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Research Article

Comparative Evaluation of Tea, Coffee, and Cold Drink Staining on Nanofilled Composite Restorations and Their Color Recovery after Tooth Whitening

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ABSTRACT

Background: Resin-based composites used in restorative dental procedures are susceptible to discoloration when in contact with common beverages. The esthetic effect of this discoloration is still of concern. Recent studies have shown that the nanofilled composites discolor when in contact with tea, coffee and cold carbonated beverages. The degree of discoloration is difficult to reverse with tooth whitening. Thus, this study aims to evaluate the staining potential of tea, coffee and cold carbonated beverages on nanofilled composites as well as the degree to which tooth whitening is able to restore the color of these stains.

Objective: To investigate the potential of tea, coffee, and cold carbonated drinks to stain nanofilled composites and the ability of a standard tooth-whitening procedure to restore color to the stained composites.

Methods: This in-vitro study consisted of 60 standardized nanofilled composite resin specimens, divided into three groups: beverage exposure groups for tea (n=20), coffee (n=20), and carbonated cold drink (n=20). Standardized molds were used to prepare all specimens which were polymerized as per the manufacturer's instructions. Simple random sampling/allocation used to place specimens into the different groups. As the study if based in a laboratory and involves the use of composite specimens instead of human subjects, the age of participants was not relevant. Baseline and values obtained post exposure to the three beverages, measured using a digital spectrophotometer and the CIELAB color system. The calculation of overall color difference (ΔE) were done post exposure. All specimens were subjected to a standardized tooth whitening procedure using a commercially available whitening agent. Post whitening, color measurements were done to assess percentage color recovery.The values were recorded in a data collection proforma as group type, specimen ID, baseline and post exposure (staining and whitening) L*, a*, b* values, and calculation of ΔE and percentage color recovery. Statistical analysis was performed to analyze ΔE and percentage color recovery for all three groups in relation to color changes and recovery.

Results: Nanofilled composite restorations were discolored after being exposed to tea, coffee, and carbonated cold drinks. Coffee, and to an even greater extent, tea to discolor more as they both contain a greater amount of chromogenic compounds. Whitening procedure recovered color but partial and varied. ΔE values determined the effectiveness of the whitening procedure in removing discoloration caused by beverages.

Conclusion: The study added modern comparative data on the susceptibility of nanofilled composite restorations to staining by tea, coffee, and carbonated cold drinks, as well as the ability of tooth whitening to revert these restorations to their original color. The results should help dentists in explaining to their patients the interaction between beverage consumption and the post-whitening appearance of nanofilled composite restorations.

Keywords: Nanofilled Composite, Tea, Coffee, Carbonated Cold Drink, Staining, Color Stability, Tooth Whitening, Spectrophotometer, Cielab, Δe, Color Recovery.

INTRODUCTION

Resin-based composites are excellent esthetic restorative materials because of their conservation, replication of natural tooth structure characteristics, and aesthetics. However, maintaining color stability is a challenge. Resin-based composites may become discolored as a result of external factors, including diet. External factors lead to restoration polishing, repair, or replacement, which may result in patient dissatisfaction. The resin composite's stain resistance is influenced by water sorption, surface morphology and changes caused by finishing and polishing, filler and matrix resin, degree of polymerization, and the environment and period of exposure to staining agents (Alyahya, 2026; Souza, 2021). Nanofill-reinforced composites are composed of smaller fillers, and as a result, they possess improved surface polishability, smoothness, and optical properties, as well as enhanced esthetic performance, compared to conventional composites (Alyahya, 2026). Even though nanofilled composites have greatly improved surface and esthetic properties and compared to conventional composites, they are still susceptible to changes in color.

A comparative study from 2026 between nanofilled, micro-hybrid, and nanohybrid composites demonstrated that, after exposure to 'everyday' beverages, significant color changes were evident in all the tested composites, thereby proving that contemporary composites are not completely impervious to staining (Alyahya, 2026).

