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Application of the "Wallpapering Technique" for Direct Fiber-Reinforced Composite Restoration of Non-Vital and Vital Teeth: Case Report

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ABSTRACT

Introduction: The reconstruction of severely damaged teeth presents significant challenges in dentistry. A key aspect of successful restorative procedures is the preservation of the dentin-enamel junction (DEJ), which serves as a protective interphase against crack propagation. Incorporating fibers into composite restorations can enhance stress distribution, increase fracture resistance, and effectively prevent crack propagation, thereby improving the toughness of composites.

Case Report: This article presents two cases—one vital and one non-vital—where composite build-up was performed using a fiber design based on the "Wallpapering Technique." This technique involves covering cavity walls with overlapping, closely adapted polyethylene ribbons (Ribbond, USA), which serve as a substitute for the DEJ and provide reinforcement. The stress-reduced direct composite (SRDC) protocol, combined with the Wallpapering Technique, preserves remaining sound tooth structure. Unlike indirect restorations, this approach allows for treatment to be completed in a single visit and at a lower cost.

Conclusion: Fiber-reinforced composites may offer a viable alternative to indirect restorations for structurally compromised vital and non-vital teeth, particularly for certain patients under specific conditions.

Introduction

Multiple factors contribute to the loss of structural integrity in teeth, including caries, endodontic treatment, fractures, and extensive restorations. Selecting an appropriate restoration for severely damaged teeth, particularly non-vital ones, presents a considerable challenge in dentistry due to the significant loss of tooth structure [1]. The choice of a suitable treatment plan should be guided by several factors, including the remaining tooth structure, the thickness of the walls, the tooth's location in the arch, and the load applied to the tooth [2, 3].

The dentin-enamel junction (DEJ) serves as the interface between the highly mineralized enamel and the softer dentin [4]. This junction plays a crucial role in effectively transferring stresses between these two distinct layers [5]. Additionally, the mantle dentin layer adjacent to the DEJ typically exhibits lower hardness than bulk dentin, which helps inhibit crack propagation. Overall, the phenomenon of crack arrest in teeth can be attributed to the gradual increase in toughness from enamel to mantle dentin and the DEJ, which acts as a protective functional interphase. In cases of severely damaged teeth, the risk of catastrophic failure increases with greater loss of the DEJ region and surrounding tooth structure [6, 7]. Therefore, selecting a restoration that can mimic these structural characteristics is imperative [8].

Historically, extensive amalgam and cast coverage restorations were commonly employed for severely damaged teeth. However, this approach has several potential drawbacks, including the loss of sound tooth structure, lack of adhesion to the tooth, and an increased risk of cracks and failure [9]. Currently, adhesive systems are utilized to restore damaged teeth, with a primary goal of conserving as much residual tooth structure as possible. The objective of such interventions is to reduce stress and replicate the functional properties of a natural tooth [8]. In addition to aesthetic considerations, composite materials can effectively preserve tooth structure and bond well to teeth. Composite build-up offers a favorable alternative for patients who may not afford the high costs associated with indirect restorations and allows for reconstruction in a single visit [3]. Despite advancements in composite resins, polymerization shrinkage and resultant stress remain significant concerns. Various methodologies have been proposed to mitigate polymerization stress, such as employing an incremental approach for composite insertion and utilizing the soft-start technique [10, 11].

It is important to note that composites are rigid materials that lack toughness; toughness refers to a material's resistance to rapid crack propagation. Consequently, composites do not perform well in terms of crack resistance [12]. The incorporation of fibers can enhance force distribution and energy absorption, thereby preventing catastrophic failures. Furthermore, fibers improve the fracture resistance of restorations. Fiber-reinforced composites have been developed to increase the toughness of restorations and improve their durability [13, 14].

Incorporating fibers into cavity walls while restoring with composite represents a practical solution that can enhance the properties of the composite and help prevent catastrophic dental failures by distributing forces more effectively [3, 7]. This study presents a clinical intervention involving the reconstruction of severely damaged posterior teeth in two cases—one non-vital and one vital—and their restoration with fiber-reinforced composite (FRC) using the wallpaper technique. Additionally, the advantages and disadvantages of this therapeutic approach are critically evaluated.

