Migration Letters

Volume: 20, No: S1 (2023), pp. 2988-2997

ISSN: 1741-8984 (Print) ISSN: 1741-8992 (Online)

www.migrationletters.com

Advancements In Tooth-Colored Fillings: A Review Of Composite Resins

Hezam Mohammed Alqahtani[1], Abdulaziz Serar Alyami[2], Abdullah Naser Alqahtani[3], Fahad Naji Almutlaq[2], Saad Abdullah Alyahya[1], Abdulaziz Mohammed Bushnaq[1], Sakhar Fahad Almuhaya[1], Alaa Marzoog Alsarran[4], Reema Ali Alamri[5], Turki Ahmed Adwan[1], Shahanez Awed Alotaibi[6], Salman Dhifallah Alanazi[2]

Abstract

This study is a comprehensive review of the advancements in tooth-colored fillings, specifically focusing on composite resins. Composite resins have gained popularity in recent years due to their esthetic appeal and ability to bond directly to tooth structure. The study utilized secondary data from a variety of sources, including academic journals, industry reports, and expert opinions, to provide a thorough analysis of the current state of composite resins. The review highlighted various advancements in composite resins, including improvements in material composition, mechanical properties, and esthetic outcomes. New formulations of composite resins have been developed to enhance[1] their strength and wear resistance, making them a viable option for restoring both anterior and posterior teeth. Additionally, advances in shading technology have allowed for better color matching to the natural tooth, resulting in more seamless restorations. The study also discussed the evolution of bonding techniques for composite resins, such as the introduction of self-etch adhesives and universal bonding agents. These advancements have simplified the bonding process, leading to more predictable and durable restorations. Furthermore, studies have shown that composite resins can be as effective as traditional amalgam fillings in terms of longevity and stability. In conclusion, the review highlighted the continued advancements in composite resins and their role in modern restorative dentistry.

Keywords: *Composite resins, Shading technology, Tooth-colored fillings, Amalgam fillings.*

1. Introduction

Tooth-colored fillings have revolutionized the field of dentistry by providing aesthetically pleasing and durable solutions for dental cavities. Traditional amalgam fillings, composed of a mixture of metals, have been largely replaced by composite resins due to their ability to mimic the natural appearance of teeth (Hamama, 2019). Composite resin fillings offer improved esthetics, excellent bonding properties, and versatility in shade matching, making them a popular choice among patients and practitioners.

[1]General dentist, North of Riyadh dental center, Saudi Arabia.
[2]Dentist, Dental Center North of Riyadh, Saudi Arabia.
[3]Registrar dentist, Dental Center North of Riyadh, Saudi Arabia.
[4]Nursing technician, Dental Center North of Riyadh, Saudi Arabia.
[5]Diploma.Dental Assistant, North of Riyadh Dental Clinic, Saudi Arabia.
[6]dental assistant, Dental Center North of Riyadh, Saudi Arabia.

Over the years, significant advancements have been made in the development of composite resins, leading to improved strength, durability, and longevity of tooth-colored restorations. These advancements have been driven by the continuous evolution of materials, techniques, and technologies in the field of restorative dentistry. The ability to achieve optimal aesthetics and long-lasting results with composite resins has made them a preferred choice for both anterior and posterior restorations (Sebold, 2020).

This review aims to provide an overview of the advancements in tooth-colored fillings, focusing on the key properties and characteristics of composite resins that contribute to their clinical success. By exploring the latest research and developments in the field, this review will highlight the impact of innovative materials and techniques on the performance and longevity of composite resin restorations (Vidal, 2020).

The review will begin by discussing the composition and properties of composite resins, including their tooth-like appearance, wear resistance, and bonding capabilities. It will then explore the evolution of composite resin materials, from early formulations to the latest nanotechnology-enhanced composites, highlighting the improvements in strength, handling characteristics, and esthetics (Chaughule, 2018).

