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Fiber-Reinforced Composites in Dentistry: Enhancing structural integrity and aesthetic appeal

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Abstract

This review explored the recent advancements in fiber-reinforced composites (FRCs) within the context of restorative dentistry. Dental composites have undergone significant transformations, with FRCs emerging as a groundbreaking development at the intersection of aesthetics and mechanical performance. The objective of this review is to provide a comprehensive understanding of the innovative strategies employed in FRCs to address the challenges of polymerization shrinkage, wear resistance, mechanical strength, and aesthetics. FRCs, composed of fiber reinforcements strategically aligned within a resin matrix, offer enhanced flexural strength, fracture toughness, and wear resistance, essential for the longevity of dental restorations. The review further explored the dynamic relationship between fiber alignment and restoration design, highlighting the adaptability of FRCs for varied applications, from post and core restorations to bridges and splints. Through an intricate interplay of materials science and clinical demands, FRCs have revolutionized dental composites by seamlessly integrating form and function. This review underscores the transformative potential of FRCs in restorative dentistry, shedding light on the path to enhanced clinical outcomes and patient satisfaction.

Keywords: Fiber-reinforced composites, Restorative dentistry, Properties, Fiber alignment, Dental composites.

1. Introduction

Dental composites, the cornerstone of modern restorative dentistry, have undergone remarkable advancements that have redefined the landscape of dental materials. These composite resins, composed of a matrix and inorganic fillers, have evolved from rudimentary formulations to sophisticated materials boasting an impressive balance of aesthetics, mechanical properties, and clinical longevity [1-3]. As the demand for minimally invasive and aesthetically pleasing dental treatments continues to rise, researchers and manufacturers have embarked on a journey of innovation to create dental composites that not only mimic the natural dentition but also surpass the mechanical limitations of their predecessors.

The pursuit of improving dental composites has been driven by the desire to address several key challenges that have traditionally been associated with these materials. Polymerization shrinkage, which leads to microleakage and postoperative sensitivity, has prompted research into novel monomers and polymerization techniques aimed at minimizing shrinkage stress [4]. The quest for enhanced mechanical properties has led to the incorporation of nanofillers, fibers, and innovative resin matrices to elevate the fracture toughness and wear resistance [5,6].

The convergence of materials science and clinical needs has given rise to bioactive composites that promote remineralization and exhibit antibacterial properties, contributing to the preservation of both the restoration and the surrounding tooth structure [7]. Furthermore, the seamless integration of digital dentistry into the field has spurred the development of composites tailored for CAD/CAM systems, streamlining the chairside and laboratory fabrication processes [8].

Dental composites have entered a new era of innovation, and among the most exciting developments is the evolution of fiber-reinforced composites (FRCs). These cutting-edge materials are redefining restorative dentistry by harnessing the potential of fibers to enhance both aesthetics and mechanical properties. As the demand for minimally invasive and aesthetically pleasing dental treatments continues to rise, researchers and manufacturers have embarked on a journey of innovation to create FRCs that combine the benefits of traditional dental composites with the unique advantages of fiber reinforcement [9].

The inherent challenges of polymerization shrinkage, wear resistance, and mechanical strength in dental composites have been tackled through the incorporation of various fiber types. These fibers, ranging from glass and carbon to aramid and ceramic, play a pivotal role in augmenting the mechanical properties of composites [10]. By strategically aligning fibers within the resin matrix, researchers have engineered materials that exhibit enhanced flexural strength, fracture toughness, and wear resistance, crucial for ensuring the longevity and clinical success of dental restorations [11].

Furthermore, FRCs have paved the way for a seamless integration of form and function. The alignment of fibers, whether unidirectional or bidirectional, directly impacts the load-bearing capacity and distribution of stresses within the restoration [12]. Unidirectional alignment, for instance, offers superior strength along a single axis, making it ideal for applications like post and core restorations, while bidirectional alignment ensures balanced strength in both primary directions, suitable for bridges and splints [13].

The convergence of materials science and clinical needs has also led to innovations in the realm of aesthetics. Glass fibers, known for their biocompatibility and translucency, seamlessly blend with the natural dentition, making them a popular choice for anterior restorations [14]. Ceramic fibers, on the other hand, excel in providing both mechanical robustness and tooth-like appearance, an invaluable combination for posterior restorations [14,15].