Case Report

***Case 1*:** A 38-year-old male patient presented with secondary caries beneath an old amalgam restoration in the first right upper molar (#16) (Figure 1). Vitality tests confirmed that the tooth was vital. We proceeded to remove the existing amalgam restoration and the secondary caries. Upon examination, we noted that both the distal and mesial walls were compromised, and the palatal cusps were fragile (Figure 2). After discussing the treatment plan with the patient and obtaining informed consent, we opted for a fiber-reinforced direct composite restoration for the upper first molars, following the six-step stress-reducing direct composite (SRDC) protocol [3, 7, 15].

1. Analysis of Occlusion:
We identified occlusal overload areas on each cusp. The analysis revealed that the palatal cusps bore significant load, leading us to decide on reducing them to better distribute the occlusal stress.

2. Cavity Preparation and Caries Removal End Points:

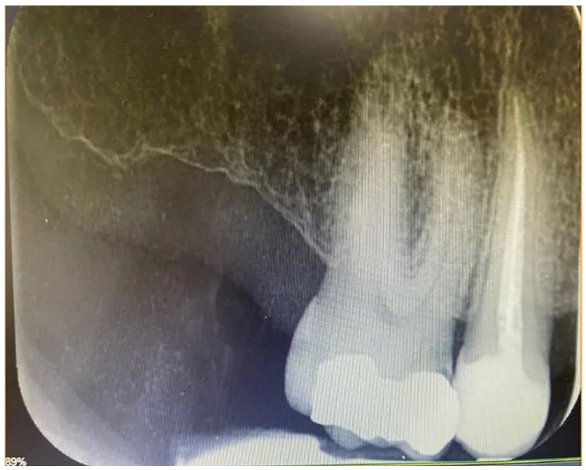

Figure 1: *Preoperative Radiographic view of teeth #16 with amalgam restoration and secondary caries*

Figure 2: *Clinical view of tooth #16 after removal of amalgam restoration and secondary caries*

The existing amalgam was removed using #2 and #4 round burs (Tizkaven, Iran), preserving as much sound structure as possible in line with minimally invasive dentistry principles. Residual sharp angles and unsupported enamel were smoothed, and caries-free peripheral enamel was preserved for bonding. Isolation was achieved using cotton rolls and suction. A Tofflemire matrix retainer and band were placed around the tooth, with interproximal adaptation secured using a wooden wedge. Despite normal clinical symptoms and radiographic findings confirming vitality, we placed a resin-modified glass ionomer (RMGI) (Fuji II LC, GC; Tokyo, Japan) in the deep axial wall of the mesial box as a base (Figure 3).

3. Analysis of Residual Tooth Structure:

After removing the Tofflemire matrix retainer and band, we assessed the residual tooth structure. The palatal cusps were reduced while the buccal cusps remained intact. The facial walls measured over 2 mm in thickness, providing adequate support for the fiber-reinforced composite restoration.

4. Preparing the Dental Substrate for Bonding:

We reinserted the Tofflemire matrix retainer and band, using a wooden wedge for interproximal adaptation. The tooth was etched for 15 seconds with 37% phosphoric acid (FGM, Brazil), rinsed, and dried while maintaining a moist dentin surface. A two-step etch-and-rinse adhesive system (Amber APS, FGM, Brazil) was applied, air-thinned gently, and light-cured for 20 seconds using a LED curing light (Woodpecker, PRC).

5. Control of Polymerization Stress:

Buildup of the Skeleton: We reconstructed the missing peripheral tooth structure using 2 mm wedge-shaped composite increments. Opalis conventional composite (FGM, Brazil) was utilized to restore the distal and mesial marginal ridges. The EA2 shade composite was used around the teeth on the distopalatal and mesiopalatal walls to simulate enamel (Green Arrow in Figure 4).

Wallpapering Technique with Polyethylene Fiber Strand: We measured the mesiodistal distance and pulp chamber-coronal length of the cavity walls using a dental probe (Hu-Friedy, USA). A piece of Lenoweave polyethylene fiber (Ribbond, USA), measuring 4 mm wide and 12 mm long, was cut with Ribbond scissors (Ribbond, USA), wetted with unfilled resin (Ribbond Wetting Resin, Ribbond, USA), and excess resin was removed. Prior to inserting the fiber, we applied a layer of flowable composite (Opalis Flow, FGM, Brazil) to the mesial, distal, and palatal walls. The pre-contoured C-shaped fiber was placed in the cavity using cotton pliers, adapted to the cavity walls with a small microbrush, and cured for 20 seconds (Red Arrow in Figure 4). This tight fitting of the fibers with the tooth structure minimizes polymerization shrinkage stress on the remaining weak structures. The remaining dentin and enamel volume in the facial wall was deemed sufficient, eliminating the need for dentin-enamel junction (DEJ) reconstruction with fiber strands.

