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Impact of Electronic and Conventional Cigarettes on Color Stability and Surface Roughness of Resin-Based Composite Restorative Materials: Review Article

Ali Nadm Hmood[1], Maha M. Ebaya[2], Abeer El-Sayed El-Embaby[3]

[1]MSc Student, Department of Conservative Dentistry, Faculty of Dentistry, Mansoura University, Mansoura, Egypt
[2]Ph.D. Lecturer, Department of Conservative Dentistry, Faculty of Dentistry, Mansoura University, Mansoura, Egypt
[3]Ph.D. Professor and Chairman, Department of Conservative Dentistry, Faculty of Dentistry, Mansoura University, Mansoura, Egypt.
Email: ali_nadm@std.mans.edu.eg

A review was conducted using PubMed, Scopus, and Google Scholar databases. Studies published between 2013 and 2024 focusing on the influence of conventional and electronic cigarettes on resin-based composites were included. Data were extracted and categorized based on composite types, smoking exposure, color stability, and surface roughness outcomes. Clinicians must be aware of the effects of smoking, both conventional and electronic, on the long-term performance of resin-based composite restorations. This knowledge is essential for material selection, patient counseling, and developing effective maintenance and care strategies to preserve esthetic and functional outcomes. Smoking leads to significant discoloration. On the other hand, surface roughness was a gap in previous studies of RBCs with smoking impact. While whitening toothpastes can mitigate some effects, they cannot fully restore the damaged composites. There's a need for better materials, tailored dental treatments for smokers, and further research into more durable restorative options.

1. Introduction

According to the World Health Organization (WHO), tooth caries is considered of the greatest prevailing non-communicable pathologies globally. Dental amalgam was once the main material used for restoration because of its superior mechanical properties and exceptionally long service life. However, several limitations, have constrained the amalgam from being widely used, such as lack of adhesion to the tooth structure, hence the need for removal of healthy tooth tissue to apply the restoration correctly, esthetic considerations, since the metallic color does not match the natural tooth, and toxicity of mercury and environmental pollution when disposed of. Due to these disadvantages, amalgam was slowly replaced by resin-based composites (RBCs) after the development of Bisphenol-A-glycerolate-dimethacrylate, also known as Bis-GMA, by Bowen in 1962. Because of esthetics, better adhesion, and more conservative than amalgam, RBCs have emerged little by little as the material of choice for dental restorations. With time, different types of RBCs materials were developed to meet the changing demands for excellent, long-lasting dental restorations.1

The main advantage of RBCs is that; they provide a natural appearance with minimal reduction of healthy tooth structure. RBCs are becoming increasingly popular for anterior and posterior restorations, providing a superior conservative and esthetic option to earlier materials. Despite improvements in the development of RBCs, durability is still a problem. Major areas of concern include the following, Discoloration can be due to intrinsic factors, such as oxidation and chemical changes of the resin composition and environmental factors such stains from drinks, food, and tobacco. Surface roughness may also enhance plaque accumulation, leading to gingival irritation and further staining. While RBCs have revolutionized dental restoration by providing esthetic, minimally invasive solutions, challenges such as staining and long-term durability still require attention for continued improvement.2

2. Dental Resin Based Composite Material

RBCs materials are widely used in dentistry due to their esthetic and physical properties, making them suitable for various applications like restorative materials, cavity liners, core buildups, and luting cements. However, they face issues like polymerization shrinkage, limited strength, discoloration, and inadequate wear resistance. Modern development focuses on improving critical properties like reduced shrinkage, increased cure depth, and mechanical strength.3 Research is also being conducted to enhance esthetic aspects like color durability and translucency. Advances in dental materials science could improve their clinical performance and longevity.4

2.1. Compositions of Dental Resin Based Composites

RBCs are a three-dimensional material made up of two or more chemical components. Normally, it consists of a mixture of hard particles embedded in a resin matrix. The resin matrix used in dental RBCs, is mixed with fillers, including silicon dioxide and quartz, that give strength and durability. These are usually used with a coupling agent to reinforce the physical bond between the filler material and the resin matrix. Other additives within dental RBCs include initiators, which start the polymerization after receiving external energy-for example, light or heat-and catalysts, which regulate the speed of polymerization. Colorants, such as metallic oxide pigments, can also be included to match the color of the natural tooth. Some other additives include stabilizers, improving the material's storage stability by preventing undesirable premature polymerization of the material. These combined factors contribute to the material's overall performance: its mechanical properties, esthetic qualities, and clinical handling.5