Overall, these advanced materials offer a unique combination of mechanical properties, aesthetics, and biocompatibility, making them a valuable addition to the dental field [16]. In recent years, the application of fiber-reinforced composites has gained significant traction, enabling dentists to provide patients with improved restorative solutions [17]. This paper delves into the fascinating realm of fiber-reinforced composites in dentistry, exploring their composition, fabrication, properties, and diverse clinical applications.

2. Composition of FRCs

Fiber-reinforced composites in dentistry consist of a matrix phase reinforced with high-strength fibers, typically made from materials like glass, carbon, or polymers. The matrix, often composed of resin-based materials like Bis-GMA (Bisphenol A-glycidyl methacrylate) or UDMA (Urethane dimethacrylate), surrounds and encapsulates the fibers, providing cohesion, aesthetics, and durability [16]. The fibers impart exceptional mechanical properties, enhancing the material's strength, stiffness, and fracture resistance. The fabrication process involves layering the fibers within the matrix, followed by polymerization to create a solid, structurally robust material [16].

3. Clinical applications

FRCs find a wide array of applications in dentistry, ranging from restorative and prosthetic to orthodontic and surgical interventions. In restorative dentistry, they are used as core materials for endodontically treated teeth, providing reinforcement and preventing vertical root fractures [15].

The biocompatibility and aesthetic qualities of these composites make them an excellent choice for anterior restorations, where preserving a natural appearance is paramount [16].

In the realm of prosthetics, fiber-reinforced composites are employed for fabricating removable partial dentures, implant-supported prostheses, and fixed dental prostheses [17]. Their strength-to-weight ratio and customization capabilities allow for the creation of durable yet comfortable prosthetic devices. Furthermore, these composites are extensively used in orthodontic applications, serving as esthetically pleasing alternatives to traditional metallic braces. Fiber-reinforced composites can be incorporated into orthodontic appliances like space maintainers, splints, and aligners.

Surgical applications encompass the use of fiber-reinforced composites for guided bone regeneration and socket preservation. Their biocompatibility and ability to conform to complex anatomical shapes make them suitable for augmenting bone defects and supporting tissue regeneration.

4. Alignment of fibers

The alignment of fibers in FRCs plays a significant role in the design of dental restorations. The choice of fiber alignment technique directly impacts the mechanical properties and overall performance of the restorations. Different fiber alignment designs are utilized to tailor FRCs for specific dental applications.

4.1 Unidirectional alignment

Unidirectional fiber alignment (Figure 1a) involves arranging all the fibers in a single direction within the resin matrix. This alignment is typically achieved by manual placement or using mechanical alignment devices during the fabrication process [19]. This alignment design is particularly suitable for applications where higher strength along a specific axis is required. Unidirectional alignment allows the composite to exhibit improved strength along the direction of the fibers. However, it may result in reduced strength in other directions, making it important to consider the specific application and loading conditions. Unidirectional FRCs are commonly used in the construction of posts and cores for endodontically treated teeth. The aligned fibers effectively distribute forces along the longitudinal axis, enhancing the load-bearing capacity and preventing root fracture [19,20]. Additionally, unidirectional FRCs are utilized for fabricating fixed dental prostheses, where improved tensile strength is vital for longevity and stability [21].

4.2 Bidirectional alignment

Bidirectional alignment (Figure 1b) involves aligning fibers in two primary directions, usually at right angles to each other [19,20]. This technique is also known as cross-ply alignment design offers improved strength and stiffness in both orthogonal directions. Bidirectional alignment is commonly used in dental applications where a combination of flexural and tensile strength is required including, in dental bridge frameworks, removable dentures, and splints. The combination of fibers in two directions enhances the load-bearing capacity and fracture resistance, ensuring optimal performance under various occlusal and functional forces [12].

4.3 Random orientation

In some cases, fibers are randomly dispersed, as shown in Figure 1c, within the resin matrix during fabrication [14,19]. Random orientation is simple and easy to achieve, but it may result in anisotropic properties, where the mechanical properties vary in different directions. Randomly oriented FRCs are commonly used for provisional or temporary restorations, such as interim fixed dental prostheses. While random orientation may not provide as high strength as aligned FRCs, it offers a simpler and more cost-effective fabrication process for short-term restorations [22].