Dentin and Occlusal Surface Buildup: For the final reconstruction, we applied 2 mm thick layers of Opalis DA2 composite to restore the dentin surface, followed by Opalis EA2 composite to achieve the final morphology. After removing the wedge and matrix band, we post-cured the restoration through the palatal surface and occlusal for 40 seconds. Finishing was accomplished using fine diamond burs and polishing wheels (Shofu Dental, Japan).

Figure 3: *Placing the Tofflemire matrix retainer and the band, and the RMGI in the axial wall of the mesial box as the base*

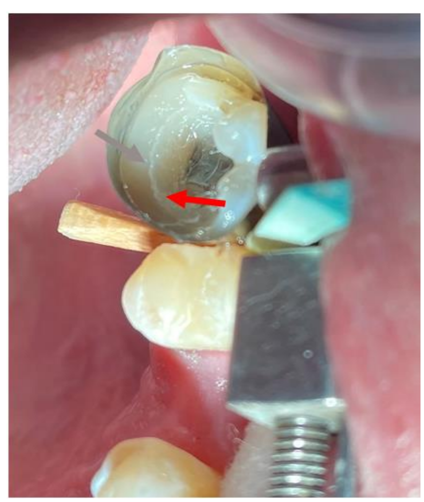

Figure 4: *Peripheral enamel skeleton was built up in the palatal wall, mesial, and distal marginal ridge (Green Arrow) and placed appropriate length fiber in close contact with walls (Red Arrow).*

6. Occlusal Force Equilibration:
We adjusted the central occlusion to ensure better load distribution and prevent excessive force on the reconstructed tooth. The final result mirrored the adjacent tooth, achieving duplicate contacts and consistent intensity on both the natural tooth structure and the composite restoration (Figure 5).

Figure 5: *Composite buildup of #16*

Case 2: An 18-year-old female presented with an endodontically treated first left upper molar (#26) one week after completing root canal therapy. During the removal of caries, the pulp was inadvertently exposed, prompting a referral to an endodontist. Given the inadequate occlusogingival length and insufficient enamel width, direct cuspal coverage was chosen for the restoration. An indirect restoration would have necessitated the removal of significant sound tissue from the tooth. Consequently, fiber-reinforced composite resin was selected for this case with the patient's informed consent. The six steps of the SRDC (Simplified Resin-Dentin Composite) technique were performed using the same materials and tools as in previous cases. All four cusps were reduced, and fiber strands (Ribbond, USA) were employed using the wallpapering technique. In this instance, two C-shaped fibers (4 mm wide and 12 mm long) were placed on both the buccal and palatal walls to simulate the dentin-enamel junction (DEJ) in the axial walls. These two fibers overlapped by 1-1.5 mm on the proximal surface (Figure 6).