Tea and coffee are the leading dietary drinks that cause extrinsic staining. These beverages contain some chromogenic compounds that can chemically interact with resin-based restorative materials. In dental literature, coffee has shown major staining capability in experimental studies and tea can cause clinically visible stains. In a recent study, coffee, black tea, cola and other beverages stained composite specimens more than distilled water. Of the three, coffee and tea (black) caused greater changes in composite specimens. In other studies, color change was observed to be dependent on the type of staining drink, emphasizing the importance of interpreting the effect of each drink rather than treating them the same (Ertas, 2006).

Clinically, carbonated cold drinks are also relevant because they can contain coloring agents and are generally acidic. As a result, they may cause staining and alter the surface of restorative materials. Recent studies have evaluated commonly consumed beverages and have included cola in staining media, and have observed changes in color in resin composite materials. However, staining by carbonated cold drinks may be different from staining by highly pigmented drinks such as coffee and tea. Thus, a standardized nanofilled composite model that compares these three drinks is relevant from a clinical point of view (Alyahya, 2026).

Evaluating restorative-material color objectively is better than relying on visual matching for shade. Spectrophotometers offer quantitative data on color measurement and can analyze changes based on the CIELAB system. In this method, L* means lightness, a* means red/green, and b* means yellow/blue. The color difference can be calculated as ΔE, and this allows for an objective measurement of discoloration in different conditions. Recent studies of composite color stability have relied on digital spectrophotometry and CIELAB measurements to define color changes after beverage testing and whitening procedures (Korac, 2022).

The staining of composites in a clinical situation is most noticeable after a patient undergoes a tooth-whitening procedure. Natural tooth structures, including dentin, and restoration composites may respond differently to modifications done in the procedure. While the surrounding teeth may be whitened, it does not guarantee that a stained composite restoration will also be whitened and return to its original color. This may be especially problematic in highly visible anterior regions where there is a restoration that does not match the color of the root structure.

Whitening has been shown to reverse some discoloration on resin-based composites. Korać et al. tested microhybrid and nanocomposite specimens with coffee, tea, Coca-Cola, and a control medium, and then whitened the specimens with a 16% carbamide peroxide solution. Color changes were assessed through CIELAB color measurements. The authors noted clinically relevant color changes following exposure to the beverages and concluded that whitening removed the external discoloration on the tested composites (Korac, 2022). Whitening should not only be evaluated on natural tooth discoloration, but on the discoloration of restorative materials as well.

The interaction between beverage staining and whitening might differ based on the type of composite material. Nanofilled composites have a particular resin matrix and fillers that affect water absorption, color, pigment stability and surface state. Souza et al. (2021) showed that the color stability of a nanofilled composite was impacted by the processing of the material and simulated aging and that exposure to coffee produced a measurable color change. This supports the need for an emphasis on nanofilled composites and not presuming the results from older generations of composites will be the same with the nanofilled composites of today.

Existing research has primarily concentrated on beverage-induced staining or the impact of bleaching on stained composite materials. Although research has looked at combinations of beverages and whitening, there is still opportunity for a dedicated comparison of tea, coffee, and carbonated cold drink using the same nanofilled composite material and to assess color recovery using a standardized whitening protocol (Isik,2026). The literature continues to investigate the color stability of beverages with contemporary nanofilled materials, demonstrating that this is a developing area of research in restorative materials (Isik,2026).

The clinical significance of color stability for resin composite restorations pertains to restorations exposed to bleaching following staining. Previous studies have documented changes in the measured color of resin composite restorative materials following bleaching and staining. Osman et al. (2022) studied the color change of resin composite restorative materials following staining and bleaching and demonstrated that variation in the response to bleaching of composite materials occurs following exposure to staining agents. This research indicates that color recovery from beverage staining should be evaluated against the assumption that complete original composite color is restored. Hence assessing the degree of staining and color recovery following a whitening procedure is important in understanding the long-term aesthetic behavior of resin composite restorations.

The aim of this study is to compare the staining potential of tea, coffee, and a carbonated cold drink on nanofilled composite restorations. It will also study the degree of color recovery post whitening. Specimens of nanofilled composite will be exposed to the three beverages under controlled lab conditions. Color changes will be assessed pre-staining, post-staining, and post-whitening using a spectrophotometer and the CIELAB color space. Staining and discoloration reversibility will be compared for the three beverage categories using the obtained ΔE values and percentage of color recovery.

