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Original Article

Spectrophotometric Evaluation of Direct Resin Composite Restoration after Staining and Bleaching: An In Vitro Study

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Abstract

Objective: *The study evaluated the discoloration effects of various staining agents, specifically coffee, qat, a mixture of qat and red soft drink, and distilled water, on different resin-based composite materials. Additionally, the effectiveness of an in-office bleaching agent in restoring color stability and removing stains from these composites was assessed.*

Materials and Methods: *An in-vitro experimental observational study was conducted, where 60 disc-shaped resin composite specimens (Merfill Bulk Fill, Charm Microhybrid, Tokuyama Supra-Nano) were immersed in the staining solutions for 7 days, followed by an in-office bleaching protocol and a home bleaching treatment. Color measurements were taken before immersion, after staining, and post-bleaching using a VITA Easy Shade V Spectrophotometer, with color differences (ΔE values) calculated.*

Results: *All resin composite specimens exhibited significant color changes after immersion in staining solutions, with coffee causing the most discoloration, especially in Merfill Bulk Fill and Tokuyama Supra-Nano composites. In-office bleaching effectively restored color stability, with the most significant improvements seen after two applications.*

Conclusion: *The study confirmed that staining agents significantly affect the color stability of resin-based composites. Tokuyama Supra-Nano Composite exhibited superior stain resistance and effective recovery post-bleaching, making it a preferred choice for aesthetic restorations. The findings emphasize the importance of material selection and patient education regarding staining potential.*

The study evaluated the discoloration effects of various staining agents, specifically coffee, qat, a mixture of qat and red soft drink, and distilled water, on different resin-based composite materials. Additionally, the effectiveness of an in-office bleaching agent in restoring color stability and removing stains from these composites was assessed.

Material and methods

60 disc-shaped specimens were fabricated for three brands of resin composites: bulk fill (Merfill bulk), micro hybrid (Charmfil Plus), and supra- nano filled (Tokuyama) of A2 shade and randomly divided into three groups (n = 20). The specimens were immersed in coffee, qat, mix of qat and red soft drink and distilled water, respectively, 24hrs for 7 days. Each group was then equally divided into 4 sub-groups (n = 5), which were subjected in-office bleaching agent (pola office), respectively. The color of the specimens was measured by a spectrophotometer at baseline, after staining and after bleaching. The color differences (ΔE values) between baseline and after treatments were calculated. For statistical evaluation, analysis of variance (ANOVA), Whitny-mann tests were used at a significance level of value ($p<0.05$).

Methods

Specimen Preparation

A total of 60 disc-shaped specimens (10 mm diameter, 2 mm thickness) were prepared using prefabricated metallic molds. After filling the molds with composite materials, they were light-cured using an LED light-curing unit according to the manufacturer's instructions. A manual caliper ensured correct dimensions. Specimens were then divided into four subgroups based on the staining solution: distilled water (control), coffee, qat, and a mix of qat and red soft drink.

Each subgroup consisted of 5specimens.

Staining Solution Preparation

Staining solutions were freshly prepared daily. Yemeni coffee was brewed from 2 g of

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coffee in 100 ml of boiling water. The Qat solution was prepared by blending 20 g of Ansi Qat with 500 ml of mineral water. The mix of Qat and red soft drink was made by blending 20 g of Qat with 500 ml of Hania juice.

Results

In this study, a total of 60 specimens were prepared using three different resin-based composite materials: Merfill Bulk Fill, Charm Microhybrid, and Tokuyama Supra-Nano Composite, with 20 specimens allocated to each material. The specimens were randomly divided into four groups of five, and immersed in four different staining solutions (distilled water, coffee, qat, and a mixture of qat and red soft drink) for a duration of 7 days (24 hours per day). Following immersion, each subgroup underwent bleaching treatment with an in-office bleaching agent (38% hydrogen peroxide) for a period of 7 days. Color measurements were recorded for each specimen at three distinct intervals: baseline, after 7 days of staining, and after bleaching. The obtained results are meticulously summarized and presented in the subsequent sections, tables, and figures.