4.4 Woven fabric

Woven fabric (Figure 1d) involves interlacing fibers in a specific pattern, such as plain weave or twill weave [23]. The woven fabric can be impregnated with the resin matrix, resulting in a composite with well-controlled and evenly distributed fiber alignment. This design allows for a more tailored distribution of fibers, providing enhanced mechanical properties. Woven fabric FRCs are commonly used in the fabrication of orthodontic appliances, indirect restorations, including inlays, onlays, and veneers [24].

4.5 Laminated layers

In some cases, layers of FRCs with different fiber orientations are stacked and bonded together using the resin matrix [19]. This creates a laminated composite with improved strength and mechanical properties compared to a single-layer composite. Laminated layers can provide enhanced resistance to fracture and offer versatility in designing custom dental prostheses.

4.6 Pre-impregnated fibers

Pre-impregnated or prepreg fibers are fibers that have been impregnated with the resin matrix beforehand. These fibers are often available in sheets or rolls and come with a specific fiber alignment [23]. Pre-impregnated fibers allow for precise control of fiber orientation and ensure consistent mechanical properties.

The choice of fiber alignment technique depends on the specific application and the desired mechanical properties of the FRC. Manufacturers and dental professionals carefully select the appropriate fiber alignment method to tailor the composite material for various dental restorations, including direct and indirect restorations, splints, bridges, and orthodontic appliances.

5. Properties and advantages

Fiber-reinforced composites possess a range of properties that make them uniquely suited for dental applications. Their high modulus of elasticity closely resembles that of natural tooth structure, reducing the occurrence of stress concentration and enhancing load distribution, thus minimizing the risk of material failure [18]. Moreover, their excellent biocompatibility ensures minimal adverse reactions within the oral environment. The aesthetic appeal of fiber-reinforced composites is particularly noteworthy, as they can be colour-matched to the patient's natural teeth, ensuring a seamless integration with the surrounding dentition [16].

The incorporation of fibers further augments these materials. Glass fibers, for instance, offer excellent biocompatibility and radiopacity, making them suitable for applications like splinting fractured teeth or reinforcing dentures [17]. Carbon fibers, on the other hand, exhibit superior mechanical properties and are often used for fabricating durable and lightweight prosthetic frameworks [18]. Polymers, such as polyethylene fibers, contribute to increased toughness and flexibility, making them valuable for denture applications [17]. The advantages of individual dental FRCs are presented in Table 1.

6. Factors affecting the success of FRCs

The FRCs have gained significant popularity in restorative dentistry due to their unique mechanical properties, aesthetics, and biocompatibility. In addition to the relationship between fiber alignment and restoration design, there are other important aspects related to fiber-reinforced composites (FRCs) in restorative dentistry.

6.1 Effect of fiber volume fraction

The volume fraction of fibers in the composite directly influences its mechanical properties. Higher fiber volume fractions generally result in improved strength and stiffness [25]. However, an excessively high fiber content may compromise the flowability of the composite during fabrication, affecting its adaptability to the tooth cavity.

6.2 Influence of fiber length

The length of the fibers affects the load-bearing capacity and reinforcement of the composite. Longer fibers can transfer stress more efficiently, enhancing mechanical properties [29]. However, shorter fibers might offer better handling properties and reduce the risk of fiber agglomeration.

6.3 Interfacial bonding

Effective interfacial bonding between the fibers and resin matrix is crucial for optimizing the mechanical performance of FRCs.

