo Spectra™ ST
- **Group III:** Beautifil II LS
- **Group IV:** Palfique Omnichroma

Specimen Preparation

A total of 60 disc-shaped specimens were fabricated using customized silicone moulds, with 15 specimens allocated to each material group. Each specimen measured 10 mm in diameter and 2 mm in thickness. Composite material was inserted into the mould in a single increment and covered with Mylar strips and glass slides to obtain a smooth, standardized surface and minimize air entrapment.

Polymerization was performed using an LED light-curing unit for **20 seconds** according to the respective manufacturers' recommendations. Following curing, specimens were removed from the moulds, inspected for defects, and stored in artificial saliva at **37 °C for 24 hours** before baseline evaluation.

Experimental Groups and Immersion Protocol

Each material group was subdivided into:

- **Control subgroup (n = 5):** Stored continuously in artificial saliva for 28 days.
- **Test subgroup (n = 10):**
  - ✓ Evaluation after 7 days (n = 5)
  - ✓ Evaluation after 28 days (n = 5)

To simulate repeated dietary exposure, specimens in the test group were immersed in Coca-Cola for 15 minutes, three times daily. Between immersion cycles, specimens were stored in freshly prepared artificial saliva at 37 °C. Fresh beverage was used for each immersion cycle throughout the experimental period. Control specimens remained immersed in artificial saliva, which was replaced daily to maintain consistent storage conditions.

Evaluation of the study outcomes was performed using standardized laboratory methods. Color stability, surface microhardness, surface roughness, and solubility were assessed using the instruments and protocols summarized in Table 1.

Parameter	Instrument/Method	Measurement Protocol	Outcome Variable
Color stability	VITA Easyshade Advance V spectrophotometer (VITA Zahnfabrik, Germany) based on the CIE L*a*b* color system	Baseline color values (L*, a*, b*) were recorded before immersion and repeated after 7 and 28 days. Color change (ΔE) was calculated from differences in L*, a*, and b* coordinates.	Color difference (ΔE)
Surface microhardness	Vickers microhardness tester	A load of 50 g was applied for 20 s. Three indentations were made at different locations on each specimen, and the mean value was recorded.	Vickers Hardness Number (VHN)
Surface roughness	Contact profilometer	Surface roughness was measured at a stylus speed of 0.5 mm/s. Three readings were obtained from different areas of each specimen, and the mean roughness value was calculated.	Mean surface roughness (Ra, μm)
Solubility	Precision analytical balance	Specimens were desiccated and weighed before immersion and reweighed after the experimental period. Solubility was determined from the difference between the initial and final specimen weights following standard laboratory procedures.	Solubility (mg/mm^3 or as calculated according to the study protocol)

Table 1: Methods used for evaluation of the tested properties Statistical Analysis

The collected data were entered into a spreadsheet and analyzed using appropriate statistical software. Descriptive statistics were calculated for all outcome variables. Intergroup comparisons were performed using one-way analysis of variance (ANOVA) followed by suitable post hoc tests. Statistical significance was established at $p < 0.05$.

RESULTS

Sixty specimens prepared from four contemporary resin-based restorative materials were evaluated following exposure to an acidic beverage. The study assessed color stability (ΔE), surface microhardness, surface roughness, and solubility

Color Stability

The restorative materials demonstrated significant differences in color stability following acidic beverage exposure (One-way ANOVA revealed a highly significant intergroup difference ($F = 17.628$, $p < 0.001$). Neo

Spectra™ ST exhibited the lowest mean ΔE value, indicating superior resistance to discoloration, followed by Beautifil II LS. In contrast, Vittra APS Unique and Palfique Omnichroma demonstrated significantly higher ΔE values, indicating greater color alteration after acidic exposure. Post hoc analysis showed no significant difference between Vittra APS Unique and Palfique Omnichroma, whereas Neo Spectra™ ST differed significantly from both materials.

Surface Microhardness

Significant differences in surface microhardness were observed among the four restorative materials ($F = 18.979$, $p = 0.001$). Beautifil II LS exhibited the highest mean Vickers hardness value, closely followed by Neo Spectra™ ST. Vittra APS Unique demonstrated intermediate hardness, whereas Palfique Omnichroma recorded the lowest microhardness. Pairwise comparisons indicated no statistically significant difference between Beautifil II LS and Neo Spectra™ ST, while both materials demonstrated significantly greater hardness than Palfique Omnichroma.

Surface Roughness

Surface roughness did not differ significantly among the evaluated restorative materials. Although Vittra APS Unique showed the highest mean roughness and Beautifil II LS demonstrated the lowest, one-way ANOVA indicated that these differences were not statistically significant ($F = 1.816$, $p = 0.198$). Pairwise comparisons similarly revealed no significant differences between any material combinations.