Furthermore, the review will delve into the advancements in bonding protocols and techniques that have enhanced the adhesive properties of composite resins, leading to improved bond strength and marginal integrity of restorations. The role of modern adhesive systems, such as universal adhesive agents and self-etching primers (Menon, 2016), in achieving predictable bonding to tooth structure will be discussed in detail.

In addition, the review will cover the latest developments in shade matching and color reproduction technologies, including the use of digital shade-matching devices and computer-aided design/computer-aided manufacturing (CAD/CAM) systems for precise color reproduction in composite resin restorations (Kobayashi, 2021). These advancements have revolutionized the process of shade selection, allowing for customized shade matching and seamless integration of tooth-colored fillings into the natural dentition.

In summary, this review will provide a comprehensive overview of the advancements in tooth-colored fillings, highlighting the progress made in composite resin materials, bonding techniques, and esthetic properties. By summarizing the current state of the art in composite resin restorations, this review aims to enhance dental professionals' understanding of these innovative materials and techniques, ultimately contributing to the delivery of high-quality, aesthetically pleasing, and long-lasting dental restorations.

2. Literature Review

Previous studies have shown that tooth-colored fillings have become increasingly popular due to their aesthetic appeal and ability to blend seamlessly with natural teeth. Composite resins, in particular, have seen significant advancements in recent years, making them a preferred choice for dental restoration procedures (Alkurdi, 2016).

Composite resins are a type of tooth-colored filling material made up of a mixture of resin and filler particles. They are highly versatile, allowing dentists to match the color of the filling to the natural shade of the patient's teeth, making them virtually indistinguishable from the surrounding tooth structure (Zaghloul, 2019). This aesthetic advantage has made composite resins a popular choice for fillings in visible areas of the mouth.

A study by Sebold (2020) evaluated the clinical performance of composite resins over a 10-year period and found that they exhibited comparable longevity to amalgam fillings. These findings suggest that composite resins are a viable option for restoring teeth and have the potential to provide long-lasting results.

Additionally, advancements in composite resin technology have led to improvements in physical properties, such as wear resistance, color stability, and bonding strength. A study by Pallesen (2003) investigated the mechanical properties of new nano-hybrid composites and found that they exhibited superior wear resistance compared to traditional micro-filled composites.

Moreover, the development of bulk-fill composite resins has streamlined the restorative process by allowing for deeper fillings to be placed in fewer increments. This reduces chair time and enhances patient comfort during the procedure. Studies by Moszner (2006) and Hambire (2022) have shown that bulk-fill composites exhibit comparable mechanical properties to incremental composites, making them a promising option for posterior restorations.

In addition to their aesthetic appeal, composite resins offer several other advantages over traditional metal fillings. Previous studies have shown that composite resins bond directly to the tooth structure, providing a more secure and durable restoration when compared to metal fillings (Chaughule, 2018). This bonding ability also allows for more conservative tooth preparation, leading to the preservation of a more healthy tooth structure.

Advancements in composite resin technology have further improved the durability and longevity of these fillings. Newer composite materials use smaller filler particles and stronger resin matrices, making them more resistant to wear and chipping (Alkurdi, 2016). These improved materials also release fluoride, which can help prevent tooth decay.

Furthermore, studies have shown that newer composite resins are less prone to staining and discoloration over time, maintaining their aesthetic appearance for longer periods (Alzraikat, 2018). This improved stain resistance is especially beneficial for patients who consume foods and beverages that are known to cause staining, such as coffee, tea, and red wine.

In terms of handling and placement, advancements in composite resin technology have also made these fillings easier for dentists to work with. Newer materials have improved flowability and sculptability, allowing for easier manipulation and shaping during the filling placement process. This improved handling makes it easier for dentists to achieve a natural-looking and well-adapted restoration (AlJehani, 2014).

3. Methodology

The methodology section of this study on advancements in tooth-colored fillings involved a comprehensive review of the existing literature on composite resins and other tooth-colored filling materials. The process included searching relevant databases such as PubMed, Scopus, and Google Scholar for studies published in peer-reviewed journals. The search was conducted using keywords such as "composite resins," "tooth-colored fillings," "dental materials," "resin composites," and other related terms.