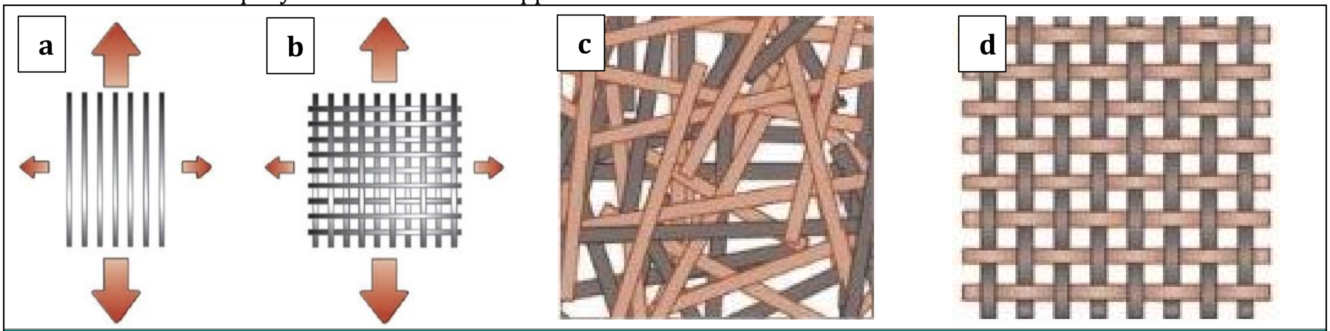

Figure 1. Different orientations of fibers in FRCs. Where a. Unidirectional, b. Bidirectional, c. Random orientation, and d. Woven fabric.

Table1. Advantages and disadvantages of composites reinforced with various fibers.

Type of fibers	Advantages	Disadvantages
Glass fibers	• Biocompatible [25]. • Offer high tensile strength, modulus of elasticity, contributing to increased flexural strength and fracture toughness of the composite [19]. • Tooth-colored or translucent [14].	• High density [19]. • Lower fatigue resistance [19].
Carbon fibers	• Offer excellent tensile strength, stiffness, and lightweight characteristics [25,26].	• Non-aesthetic [27].
Aramid fibers (Kevlar)	• Offer exceptional toughness and impact resistance [15]. • Contribute to improved fracture resistance and durability of the composite [28].	• Non-aesthetic.
Polyethylene fibers	• Provide high ductility and toughness to the composite [14]. • Enhance impact resistance and prevent brittle failure of the restoration [19]. • Aesthetic.	• The strength is not as great as the glass and carbon fibers.
Silica fibers	• High tensile strength and stiffness [25]. • Contribute to the overall strength and load-bearing capacity of the composite. • Aesthetic.	• Poor impact resistance compared to aramid fibers.
Ceramic fibers (Zirconia)	• Possess high tensile strength and hardness [25]. • Contribute to enhanced flexural strength and wear resistance of the composite. • Closely match the color and translucency of natural teeth, making them ideal for anterior restorations requiring superior aesthetics [15].	• More brittle compared to other fibers, and care should be taken during handling and processing.
Polyethylene Naphthalate (PEN) fibers	• High tensile strength and modulus of elasticity [25]. • Contribute to improved load-bearing capacity and fracture resistance of the composite. • Translucent and can blend well with natural teeth, enhancing the overall appearance of dental restorations.	• Poor fatigue resistance compared to carbon fibers.
Polyether Ketone (PEK) fibers	• High tensile strength and modulus of elasticity [25]. • Contribute to increased flexural strength and stiffness of the composite. • Aesthetic.	• PEK fibers may not be as widely used as other fibers, and further research is needed to fully understand their long-term performance in dental restorations.

Proper use of silane coupling agents enhance the bond strength between the fibers and the resin [30]. Various bonding mechanisms involved in improving the adhesion between the resin matrix and different fibers are discussed in section 7.

6.4 Curing and polymerization

Proper curing and polymerization of the resin matrix are essential for achieving optimal mechanical properties and avoiding internal voids or defects in the composite. Light-curing techniques should be carefully managed to ensure complete polymerization throughout the restoration.

6.5 Clinical application and longevity

The success of FRC restorations depends on their clinical application and longevity. Factors such as occlusal forces, oral hygiene, and the patient's oral habits can influence the long-term performance of the restoration. Regular follow-ups and maintenance are crucial to ensure the integrity and longevity of the FRC restorations.

6.6. Biocompatibility and tissue response

Biocompatibility is a critical aspect when using FRCs in dentistry. Extensive research has demonstrated the biocompatibility of most fibers used in dental FRCs, ensuring minimal adverse reactions and tissue responses [31]. Nevertheless, long-term clinical studies are necessary to confirm their biocompatibility over extended periods.

