Fiber-reinforced stress reduced direct composites for endodontic treated tooth: a serial case report

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ABSTRACT

Introduction: Endodontically treated teeth (ETT) become more fragile due to the loss of tooth structural integrity as a result of caries, access preparation, decreased moisture content, and/or tooth fracture. These conditions influence the choice of restorative materials and techniques for ETT. Fiber-reinforced, stress-reduced direct composite (FR-SRDC) is a promising approach for restoring ETT because it preserves the remaining tooth structure and enhances fracture resistance. This case report evaluates the use of FR-SRDC in Class II cavities of ETT first maxillary molars with a six-month follow-up. **Case Report:** Case 1: A 35-year-old woman presented with a complaint of decay under an old filling placed two years ago in the left first maxillary molar, without pain on biting. Radiographic examination revealed a radiopaque filling on the mesio-occlusal surface and leakage marked by radiolucency between the restoration and the tooth structure extending toward the pulp. The diagnosis was pulp necrosis with asymptomatic apical periodontitis. The prognosis was good, considering the absence of pain and asymptomatic presentation. Case 2: A 29-year-old male complaining of decay in the left first maxillary molar and pain on biting for a week. The diagnosis was pulp necrosis with symptomatic apical periodontitis. The prognosis was fairly good, but required attention due to pain. Treatment for both cases consisted of root canal treatment (RCT) followed by restoration with FR-SRDC. The six-month follow-up showed good results for both cases, demonstrating the effectiveness and durability of fiber-reinforced, stress-reduced direct composite restorations. **Conclusion:** Fiber-reinforced, stress-reduced direct composites appear to be an effective restorative option for class II cavities in endodontically treated first maxillary molars, yielding favorable results over a six-month follow up period.

Keywords

Direct composite, endodontic treated tooth, fiber reinforced, fiber ribbond, endodontic treatment

Restorasi direk komposit dengan penguat fiber pada gigi pasca perawatan saluran akar: laporan kasus berserial

ABSTRAK

***Pendahuluan**: Gigi yang telah dirawat endodontik (ETT) menjadi lebih rapuh karena hilangnya integritas struktur gigi akibat karies, preparasi akses, berkurangnya kadar air, dan/atau fraktur gigi. Kondisi ini menentukan pilihan bahan dan teknik restorasi ETT. Komposit direk pengurangan stres yang diperkuat fiber (FR SRDC) adalah pendekatan yang baik untuk ETT karena akan mempertahankan struktur gigi yang tersisa dan meningkatkan ketahanan fraktur. Laporan kasus ini mengevaluasi penggunaan FR SRDC pada kavitas kelas II ETT molar pertama rahang atas dengan tindak lanjut 6 bulan. **Laporan Kasus**: Kasus 1: Wanita 35 tahun mengeluhkan kerusakan di bawah tambalan lama 2 tahun yang lalu pada molar pertama rahang atas kiri, tanpa rasa sakit saat menggigit. Pemeriksaan radiografi menunjukkan tambalan radiopak pada mesio-oklusal dan kebocoran tambalan yang ditandai dengan radiolusensi antara tambalan dan gigi hingga ke pulpa. Diagnosis: nekrosis pulpa, periodontitis apikal asimptomatik. Prognosis: Baik, mengingat tidak adanya rasa sakit dan kondisi asimptomatik. Kasus 2: Pria 29 tahun mengeluhkan kerusakan pada molar pertama rahang atas kiri dan rasa sakit saat menggigit selama seminggu. Diagnosis nekrosis pulpa, periodontitis apikal simptomatik. Prognosis cukup baik, namun memerlukan perhatian karena adanya rasa sakit. Indikasi perawatan untuk kedua kasus: Perawatan saluran akar (PSA) diikuti dengan FR SRDC. Tindak lanjut 6 bulan menunjukkan hasil yang baik untuk kedua kasus, mendemonstrasikan efektivitas komposit langsung pengurangan stres yang diperkuat serat. **Simpulan:** Komposit direk pengurangan stres yang diperkuat fiber dapat menjadi pilihan yang efektif pada kavitas kelas II gigi yang telah dirawat endodontik pada molar pertama rahang atas dengan hasil yang baik selama periode 6 bulan*