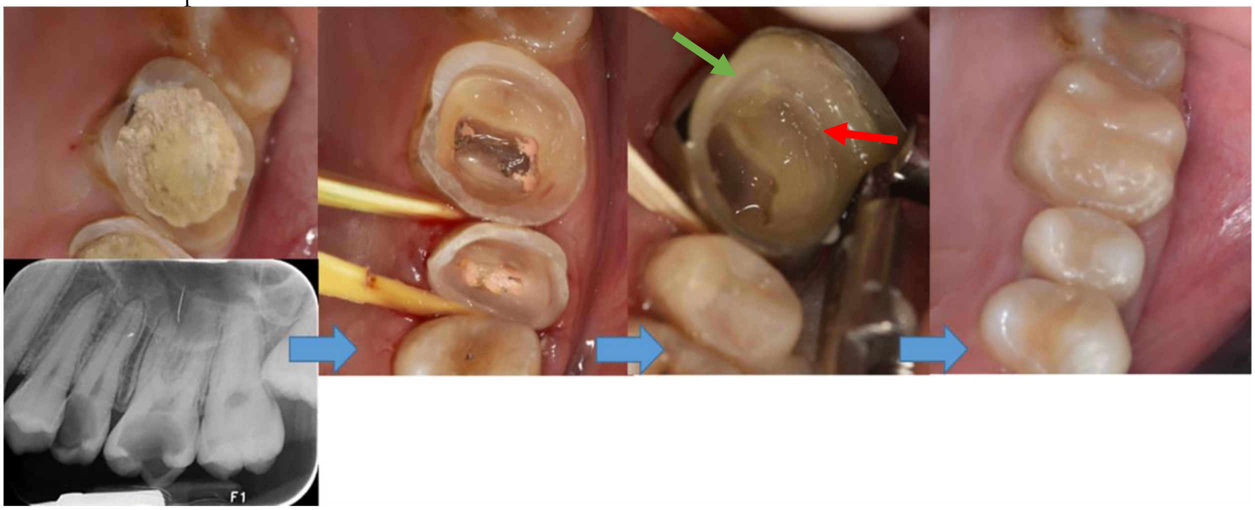

Figure 6: *The similar treatment process for tooth #26 (Blue Arrows indicate the sequence of photos)*
Green Arrow: Peripheral enamel skeleton in the palatal and buccal walls, mesial, and distal marginal ridge
Red Arrow: Appropriate length fiber in close contact with walls.

This technique has been successfully applied in two reported cases involving vital and non-vital teeth, based on clinical judgment and utilizing similar materials. Follow-up assessments were conducted after one year (Figure 7).

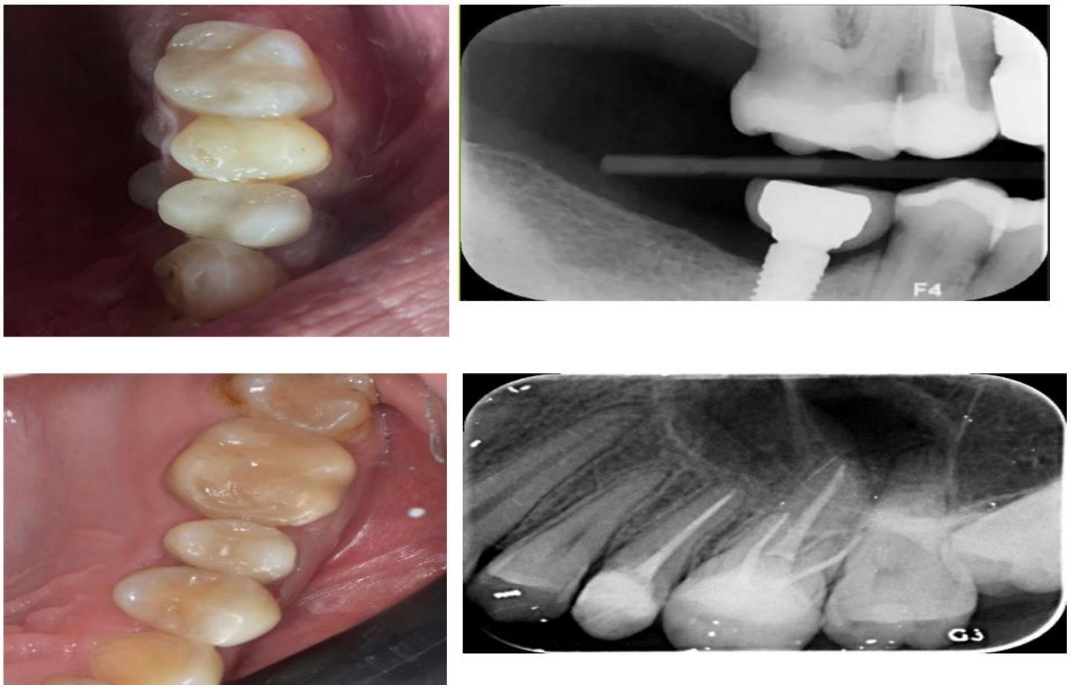

Figure 7: *Clinical and radiographic follow-up after one year in case 1 and 2*

Discussion

The most critical factor influencing the longevity of coronal restorations is the extent of dentin structure loss. Consequently, tooth strengthening should be a primary consideration when selecting an appropriate restoration method [3]. Historically, full cusp coverage with amalgam was a common treatment approach, demonstrating an acceptable long-term survival rate [16]. However, global efforts to reduce and eliminate amalgam usage due to its mercury content have prompted the exploration of alternative restorative materials [17]. Additionally, amalgam's lack of aesthetic appeal, its non-adhesive properties to tooth structure, and its inability to enhance tooth strength further justify the need for alternative restorations [18]. Full crowns, posts, and cores can be both costly and time-consuming, often requiring the removal of sound tooth structure [1]. In contrast, modern conservative dentistry emphasizes the use of materials that can bond to the residual tooth structure, thereby strengthening it—such as composite build-ups and fiber posts. This approach aims to maintain tooth resistance while minimizing the removal of healthy tissue [10, 15].