7. Bonding mechanisms between restorative dental resins and different fibers

The successful integration of fiber-reinforced composites (FRCs) in restorative dentistry hinges upon strong and durable bonding between dental resins and various types of reinforcing fibers. Understanding the bonding mechanisms at play is essential for optimizing the performance and longevity of FRC-based dental restorations. The following are the different bonding mechanism observed between the resin matrix and the fibres.

7.1 Bonding mechanisms

7.1.1 Mechanical interlocking: One of the primary bonding mechanisms between dental resins and fibers is mechanical interlocking. This occurs when the resin matrix infiltrates and surrounds the interstices of the fibers, creating a mechanical grip. The micro-mechanical interlocking increases the surface area of contact, leading to improved stress distribution and load transfer between the resin matrix and the fibers [25]. The mechanical interlocking mechanism is particularly prominent in FRCs with irregular or roughened fiber surfaces.

7.1.2 Chemical bonding: Chemical bonding between dental resins and fibers can result from interactions at the molecular level. This bonding mechanism involves the formation of covalent or ionic bonds between functional groups present on the fiber surface and the resin matrix. Such interactions enhance the adhesion between the two materials, contributing to improved composite strength and resistance to debonding [28]. Silane coupling agents are often employed to facilitate chemical bonding between inorganic fibers (e.g., glass fibers) and resin matrices [32].

7.1.3 Wetting and capillary action: Successful bonding between dental resins and fibers relies on proper wetting of the fiber surface by the resin matrix. Wetting is influenced by the surface tension of the resin, the fiber's surface characteristics, and the viscosity of the resin. Capillary action aids in drawing the resin into the spaces between fibers, promoting intimate contact and enhancing adhesion [26]. Proper wetting and capillary action contribute to the formation of a continuous resin-fiber interface, which is crucial for load transfer and stress distribution.

7.1.4 Interdiffusion: Interdiffusion occurs when there is a gradual mixing and diffusion of resin molecules into the fiber network and vice versa. This mechanism results in a gradual transition zone at the interface, where the properties of the resin and fiber intermingle [33]. Interdiffusion strengthens the bond by creating a gradient of properties, ensuring a gradual stress transfer and reducing the risk of abrupt debonding.

7.1.5 Hybrid layer formation: In certain cases, a hybrid layer is formed at the interface between the fiber and the resin matrix. This layer is a result of the interpenetration of resin and fiber components, leading to a unique structure that combines properties of both materials [34]. The hybrid layer contributes to enhanced adhesion and improved mechanical properties, further reinforcing the bond between the fiber and the resin matrix.

7.2 Silanization of fibers for improving the bonding

Silanization plays a crucial role in enhancing the bonding between various fibers and restorative dental resins in fiber-reinforced composites (FRCs). Silanization involves the application of silane coupling agents to the fiber surface, which promotes chemical bonding and improves the adhesion between the fiber and the resin matrix [35]. This process is essential for optimizing the mechanical properties and long-term performance of FRCs in restorative dentistry. The role of Silanization in bonding can be summarized as follows:

7.2.1 Surface activation: Many fibers used in FRCs, such as glass fibers and ceramic fibers, have inherently inert surfaces that do not readily bond with resin matrices. Silanization acts as a surface activation step, where the silane coupling agent chemically modifies the fiber surface, creating active sites for bonding [36]. The silane molecules bind to the fiber surface through chemical reactions, creating functional groups that can interact with the resin matrix.

7.2.2 Chemical bonding: Silanization facilitates chemical bonding between the fiber and the resin matrix. Silane coupling agents contain both hydrophobic and hydrophilic groups, allowing them to bond covalently with the inorganic fibers and form hydrogen bonds with the organic resin matrix [23]. This dual interaction enhances the overall adhesion and prevents debonding between the fiber and the resin.

7.2.3 Water repellence: Silanization imparts water repellence character to the fiber surface. This is particularly important in FRCs, as water absorption can compromise the integrity of the composite over time. Silane coupling agents create a hydrophobic layer on the fiber surface, reducing water sorption and minimizing the risk of degradation or delamination of the composite [25].

7.2.4 Stress transfer and load distribution: Effective bonding through silanization ensures efficient stress transfer and load distribution between the fiber and the resin matrix. The strong chemical bond formed between the silane and the fiber enhances the load-bearing capacity of the composite and reduces the risk of failure at the interface [19].