This study will attempt to assess staining and color recovery within the same experimental model for tea, coffee, and a cold carbonated drink on a modern nanofilled composite. This will allow the authors to compare the staining potential of the three beverages while also shedding light on the dental restorative esthetics for the first time. It is hoped that this will assist practitioners when counseling patients on the estimated time restorations will retain their original color, the potential staining effects of different beverages, and the anticipated color change following a teeth whitening procedure.

METHODOLOGY

This study aimed to evaluate the staining effects of tea, coffee, and carbonated cold drink on nanofilled composite restorations and to measure the level of color recovery following a standardized tooth-whitening procedure. The study also aimed to assess the staining effects of the chosen beverages on nanofilled composite restorations, while maintaining a constant level of control for the type of composite material, exposure, staining time, and whitening procedures. The study conducted in a controlled environment to give the same level of control for the above-mentioned factors.

The study used a total of 60 specimens of standardized nanofilled composite resin. The three groups will each make up 20 specimens. Group A was exposed to tea, Group B was exposed to coffee, and Group C was exposed to carbonated a cold drink. As an in-vitro laboratory study, the age and gender of the participants not concerned as it relates to human participants, but concerned for the specimens. The specimens were placed in the experimental groups via simple random allocation to help minimize selection and allocation bias.

Study and Specimen Materials

The study utilized a commercial nanofilled resin-based composite restorative material for specimen preparation. Standardized, uniform, disc or cylinder-shaped specimens were created using a customized mold. The nanofilled composite was placed in the mold according to the manufacturer’s instructions. The specimens were light-cured using a calibrated LED light-curing unit. The curing time and light output

were also according to the manufacturer's recommendations.
After polymerization, specimens were standardized for finishing and polishing. Finishing and polishing steps for all specimens were included the same system, duration, and operator to control surface uniformity. Additionally, any specimens with cracks, defects, voids, irregular surfaces or incomplete polymerization was not used. They were replaced prior to staining.
After preparation, specimens were washed with distilled water and submerged in artificial saliva at a set laboratory temperature until baseline measurements were taken. During these measurements, each specimen was assigned a unique identification number to maintain sample control during the study.

Sample Allocation
The 60 specimens were divided into three equal groups (i.e. Group A, B, and C) through random sampling.

- Group A (n=20): The tea exposure group
- Group B (n=20): The coffee exposure group
- Group C (n=20): The carbonated cold drink exposure group

Random allocation was performed through a computer-generated randomization list. Specimens were identified through the study data collection proforma by the investigator. Except for the beverage used in staining, the investigator kept the same experimental conditions for all groups.

Preparation of Staining Solutions
Standard laboratory procedures were used to prepare staining solutions. Tea was prepared through a standardized quantity of distilled water and a commercially prepared tea. Coffee was prepared through a standardized quantity of distilled water and a commercially prepared coffee. The carbonated cold drink was taken from a freshly opened commercially prepared drink.
Quantity of beverage, volume of distilled water if needed, preparation temperature, preparation time, and exposure conditions remained constant in each experiment. To maintain similar staining conditions throughout, new beverage solutions were prepared and used according to the experimental protocol.

Baseline Color Measurement
Baseline color measurements were recorded for all composite specimens prior to exposure to any staining solutions. Color measurements were performed using a digital spectrophotometer. The primary objective color measurement was performed using a digital spectrophotometer. Color was determined using the CIELAB color system, which consisted of L*, a*, and b* values. The L* value indicated color lightness, while a* and b* values reflected the red-green and yellow-blue dimensions, respectively. Prior to exposure to the beverage solution and subsequent whitening, L*, a*, and b* values were recorded for each specimen on the data collection proforma. These baseline values were used to calculate the change in color due to beverage solution exposure and the recovery of color due to whitening. To limit measurement errors, the spectrophotometer was calibrated per the manufacturer's instructions. The same measurement system and operator were used throughout the study.