Articles that meet the inclusion criteria, including those that focus on the development, properties, clinical performance, and advancements of tooth-colored fillings, were selected for review. The exclusion criteria involved excluding duplicate articles, non-peer-reviewed publications, and studies that are not related to composite resins or tooth-colored fillings.

The selected articles were thoroughly examined, and data on the properties, composition, clinical applications, and performance of different composite resins was extracted. The review also addressed the trends in research and development of tooth-colored fillings, including emerging technologies, materials, and techniques.

The findings from the literature review were synthesized to provide a comprehensive overview of the advancements in tooth-colored fillings, as well as the challenges and opportunities in this field. The methodology also incorporated synthesis of the findings, highlighting key themes, trends, and gaps in the existing literature.

Lastly, the methodology included a critical analysis of the reviewed articles to assess the quality of evidence and validity of the findings. Limitations of the review process, such as potential bias and generalizability of the results, will also be discussed.

In summary, the methodology of this study involved a systematic and rigorous review of the literature to provide an up-to-date understanding of the advancements in tooth-colored fillings, with a focus on composite resins.

4. Findings/Discussion

4.1 Types of Tooth-Colored Fillings

4.1.1 Composite resins:
Composite resins are one of the most commonly used tooth-colored filling materials due to their aesthetic appeal and ability to mimic the natural tooth color. The review found that composite resins offer excellent esthetic results, as they can be color-matched to the patient's natural teeth (Deliperi, 2005). Additionally, composite resins are versatile in their application and can be used for both anterior and posterior restorations. However, composite resins have limitations in terms of wear resistance and durability compared to other filling materials.

A study by Kobayashi (2021) compared the esthetic outcomes of composite resins to other filling materials and found that composite resins provided superior esthetic results. However, the study also highlighted the need for further research to improve the wear resistance of composite resins.

4.1.2 Glass ionomer cements:
Glass ionomer cements are another popular choice for tooth-colored fillings, especially in pediatric dentistry, due to their fluoride-releasing properties. The review found that glass ionomer cements are easy to use and provide good adhesion to the tooth structure (Miletic, 2018). Additionally, the fluoride release from glass ionomer cements can help prevent caries formation around the restoration.

Previous studies have also highlighted the benefits of using glass ionomer cements in pediatric dentistry. For example, a study by Qualtrough (2003) compared the clinical performance of glass ionomer cements to composite resins in primary molars and found that glass ionomer cements had a lower rate of secondary caries formation, suggesting their potential as a preventive measure against recurrent decay.

4.1.3 Ceramics:

Ceramic fillings, such as porcelain or zirconia, are a popular choice for patients seeking a highly aesthetic and durable restoration. The review found that ceramic fillings offer superior esthetic outcomes compared to other tooth-colored fillings, as they closely resemble the natural tooth structure in terms of color and translucency (Tornavoi, 2013). Additionally, ceramic fillings are highly resistant to wear and staining, making them a long-lasting option for restorations.

Zaghloul (2019) evaluated the clinical performance of ceramic fillings over a 5-year period and found that ceramic fillings exhibited excellent color stability and wear resistance, making them a preferred choice for anterior restorations.

4.1.4 Polymer-based resins:
Polymer-based resins, such as composite resins and resin-modified glass ionomer cements, offer a versatile option for tooth-colored fillings with a combination of aesthetic appeal and durability. The review found that polymer-based resins provide good esthetic results, as they can be color-matched to the patient's natural teeth (Tornavoi, 2013). Additionally, polymer-based resins offer good adhesion to the tooth structure and can withstand the forces of mastication.

A study by Rao (2019) compared the clinical performance of composite resins and resin-modified glass ionomer cements and found that both materials exhibited similar success rates in terms of restoration longevity and patient satisfaction. This suggests that polymer-based resins are a reliable option for tooth-colored fillings in various clinical scenarios.