7.2.5 Preventing microleakage: Silanization helps to seal potential gaps or microvoids between the fiber and the resin matrix, minimizing microleakage and preventing the ingress of oral fluids, bacteria, and other contaminants into the interface [36].

7.2.6 Improving longevity: Silanization enhances the long-term stability and longevity of FRCs. The improved bonding between the fiber and the resin matrix reduces the risk of premature debonding or degradation, leading to more durable and reliable dental restorations [19].

7.3 Silanizing agents

Silanizing agents play a crucial role in providing bonding between various fibers and restorative dental resins in fiber-reinforced composites. Different fibers may require specific types of silane coupling agents to achieve optimal bonding. Table 2 presents the different types of silanizing agents used with various fibers and their type of bonding mechanisms.

8. Fibers responsible for improving the structural integrity of composites

Various fibers enhance the structural integrity of restorative resins in fiber-reinforced composites (FRCs) by providing additional reinforcement and improving mechanical properties. The incorporation of fibers within the resin matrix contributes to increased strength, fracture resistance, and toughness. Different types of fibers, such as glass fibers, carbon fibers, and aramid fibers, offer unique benefits in enhancing the structural integrity of FRCs.

8.1 Glass fibers

Glass fibers are widely used in dental FRCs due to their excellent mechanical properties and biocompatibility [25]. The incorporation of glass fibers increases the flexural strength, impact resistance, and fatigue resistance of the composite [19]. The fibers act as a load-bearing framework, effectively distributing occlusal forces and reducing stress concentration in the resin matrix. Glass fibers also exhibit a good bond with the resin matrix, enhancing interfacial adhesion [14].

Table 2. Different types of Silanizing agents used with various fibers and their type of bonding mechanisms.

Type of fibres	Silanizing agent (Silane coupling agent)	Possible bonding mechanism
Glass fibers	3-methacryloxy-propyl-trimethoxy-silane (MPS).	Methacrylate group of the coupling agent reacts with the resin matrix during polymerization, facilitating chemical bonding and improving adhesion [19].
Carbon fibers	Vinyltriethoxysilane (VTEOS).	The vinyl group in VTEOS enhances the compatibility with the organic resin matrix, enabling covalent bonding and promoting adhesion [23].
Aramid fibers	Aminoethylaminopropyltrimethoxysilane (AEATMS)	The amino groups in AEATMS react with the fiber surface, creating covalent bonds that enhance adhesion to the resin matrix [23].
Polyethylene fibers	Methacryloyloxypropyltrimethoxysilane (MPTMS)	The methacrylate group in MPTMS enables chemical bonding and interfacial adhesion [19].
Polymethylmethacrylate (PMMA) fibers	3-(trimethoxysilyl)propyl methacrylate (γ-MPS)	The methacrylate functional group reacts with the resin matrix during polymerization, promoting adhesion [23].
Polyethylene Terephthalate (PET) fibers	3-aminopropyltriethoxysilane (APTES)	The amino groups in APTES enable chemical bonding with the resin matrix, enhancing the adhesion and mechanical properties of the composite [36].

8.2 Carbon fibers
Carbon fibers offer high tensile strength and stiffness, making them particularly suitable for applications where superior mechanical properties are required [26]. When used in dental FRCs, carbon fibers significantly improve the tensile strength and fracture toughness of the composite [25]. The high modulus of elasticity of carbon fibers also contributes to reducing the flexural deformation of the composite under load.

8.3 Aramid fibers
Aramid fibers, such as Kevlar, exhibit exceptional toughness and impact resistance [15]. When incorporated into restorative resins, aramid fibers contribute to enhanced resistance against crack propagation and prevent catastrophic failure [28]. The unique combination of strength and toughness in aramid fibers helps absorb and dissipate energy during functional loading, resulting in improved durability and reliability of the FRC.

8.4 Polyethylene fibers
Polyethylene fibers provide high ductility and toughness to the composite [14]. The incorporation of polyethylene fibers increases the impact resistance of the FRC and reduces the risk of brittle failure. These fibers also facilitate excellent stress transfer between the resin matrix and the fibers, resulting in improved load-bearing capacity [19].