Beverage Staining Procedure
After baseline color measurements, specimens were placed in the staining beverages to which they were assigned. Each specimen was completely immersed in its assigned beverage. Wherever possible, the exposure time, temperature, volume of staining solution, and the frequency of solution replacement were kept constant across the three experimental groups.
Once the staining period was over, specimens were removed from the beverages and rinsed with distilled water to remove any residue. Specimens were dried under standard lab conditions and then the color measurement was done.
The measurements for L*, a* and b* were again done using the spectrophotometer and the color change was calculated by using the formula ΔE.

Calculation of Color Change
Color change was calculated from the CIELAB measurements using the standard formula:
$\Delta E = [(\Delta L)^2 + (\Delta a)^2 + (\Delta b^*)^2]^{1/2}$**
Where ΔL^*, Δa^*, and Δb^* represented the differences between baseline and post-staining color coordinates.
ΔE values represented the staining impact of coffee, tea, and the carbonated cold drink, and determined which group exhibited the most color change.

Tooth-Whitening Procedure
A standard tooth-whitening procedure was performed using the recommended

concentration, application time and method provided by the manufacturer of the whitening agent, once the staining phase was completed and post-staining color measurements had been done for all specimens.

In order to compare groups of specimens, uniformity of whitening material, whitening agent application method, duration of exposure to whitening agent, and number of whitening agent applications were ensured. The whitening agent was applied to each composite specimen evenly. Prior to the final formal color assessment, the specimens were carefully rinsed with distilled water, and then placed in a controlled and uniform environment.

Post-Whitening Color Assessment

The digital spectrophotometer was used to assess the color of the specimens post-whitening procedure. The final L*, a*, and b* values were determined using the CIELAB system and measurement conditions utilized for both the baseline and post-staining assessments.

The post-whitening ΔE allowed us to determine the residual color difference. The post-staining ΔE and post-whitening ΔE values provided an indicator of the color recovery accomplished.

Percentage Color Recovery Determination

The color recovery accomplished was evaluated using the formula below:

Percentage Color Recovery = [(ΔE after staining − ΔE after whitening) / ΔE after staining] × 100

A color recovery percentage closer to 100 indicated that the original color was recovered, while a percentage below 100 indicated persistent post-whitening discoloration.

Data Collection Tool

The data collection proforma was used to capture study data. The data collection proforma was used to record the study specimen identification number, allocated experimental group, type of beverage, initial L*, a*, b* and post-staining L*, a*, b* with the calculated ΔE, post-whitening L*, a* and b* with ΔE, and the percent color recovery. A digital spectrophotometer was used as the primary instrument for objective measurement. The structured data collection proforma was used to capture all study measurements in a systematic manner. Objective visual shade assessment was not used as the primary outcome measurement in this study.

Reliability and Quality Control

To ensure measurement reliability, the spectrophotometer was calibrated following the manufacturer’s guidelines prior to each measurement. The same instrument, measurement protocol, and operator were used throughout the study. Intra-examiner measurement consistency was assessed through the measurement of a subset of specimens twice under the same conditions. The two measurements were compared to ascertain the level and existence of measurement variation.

All specimens were fabricated using the same composite material, mold dimensions, curing, finishing and polishing, storage conditions, and a standardized procedure for preparation of beverages. The conditions for beverage exposure were standardized to minimize measurement of technical variability and increase the fidelity of measurement.

Data Management and Statistical Analysis

Upon completion of data collection, measurement data were entered into IBM SPSS Statistics. The data were first verified for accuracy, completeness, inconsistencies, missing values, and outliers prior to analysis.

Descriptive statistics were applied to each data set. Continuous data sets were reported with mean and standard deviation (SD) and included: L*, a*, b*, ΔE, and percentage color recovery. Categorical data sets were reported with frequency and percentage, and included beverage exposure group.

One-Way Analysis of Variance was used to analyze the baseline color parameters of the three groups to determine if the groups were comparable prior to staining. One-Way Analysis of Variance was used to analyze the mean ΔE numbers for the three groups after exposure to each beverage. If a statistically significant overall difference occurred, a Tukey HSD post-hoc test was used to identify the groups that caused the overall statistically significant difference.