Descriptive Statistics

The mean values and standard deviations of color differences for the three resin composites (Merfill Bulk Fill, Charm Microhybrid, and Tokuyama Supra-Nano Composite) across the four staining solutions (distilled water, coffee, qat, and a mix of qat and red soft drink) are encapsulated in Table 4.1. The impact of bleaching with in-office agents is further examined in Table 4.2, using the National Bureau of Standards (NBS) units to assess and evaluate color deviations resulting from immersion and bleaching treatments, thereby correlating these changes with clinical relevance.

Effect of Staining Media on Composite Materials

After a 7-day immersion period, all resin composite specimens exhibited noticeable color changes.

- Coffee was found to impart the greatest staining effect on both Merfill Bulk Fill and Tokuyama Supra-Nano composites.
- The combination of qat and red soft drink caused the most significant staining in Charm Microhybrid composites.
- Conversely, distilled water induced minimal color alterations across all composite types.

Table 1 provides mean values and standard deviations for each composite material and staining solution. Most samples exhibited clinically perceptible color changes, with the exception of Charm specimens immersed in coffee and qat, which demonstrated extreme alterations.

Effect of Bleaching Agents on Color Stability

The bleaching treatments were successful in restoring color stability in stained resin composites:

- The in-office bleaching (38% hydrogen peroxide) was most effective after two applications.

Statistical analysis

Statistical analysis, employing one-way ANOVA and Mann-Whitney tests, indicated:

- Significant differences in color changes among the various composite types and staining solutions.
- The Bulk Fill Composite exhibited the highest

Comparison of Bleaching Efficacy

The in-office bleaching treatment proved to be more effective in restoring the color of composites:

- The Charm and Tokuyama composites showed substantial color recovery when treated after immersion in the mix of qat and red soft drinks.
- The Bulk Fill composites demonstrated the best response to coffee staining.

Statistical tests confirmed:

- Significant differences in color changes among composite materials and staining solutions.
- Prolonged immersion time (7 days) notably intensified color changes.

Table 1. *Mean Values (±SD) After 7 Days of Staining.*

Composite material	Staining solution	Mean ±SD	NBS unit	Critical remarks of color differences
Merfill bulk	Coffee	43.11±13.63	39.6	Change to other colors
	Qat	28.21±5.70	25.9	Change to other colors
	Mix	27.55±6.33	25.3	Change to other colors
	Distilled water	8.69±4.87	7.9	Extremely marked change
Charm	Coffee	12.33±5.48	11.3	Extremely marked change
	Qat	12.59±2.05	11.5	Extremely marked change
	Mix	18.77±7.00	17.2	Change to another color
	Distilled water	6.70±4.87	6.1	Extremely marked change
Tokuyama	Coffee	30.58± 11.46	28.0	Change to other colors
	Qat	19.19 ± 3.65	17.5	Change to other colors
	Mix	25.29 ± 5.80	23.1	Change to other colors
	Distilled water	1.48 ±0.98	1.2	slight change

Table 2. *Mean Values (±SD) for Each Composite and In-office Bleaching Agent.*

Composite material	Staining solution	In-office (HP)	NBS unit	Critical remarks of color differences
Merfill bulk	Coffee	27.04±12.04	24.8	Change to other
	Qat	18.63±4.05	17.1	Change to other colors
	Mix	20.87±3.06	19.1	Change to other colors
	Distilled water	1.47±0.63	1.2	slight change
Charm	Coffee	14.82±2.98	13.6	Change to other color
	Qat	18.45±2.39	16.9	Change to other colors
	Mix	21.92±6.69	20.1	Change to other colors
	Distilled water	3.15±2.66	2.8	Perceivable change
Tokuyama	Coffee	15.05± 4.05	13.8	Change to other colors
	Qat	16.47 ± 3.31	15.0	Change to other colors
	Mix	19.61 ± 9.54	18.0	Change to other colors
	Distilled water	1.39 ±1.08	1.1	slight change