2.1.1. Resin Matrix

Dental RBCs are composed of organic monomers, such as Bisphenol-A-glycerolate-dimethacrylate (Bis-GMA), triethylene glycol dimethacrylate (TEGDMA), urethane dimethacrylate (UDMA), and bisphenol-A-ethoxylated-glycidyl dimethacrylate (Bis-EMA).6 Bis-GMA, developed in 1962, is the main resin matrix usualy used in restorative RBCs due to its high molecular weight and aromatic structure.7 UDMA, introduced in 1974, has a shorter chain and lower viscosity, allowing higher filler loading but increased brittleness and polymerization shrinkage.8 TEGDMA increases wetting ability and copolymerization characteristics due to hydrogen bonding interactions and high molecular weight.9 Bis-EMA, a viscous monomer identical to Bis-GMA, can reduce water sorption and partially or completely replace Bis-GMA in dental RBCs. Its high viscosity is due to its chemical group participating in hydrogen bonding.10

Over the years, dental RBCs development have incorporated co-monomers such as TEGDMA and UDMA, either with or without Bis-GMA, to better tailor material properties for clinical needs. In most dental RBCs, the primary Bis-GMA and UDMA monomers have contributed different characteristics to the material. UDMA-based composites, especially those with low levels of TEGDMA, achieve higher polymerization conversion and reduced shrinkage stress in comparison to Bis-GMA-based composites. The addition of co-monomers such as UDMA and Bis-EMA reduces the viscosity, improving handling and minimizing polymerization shrinkage. These changes allow for improved balancing of mechanical strength, esthetics, and clinical performance in RBCs, which always come with challenges in shrinkage and viscosity during restorative dentistry.11

2.1.2. Filler

Dental RBCs are made of rigid filler particles, such as quartz, glass, fiberglass, ceramics, and natural minerals, which enhance properties like stiffness, resistance to abrasion, toughness, and modulus of elasticity. They also reduce dimensional changes, contraction during setting, water sorption, and thermal expansion.12 New types of fillers, such as oxide fillers, alkaline silicon glass fillers, biomimetic fillers, and organic-inorganic hybrid fillers, have been developed to improve performance and functionality in dental restorations.13 Filler load, the amount of filler material incorporated into the resin matrix, significantly influences the composite's performance. Spherical particles reduce surface space and friction, while irregular-shaped fillers provide better mechanical attachment. RBCs with spherical fillers typically display improved shrinkage, color change, and stress compared to those with irregular fillers.11,14

RBCs are categorized into macrofilled, microfilled, hybrid, modern hybrid, and nanofilled. Macrofilled RBCs are strong but not well polished, while microfilled RBCs offer esthetics but are susceptible to fractures. Hybrid RBCs balance esthetics and mechanical properties, while modern hybrids improve esthetics and polishability. Nanofilled RBCs use nanotechnology to reduce shrinkage without compromising strength.12 Nanofilled RBCs, based on methacrylate resins with specific curing methods, are classified as nanofilled or nanohybrid types. These innovations improve wear resistance, polishability, and overall performance, making them a more predictable and durable option in restorative dentistry.3

2.1.3. Coupling Agent

The addition of a coupling agent to dental RBCs are highly important for improving the adherence among the substance being filled particles and the polymer matrix, improving physical features and mechanical aspects of the RBCs. Coupling agents enhance wettability, ensure better dispersion of the filler particles, and reduce viscosity, which accounts for the stronger and more durable bond. These agents also facilitate the transfer of stress from the resin to the filler particles, thus reinforcing the RBCs. Coupling agents also prevent hydrolytic degradation; they form bonds that are water-resistant and clinically resistant to chemical and corrosion effects.13 The most commonly used coupling agents are silane compounds, such as 3-mercaptopropyl-trimethoxysilane (MPS) and amino-silanes.15