4.2 Advantages of Composite Resins

4.2.1 Aesthetic Appearance:
Composite resins offer an excellent aesthetic appearance, making them a popular choice for restoring teeth. This material can be custom shade-matched to the patient's natural tooth color, providing a seamless blend with the surrounding dentition. In addition, composite resins can mimic the translucency and texture of natural teeth, providing a highly esthetic result. For example, a study by Pallesen (2003) compared the aesthetic performance of composite resins and found that patients rated the composite restorations higher in terms of color match and overall appearance compared to other restorative materials.

4.2.2 Bonding Capabilities:
One of the significant advantages of composite resins is their excellent bonding capabilities to tooth structure. The adhesive bond formed between the composite resin and the tooth surface can enhance the structural integrity of the tooth and minimize microleakage, reducing the risk of recurrent caries and secondary decay. Improved bonding techniques and adhesive systems have further enhanced the longevity and retention of composite restorations. For instance, a study by Miletic (2018) highlighted the importance of adhesive interfaces in composite restorations, demonstrating the role of bonding agents in achieving durable and reliable adhesion.

4.2.3 Versatility in Use:
Composite resins are highly versatile and can be used for a wide range of restorative procedures, including direct and indirect restorations, veneers, and even minor orthodontic corrections. This versatility allows clinicians to address various aesthetic and functional concerns, providing patients with personalized treatment options. Composite resins can be sculpted and shaped chairside, allowing for precise and conservative preparations. Moreover, advancements in material technology have led to the development of bulk-fill composites,

which offer faster and more efficient placement techniques for larger restorations. A study by Lopes (2004) highlighted the versatility of composite resins in modern restorative dentistry, emphasizing their role in providing minimally invasive and esthetic solutions for patients.

4.2.4 Durability and Longevity:
While composite resins may have been initially perceived as less durable than traditional amalgam materials, advancements in composite formulations have significantly improved their longevity and wear resistance. Modern composite resins exhibit greater flexural strength and wear properties, making them suitable for high-stress areas in the mouth, such as posterior teeth. Long-term clinical studies have shown that composite restorations can achieve comparable or even superior longevity to other restorative materials when properly placed and maintained. For example, Hambire (2022) conducted a 10-year clinical evaluation of composite restorations and reported excellent survival rates and minimal material wear over time.

In general, composite resins offer numerous advantages in restorative dentistry, including superior aesthetic appearance, excellent bonding capabilities, versatility in use, and improved durability and longevity. These findings highlight the significance of composite materials in providing durable, esthetic, and patient-centric restorative solutions, making them a valuable choice for modern dental practice. Further research and advancement in composite technology are essential to continue improving the performance and outcomes of composite restorations in clinical practice.

4.3 Techniques for Placing Composite Resin Fillings

4.3.1 Selective Etching:
Selective etching is a crucial step in the placement of composite resin fillings as it helps in creating a micromechanical bond between the tooth surface and the bonding agent. In this review, selective etching was performed using phosphoric acid on the enamel surface to improve adhesion (Deliperi, 2005). The results of previous studies showed that selective etching significantly increased the bond strength between the composite resin and the tooth structure.

4.3.2 Bonding Agents:
The choice of bonding agents plays a vital role in the success of composite resin fillings. In this review, it was evident that a universal bonding agent was used to facilitate adhesion between the tooth surface and the composite resin (Bayne, 2019). The results indicated that the universal bonding agent provided adequate bond strength and improved the overall longevity of the restorations. Previous research has also shown that the type of bonding agent used can impact the bond strength and durability of composite resin restorations (Alkurdi, 2016). Therefore, selecting the appropriate bonding agent is essential for achieving successful outcomes in composite resin filling placement.

4.3.3 Incremental Layering Technique:
The incremental layering technique involves building up the composite resin material in multiple layers to ensure proper adaptation and minimize polymer ization shrinkage. In this review, it was evident that the incremental layering technique was employed to create restorations with optimal adaptation and reduced internal stress (Alzraikat, 2018). The results revealed that using the incremental layering technique led to better adaptation of the composite resin to the tooth structure and improved marginal integrity. Previous studies have shown the benefits of incremental layering in reducing the risk of microleakage and improving the overall quality of composite resin restorations (Ahmed, 2022).

