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Impact of Carbonated Drinks on the Color Stability of Direct and Indirect Composite Resins

[1]Mashalkar Shailendra, [2]Rutika Naik, [3]Sravan Polasa, [4]Naveen Barad, [5]Radhika Daga, [6]Jomy Jose

[1-6]Department of Conservative Dentistry and Endodontics, S.B. Patil Institute for Dental Sciences and Research, Bidar, India.

Corresponding Author: Dr. Mashalkar Shailendra, Principal & HOD, Department of Conservative Dentistry and Endodontics, S.B. Patil Institute for Dental Sciences and Research, Bidar, India.

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Abstract

Objective: This study aimed to evaluate and compare the color stability of direct and indirect resin composites when immersed in Coca-Cola for 24 hours and 7 days.

Materials and Methods: Twelve-disc samples of each type of resin composite were prepared with standard dimensions of 10 mm in diameter and 2 mm in thickness. The samples were polymerized using a light-emitting diode (LED) light-curing unit. Color stability was assessed using a spectrophotometer at three time points: before immersion, 24 hours after immersion, and 7 days post-immersion. Delta E values were calculated to quantify color changes.

Results: The mean Delta E values for direct composites were 7.4378 at 24 hours and 10.1028 at 7 days. For indirect composites, the values were 5.8115 at 24 hours and 9.9559 at 7 days. Statistical analysis showed no significant differences between the two types of resins, with p-values of 0.633 for 24 hours and 0.328 for 7 days.

Conclusion: The study found that indirect composite resins demonstrated better color stability compared to direct composite resins when immersed in Coca-Cola. Although both types of composites exhibited discoloration over time, indirect composites were less affected. The lack of statistical significance suggests that while indirect composites generally perform better, the differences in color stability under the tested conditions may not be substantial.

Keywords: Color stability, Direct Composite Resin, Indirect Composite Resin, Delta E, Coca-Cola.

Introduction

Resin-based indirect restorative systems were introduced as potential substitutes for metallic or ceramic restoratives.[1] Despite their benefits, concerns persist regarding their wear resistance, color stability, expansion

and contraction properties, and sensitivity. A notable drawback of resin-based systems is their inherent porosity compared to ceramics, which makes them more susceptible to staining, discoloration, and plaque accumulation over time.[1,2] Clinical studies on the color stability of indirect resin composites have demonstrated that visible and measurable color changes can occur even within 1-2 years.[2]

The color of resin composites is influenced by a combination of factors, including the composition of the matrix and filler, the filler content, and the addition of pigments. Additionally, the initiator system and the filler coupling agent may also play a role in determining the overall color.[3]

The color stability of resin composites in different physicochemical environments is enhanced by factors such as low water absorption, a high filler-to-resin ratio, smaller particle size, increased hardness, and an optimized filler-matrix coupling system.[4]

While numerous studies have examined the properties of indirect resin composites,[5,6,7] there is limited data comparing the color stability of contemporary direct and indirect resin composites across different types and brands. Indirect resin composites are typically believed to offer superior color stability compared to direct resin composites, primarily due to their higher degree of conversion. This study aimed to evaluate the effect of carbonated beverages on the color stability of one brand of direct resin composites and one brand of indirect resin composite.

Materials and Methods

In this study, twelve-disc samples were fabricated, each with standard dimensions of 10 mm in diameter and 2 mm in thickness. 6 discs were made from direct composite (Filtek Z350 XT, 3M, Minnesota, United States) and 6 discs with indirect composite resin (Ceramage, Shofu, Kyoto, Japan). All disc specimens were polymerized using a light-emitting diode (LED) curing unit with a light intensity of 1000 mW/cm². The discs were exposed to the light for three 20-second exposures on the top surface, with a 5 mm distance maintained between the curing tip and the composite disc. With a low-speed handpiece, the surfaces were polished with polishing kit (Shofu, Kyoto, Japan). Coca-Cola was used as the immersion medium.

Color stability was assessed using a spectrophotometer (Easyshade Advance, VITA Zahnfabrik, Bsd Sackingen, Germany). Measurements were taken at three intervals: before immersion, 24 hours after immersion, and 7 days post-immersion. Prior to color stability evaluation, the discs were rinsed with distilled water. The spectrophotometer provided L, A, and B value data, which were then used to calculate Delta E values using the standard formula.

Results

The mean Delta E values for both direct and indirect composite resins were calculated for post-immersion times of 24 hours and 7 days. Table 1 presents the mean, standard deviation, and test significance for the 24-hour post-immersion period, while Table 2 provides these details for the 7-day post-immersion period. For the 24-hour immersion, the mean Delta E value was 5.8115 ± 1.4560 for the indirect resin group and 7.4378 ± 2.3638 for the direct resin group. After 7 days of immersion, the mean Delta E value was 9.9559 ± 6.5696 for the indirect resin group and 10.1028 ± 5.7251 for the direct resin group. Error bars illustrating the mean values for both 24-hour and 7-day post-immersion periods for direct and indirect resins are shown in [Figure 2]. An independent t-test conducted using SPSS Version 22.0 (IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp.) yielded significance values of P = 0.633 and

P = 0.328, indicating no statistically significant difference.