Kata kunci

restorasi direk komposit, perawatan saluran akar, penguat fiber, perawatan endodontik

INTRODUCTION

Endodontically treated teeth (ETT) have a structurally compromised condition due to caries, trauma, large restorations, access preparation, and subsequent restorative procedures, which collectively lead to the weakening of the tooth structure.[1,2] This structural compromise significantly increases the risk of fracture and failure in ETT, making their restoration a critical challenge in restorative dentistry.[3] The success of root canal treatment can be undermined by inappropriate coronal restoration, with studies showing that 59.4% of ETT failures are due to inadequate restorations, compared to only 8.6% from poor endodontic treatment quality.[4] This finding highlights the urgent need for effective, durable restorative solutions for ETT to ensure the long-term success of endodontic treatments.

Traditionally, ETT were restored with a post-and-core system followed by full-coverage crowns. However, this approach carries risks such as root perforation, excessive removal of sound tooth structure, and a higher likelihood of tooth fracture.[5,6] These drawbacks have led to a shift toward more conservative approaches aligned with with the principles of minimally invasive dentistry.[7] Modern adhesive dentistry has introduced alternative methods aimed at preserving the remaining tooth structure while providing adequate strength and protection to the compromised tooth.[8]

Fiber-reinforced composite (FRC) restorations have emerged as a promising option for restoring ETT. FRC materials can increase restoration durability, enhance stiffness, and provide better force distribution.[9,10] The use of short fiber-reinforced composite (SFRC) in particular may help compensate for dentin loss by mimicking dentin's stress absorbing capacity and limiting fracture risk.[11] In addition, incorporating polyethylene fiber ribbons using the "wallpapering" technique can decrease polymerization shrinkage stress and improve bond strength.[12,13]

Recent studies have shown that FRC restorations can significantly improve the fracture resistance of ETT compared to conventional composite restorations.[14,15] The combination of SFRC as a dentin replacement and nanohybrid composites for the enamel layer has demonstrated promising results in terms of load-bearing capacity and fracture patterns.[16] Moreover, the use of fiber-reinforced materials allows for more conservative cavity preparations, aligning with the concept of minimally invasive dentistry.[17] The potential benefits of this method include preservation of tooth structure, improved biomechanical performance, and enhanced long-term prognosis of restored teeth.[18]

The case combines FRC, SFRC, the wallpapering technique using Ribbond (polyethylene fiber), and stress-reducing protocols such as incremental layering, progressive or pulse curing. This case report demonstrates a conservative approach to restoring endodontically treated molars with class II cavities while avoiding full crowns or posts, which are traditionally used.

By exploring this innovative approach, we seek to contribute to the growing of evidence supporting conservative, adhesive techniques for restoring ETT. As the field of restorative dentistry continues to evolve, it is crucial to explore and validate new techniques that can offer optimal outcomes for patients while adhering to conservative principles. The purpose of this case report is to evaluate the use of fiber-reinforced direct composite restorations for ETT over a six-month follow-up period.

CASE REPORT

In the first case, a 35-year-old woman presented to Prof. Soedomo Dental Hospital, Yogyakarta, complaining of a cracked upper left first molar that had been filled two years ago. The patient reported no pain. Clinical examination revealed a visible crack in the previously restored tooth #26 (Figure 1A). Radiographic examination revealed a radiopaque

filling on the mesio-occlusal surface with evidence of leakage, indicated by radiolucency between the restoration and the tooth structure (Figure 1B). Based on the clinical and radiographic findings, a diagnosis of pulp necrosis with asymptomatic apical periodontitis was made. The prognosis was good, considering the absence of pain and asymptomatic condition.

In the second case, a 29-year-old male man presented with a complaint of a cavity in his upper left first molar and pain while chewing for approximately one week. Clinical examination confirmed the presence of a cavity in the mesio-occlusal area of tooth #26 (Figure 1C). Radiographic examination revealed a radiolucency in the mesial area indicating pulpal involvement (Figure 1D). Based on the clinical presentation and reported symptoms, a diagnosis of pulp necrosis with symptomatic apical periodontitis was established. The prognosis was fairly good, but required attention due to the presence of pain.