Solubility

The materials exhibited statistically significant differences in solubility following acidic beverage exposure ($F = 4.288$, $p = 0.028$). Palfique Omnichroma demonstrated the highest mean solubility, followed closely by Vittra APS Unique, indicating greater material degradation. Neo Spectra™ ST and Beautifil II LS showed significantly lower solubility values, reflecting superior resistance to chemical degradation. Post hoc analysis demonstrated significant differences between Beautifil II LS and Vittra APS Unique, as well as between Beautifil II LS and Palfique Omnichroma, whereas Neo Spectra™ ST and Beautifil II LS exhibited comparable performance.

DISCUSSION

The present in vitro study evaluated the effect of an acidic beverage on the color stability, microhardness, surface roughness, and solubility of four contemporary resinbased restorative materials—Vittra APS Unique, Neo Spectra™ ST, Beautifil II LS, and Palfique Omnichroma. The growing clinical use of single-shade composites, nanohybrids, and giomer-based materials warrants critical evaluation of their resistance to chemical degradation under dietary acidic challenges.

Color stability is one of the most critical determinants of long-term esthetic success of composite restorations. In the present study, statistically significant differences were observed among the materials ($p < 0.001$), with Neo Spectra ST showing the lowest ΔE values (best color stability), followed by Beautifil II LS, while Vittra APS Unique and Palfique Omnichroma demonstrated the highest discoloration. These findings are in agreement with recent investigations on single-shade and CAP (color adjustment potential) composites. Duzyol et al. (2024)[15] reported that monoshade composites exhibit significantly greater color changes when exposed to coffee and cola compared with conventional nanohybrid composites. Similarly, Maghaireh et al. (2025)[16] in their evaluation of Omnichroma and Neo Spectra ST in common staining solutions, demonstrated that Neo Spectra ST exhibited superior color stability, which directly supports the findings of the present study.

Surface microhardness is an important indicator of a material's resistance to wear and mechanical degradation. In this study, Beautifil II LS demonstrated the highest microhardness values, followed closely by Neo Spectra ST, while Palfique Omnichroma showed the lowest hardness. These results are supported by Das et al. (2025),[17] who reported that acidic beverages significantly reduce microhardness of resin composites, but the magnitude of degradation depends on filler type and resin chemistry. Giomer-based materials such as Beautifil II LS have been shown to maintain superior hardness due to the reinforcing effect of S-PRG fillers, as demonstrated by De La Cruz et al. (2024), who reported significantly higher hardness for Beautifil II LS compared to conventional composites.[18]

Thus, the microhardness ranking observed in this study (Beautifil II LS ≈ Neo Spectra ST > Vittra APS Unique > Omnichroma) is strongly supported by contemporary literature.

Surface roughness plays a key role both in esthetics and oral biofilm accumulation. In this study, although minor numerical differences were observed, no statistically significant difference in surface roughness was found among the four materials. This finding is consistent with the observations of Meenakshi et al. (2020),[19] who reported that when composite specimens are fabricated using Mylar strips and standardized curing protocols, surface roughness values tend to remain comparable across materials, even after acidic immersion. These authors suggested that specimen preparation techniques often play a greater role in determining surface roughness than material composition alone. However, other authors such as Tanthanuch et al. (2014)[20] have reported that prolonged exposure to acidic beverages may increase surface roughness, especially in giomers and flowable composites. Therefore, the absence of significant differences in the present study may be related to the controlled experimental conditions and limited duration of exposure.

Solubility analysis revealed that Omnichroma and Vittra APS Unique exhibited the highest solubility values, while Beautifil II LS and Neo Spectra ST showed better resistance. These findings are supported by Rusnac et al. (2019),[21] who reported that materials with higher resin content and hydrophilic monomer systems exhibit increased solubility due to leaching of unreacted monomers. Maghaireh et al. (2025)[22] also reported that monoshade composites such as Omnichroma exhibit greater interaction with aqueous media, leading to increased solubility when compared with conventional nanohybrid composites. This explains the higher solubility and poorer color stability observed with Omnichroma in this investigation.

CONCLUSION

When all parameters are considered collectively, Neo Spectra ST demonstrated the most balanced performance, exhibiting excellent color stability, high microhardness, and low solubility. Beautifil II LS also performed favorably, particularly in mechanical and chemical stability. In contrast, Palfique Omnichroma and Vittra APS Unique, despite their innovative esthetic concepts, demonstrated greater susceptibility to acidic degradation.

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CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest related to this study.