A significant challenge associated with composite materials is the stresses resulting from polymerization shrinkage. The Stress-Reduced Direct Composite (SRDC) technique has emerged as a promising alternative to indirect restorations [8, 15]. Research by Deliperi et al. [19] indicated that when the thickness of remaining walls in vital teeth exceeded 2 mm, the SRDC technique exhibited no failures in large three-surface restorations even after two years. Two effective methods for reducing polymerization shrinkage stress include the maturation of the bond layer and the layering technique. After a maturation period of 5 minutes, the bond strength of dentin can surpass that of enamel. During the initial polymerization phase (3 to 5 minutes), the bond strength to enamel is initially stronger than that to dentin. The layering technique employs small increments of composite material, ensuring that each layer bonds to no more than two cavity walls. This strategy effectively influences the C-factor by increasing the number of unbonded surfaces [7, 20, 21]. Furthermore, previous studies [22, 23] have demonstrated that polymerization protocols utilizing low intensity and extended curing times promote more extensive polymer chain formation, thus enhancing polymerization quality. Prolonging the duration of polymerization can alleviate stresses associated with shrinkage.

Integrating fibers with composite materials presents a viable treatment option for addressing the inherent deficiencies of resin composites [12]. The dense network of fibers mitigates rapid crack propagation and alters stress distribution pathways [13, 14]. A review article from 2021[24] highlighted that incorporating fibers increases restoration resistance to failure and reduces microleakage by minimizing resin volume. In Ruprai et al.'s study [25], biomimetic protocols aimed at preserving tooth structure and enhancing fracture resistance demonstrated that fiber inclusion improves modulus of elasticity, impact strength, and flexural strength while contributing to crack-stopping mechanisms. This integration also helps prevent catastrophic failures.

The dentin-enamel junction (DEJ) serves as a robust interface between enamel and dentin. Research indicates that cracks originating from enamel toward dentin can be arrested at this junction; however, cracks initiating from dentin are likely to lead to specimen fracture following elastic and plastic deformation [26]. Thus, preserving the DEJ during cavity preparation is crucial to preventing crack propagation.

In structurally compromised teeth, walls thinner than 2 mm exhibit significant reduction in DEJ integrity at proximal and lateral surfaces. The phenomenon known as Poisson's effect explains how vertical loads generate lateral forces on cavity walls during occlusal loading. These forces can induce cracks in the remaining walls by generating tensile stress on the pulpal floor [10, 27-29]. The limited toughness of composites, combined with the protective role of the dentin-enamel junction (DEJ), underscores the rationale for utilizing bonded onlay restorations to cover weakened cusps [7]. By incorporating Ribbond polyethylene fibers using the wallpaper technique along the remaining walls, multiple load distribution pathways are established. This method allows for better control of polymerization stresses, as the load is spread over a larger area. The Ribbond fibers bond effectively to the cavity walls, facilitating strain harmony between the tooth substrate and the restorative composite material. This mimics the performance of the DEJ while reinforcing it, thereby preserving sound tissue and preventing catastrophic failures [3, 7].

In this approach, fiber segments were placed circumferentially near the remaining facial and lingual vertical walls, overlapping at the proximal surfaces before applying the composite build-up. This technique creates a peripheral skeleton from the outset. The prepared cavity assumes a Class I configuration, promoting a smooth surface restoration without necessitating additional margins. Belli et al. [30] demonstrated that positioning fibers against the dentinal wall enhances fracture strength and reduces cusp movement. Additionally, this technique decreases the C-factor and increases microtensile bond strength. After one year of observation, no secondary caries, chipping, or failures were noted. Nevertheless, further long-term studies under both clinical and radiographic conditions are essential to validate this treatment approach.

Conclusion

The reconstruction of severely damaged teeth using fiber-reinforced composites with the Stress-Reduced Direct Composite (SRDC) protocol presents a viable alternative to indirect restorations in certain cases. This method has gained acceptance in specific clinical scenarios within minimally invasive dentistry due to its ability to preserve sound tooth structure while also reducing costs.

Conflict of Interest

No potential conflict of interest relevant to this article was reported

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No financial support was received from any organization or legal or natural person to conduct this study.

Authors' Contributions

Conceptualization, Investigation, Methodology and Writing Original: Sara Nabizadeh and Faezeh Aghajani

All authors declare that they contributed to critical review of intellectual content and approval of the final version to be published.

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