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RESEARCH ARTICLE

Effect of Different Polishing Systems on the Colour Stability of Nano-Filled Composite Stained by Common Food Colourants: An *In-Vitro* Spectrophotometer Analysis

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ABSTRACT:
Aim: The present study aims to assess the color stability of nano-filled composite resin polished using three different polishing systems (Sof-lex, Enhance, and mylar strip) and stained with commonly consumed discoloring agents (tea, dal, and Coca-Cola) in India.
Materials and Methods: 120 Disc-shaped samples were prepared and divided into polishing groups, with each group subjected to specific polishing procedures. After baseline measurements, samples were immersed in staining solutions, and color differences were measured by a spectrophotometer to assess discoloration.
Results: Statistical analysis revealed significant staining differences among the polishing groups ($P<0.001$ by ANOVA). Group 3 (Enhance) exhibited higher staining compared to Group 2 (Sof-Lex). Dal caused significantly greater staining compared to other agents in all groups. The staining potential of beverages ranked as Dal > Tea > Distilled water ≥ Coca-Cola.
Conclusion: This study highlights the impact of polishing systems on the color stability of nano-filled composite resin restorations when exposed to common discoloring agents. The findings underscore the importance of selecting appropriate finishing and polishing techniques to mitigate discoloration risks, particularly in the context of varied staining potentials of different agents. This knowledge contributes to improving clinical practices for enhancing the long-term aesthetic outcomes of composite resin restorations in dental applications.
Keywords: Composite Resin; Restoration; Conservative dentistry; Aesthetics

Introduction:

In everyday dental practice, composite resin restorations play a crucial role and are widely preferred for their focus on achieving optimal aesthetics. One of the key requirements for an aesthetic restorative material is long-term color stability.[1] The primary cause of discoloration in composite resin restorations is the presence of colorants found in commonly consumed beverages such as coffee, tea, sports drinks, cola, dal, and fruit juices, as well as factors like smoking and poor oral hygiene.[2,3,4]

To enhance aesthetics, polishability, gloss, color stability, retention, and wear resistance, nano-filled composites were developed, combining the advantages of hybrid and micro-filled composites within the same restorative material. These composites exhibit favorable mechanical properties, superior surface quality, better polish and gloss, increased retention, and improved wear resistance.[5]

The roughness of restorations significantly impacts their aesthetic appearance. A rough surface can lead to staining and discoloration due to the infiltration of colorants into the irregular surfaces of the restorations. Various finishing and polishing systems are employed to achieve a smooth surface, including abrasive finishing strips, carbide and diamond instruments, abrasive-impregnated polishing discs, burs, and polishing pastes.[3]

The color stability of a restorative material is influenced by both intrinsic and extrinsic factors. Intrinsic discoloration is linked to the resin matrix type, filler loading, photo-initiator system, and degree of conversion. Extrinsic staining results from factors such as surface roughness, food colorant adsorption, water sorption, UV exposure, heat, and poor oral hygiene.[6] Staining primarily occurs due to the degradation of the composite's matrix phase when exposed to oral fluids, leading to water absorption, hydrolytic breakdown of the filler bonding agent, and leaching of unreacted monomers, resulting in discoloration.[7]

Given this background, the present study was designed to assess the color stability of nano-filled composite resin polished using three different polishing systems (Sof-lex, Enhance, and mylar strip) and stained with commonly consumed discoloring agents (tea, dal, and Coca-Cola) in India.

Materials and Methods:

A total of 120 disc-shaped samples were prepared using a nano-filled composite (A2 shade; 3M™ ESPE™ Filtek™ Z350 XT Universal Restorative; 3M, MN, United States) in a metal mold of dimensions 15mm×2mm (Figure 1). The composite was packed into the mold using a plastic filling instrument and polymerized with an LED light curing unit. The samples were stored in distilled water for 24 hours, numbered, and randomly divided into three polishing groups (n=40) using computer-aided software (www.random.org). The groups were polished as follows:

Group 1 (Mylar strip, control): Samples in this group were not subjected to finishing and polishing procedures.

Group 2 (Sof-Lex): The samples in this group received finishing and polishing using Sof-Lex Contouring and polishing discs according to the manufacturer's instructions.

Group 3 (Enhance): The samples in this group underwent finishing and polishing using the Enhance Finishing and Polishing System as per the manufacturer's guidelines.