8.5 Polymethylmethacrylate (PMMA) fibers
PMMA fibers offer good compatibility with resin matrices and contribute to increased toughness and resistance to crack propagation [23]. The incorporation of PMMA fibers enhances the flexural strength and prevents premature failure of the composite under mechanical loading.

The combination of different fibers in FRCs allows for a synergistic effect, where each type of fiber contributes its unique mechanical properties to enhance the overall structural integrity of the composite. The incorporation of these fibers helps overcome the limitations of conventional dental resins and provides a durable and reliable material for various restorative applications.

9. Fibers responsible for improving the aesthetic appeal of composites

Various fibers can enhance the aesthetic appeal of restorative resins in fiber-reinforced composites (FRCs) by offering unique optical properties and natural-looking characteristics. The incorporation of certain fibers can provide improved color-matching, translucency, and light reflection, making them suitable for esthetic dental restorations. Different types of fibers, such as glass fibers and ceramic fibers, contribute to the aesthetic appeal of FRCs in restorative dentistry.

9.1 Glass fibers
Glass fibers used in dental FRCs are typically tooth-colored or translucent, which allows for better color blending with the surrounding natural teeth [19]. The translucency of glass fibers enables light transmission through the composite, resembling the natural appearance of dental enamel. This characteristic is particularly valuable for anterior restorations, where mimicking the optical properties of natural teeth is crucial for achieving aesthetic appeal [14].

9.2 Ceramic fibers
Ceramic fibers, such as zirconia fibers, are known for their excellent aesthetic properties [25]. The colour and translucency of zirconia fibers closely match that of natural teeth, making them an ideal choice for anterior restorations. The use of ceramic fibers in FRCs allows for making of dental restorations that seamlessly blend with the patient's natural dentition, enhancing the overall aesthetic appearance [15]. Incorporation of these aesthetically appealing fibers impart

aesthetically pleasing dental restorations that closely resemble natural teeth, resulting in improved patient satisfaction and confidence.

According to the literature, the best fiber that can be reinforced into restorative dental composites is still a subject of debate and may vary based on the specific application and desired properties of the composite. However, glass fibers have been extensively studied and widely used in dental FRCs due to their favorable mechanical properties and biocompatibility, making them a popular choice for various restorative applications.

Glass fibers offer high tensile strength, good flexural properties, and excellent bond strength with the resin matrix [30]. The incorporation of glass fibers into restorative composites enhances the overall mechanical performance, including increased flexural strength, fracture toughness, and resistance to deformation. Glass fibers also exhibit good color-matching ability, especially when the fibers are tooth-colored or translucent, allowing for a natural aesthetic appearance in anterior restorations [14].

Moreover, glass fibers have demonstrated effective stress distribution and transfer properties, reducing the risk of catastrophic failure in the composite [30]. They act as a load-bearing framework, efficiently distributing occlusal forces and minimizing stress concentration in the resin matrix. Another advantage of glass fibers is their biocompatibility, ensuring minimal adverse reactions within the oral environment [31]. Glass fibers have been shown to be safe for dental applications and are compatible with the surrounding dental tissues.

The transformative potential of FRCs lies in their ability to address the shortcomings of traditional dental composites while offering a comprehensive array of advantages. By providing enhanced mechanical properties, reduced polymerization shrinkage, bioactivity, superior aesthetics, versatility, and improved longevity, FRCs pave the way for restorative dentistry that achieves optimal clinical outcomes and elevates patient satisfaction to new heights. The amalgamation of these benefits positions FRCs as a transformative force in modern dentistry, offering a promising path to improved patient care and long-lasting restorations.

10. Conclusion

The fiber-reinforced composites have revolutionized restorative dentistry by offering a versatile and innovative material solution. The use of different fibers allows tailoring the properties of FRCs to meet specific clinical requirements, resulting in improved strength, aesthetics, and biocompatibility. However, the choice of fiber reinforcement should consider the specific application, load requirements, and aesthetic demands of the restoration. As research continues to evolve, new fiber types with improved properties may further enhance the performance of FRCs in dental restorations and prostheses, benefiting both patients and dental professionals.

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