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Review Article

Discoloration patterns in dental restorations linked to common beverages and spices

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ABSTRACT

Discoloration of dental restorations remains a major concern in aesthetic dentistry, driven largely by the interaction between restorative materials and commonly consumed staining agents such as beverages and spices. The degree and permanence of staining depend on several variables including the chemical structure of chromogens, the composition and surface characteristics of restorative materials, and patient-related factors such as oral hygiene and dietary habits. Resin-based composites are particularly vulnerable to color change due to their hydrophilic resin matrix and capacity for pigment absorption, especially when exposed to substances like coffee, red wine, and turmeric. In contrast, ceramics display better color stability, though they can still stain when surface glaze is compromised. Glass ionomer cements, frequently used in non-load bearing areas, demonstrate the highest susceptibility due to their porous structure and water sorption. The mechanism of discoloration involves both surface adsorption and deeper absorption, influenced by the acidity, temperature, and duration of exposure to staining agents. Surface treatments, including polishing and glazing, significantly affect the resistance of restorations to external pigmentation. Clinical management focuses on minimizing aesthetic deterioration through material selection, polishing techniques, dietary counseling, and regular maintenance. While polishing can address superficial stains, intrinsic discoloration often requires restoration replacement. Bleaching therapies pose additional challenges, as restorative materials do not respond predictably to whitening agents, potentially creating shade mismatches. Understanding the dynamics of staining allows for more informed clinical decisions and improved patient outcomes. Ongoing research continues to explore advanced materials with enhanced stain resistance and surface durability, aiming to reduce the frequency of aesthetic failures and extend restoration longevity in pigment-rich oral environments.

Keywords: Discoloration, Dental restorations, Staining agents, Resin composites, Aesthetic dentistry

INTRODUCTION

Dental aesthetics are a significant concern in modern restorative dentistry, with patients increasingly demanding restorations that mimic natural dentition not only in function but also in long-term visual appearance. Discoloration of dental restorations over time presents a major challenge to aesthetic outcomes, frequently leading to dissatisfaction and the need for replacement procedures. The discoloration of restorative materials is influenced by a variety of intrinsic and extrinsic factors. Among extrinsic contributors, the consumption of common beverages and spices plays a dominant role due to their chromogenic potential and frequent intake in daily diets.

Beverages such as coffee, tea, red wine, and cola are well-known for their staining capabilities. These liquids contain tannins, polyphenols, and other pigmented compounds that can adhere to the surface of restorative materials, causing visible color changes over time.[1] Similarly, spices like turmeric, paprika, and curry powders are rich in natural dyes such as curcumin and carotenoids, which can impart persistent stains on dental restorations through repeated exposure.[2] The nature of the staining depends not only on the pigment concentration of these agents but also on their pH, viscosity, and the frequency of exposure. Acidic beverages, for instance, may etch the surface of restorative materials, making them more susceptible to discoloration from pigments that subsequently come into contact with the surface.

The type of restorative material used is another critical determinant in discoloration susceptibility. Composite resins, glass ionomer cements, and ceramic materials all vary in surface roughness, porosity, and resin matrix composition, which influence their interaction with staining agents.[3] For instance, resin-based composites are more prone to staining due to their hydrophilic nature and potential for water absorption, which can facilitate the penetration of staining molecules. On the other hand, certain ceramics exhibit better color stability but are not immune to superficial staining, especially in the presence of surface wear or glazing loss over time.

Surface finishing and polishing procedures also play a pivotal role in resistance to discoloration. A smoother surface finish reduces pigment adherence by minimizing surface roughness and micro-defects. Nonetheless, even highly polished restorations can exhibit discoloration when exposed chronically to pigmented substances, especially if the patient demonstrates poor oral hygiene or if the material degrades over time due to thermal and mechanical fatigue.[4] Furthermore, the use of whitening agents or bleaching procedures to counteract discoloration may alter the physical properties of restorations, potentially leading to increased surface degradation or color mismatch with adjacent natural teeth. Understanding the interaction between dietary habits and dental material science is essential for clinicians aiming to optimize the longevity and aesthetic performance of restorations. An evidence-based approach to material selection, patient education on dietary impacts, and preventive maintenance can significantly enhance restoration outcomes.

REVIEW

The discoloration of dental restorations remains a multifactorial issue influenced by the chemical nature of staining agents, restorative material properties, and environmental exposure. Pigmented beverages such as coffee and red wine contain high levels of chromogens and acidic components, which not only deposit surface stains but may also cause surface degradation, increase porosity and promote further stain uptake. Similarly, spices like turmeric are rich in curcuminoids that exhibit strong staining capabilities, particularly on resin-based composites that tend to absorb water and pigments over time.[5] These extrinsic agents interact differently with restorative materials depending on their surface characteristics and resin matrix composition.