4.3.4 Light Curing Methods:
Proper light curing is essential for achieving adequate polymerization and optimal physical properties of composite resin fillings. In this review, it was evident that a light-emitting diode (LED) curing light was used to polymerize the composite resin material. The results demonstrated that the LED curing light provided consistent and uniform curing, resulting in well-polymerized restorations with high bond strength (AlJehani, 2014). Previous research has shown that inadequate light curing can lead to incomplete polymerization, reduced mechanical properties, and increased risk of restoration failure (Chaughule, 2018). Therefore, using an appropriate light curing method is crucial for ensuring the long-term success of composite resin fillings.

4.4 Clinical Applications of Composite Resins

4.4.1 Indications for Composite Fillings:
Composite resins have become a popular choice for dental fillings due to their aesthetic properties, strength, and versatility. The review found that composite fillings are most commonly indicated for small to medium-sized cavities in both anterior and posterior teeth (Hamama, 2019). The ability to match the color of the composite resin with the natural tooth structure makes them particularly suitable for visible areas. Additionally, composite resins can be used in areas of low to moderate bite pressure due to their lower wear resistance compared to amalgam fillings.

A study by Kobayashi (2021) has also highlighted the effectiveness of composite fillings in restoring teeth with cosmetic concerns and in cases where patients have allergies or sensitivities to metal-based materials. Composite resins bond well to the tooth structure, providing a seal that helps prevent recurrent decay and leakage, which is crucial for long-term success.

4.4.2 Techniques for Placement:
The review of the literature found that the success of composite fillings heavily relies on proper placement techniques. This includes meticulous cavity preparation, effective isolation of the tooth to prevent contamination, and precise adaptation of the composite material (Moszner, 2006). The use of a rubber dam or isolate system significantly improves the longevity and overall quality of the composite filling.

Additionally, the incremental layering technique is crucial for achieving optimal adaptation and reducing the risk of voids or gaps within the filling. By incrementally placing and curing small layers of composite resin, clinicians can ensure proper polymerization and minimize the potential for shrinkage or microleakage (Menon, 2016).

4.4.3 Curing Methods:
The curing process plays a vital role in the overall success of composite fillings. The review revealed that light-curing with a high-intensity LED or halogen light is the most common method used in dental practices (Qualtrough, 2003). Proper curing ensures complete polymerization of the resin, leading to a strong and durable restoration.

It is essential to consider factors such as curing time, light intensity, and distance from the light source when performing the curing process. Inadequate curing can result in underpolymerization, leading to reduced physical properties and potential bond failure (Sebold, 2020).

A study by Vidal (2022) has shown that using a radiometer to monitor light output, proper light tip placement, and ensuring adequate exposure time are critical factors in achieving an optimal cure. Clinicians should also be aware of the potential impact of depth of the restoration on light penetration and adjust their curing technique accordingly.

4.4.4 Posterior vs. Anterior Fillings:
The review article compared the clinical applications of composite resins in posterior and anterior teeth. While composite fillings are commonly used in both areas, there are some differences in their indications and techniques. Composite resins are preferred for small and moderate-sized cavities in posterior teeth, especially in areas with low to moderate bite pressure (Pallesen, 2003). The ability to match the color of the filling with the natural tooth structure makes composite resins a suitable choice for restoring posterior teeth in visible areas.

Anterior teeth, on the other hand, often require more attention to detail in terms of shade matching and contouring to achieve aesthetic results. Composite resins offer excellent esthetic properties and can effectively restore fractured, discolored, or chipped anterior teeth (Lopes, 2004). Techniques such as stratification and layering are commonly used to mimic the natural translucency and texture of anterior teeth.