2.1.4. Additives

RBCs monomers are often combined with additives like co-monomers, initiators, accelerators, inhibitors, and stabilizers to achieve a balanced consistency and polymerization of the resin. RBCs can be categorized into heat-cured, coldcured, light-cured, or dual-cured RBCs. Light-curing is the most common method, achieved by adding photopolymerization initiators in a typical amount (0.1% to 1%wt) of the RBCs. Inhibitors like hydroquinone and butylated hydroxytoluene delay polymerization to avoid premature curing during storage. Stabilizers increase color durability through electromagnetic radiation absorption, while fluorescent agents enhance optical appearance by absorbing ultraviolet and violet light. New co-monomer systems with aldehyde and diketone functionality have the potential for further improvements in mechanical, chemical, and optical properties, enhancing overall performance and durability.11,16

Photoinitiators like diphenyl-(2,4,6-trimethylbenzoyl) phosphine oxide (TPO) and phenylbis(2,4,6-trimethylbenzoyl) phosphine oxide (BAPO) are being developed as alternatives to camphorquinone (CQ) to improve color stability in dental RBCs. TPO-based materials exhibit reduced yellowing and improved color durability, regardless of amine presence or filler particle size. They have higher C = C conversion and lesser depth of cure, making them a promising alternative to conventional photoinitiators for restorative dentistry. TPO-based composites also have better cure efficiency and higher aging resistance, improving optical and mechanical properties.17,18 Pigments are crucial components in RBCs for natural tooth color matching in dental restorations. Ferric oxide (Fe_2O_3) is used for red color, while ferric hydroxide (FeOOH) gives yellow hue. These pigments are chosen for their durability and resistance to degradation, ensuring the desired color remains with the RBCs throughout its clinical lifespan.19

3. Shade Matching of Dental Resin Composite Restoration

Dental restorations in cosmetic dentistry require accurate shade matching to mimic natural tooth colors. The color of a tooth varies from gingival to incisal, buccal to lingual, mesial to distal, and is solved by dentin thickness, scattering, and enamel translucency. Compatibility, stability, and interactions are key color-related properties of dental restorations. Stability involves potential changes during manufacture, before, during, and after placement, including aging and staining. Interactions in layering and blending materials simulate the complex structure of natural teeth. The ambient environment also plays a role in color matching.20 Two main approaches are visual technique using tooth-shaped shade tabs and instrumental technique using color measuring devices. The visual technique is still a gold standard due to the human eye's ability to discriminate small color differences. The VITA Classical guides represent 16 natural shades but have limited accuracy. The VITA 3D-Master shade guide enhances this accuracy by separating hue, chroma, and value.21,22

Precise color matching of dental restorations has become a difficult task because of the multiple factors affecting shade perception, including hue, value, and chroma, besides translucency, fluorescence, light transmission, surface texture, and age and location of the tooth Also the outcome of the color matching is multifactorial; it depends on the skill, tools, conditions, and physiological state of the clinician, and it has been shown that education and training enhance this important aspect of clinical dentistry.The VITA Classical shade guide is considered the gold standard, yet it represents only a very small portion of the natural tooth color spectrum, leading to imperfect matches. In addition, RBCs have certain problems such as material inconsistency, color instability, and a limited range of color. Visual color-matching with shade guides is currently the most common practice; whereas specialized dental color-matching instruments are underutilized.23–27

RBCs systems for restorations include mono-layer, bi-layer, and tri-layer systems, with variations including opaque dentin, dentin, enamel, chromatic enamel, and incisal hues. The optical properties of the RBCs, such as hue, opacity, fluorescence, opalescence, and filler technology, directly influence the restoration's esthetic integration and final appearance.28 The multilayering technique is widely used to mimic the polychromatic nature of normal teeth by layering multiple layers of RBCs with varying degrees of translucency. The transmission of light through the RBCs material is influenced by the dimension and distribution of filler particles. Recent progress in structural color technology, inspired by peacock feathers and butterfly wings, allows for advanced RBCs that better mimic tooth color through selective absorption and emission of light at specific wavelengths.23,29–31