Composite resins, due to their organic matrix, are particularly susceptible to staining compared to ceramics, which possess a more stable crystalline structure. However, the presence of surface wear or inadequate glazing on ceramics can also make them prone to discoloration when exposed to staining agents regularly.[6] The degree of staining is not solely dependent on the material but also on oral hygiene habits, frequency of consumption, and the duration of exposure. Therefore, clinicians must consider both material selection and patient dietary counseling as key elements in preventing discoloration and ensuring long-term aesthetic satisfaction with restorations.

Staining mechanisms and interactions

Discoloration of dental restorative materials is not merely a superficial phenomenon but involves complex chemical and physical interactions between external chromogenic agents and the material's intrinsic structure. These staining mechanisms are primarily influenced by the molecular properties of both the staining substance and the restorative surface, including polarity, solubility, and surface energy. The interface where these interactions occur is often mediated by the material's water absorption capacity, surface roughness, and the presence of microgaps that may trap pigments.

Pigmented beverages like tea, red wine, and soda contain chromophores and acidic components that contribute to both adsorption and absorption staining. Adsorption refers to pigment molecules binding to the external surface of a restoration, often facilitated by surface irregularities or rough finishing. In contrast, absorption staining occurs when low-molecular-weight colorants penetrate the matrix of resin-based materials, leading to intrinsic discoloration that is more resistant to polishing or cleaning procedures.[7] These interactions become more aggressive in low pH environments, as acidic exposure can soften or degrade the

resin matrix, promoting deeper pigment penetration and increasing surface porosity.

Spices such as turmeric and saffron contain highly pigmented compounds like curcumin and crocin, which display strong staining affinity for hydrophilic resin matrices. These compounds are often oil-soluble, allowing them to adhere persistently to composite surfaces, especially when the restoration is not adequately polymerized or exhibits microdefects from occlusal wear or improper finishing. Even short-term exposure to such compounds under thermal cycling can result in perceptible color changes. In a controlled study assessing various staining agents, turmeric was found to produce the most significant discoloration in nanohybrid composites after 30 days of immersion, highlighting the aggressive staining potential of spice-derived pigments.[8]

The hydrophilicity of resin-based materials plays a pivotal role in discoloration behavior. Materials with higher water sorption allow pigment molecules to diffuse more readily into the resin matrix. Bis-GMA-based composites are especially susceptible due to their aromatic and hydrophilic chemical structure, which facilitates both water uptake and pigment entrapment. Conversely, materials like Ormocer-based or silorane-based composites demonstrate lower staining susceptibility because of their reduced water affinity and denser cross-linked polymer network, which acts as a barrier to molecular infiltration.[9]

Temperature and exposure duration also modulate staining kinetics. Hot beverages may increase the mobility of pigment molecules and transiently alter the polymer matrix, allowing deeper pigment diffusion. Repetitive thermal changes, especially in combination with mechanical brushing or acidic exposure, further degrade the surface integrity of restorations.

The degradation results in microcracks or loss of filler particles, both of which compromise the smoothness of the surface and promote discoloration over time. Even polishing systems differ in their long-term resistance to stain accumulation, as submicron roughness left behind by inadequate finishing tools can act as pigment traps under cyclic exposure conditions.[10]

Material-based stain susceptibility

Dental restorative materials vary widely in their response to extrinsic staining agents, owing to differences in composition, filler particle size, surface chemistry, and degree of polymerization. Resin composites, ceramics, and glass ionomer cements each present distinct interactions with staining compounds, which influence both the intensity and permanence of discoloration. These variations become clinically relevant when assessing long-term aesthetic durability, especially in patients with dietary exposure to chromogenic substances. Resin composites are particularly susceptible to staining due to their organic resin matrix and inherent hydrophilic properties. The matrix often consists of monomers such as Bis-GMA, TEGDMA, and UDMA, each with different water sorption and solubility characteristics. Increased water absorption facilitates pigment penetration into the material bulk, leading to internal discoloration that cannot be eliminated by polishing. Studies have shown that microhybrid composites tend to discolor more rapidly than nanohybrid or nanofilled variants, a trend attributed to differences in filler loading and particle distribution.[11] Larger filler particles in microhybrids create interstitial spaces where pigments can accumulate, especially if the surface is irregular after finishing procedures.