REFERENCES

1. Manhart J, Chen HY, Hamm GH, Hickel R. Review of the clinical survival of direct and indirect restorations in posterior teeth of the permanent dentition. OPERATIVE DENTISTRY-UNIVERSITY OF WASHINGTON-. 2004 Sep 1;29:481-508.
2. Ferracane JL. Resin composite—State of the art. Dental materials. 2011 Jan 1;27(1):29-38.
3. Drummond JL. Degradation, fatigue, and failure of resin dental composite materials. Journal of dental research. 2008 Aug;87(8):710-9.
4. Ilie N, Hickel R. Resin composite restorative materials. Australian dental journal. 2011 Jun;56:59-66.
5. Ferracane JL. Hygroscopic and hydrolytic effects in dental polymer networks. Dental Materials. 2006 Mar 1;22(3):211-22.
6. Villalta P, Lu H, Okte Z, Garcia-Godoy F, Powers JM. Effects of staining and bleaching on color change of dental composite resins. The Journal of prosthetic dentistry. 2006 Feb 1;95(2):137-42.
7. Erdemir U, Yıldız E, Eren MM. Effects of sports drinks on color stability of nanofilled and microhybrid composites after long-term immersion. Journal of dentistry. 2012 Dec 1;40:e55-63.
8. Guler AU, Yilmaz F, Kulunk T, Guler E, Kurt S. Effects of different drinks on stainability of resin composite provisional restorative materials. The Journal of prosthetic dentistry. 2005 Aug 1;94(2):118-24.
9. Bagheri R, Burrow MF, Tyas M. Influence of food-simulating solutions and surface finish on susceptibility to staining of aesthetic restorative materials. Journal of dentistry. 2005 May 1;33(5):389-98.
10. Hamouda IM. Effects of various beverages on hardness, roughness, and solubility of esthetic restorative materials. Journal of Esthetic and Restorative Dentistry. 2011 Oct;23(5):315-22.
11. Catelan A, Briso AL, Sundfeld RH, Dos Santos PH. Effect of artificial aging on the roughness and microhardness of sealed composites. Journal of Esthetic and Restorative Dentistry. 2010 Oct;22(5):324-30.
12. Al Kheraif AA, Qasim SS, Ramakrishnaiah R, ur Rehman I. Effect of different beverages on the color stability and degree of conversion of nano and microhybrid composites. Dental materials journal. 2013 Mar 28;32(2):326-31.
13. Paravina RD, Powers JM. Esthetic Color Training in Dentistry. 2nd ed. St Louis: Elsevier;

2015.

14. da Silva MA, Vitti RP, Sinhoreti MA, Consani RL, da Silva-Júnior JG, Tonholo J. Effect of alcoholic beverages on surface roughness and microhardness of dental composites. Dental materials journal. 2016 Jul 29;35(4):621-6.
15. Duzyol M, Sagsoz O, Polat Sagsoz N. Color stability of single-shade resin composites after immersion in beverages. BMC Oral Health. 2024;24:112.
16. Maghaireh GA, Alzraikat H, Alakhras HK. Surface roughness and color stability of newly developed resin composites with color adjustment potential after immersion in staining solutions. Operative Dentistry. 2025 Jan 1;50(1):67-77.
17. Das K, Sharma K, Banerjee S, Raju S, Bhat N. Acidic beverage effect on surface roughness and hardness of different composite resins: An in vitro study. Int J Prosthodont. 2025; [Accepted/In Press].
18. De La Cruz DJ, Cisneros-del Águila M. Effect of two oxygen-inhibiting agents on the surface microhardness of giomer restorative materials. Acta Odontológica Latinoamericana. 2024 Sep 30;37(2):99.
19. Estrada-Villarroel L, Castro-Ramirez L, Alvino-Vales M, Tolmos-Valdivia R, Yarasca-Berrocal E, Huamani-Echaccaya J, Cayo-Rojas C. Surface microhardness of three Bulk Fill resin composites previously exposed to five carbonated beverages at different times: an in vitro study. BMC Oral Health. 2025 Dec;25(1):1-0.
20. Tanthanuch S, Kukiattrakoon B, Siripornanon C, Ornprasert N, Mettasitthikorn W, Likhitpreeda S, Waewsanga S. The effect of different beverages on surface hardness of nanohybrid resin composite and giomer. Journal of Conservative Dentistry and Endodontics. 2014 May 1;17(3):261-5.
21. Rusnac ME, Gasparik C, Irimie AI, Grecu AG, Mesaroş AŞ, Dudea D. Giomers in dentistry–at the boundary between dental composites and glass-ionomers. Medicine and pharmacy reports. 2019 Apr 25;92(2):123.
22. Maghaireh GA, Alzraikat H, Alakhras HK. Surface roughness and color stability of newly developed resin composites with color adjustment potential after immersion in staining solutions. Operative Dentistry. 2025 Jan 1;50(1):67-77.