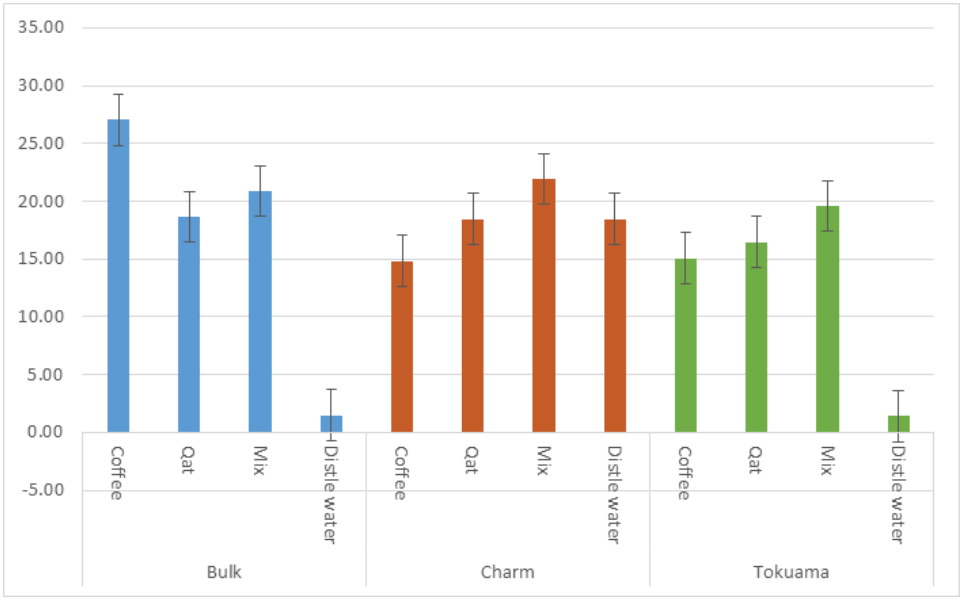

Figure 1. *Comparison of Color Change After Staining and In-office Bleaching.*

Figures and tables present a comprehensive overview of results, capturing the trends and differences in color changes through various stages of immersion and bleaching.

Discussion

This study assessed the color stability and bleaching efficacy of three different resin-based composite materials (Merfill Bulk Fill, Charm Microhybrid, and Tokuyama Supra-Nano) when exposed to various staining solutions and bleaching protocols.

Effect of Staining Media on Color Stability

All tested resin-based composites exhibited significant color changes after immersion in staining solutions, confirming their susceptibility to discoloration. Notable findings include:

- Coffee caused the highest color change in Merfill Bulk Fill and Tokuyama Supra-Nano composites, likely due to its high chromogenic potential.
- Qat and red soft drink mix resulted in significant discoloration of Charm Microhybrid composites, likely influenced by the combined effect of acidic pH and strong pigments.
- Distilled water caused minimal color alteration, reinforcing its role as a control.

These observations support previous research regarding the impact of staining solution composition on resin composite discoloration.

Efficacy of Bleaching Agents

The detected effectiveness of bleaching treatments revealed that in-office bleaching protocols are highly efficient for color restoration across all composite materials. This outcome is

Table 3. *Comparison of Color Change of Composite Materials After Staining and In-office Bleaching.*

Composite materials		**Merfill bulk**		**Charm**		**Tokuyama**	
Application of in-office bleaching	staining solution	Mean Rank	P	Mean Rank	Sig.	Mean Rank	P
Mean of 1st and 2nd application	Coffee	8.0	0.009**	6.5	0.02	8.0	0.009**
	D.W	3.0		2.5		3.0	
Mean of 1st and 2nd application	Qat	8.0	0.009**	6.5	0.02	8.0	0.009**
	D.W	3.0		2.5		3.0	
Mean of 1st and 2nd application	Mix	8.0	0.009**	6.5	0.02	8.0	0.009**
	D.W	3.0		2.5		3.0	
**= There was statistical significance where the p-value < 0.05							