Ceramic materials, although more color-stable overall, are not impervious to discoloration. Their surface glaze can wear away over time due to mechanical abrasion or acidic exposure, which increases surface roughness and encourages pigment adherence. Feldspathic porcelain and lithium disilicate ceramics, commonly used in aesthetic zones, show better color retention when properly glazed and maintained. Yet even these materials may exhibit superficial staining after long-term exposure to coffee or red wine, particularly when glazed layers are compromised.

A comparative analysis found that polished zirconia ceramics stained more visibly than glazed ones after immersion in staining solutions for 14 days, confirming the role of surface integrity in stain resistance.[12]

Glass ionomer cements (GICs) and resin-modified glass ionomers are especially vulnerable to staining because of their porous surface and relatively low filler content. Their hydrophilic nature makes them prone to water uptake, which not only weakens mechanical strength over time but also permits chromogens to enter the material's microstructure.

GICs used in cervical lesions or pediatric dentistry may discolor rapidly when exposed to dietary agents like cola, tea, or curry, often necessitating early replacement. In one in vitro evaluation, resin-modified GICs demonstrated significantly higher color change compared to resin composites after immersion in common beverages for seven days, pointing to their limited color stability under real-life conditions.[13]

Finishing and polishing protocols further influence material susceptibility. Inadequate polishing leaves a rough surface that traps pigments and promotes adhesion of staining molecules. Even within the same material class, variations in surface treatment can result in differing stain responses.

For instance, nanofilled composites polished with multi-step systems showed less discoloration than those polished with single-step discs, regardless of the staining solution used.[14]

CLINICAL IMPACT AND MANAGEMENT

Discoloration of dental restorations presents both aesthetic and psychological implications for patients, often leading to dissatisfaction and unplanned retreatment. As restorative techniques advance and expectations for long-term esthetics increase, managing discoloration becomes a routine concern in clinical practice. Professional maintenance strategies aim to delay or minimize the impact of discoloration, but their effectiveness is influenced by the type of restorative material and the severity of staining. Surface polishing and re-glazing are viable for ceramic restorations with superficial stains. These methods can restore the optical properties lost through pigment adherence. For composite materials, polishing pastes and multi-step finishing systems can remove extrinsic stains to some extent, though they offer limited improvement once pigments penetrate the resin matrix. In a controlled comparison, composite restorations polished with aluminum oxide discs exhibited significantly lower surface roughness and better color recovery compared to those treated with abrasive brushes, reinforcing the value of refined finishing techniques in controlling long-term discoloration.[15]

Patient education plays a substantial role in preventing accelerated staining. Advising on the frequency and timing of consuming staining agents such as tea, coffee, and spice-heavy meals can help manage expectations and guide behavior. Encouraging rinsing or brushing shortly after consumption limits the contact time of chromogens with the restorative surface. The pH of beverages also contributes to surface erosion, which increases pigment retention. Acidic solutions like citrus juices or soda can degrade the outer layer of resin restorations, creating microchannels for pigment ingress. Reducing the intake or modifying the sequence of consumption, such as using a straw for pigmented drinks, has been shown to limit staining while maintaining patient habits.[3]

Bleaching procedures are frequently requested by patients experiencing general discoloration. In-office or at-home whitening agents may improve the appearance of natural teeth but often cause mismatches with existing restorations, which do not respond to peroxide-based treatments in the same way. Composite and ceramic restorations may remain visibly darker after bleaching, leading to aesthetic imbalance. Studies show that even high-concentration hydrogen peroxide gels fail to reverse intrinsic staining within composite resins, often resulting in the need for replacement to match the newly whitened dentition.[16] For clinicians, timing of bleaching in relation to restorative treatment becomes a key management consideration. Delaying the placement of anterior restorations until after tooth whitening is often recommended to achieve optimal color matching.

Routine recall visits provide opportunities to assess early signs of discoloration, particularly in patients with diets known for chromogenic exposure. During these visits, dentists can perform minor refinishing, assess oral hygiene techniques, and identify restorations at risk of aesthetic failure. In a longitudinal evaluation, early intervention through polishing and dietary counseling helped reduce the need for replacement of anterior composites, underscoring the preventive value of maintenance protocols in long-term color stability.[17]

CONCLUSION

Discoloration of dental restorations is influenced by material properties, patient habits, and exposure to pigmented substances. Understanding these interactions is essential for selecting appropriate materials and preventive strategies. Regular maintenance and patient education help preserve esthetics over time. Future advancements should focus on stain-resistant formulations and improved clinical protocols.

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