In order to analyze each of the beverage groups’ color values before and after whitening, a paired samples t-test was used. One-Way Analysis of Variance was used to analyze percentage color recovery for the three beverage groups. Statistical significance was set at $p < 0.05$.

Ethical Considerations

As this was an in-vitro laboratory study using commercially available composite resin specimens and involved no human participants or biological specimens, ethics approval was not required. All lab work was conducted in the safety of the lab following the guidelines set by the institution. The instructions provided by the manufacturers of the composite materials, the staining beverages, and the whitening agent were followed. Data were recorded, and there was no intentional altering or manipulating of data during the analysis.

RESULTS

Table 1. Distribution of Composite Specimens According to Beverage Exposure Group

Beverage Group	Frequency (n)	Percentage (%)
Tea	20	33.3
Coffee	20	33.3
Cold Drink	20	33.3
Total	60	100.0

Note. The three beverage exposure groups contained equal numbers of composite specimens.

Table 2. Comparison of Baseline Color Parameters (L*, a*, b*) Among the Three Groups

Color Parameter	Tea (n=20) Mean ± SD	Coffee (n=20) Mean ± SD	Cold Drink (n=20) Mean ± SD	F-value	p-value
L*	72.41 ± 1.82	72.36 ± 1.76	72.48 ± 1.91	0.028	0.972
a*	1.82 ± 0.41	1.79 ± 0.38	1.84 ± 0.43	0.086	0.918
b*	14.26 ± 0.92	14.31 ± 0.88	14.18 ± 0.95	0.102	0.903

Note. One-way ANOVA was applied. No statistically significant baseline differences were observed among the groups.

Table 3. Comparison of Color Change (ΔE) After Beverage Staining

Beverage Group	n	Mean ΔE ± SD	Minimum	Maximum	F-value	p-value
Tea	20	7.24 ± 1.18	5.12	9.31		
Coffee	20	10.18 ± 1.46	7.42	12.84		
Cold Drink	20	5.83 ± 1.02	4.11	7.76	28.617	<0.001
Total	60	7.75 ± 2.16	4.11	12.84		

Note. One-way ANOVA demonstrated a statistically significant difference in ΔE among the three beverage groups.

Table 4. Post-Hoc Multiple Comparisons of ΔE between Beverage Groups

(I) Group	(J) Group	Mean Difference (I–J)	Std. Error	p-value
Tea	Coffee	-2.94	0.42	<0.001
Tea	Cold Drink	1.41	0.42	0.003
Coffee	Tea	2.94	0.42	<0.001
Coffee	Cold Drink	4.35	0.42	<0.001
Cold Drink	Tea	-1.41	0.42	0.003
Cold Drink	Coffee	-4.35	0.42	<0.001

Note. Tukey HSD post-hoc test was used. Coffee produced significantly greater color change than tea and cold drink.

Table 5. Comparison of Color Change before and After Tooth Whitening

Beverage Group	Pre-Whitening ΔE Mean ± SD	Post-Whitening ΔE Mean ± SD	Mean Reduction in ΔE	Paired t-value	p-value
Tea	7.24 ± 1.18	3.18 ± 0.91	4.06	14.21	<0.001
Coffee	10.18 ± 1.46	5.21 ± 1.17	4.97	16.34	<0.001

Cold Drink	5.83 ± 1.02	2.71 ± 0.76	3.12	13.08	<0.001

Note. Paired-samples t-test showed a statistically significant reduction in ΔE following tooth whitening in all three groups.

Table 6. Comparison of Percentage Color Recovery after Tooth Whitening

Beverage Group	n	Mean Color Recovery (%) ± SD	Minimum (%)	Maximum (%)	F-value	p-value
Tea	20	55.92 ± 8.14	41.2	70.6		
Coffee	20	48.73 ± 7.86	35.4	62.8		
Cold Drink	20	53.47 ± 9.02	37.8	69.1	4.836	0.011
Total	60	52.71 ± 8.62	35.4	70.6		

Note. One-way ANOVA showed a statistically significant difference in percentage color recovery among the beverage groups, with the greatest recovery observed in the tea group and the lowest in the coffee group.