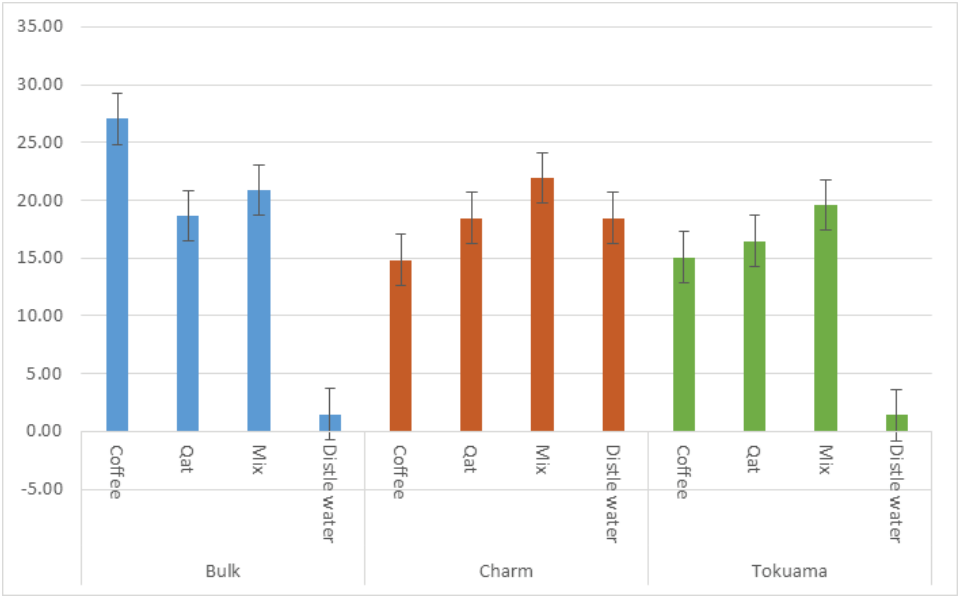

Figure 2. *Comparison of Color Change After Staining and In-office Bleaching.*

Table 4. *Composite Materials with In-office Bleaching.*

	Bulk	Charm	Tokuyama	One way Anova	P
	n=5	n=5	n=5		
Coffee	27.1±11.2	14.8±2.9	13.6±4.0	4.9	0.03
Qat	18.6±3.6	18.4±2.4	16.2±3.3	0.9	0.4
Mix	20.9±3.1	21.9±6.7	23.5±9.5	0.2	0.8

Table 4. *Mann-Whitney Test Results.*

Parameters	Comparison Groups		Mann-Whitney Test	P
Coffee	Bulk	Charm	12.2	0.03
	Bulk	Tokuyama	13.4	0.02
	Charm	Tokuyama	1.2	0.8

attributed to the high concentration of hydrogen peroxide applied during professional treatments, ensuring uniform exposure while achieving more profound discoloration.

Material-Specific Responses

The resin-based composite materials displayed varying degrees of staining and bleaching responses:

- Merfill Bulk Fill had the highest susceptibility to discoloration, especially from coffee, but showed considerable recovery post-bleaching.
- Charm Microhybrid displayed moderate discoloration, particularly with the qat and red soft drink mix.
- Tokuyama Supra-Nano Composite demonstrated superior color stability, potentially due to its advanced filler technology that reduces staining and enhances bleaching efficacy.

Clinical Implications

The study's results hold significant clinical ramifications:

1. Material Selection: Tokuyama Supra-Nano Composite is advantageous for aesthetically sensitive areas due to its better color stability and stain resistance.
2. Patient Education: Patients should be informed about the staining potential of certain foods and beverages, emphasizing good oral hygiene.
3. Bleaching Recommendations: In-office bleaching methods are advisable for severe discoloration requiring rapid and impactful restoration.