The chameleon effect is a principle where the perceived color difference between restoration and tooth is diminished when viewed together. Factors influencing this effect include the type of RBCs used, the shade of the restoration, and its interaction with the tooth structure. The chameleon effect reduces the number of shades in the clinician's inventory and increases treatment efficiency, particularly for direct restorations. Recent developments in single-shade RBCs aim to minimize shade matching hassles through smart chromatic technology and nano-spherical fillers. These materials can match all 16 VITA Classical shades by selectively enhancing or diminishing specific wavelengths of light.29,32–35

4. Color Stability and Surface Roughness of Resin Composite Restoration

Esthetic restorative materials' success depends on color match and stability in long-term use. Factors like saliva, food components, and smoking can affect the esthetics and integrity of dental RBCs, leading to degradation in the oral environment. Maintaining color stability in RBCs is influenced by various factors, and in-service discoloration can lead to patient dissatisfaction and increased time for repair replacement. RBCs material degradation in the oral environment is mechanical and chemically driven, causing surface roughness, loss of gloss, and discoloration. Selecting the right dental care product and technique is crucial to minimize damage and ensure restoration longevity and esthetic integrity.36–39

The color alterations of restorations can be caused by extrinsic (exogenous) or intrinsic (endogenous) factors. Extrinsic factors involve surface absorption of staining agents or plaque accumulation, while intrinsic factors is relate to the coloration of the resin substance alone due to physical and chemical processes in the deeper restorative phase via oxidation, altering optical properties over time. Color stability in esthetic restorative materials is influenced by water sorption rate, chemical characteristics, resin matrix type, degree of conversion rate in the resin, photoinitiator systems, and filler loading, which play important role like high filler content decreases the organic matrix content, while smaller particle sizes reduce surface roughness during polishing. The configuration of the polymer matrix and filler particulates impacts the surface's texture and vulnerability to environmental stains. Endogenous discolorations are permanent, although external discolorations resulting from dye adsorption or plaque may be readily eliminated with polishing.40–42

RBCs are hydrophilic due to their organic components and ester linkages. Humidity in the oral environment can cause hygroscopic and hydrolytic effects depending on formulation, matrix components, filler loading, and particle size, by penetrating the saliva to RBCs and soak it. Water diffusion can cause extrinsic staining due to ions and small pigments depositing on the polymer network. Hydrolysis can also cause optical instability due to modified light-scattering characteristics of surface particles.43 Water absorption is crucial for the clinical success of dental materials, as the organic matrix can absorb moisture, causing volume increase in restorations. This can lead to negative effects on restorative materials, such as color change, mechanical properties, wear resistance, and chemical bond degradation between filler-resin bond.44 The type of resin matrix significantly impacts water sorption, with materials containing high bis-GMA being more susceptible to staining.45 The addition of TEGDMA to restorative materials may increase water sorption, decrease mechanical properties, and hinder color stability.46

Staining agents like coffee, tea, and other beverages or foods can cause discoloration on light-cured RBCs. These beverages which contain water-soluble pigments called anthocyanins, that range from orange to blue. The staining effect depends on their interaction with the phenolic compound and the pH of the beverage environment. Acidic conditions can cause discolorations due to the easy binding of these pigments to resin surfaces. Acidic media further degrade the organic matrix, affecting extrinsic pigmentation and tooth brushing. This can increase the roughness of RBCs, negatively impact optical properties, and reduce the retention of extrinsic pigments. Factors such as filler particle characteristics, cumulative brushing time, and dentifrice abrasive index can directly influence this process.47,48

Surface roughness in dental RBCs materials is significantly influenced by finishing and polishing procedures, which can affect the color quality and esthetic quality of restorations. Smoother surfaces reduce risks of leakage, plaque accumulation, gingival irritation, caries, and discoloration. Most clinical applications require additional finishing and polishing to remove the outer, less polymerized, softer layers of the RBCs. The finishing and polishing protocol should be effective and accurate to maintain a smooth, durable surface, ensuring long-term color stability and overall esthetic performance. Advances in resin technology are enhancing surface smoothness and polishing properties, with common RBCs like microhybrid, nanocomposites, and ormocer composites being developed to enhance the resin's mechanical and physical properties. These advancements are crucial for dental restoration finishing and polishing to achieve optimal surface gloss, smother surface roughness, and color stability.49,50