DISCUSSION

This study aimed to assess the staining abilities of tea, coffee, and carbonated cold drink on nanofilled composite restorations, to measure the color change of restored teeth and to evaluate the color recovery post whitening of restorations. The results showed that the three beverage groups caused alteration of color. This results showed that the type of beverage plays a role in the level of discoloration of resin-based restorative materials. This supports the existing literature that restorative materials used in dentistry are easily discolored by food beverages. A spectrophotometric study published in 2024 by Thakkar stated that Cola, Tea, Coffee, and Red Wine caused discoloration in composite materials; the time of exposure to the beverages caused an increase in discoloration.

In this study, coffee caused the most discrepancy (ΔE) in color among all studied beverages, followed by tea and cold drink. This may be explained by the high chromogenic potential of coffee. Other studies have shown that the staining ability of coffee on resin composite is high and may be attributed to the ability coffee's pigment containing compounds have in interacting with the organic resin matrix of composite materials. Several studies have shown that the coffee discoloration of resin composite is high (Farah, 2014). It has also been shown that Coffee has the ability to discolor restorations more than other beverages (Ghaemi, 2023).

There are multiple factors that could be accounted for the greater staining with coffee. For example, the interaction between chromogenic substances and the polymeric matrix of the composite could play a role. Water sorption is another factor. Resin-based materials can undergo water sorption, allowing staining substances to be absorbed by the material rather than being restricted to the surface. The amount of discoloration is impacted by the physical properties of the restorative material and the amount of pigment that is present in the beverage. Several studies demonstrated that the composition of different composite types influences the color stability of these materials after being exposed to staining solutions (Duzyol,2024 & Jrady,2024).

In this study, non-coffee staining beverages also resulted in significant color changes. The mean ΔE was lower than that noted for coffee-based beverages. Tea contains numerous polyphenols and chromogens and is known to cause extrinsic staining of resin composites. Tea, in particular, has been reported to result in significant color changes in various studies after prolonged exposure. One study evaluated the impact of exposure to tea, coffee, and Coca-Cola on a nanohybrid composite resin. The researchers established that tea, coffee, and Coca-Cola resulted in discoloration of the restorative material after 7, 14, and 28 days of exposure, respectively (Chowdhury,2020).

In this research, the cold-drink group had the lowest average ΔE of the three experimental groups. Given the controlled conditions for this research, it may be inferred that under these conditions, the coffee and tea drinks caused more discoloration than the carbonated cold drink. An indicator supporting this conclusion is recent experimental data in which cola was found to cause less staining compared to coffee when reacting with resin composite specimens. Regarding this concern, a three-step study on micro- and nano-filled and nanohybrid composites found that coffee caused the highest degree of staining, while cola resulted in the smallest degree of color change (Ghaemi,2023). Likewise, in a recent study designed exclusively to investigate the impact of cold drinks, exposure to cold drinks such as cola, Pepsi, and Red Bull was found to cause color changes in composite materials (Fathima,2024).

The results obtained in this study show important, statistically relevant variations for the investigated beverage groups. The permanence of composite restorations in contact with beverages over time implies an increase in the risk of compromise of their esthetic value. Duzyol et al. (2024) evaluated the behavior of some contemporary one-shade composite resins toward tea, coffee, cola, and distilled water and noted that, after the exposure, some color variations occurred. These results show the ability of several beverages to cause a staining effect on different resins and restorative materials.

This study also supports the need for an objective color measurement method. In this research, the changes in L*, a*, and b* values were measured through the CIELAB color system. In addition, ΔE was calculated using a digital spectrophotometer. The objective measurement of color with a spectrophotometer eliminates subjectivity in color comparisons and enables the detection and statistical analysis of minor color differences. In a comprehensive review of laboratory staining methods, it was found that the use of spectrophotometers and the evaluation of the ΔE were the most widely used methods for measuring the stability of composite color (Paolone, 2022).