For both cases, the treatment plan consisted of root canal treatment (RCT) followed by restoration using composite resin reinforced with Ribbond fiber. The materials used included Gutta-Percha Protaper Gold (Dentsply), AH Plus epoxy resin sealer (Dentsply), Scotchbond Universal (3M), Ribbond THM (Ribbond Inc.), Ever-X (GC), glycerin gel, caries detector dye (Kuraray), flowable resin composite, and conventional resin composite. The armamentarium included Protaper Gold endodontic files (Dentsply), LED curing light (3M), sectional matrix system, rubber dam set, and spiral rubber discs (Diacomp Eve). Prior to initiating treatment, all patients provided informed consent. Local anesthesia was administered, followed by the application of a rubber dam isolator. Existing restorations and caries were removed using a round diamond bur, and endodontic access was established with an endo access bur (Dentsply).

Endodontic therapy was completed in a single visit. Following root canal preparation, the canal system was irrigated sequentially with 2.5% sodium hypochlorite (NaOCl), 17% ethylenediaminetetraacetic acid (EDTA), and 2% chlorhexidine digluconate, with ultrasonic activation. Normal saline was used as an intermediate irrigant. The canals were then dried using paper points (Figure 2A, 3A). A gutta-percha trial cone (size F2) was fitted, sterilized in NaOCl, and rinsed with 70% ethanol. Obturation was performed using the single-cone technique with AH Plus sealer (Dentsply) (Figures 2B, 3B). After obturation, residual sealer was removed from the cavity, and a temporary restoration was placed.

At the two-week follow-up after obturation, clinical examination was conducted. The patient reported no symptoms, and the restorations remained intact. Clinical findings included negative percussion and palpation tests, with tooth mobility assessed as grade 0. A fiber-reinforced direct composite restoration was planned for this appointment. Rubber dam isolation was maintained to ensure a sterile field. The temporary restoration was removed using a diamond bur and ultrasonic scaler. Caries excavation was performed with diamond and tungsten carbide burs, and completeness was verified with a caries detector dye (Kuraray).

Cavity disinfection was achieved with 2% chlorhexidine digluconate solution (Cavity Cleanser, Bisco) for 60 seconds. Chlorhexidine digluconate 2% was chosen for its cleansing and moistening/re-wetting effect on dentin, which enhances bond strength when applied before adhesive procedures. Selective etching of the enamel surface was performed with 37% phosphoric acid, followed by water rinsing and gentle air drying. Dentin moisture was controlled using cotton pellets. A universal bonding agent (Scotchbond Universal, 3M) was applied using a rubbing motion for 20 seconds, followed by gentle air-thinning for five seconds. Initial polymerization was carried out with an LED curing light (800 mW/cm2) for ten seconds from the occlusal direction. The bonding procedure was repeated once, and a five-minute waiting period was observed to allow for optimal bond maturation (Decoupling with Time technique)[19]. Bulk-fill composite resin was then applied in increments not exceeding 1.5 mm thickness.

A 0.5-mm layer of flowable low-shrinkage composite resin was applied on the dentin surface as a resin coating and polymerized for 20 seconds using the LED curing light (800 mW/cm2) in progressive mode to protect the hybrid layer. The cavity's base and

circumference were measured using a probe. Leno-weaved ultra-high molecular weight polyethylene (LWUHMWPE) ribbon fiber (Ribbond THM, Ribbond Inc) was cut to 3 mm width and 5 mm length for the cavity base, and 3 mm width and 12 mm length for the cavity walls. The fiber ribbon was wetted with composite wetting resin.

Fiber-reinforced composite (Ever-X, GC) was applied to the cavity base, followed by adaptation of the fiber ribbon until a homogeneous and tight surface adaptation was achieved (Figure 2C). This process was repeated around the cavity walls, applying Ever-X and fiber tape (fiber wallpapering) (Figures 2D and 3C). Polymerization was performed for 20 seconds using the LED curing light (800 mW/cm2) in progressive mode from the occlusal, buccal, and lingual directions. Ever-X was used as dentin replacement material, applied in horizontal layers 1-1.5 mm thick, and polymerized for 20 seconds.