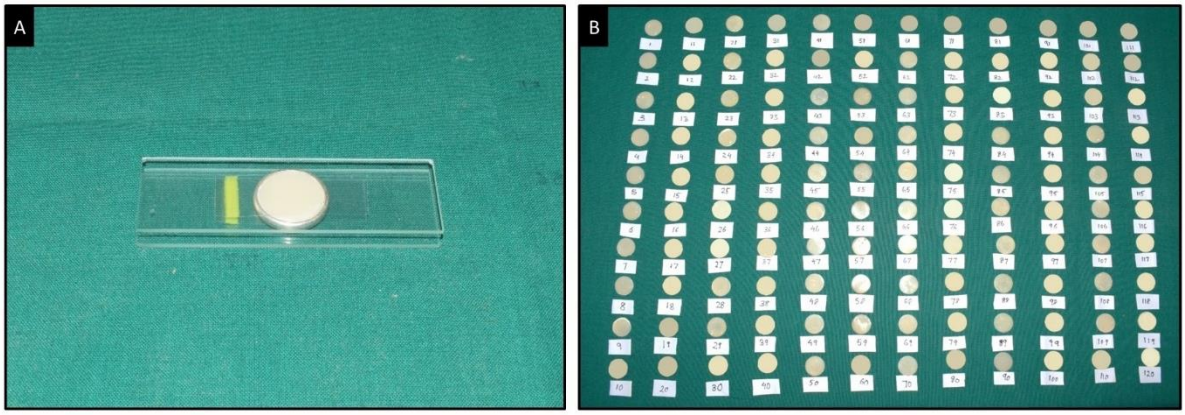

Figure 1: A) Preparation of a specimen in the mould, and **B)** 100 prepared specimens

Figure 2: A) Sets of 3 units of different beverages for different polishing systems, **B)** Spectrophotometer, and **C)** specimen placed on the pore for reading by the spectrophotometer

Following the completion of the polishing procedures for all groups, the samples were analyzed using a spectrophotometer to establish baseline measurements. The specimens were then randomly divided into four staining subgroups (n=10) for immersion in different solutions: distilled water (Control), Tea (Taj mahal tea), Coca Cola (Hindustan Coca-cola beverages Pvt. Ltd.), and dal. The staining solutions were prepared accordingly.

After 24 hours of immersion in the staining solutions at 37°C, the samples were retrieved, rinsed with distilled water, and remeasured using a spectrophotometer to calculate the color difference (ΔE), which indicates the level of discoloration.

STATISTICAL ANALYSIS:
Descriptive and inferential statistical analyses were carried out in the present study. Results on continuous measurements were presented on Mean ± SD and results on categorical measurement were presented in number (%). Level of significance was fixed at P=0.05 and any value less than or equal to 0.05 was considered to be statistically significant.

Analysis of variance (ANOVA) was used to find the significance of study parameters between the groups (Inter group analysis). Further Tukey's post hoc analysis was carried out to find out the significance between the groups. The individual values of each specimen per group and subgroups are tabulated in the annexure. The Statistical software IBM SPSS statistics 20.0 (IBM Corporation, Armonk, NY, USA) was used for the analyses of the data. Microsoft word and Excel were used to generate graphs, tables etc.

Results:

The polished samples in all groups exhibited varying degrees of staining, and the differences were statistically significant (P<0.001 by ANOVA). Among the different polishing systems, group 3 showed higher staining capacity compared to group 2 (P=0.026). Regardless of the polishing system, dal caused significantly higher staining compared to the other staining agents (12.430, 8.4555, and 15.6227 for groups 1, 2, and 3, respectively). The staining potential of the beverages ranked in decreasing order as Dal > Tea > Distilled water ≥ Coca Cola. The inter-group comparison of staining for different beverages is denoted in Table 1.

Table 1: Intergroup comparison of all foodstuffs (Tukey's post hoc analysis)

	Distilled water	Tea	Coke	Dal Water
Distilled Water	-	0.411	0.994	**<0.001*** **
Tea	0.283	-	0.411	**<0.001** **
Coke	0.994	0.411	-	**<0.001** **
Dal water	**<0.001*** **	**<0.001** **	**<0.001** **	**-**

Discussion:

Aesthetic restorative materials must replicate the natural tooth's appearance, which is intricately linked to shade matching and long-term color stability within the oral cavity. However, over time, these materials tend to undergo discoloration due to exposure to various beverages and foods.[8] Thus, assessing their susceptibility to color change is crucial.