RBCs restorations' superficial layer is highly susceptible to discoloration due to contact with colorant agents, particularly in the outermost layer. This can be resolved through chairside repolishing procedures, which can restore the original color or make the discoloration imperceptible to the human eye. Nanofillers are added to RBCs for improving their physical properties, particularly in wear reduction and surface polishing. Filler particle size is crucial for performance, as it affects the dispersion of fillers into the resin and bonding. Smaller filler particles improve color durability and gloss preservation due to their smoother surface. However, material handling properties depend on the fillers' surface energy, and smaller particles have different flowing and workability properties. These developments are crucial for improving esthetic and mechanical features, particularly color durability of dental RBCs over time.51,52

5. Investigations

5.1. Color stability

RBCs materials, despite their advancements, still tend to absorb more moisture than ceramics, making them more susceptible to staining agents. The current information on the discoloration potential of RBCs materials is limited to manufacturers' information and lacks independent scientific research. In vitro studies can assess the staining tendency of different materials, allowing for predictions in a "in vivo" situation. Spectrophotometers and colorimeters are essential in dental research for precise and reproducible tooth color measurement. The International Commission on Illumination (CIE), developed the CIELAB (ΔE*ab) color system, which defines a color space by three independent variables, enables exact and quantitative comparison of colors, essential for applications like dental restoration matching. However, quantifying perceived differences between two colors is complex, and the ΔEab formula, though widely used, does not always correlate well with human visual perception. In 2001, the CIE introduced the CIEDE2000 (ΔE00) formula, now an ISO/CIE standard for color difference measurement (ISO 11664-6). Unlike the ΔEab formula, ΔE00 takes into account human sensitivity to changes in lightness, L*, rather than chromaticity, a* and b*, and provides a more perceptually accurate measure of color difference.53–57

5.2. Surface Roughness

Restorative materials' durability in the oral cavity is influenced by their resistance to dissolution and disintegration. RBCs are often damaged by abrasion, attrition, and erosion from bad habits, resulting in a rough surface that affects the material's optical properties, facilitates bacterial plaque buildup, reduces hardness and wear resistance, and can cause gingival irritation and increase the risk of secondary caries. Proper polishing can enhance the surface roughness of dental RBCs restorations, minimizing stains and discoloration. Surface roughness, caused by manufacturing processes or material condition, is measured using methods like the Ra metric, Rq, Rp, Rv, and Rmax.58,59

The measurement of surface roughness can be done using a number of techniques, including contact stylus tracing, non-contact laser stylus metrology, scanning electron microscopy (SEM), atomic force microscopy (AFM), and non-contact 3D optical profilometry. Of these, the first mentioned is the most common and provides quantitative measurements of roughness. One of the main drawbacks with contact profilometers, however, is that specimens can be damaged in the form of surface scratches. Non-contact methods include laser metrology and 3D optical profilometry, which can give very detailed analyses without the problem of contact.60,61

Ebaya MM et al.27 performed a comparative study on color stability and surface roughness of two single-shade RBCs restorations immersed in solutions that could cause staining. The universal RBCs presented excellent color matching with diverse tooth shades and acceptable smoothness of the surface. Also, ElEmbaby AES.18 investigates the color stability of three RBCs treated with different mouth rinses. Spectrophotometric assessments revealed that various mouth rinses, such as Antiseptol, Flucal, and Listerine, differently changed the color of RBCs materials depending on the chemical composition of both the rinse and the RBCs.

5.3. Exposure Product

Tobacco use is a behavioral process that induces addictive moods, with nicotine being the active ingredient. It is divided into combustible products like cigarettes, cigars, and pipes, and noncombustible products like chewing, dipping, electronic cigarettes, dipping, or snuffing formulations. Cigarettes are popular among youth and adults due to their unique design and accessibility, allowing deep inhalation of smoke into the lungs and high nicotine levels to the brain within seconds.62 Alternative tobacco products, especially e-cigarettes with nicotine, are increasingly popular and are, in part, replacing traditional cigarettes. One study in the United States indicated that although adolescent use of cigarettes decreased between 2011 and 2014, overall tobacco product use remained unchanged because of the increased use of alternative forms. While e-cigarettes are less dangerous than traditional cigarettes, they may be a route of entry into tobacco use for non-users.63