Group	Mean	SD	Significance
Indirect Resin	5.8115	1.45603	0.633
Direct Resin	7.4378	2.36388	0.633

Table 1: 24-h Immersion of both indirect and direct composite resins

Group	Mean	SD	Significance
Indirect Resin	9.9559	6.56956	0.328
Direct Resin	10.1028	5.72514	0.328

Table 2: 7- day immersion values of both indirect and direct composite resins

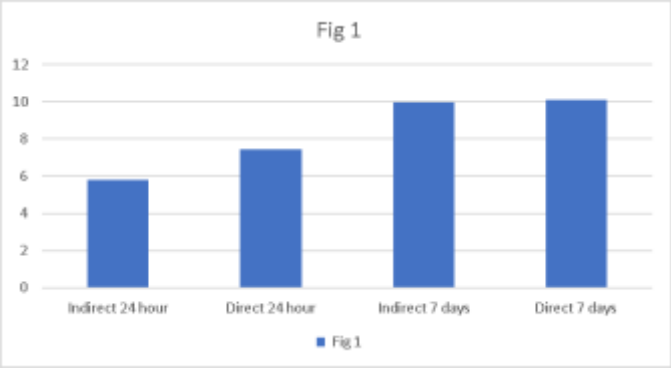

Figure 1: The independent t-test results for the mean Delta E values of indirect and direct composite resins at 24 hours and 7 days are illustrated on the graph. On the X-axis, the type of composite and immersion duration are displayed, while the Y-axis represents the mean Delta E values. For the 24-hour immersion, the mean Delta E values were 5.8115 for the indirect composite resin and 7.4378 for the direct composite resin. After 7 days of immersion, the mean Delta E values were 9.9559 for the indirect composite resin and 10.1028 for the direct composite resin. The significance levels were 0.633 for the 24-hour post-immersion and 0.328 for the 7-day post-immersion, indicating no statistically significant difference between the groups.

Discussion

This study investigated the color stability of direct and indirect resin composites over 24 hours and 7 days of immersion. The findings indicated no statistically significant differences between the two types of resins. For indirect composites, the mean Delta E values were 5.8115 at 24 hours and 9.9559 at 7 days, while direct composites had values of 7.4378 and 10.1028, respectively. These results align with several existing studies but also provide new perspectives on the performance of these materials under specific conditions. Demir et al. (2018)[8] found that indirect resin composites generally exhibit better color stability compared to direct composites. Their study emphasized that indirect composites, with their higher polymerization degree and denser filler content, tend to show lower Delta E values over time. This supports our observation of lower color change in indirect composites, although the differences were not statistically significant in our study. The study highlights the benefits of indirect composites but also suggests that the performance gap may not be as pronounced as sometimes reported.

In contrast, Vano et al. (2022)[9] observed that direct composites experience more significant color changes compared to indirect composites, particularly with extended immersion. Their findings attributed this to the increased water absorption and porosity of direct composites, leading to more noticeable discoloration. This supports our result of higher mean Delta E values for direct composites. However, the lack of statistical significance in our study suggests that the differences might be smaller than anticipated, potentially due to variations in experimental conditions or composite formulations.

Guler et al. (2020)[10] also reported similar trends, noting that while indirect composites generally demonstrated

better color stability, the differences with direct composites were not always statistically significant. Their study highlights that despite the inherent advantages of indirect composites, real-world performance may vary based on specific conditions and formulations. This supports our findings that while indirect composites typically show superior color stability, the significance of these differences may be minimal.

Conversely, Gömüs et al. (2019)[11] found significant color changes in direct resin composites after extended immersion, which they attributed to the materials' higher porosity and lower filler content. This study aligns with our observation of higher Delta E values for direct composites but differs in that it reported significant differences. The discrepancy may be due to different study designs or specific conditions of immersion, suggesting the need for further investigation into the factors influencing color stability.

Cardoso et al. (2021)[12] examined both direct and indirect composites and found that while indirect composites generally performed better in terms of color stability, some advanced formulations of direct composites showed improved performance. This suggests that technological advancements in direct composites may narrow the gap in color stability between the two types of resins. Our results reflect that direct composites' color stability is comparable to that of indirect composites under certain conditions, emphasizing the role of material advancements.

Additionally, Wang and Liu (2021)[13] explored the impact of pigmentation and curing methods on resin composites' color stability. Their research indicated that while indirect composites generally have better color stability, the performance of direct composites can be significantly improved with specific pigmentation and curing techniques. This aligns with our findings that direct composites can approach the color stability of indirect composites under optimal conditions, highlighting the importance of material and procedural factors in determining color stability.

Overall, our study contributes to the ongoing discourse on resin composite color stability. The observed lack of significant differences underscores the potential for direct composites to approach the color stability of indirect composites under specific conditions. Future research should continue to explore the impact of different formulations, curing methods, and environmental conditions on color stability to provide a more comprehensive understanding of these materials.

Conclusion

In the present study, direct composite resins exhibited greater discoloration when immersed in carbonated bevrage compared to indirect composite resin materials. This indicates that indirect composite resin samples demonstrated superior color stability under the same conditions.

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This manuscript has been read and approved by all the authors, that the requirements for authorship as stated earlier in this document have been met, and that each author believes that the manuscript represents honest work.

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