In the past, hybrid composites demonstrated adequate mechanical properties but lacked the ability to achieve a high polish, while micro-filled composites offered superior polishability but compromised mechanical strength. The recent innovation in composites comes in the form of "nano-filled" composites, incorporating nanoscale particles.[8] These advanced composite systems combine the strengths of both hybrid and micro-filled composites. The nanomeric particles are monodispersed, non-aggregated, and non-agglomerated silica nanoparticles.[9] Notably, nano-filled composites have shown a significant improvement in surface smoothness and polish retention compared to conventional micro-filled composites. Smaller filler sizes contribute to reduced staining and enhanced aesthetics.[10] Consequently, our study incorporates a nano-filled composite, 3M™ ESPE™ Filtek™ Z350 XT Universal Restorative, given its pivotal role in ensuring the esthetics and longevity of composite resin restorations.[11] Surface irregularities arising from poor finishing and polishing techniques, or the use of inappropriate instruments, may lead to issues such as staining, plaque retention, gingival irritation, recurrent caries, abrasion, wear kinetics, and tactile perception.[12]

Traditionally, clinicians have relied on various instruments, including abrasive finishing strips, carbide and diamond burs, and polishing pastes, to finish tooth-colored restorative materials.[13] While the application of progressively finer grits of abrasives was a common practice, recent efforts have been directed at developing composite finishing instruments that streamline the process. One-step systems have emerged, claiming effectiveness comparable to multi-step systems in polishing dental composites.[14] These one-step systems aim to achieve a smooth surface with fewer steps, which appeals to clinicians. Due to the diversity of composites and polishing systems available, evaluations are essential to determine the most effective polishing systems for specific composites. Hence, this study investigates the impact of a two-step polishing system, Enhance Finishing and Polishing, and a multi-step polishing system, Sof-Lex Polishing, on the color stability of nano-filled composite materials.

Color alteration in composites is frequently attributed to food colorants such as coffee, tea, turmeric, alcohol, red wine, grape juice, sports drinks, etc.[2,15-18] Turmeric, derived from Curcuma longa, has been used for its flavoring and coloring properties for thousands of years. It contains diarylheptanoids like curcumin, responsible for its orange color.[19] In our study, we used cooked dal to evaluate the staining potential of turmeric to better simulate clinical situations. Tea is another common beverage, known for its yellow colorants, with varying polarities, which can lead to staining in resin composite.[10] Staining caused by tea is primarily due to the presence of tannic acid.[20] Coca-Cola, widely popular in India, gains its color from caramel, which can range from pale yellow to deep brown.[21] Given the popularity of these beverages in India, we evaluated their staining potential alongside distilled water as a control. Notably, distilled water, while lacking artificial pigments, still led to minimal color change, likely due to water sorption by the organic matrix or hydrolytic breakdown of filler particles.[17,23] Tea exhibited the second-highest color change, primarily because of the compatibility of the polymer phase with the yellow colorants in tea. Minimal color changes, within clinically acceptable limits, were observed with Coca-Cola, possibly due to its low polarity and the presence of phosphate ions, which reduce dissolution rates. Nonetheless, the findings on staining potential were consistent with previous literature.[6,20,21]

Considering the polishing systems, our study results favor multistep polishing (Sof-Lex) over two-step polishing (Enhance) in maintaining the color stability of the tested samples. This aligns with previous research.[2] The reduced color change values associated with multistep polishing can be attributed to the use of polishing discs with

decreasing abrasiveness levels, resulting in a more uniform level of wear. Additionally, the aluminum oxide-impregnated discs contribute to more even wear. Longer polishing times contribute to smoother surfaces, aiding in polish retention and ultimately reducing staining.[24] However, it's worth noting that contradictory findings have been reported in other studies.[14,25] Bashetty et al. found diamond-impregnated polishers to be more efficient than aluminum oxide-impregnated discs.[14] On the other hand, Gonulol et al. found no significant differences between Sof-Lex and Enhance systems in surface roughness and preferred the latter due to its convenience.[25]

In terms of surface finishing, Mylar strip finishing produces the smoothest surfaces. However, it's important to note that Mylar finishing may exhibit more color change due to lower polymerization levels at the surface, potentially leading to increased discoloration.[26,27]

Conclusion

In summary, our study highlights the significant impact of beverages like dal and tea on the color stability of nano-filled composite materials, often resulting in aesthetically unacceptable discoloration. To mitigate this effect, the use of a multistep polishing system proves more effective than a two-step system or no polishing at all, contributing to the retention of a polished surface and reducing staining. It is crucial for patients to be informed about the potential consequences of their dietary choices on dental restorations.

Moving forward, further research can explore the influence of different stains on resin-bonded composites with varying clinical characteristics. These insights will be instrumental in the development of stain-resistant composite resins and the refinement of polishing systems, ultimately improving the quality and durability of dental restorations. Our findings underscore the importance of ongoing advancements in restorative dentistry to ensure aesthetically pleasing and long-lasting outcomes for patients.

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