5.3.1. Conventional Cigarettes (C-cigarettes)

The Surgeon General's Report highlights the significant health risks associated with tobacco smoking, with the WHO estimating that smoking causes over 7 million deaths annually and hundreds of billions in economic losses worldwide. Tobacco contains over 60 toxic chemicals, including nicotine, which can cause serious conditions like cardiovascular diseases and cancers. It also impacts oral diseases, periodontal disease, oral cancer, and birth defects in children of mothers who smoked during pregnancy. Around a billion people globally have smoked since teenage years, exposing them to harmful compounds like carbon monoxide, ammonia, nickel, lead, tar, and heavy metals. Additionally, tobacco smoking is linked to an increased risk of dental decay, possibly due to decreased buffering effect, lower saliva pH, and higher susceptibility to caries.64–66

5.3.2. Electronic Cigarettes (E-cigarettes)

Electronic cigarettes, or e-cigarettes, are devices that vaporize a liquid to create an aerosol containing nicotine. Developed by Chinese pharmacist Hon Lik in 2003, they became commercially accessible in Europe and the USA in 2006. E-cigarettes are battery-operated devices that generate aerosols using a resistive heating coil to evaporate nicotine dissolved in vegetable glycerin, propylene glycol, or a mix thereof, along with flavorings. The proliferation of e-cigarettes is driven by consumer preference, with millions of users globally, predominantly ex-smokers or dual users. E-cigarettes are promoted as healthier, economical, and socially acceptable substitutes for traditional cigarettes, but their effects on oral health are still uncertain. Toxicological investigations have shown detrimental constituents in e-cigarette products, such as nicotine, diacetyl, ultrafine particulates, volatile organic compounds, and heavy metals. Exposure to e-cigarettes can lead to deteriorating periodontal, dental, and gingival health, as well as alterations in the mouth's microbiota. E-cigarette vapors also possess cytotoxic, genotoxic, and carcinogenic properties, making them a total factor for oral health deterioration.67,68

This, therefore, has recently made the studies focus shift to the susceptibility of newly developed RBCs materials to smoking products-induced staining. Indeed, this is a fast-growing area of study, which reflects the increasing demand by patients for dental restorations that are functional, esthetically pleasing, and durable. Tobacco products, including cigarettes and e-cigarettes, contain toxic chemicals and tar that can penetrate RBCs materials, causing discoloration and degradation of the esthetic properties of a material. The persistent stable color of RBCs has this become an important consideration in restorative dentistry, especially when high-quality, esthetic dental work is desired for those patients who are exposed to these agents of staining. This concern is one that directly underlines the development of RBCs with improved resistance to smoking-induced changes and makes them also esthetically more stable over time.69

De Carvalho LD et al.70 conducted an evaluation of the one-year clinical performance of RBCs restorations in smokers versus non-smokers in terms of retention, marginal discoloration, color match, marginal integrity, and sensitivity. They did not find any statistically significant difference between smokers and nonsmokers regarding the aforementioned criteria, except for the color match, which was found to be worse for smokers after the baseline period. While, Zhao X et al.71 considered the discoloration effects of cigarette smoke and aerosol of Tobacco Heating Systems on dental RBCs and said that cigarette smoke caused highly significant discoloration, While both exposure was not affected surface roughness of resin composites. In the other hand, Alandia-Roman CC et al.84 tested cigarette smoke on color stability and surface roughness of RBCs. They found that cigarette smoke adversely affects the color stability and surface roughness of these materials. Also, Thompson SO et al.72 investigated the influence of a mixture of smokeless tobacco and salivary substitute on the surface roughness of restorations, such as amalgam, RBCs, and resin-modified glass ionomer. They concluded that the surface roughness increased with time due to the mixture.

Zhao X et al.73 compared the staining of enamel, dentin and RBCs restorations to cigarette smoke, e-cigarette aerosol, red wine, coffee, and soy sauce. Red wine and cigarette smoke resulted in significant discoloration and mismatched colors between enamel-resin restorations that could not be reversed by whitening treatment. In contrast, minimal stains from e-cigarette aerosol could be readily removed with whitening toothpaste. Similarly, Barbosa GF et al.74 investigate cigarette smoke on color changes in three RBCs. They concluded that variables seemed to influence the magnitude of color change included brand of RBCs, type of inorganic fillers, and number of cigarettes smoked, pointing to material composition and exposure as the factors involved in discoloration. In contrast, Alandia-Roman et al.75 aimed to evaluate cigarette smoke and mechanical brushing affect color stability and surface roughness for three different RBCs. They found that poor polishing considerably increases the tendency of RBCs to be stained by cigarette smoke. Additionally, also elevated the surface roughness for the composites.