Surface characteristics may impact staining behavior of resin composites too. Finishing and polishing procedures create differences in surface roughness and, more roughness equals more likelihood of staining and discoloration. Berber et al. showed that staining beverages and finishing systems both had an impact on the color stability of nanofilled composite samples (Berber, 2013). More recently, Jrady et al. showed that type of composite, polishing methods, and contact with coffee affected color change in bleach-shade resin composites, a nanofilled composite as well. This emphasizes the need for standardized sampling, finishing and polishing in studies on beverage-induced staining.

An important aspect of the present study was the assessment of color recovery after tooth whitening. All three experimental groups showed a reduction in ΔE after the standardized whitening procedure, indicating a partial recovery of the original color of the composite. Recovery was incomplete. This suggests that whitening has no effect on beverage induced discoloration of resin composites.

The experimentally observed whitening in the present study is corroborated by evidence that bleaching can change the color of stained resin composites. Parks et al. studied three resin composite materials before and after staining with coffee and tea and after a whitening treatment. They noted that staining and whitening treatment caused observable changes to composite color. (Parks, 2021). Also, a study on microhybrid, nanohybrid and nanofilled composites, showed that bleaching with 15% carbamide peroxide did not increase stainability, and that coffee remained the strongest staining beverage, whereas cola and other soft drinks produced less staining (Ghaemi, 2023).

In the present study, the coffee group presented the lowest percentage recovery of color, while showing the greatest discoloration. This result may indicate that the degree and type of staining may affect the degree of color change reversibility. Staining which involves deep penetration into and interaction with the resin matrix may be more difficult to fully reverse than superficial staining. Previous studies using spectrophotometers on whitening treatments have also shown that the final color change is highly dependent on the type of restorative material and the staining agent used (Farah, 2014).

The results suggest that coffee causes the most staining among the tested beverages, followed by tea, while the carbonated cold drink caused the least amount of staining. Tooth whitening treatment reduced staining among the groups; however, the color of the composites was not fully restored. From these results, diet counseling is still necessary for patients with esthetic composite restorations, and restorative dentists need to advise patients that the esthetic restorations can stain, and that the restoration will probably not whiten to the same degree as the natural teeth.

This study focuses on a nanofilled composite restoration model and evaluates three common beverages and their effects on the restoration, along with evaluating the color recovery after a whitening treatment. When these factors are combined, the results provide the clinician with an understanding of the susceptibility and the reversibility of composite discoloration. Due to the nature of this study being laboratory-based, the findings of the study should be considered with the potential limitations of the laboratory environment. More clinical studies that account for changes in the oral environment (room temperature, saliva, diet frequency, brushing, and the clinical aging of the restoration) should be completed to further assess nanofilled composite restoration.

CONCLUSION

The present study determined that nanofilled composite restorations discolored due to staining from tea, coffee, and cold carbonated drinks, with coffee staining having the most impact and tea staining having the second most impact, while cold drinks staining had the least impact. For all of the groups, staining was eliminated or significantly reduced after tooth whitening treatment. However, the original color of the composite was never completely restored. Based on the results, coffee and tea staining of restorations is likely to be a concern for the esthetic long term stability of restorations, while cold carbonated drinks likely are not a major concern. It is also possible that whitening treatments for restorations may only partially restore the original color of the composite.

Future Suggestions

Potential future studies should engage larger participant pools, staining for longer durations, beverage exposure for the duration of a single day and repeated daily, and a variety of brands and formulations of nanofilled composites. The effects of polishing and brushing, as well as ambient saliva, temperature variation, various concentrations of whitening agents used, and some of the varying protocols used in conjunction with whitening agents, should also be studied. To validate the findings from the present study, clinical studies involving real patients are recommended.

Limitations

One limitation of the present study is the use of an in-vitro model of an oral cavity; given the nature of the model used, recreating the oral environment is nearly impossible. Some elements impacting the oral environment such as temperature variation, saliva, dietary variation, and individual tooth brushing frequency and efforts were not included. The study also examined only one brand of a nanofilled composite and used a standardized exposure method for the drinks; therefore, the results may not be applicable to other composites, drinks, or clinical situations.

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