Limitations and Future Research

While this study provided valuable insights, certain limitations must be acknowledged:

- The 7-day immersion period may not emulate long-term clinical exposure, and longer durations are recommended for future studies.
- Only one bleaching agent was evaluated; including additional agents could broaden understanding of stain removal efficacy.
- The in-vitro nature of this study limits direct applicability to clinical conditions.

Future research should also explore the influence of filler morphology, resin chemistry, and surface treatments on the staining and bleaching behavior of resin composites to further refine choices in aesthetic restorative dentistry.

This study underscores the significant impact of staining agents on the color stability of resin-based composites and confirms the efficacy of bleaching treatments in mitigating discoloration. Tokuyama Supra-Nano Composite showcased superior resistance to staining and effective recovery post-bleaching, making it an ideal choice for aesthetic restorations. In contrast, Merfill Bulk Fill exhibited a higher risk of discoloration, while Charm Microhybrid displayed moderate outcomes.

Oral practitioners should prioritize careful selection of composite materials based on expected exposure to staining agents, while emphasizing patient education on minimizing risk factors for discoloration. In-office bleaching procedures present an effective means of restoring the aesthetic integrity of resin-based composites, promoting long-lasting restorative success. Future research should further investigate the long-term performance of these materials and the adaptability of different bleaching strategies.

Conclusion

This in vitro study confirms that various staining agents significantly influence the color stability of resin-based composites, with coffee showing the highest potential for discoloration, particularly in the Merfill Bulk Fill and Tokuyama Supra-Nano composites. The Tokuyama Supra-Nano Composite demonstrated superior stain resistance and effective recovery after bleaching, making it an optimal choice for aesthetic restorations. In-office bleaching proved to be an effective method for restoring color stability across all tested composites.

Clinical implications of these findings highlight the need for careful material selection based on staining susceptibility and the importance of patient education concerning lifestyle choices that may contribute to discoloration. Furthermore, in-office bleaching represents a viable solution for restoring aesthetic integrity in cases of severe discoloration. Future studies should consider longer immersion times, additional bleaching agents, and investigate the long-term effects of these materials in clinical settings.

Discussion

This study aimed to evaluate the marginal adaptation of Class II box-type cavities restored using direct and semi-direct techniques with two types of resin composites, Nova Compo C and Estelite Sigma Quick. The results indicate distinct differences in the marginal adaptation at the tooth-restoration interface between the techniques and the composite materials used. Specifically, while there was no statistically significant difference in marginal adaptation between the direct and semi-direct techniques when using Nova Compo C, the semi-direct technique demonstrated larger mean gaps with greater variability when Estelite Sigma Quick was employed. These findings align with previous literature suggesting that marginal adaptation is critical in determining the longevity and effectiveness of dental restorations, as inadequate adaptation can lead to clinical issues such as microleakage, postoperative sensitivity, and secondary caries [3].

Furthermore, the T-test analysis revealed that the type of composite significantly influenced marginal adaptation. Estelite Sigma Quick exhibited better performance with reduced gap formation compared to Nova Compo C. This could potentially be attributed to the superior physical and mechanical properties of Estelite Sigma Quick, including its viscosity and bonding capabilities, which may enhance the interface sealing at the tooth restoration boundary. The consistent standard deviations across the two techniques when using Estelite Sigma Quick imply that this composite provides reliable performance in terms of adaptation, which is essential for clinicians when selecting materials for restorative procedures.

The stereomicroscopy employed in this study allowed for precise gap measurements and detailed analysis of the interfaces, reinforcing its efficacy in evaluating clinical restorations. Such methodology provides vital insights into the quality of the dental restorations and underscores the importance of proper technique and material selection in achieving optimal patient outcomes.

Future Research Recommendations

Future research should aim to explore the influence of filler morphology, resin chemistry, and surface treatments on the staining and bleaching behavior of resin composites. Such studies will contribute to refining choices in aesthetic restorative dentistry and enhancing the longevity and aesthetic performance of restorative materials in clinical practice.

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