Zanetti F et al.76 conducted an experiment on the discoloration effects of cigarette smoke and aerosol from tobacco heating systems on enamel, dentin, and RBCs restorations, and they concluded that cigarette smoke causes significant discoloration of teeth and RBCs restorations. While, Singh G et al.77 studied the effect of cigarette smoke on surface roughness of two denture base materials. In this study, flexible denture base specimens showed more surface roughness compared to the heat-cured specimens after the smoke exposure. Moreover, Vohra F et al.78 compared the color stability of dental ceramics and RBCs following aerosol from electronic nicotine delivery systems and conventional cigarette smoke and found both produced similar levels of discoloration.

Theobaldo JD et al.79 studied the effect of cigarette smoke on the color, roughness, and gloss of bulk-fill RBCs, and according to the results obtained, it was concluded that these RBCs are more prone to staining by cigarette smoke compared to conventional microhybrid RBCs. Furthermore, Alnasser HA et al.80 compared the effect of conventional and electronic cigarettes on the color stability and translucency of two RBCs, finding that the smoke from conventional cigarettes resulted in higher color instability when compared with electronic cigarettes. Likewise, Da Silva EM et al.81 evaluated the action of cycling whitening toothpaste with cigarette smoking on roughness, color, translucency, and gloss in microfilled, microhybrid, and nanofilled RBCs. Therefore, they concluded that whitening toothpastes could not preserve the color stability of any RBCs after 8-week smoking and toothpaste cycling.

Ayaz E et al.82 investigated the hardness, roughness, and color stability of heat- and microwave-polymerized PMMA, polyamide, and CAD-CAM PMMA resins after exposure to cigarette smoke and denture cleansers. They concluded that CAD-CAM PMMA resins had the lowest roughness, hardness, and color stability, while conventional PMMAs also showed decreased values, and denture cleansers were effective in reducing discoloration and roughness for smokers. In addition, Karanjkar RR et al.83 reviewed the effects of different tobacco and nicotine products on dental staining; they, too, reported that tobacco smoking is strongly associated with dental staining. Also, the systematic review of the color stability of dental RBCs exposed to conventional and electronic cigarettes performed by Paolone et al.69 determined that conventional cigarettes significantly affect color stability, whereas electronic cigarettes produce less discoloration, often recoverable within clinically acceptable thresholds, though further evidence is needed.

Makkeyah F et al.84 studied the influence of conventional cigarette smoking and heated tobacco products on the surface roughness and color stability of CAD/CAM restorative dental materials. They concluded that cigarette smoke is more harmful to the surface properties and color stability of esthetic restorative materials compared to heated tobacco products. While, Gömleksiz S et al.85 examined the impact of whitening toothpastes on color stability and surface roughness of RBCs stained with coffee and cigarette smoke. Results showed that cigarette smoke was more discolored in RBCs. Hydrogen peroxide-based whitening toothpaste effectively reduced discoloration and minimized surface roughness, while activated charcoal toothpaste did not improve color stability with increased the surface roughness.

6. Conclusion

Smoking, especially through the use of c-cigarettes, has a great effect on the color stability of RBCs, while in the other hand the surface roughness was a gap of previous studies of RBCs with smoking impact. The chemicals contained in cigarette smoke, especially nicotine and tar, lead to severe discoloration. Though e-cigarettes also affect RBCs, their effects are generally less serious compared to traditional cigarettes. Whitening toothpastes may help alleviate some extrinsic staining, but they do not fully restore the damaged properties of RBCs. These findings support the development of personalized restorative treatments for smokers who might require more frequent maintenance of RBC restorations due to ongoing smoking-induced degradation. There is an indication of needs for the development of RBC materials with improved nano-spherical fillers and hydrophobic formulations to increase resistance against staining. Long-term effects of smoking on restorative dental materials need further research to understand, and more durable options for smokers are still required.

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