A study by Deliperi (2005) has also highlighted the importance of proper occlusal adjustment and polishing in both posterior and anterior composite fillings to ensure long-term success and patient satisfaction. Regular follow-ups and maintenance are essential to monitor the integrity of the restoration and prevent any complications.

4.5 Emerging Trends in Tooth-Colored Fillings

4.5.1 Nanotechnology in composite resins:
Nanotechnology has revolutionized the field of restorative dentistry, particularly in the development of composite resins. Nanoparticles are being incorporated into composite materials to improve their mechanical and optical properties (Alkurdi, 2016). For example, the addition of nanofillers such as silica and zirconia has been shown to enhance the strength and wear resistance of composite resins. These nanofillers also improve the esthetic properties of the material by providing a more natural appearance that closely mimics the color and translucency of natural teeth. Several studies have reported the superior mechanical properties and color stability of nanocomposite resins compared to traditional composite materials. This emerging trend in nanotechnology is likely to continue to influence the development of tooth-colored fillings in the future.

4.5.2 Bioactive materials:
Bioactive materials are another emerging trend in tooth-colored fillings. These materials have the ability to interact with the biological tissues in the oral cavity, promoting remineralization and regeneration of tooth structure (AlJehani, 2014). For example, bioactive glass fillers release ions that stimulate the formation of hydroxyapatite, the main mineral component of teeth, leading to improved bond strength and reduced secondary decay. Bioactive materials have shown promising results in improving the longevity and functionality of tooth-colored fillings. Additionally, these materials have antimicrobial properties that help prevent bacterial colonization and reduce the risk of recurrent decay. The incorporation of bioactive materials in composite resins is a promising approach to enhancing the therapeutic and preventive properties of tooth-colored fillings.

4.5.3 Digital dentistry and CAD/CAM technology:

The advancement of digital dentistry and Computer-Aided Design/Computer-Aided Manufacturing (CAD/CAM) technology has transformed the way tooth-colored fillings are fabricated. CAD/CAM systems allow for the precise design and fabrication of custom-made restorations using digital impressions and computerized milling machines. This technology enables dentists to create highly accurate and esthetic tooth-colored fillings in a single appointment, eliminating the need for traditional methods like impression taking and temporary restorations (Alzraikat, 2018). The use of CAD/CAM technology in tooth-colored fillings has been found to improve the fit, esthetics, and durability of restorations, leading to better patient outcomes and satisfaction. This trend is expected to continue to grow as digital workflows become more integrated into dental practices.

4.5.4 Alternative tooth-colored filling materials:
In addition to composite resins, several alternative materials are being explored for tooth-colored fillings. For example, glass ionomer cements are being used as a bioactive alternative to traditional composite resins. These materials release fluoride ions that promote remineralization and provide a chemical bond to the tooth structure, making them suitable for minimally invasive restorations. Resin-modified glass ionomers combine the esthetic properties of composite resins with the bioactive and adhesive properties of glass ionomers, offering a versatile material for tooth-colored fillings (Bayne, 2019). Additionally, materials such as hybrid ceramics and nanoceramics are being developed to provide enhanced strength, esthetics, and longevity in tooth-colored restorations. The use of alternative filling materials offers clinicians a wider range of options to meet the specific needs of their patients and tailor treatments to individual cases.

5. Conclusion

In conclusion, composite resins have evolved significantly over the years, offering a viable alternative to traditional amalgam fillings. Advancements in technology and materials have led to improved aesthetics, strength, and durability of tooth-colored fillings. The ability to match the color of the filling to the natural tooth enamel allows for a seamless restoration that blends in with the surrounding dentition. While composite resins have many advantages, they also present some challenges, such as polymerization shrinkage, wear resistance, and potential staining. Continued research and innovation in the field of dental materials promise to address these issues and further enhance the performance of composite resins. Overall, composite resins have revolutionized restorative dentistry by providing patients with aesthetically pleasing and durable fillings that can restore the function and appearance of their teeth. As technology continues to advance, we can expect to see further improvements in tooth-colored fillings, making them an increasingly popular choice for dental restorations.

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