A space of 1-1.5 mm was reserved for the enamel composite layer. To minimize polymerization shrinkage stress, the enamel was layered cusp by cusp and polymerized for 20 seconds in pulse mode with the LED curing light (800 mW/cm2) (Figures 2E and 3D). Glycerin gel was applied to the tooth surface, followed by final irradiation using a 1200 mW/cm2 LED curing light for 20 seconds on occlusal, buccal, and lingual surfaces. Occlusal adjustment was carried out with a finishing bur, and polishing was performed using spiral rubber discs (Diacomp Eve) (Figure 2F). The fiber-reinforced direct composite technique produced favorable outcomes for both cases at the six-month follow-up (Figures 4B and 4C).

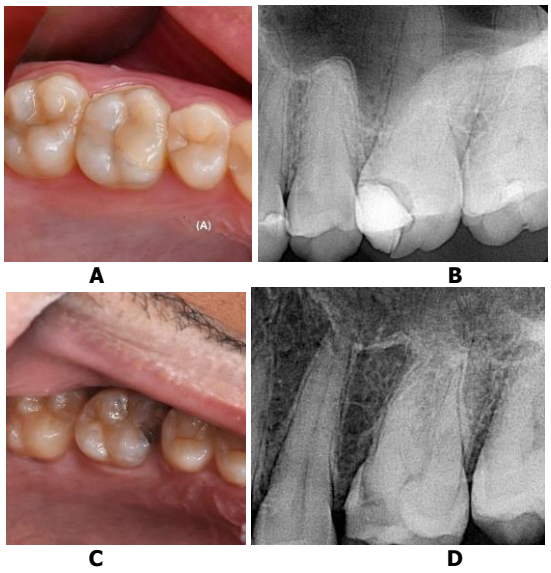
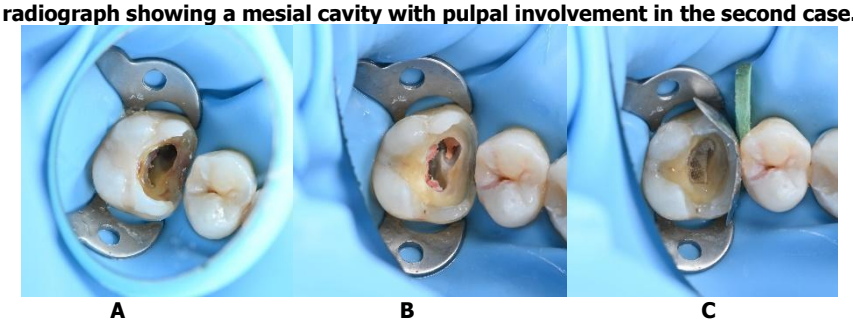
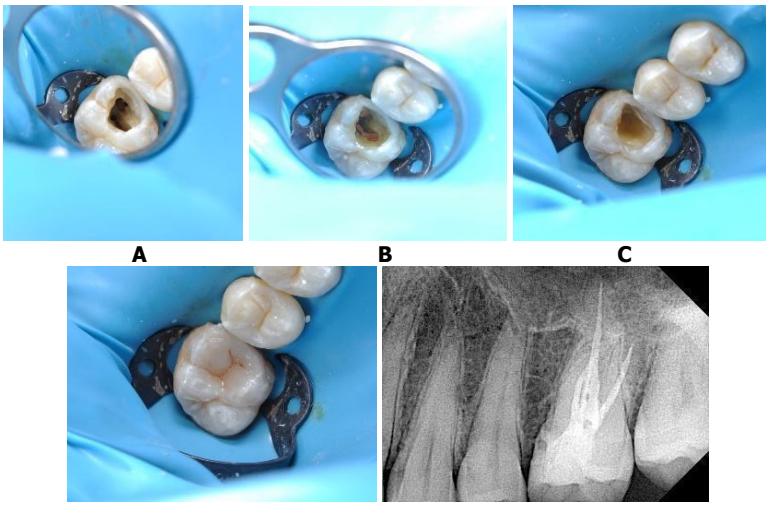


Figure 1. A. Preoperative clinical picture showing a "cracked" restoration in the first case; B. Preoperative radiograph showing restoration leakage in the first case; C. Preoperative clinical view showing a mesio-occlusal carious cavity in the second case; D. Preoperative radiograph showing a mesial cavity with pulpal involvement in the second case.



D E F G

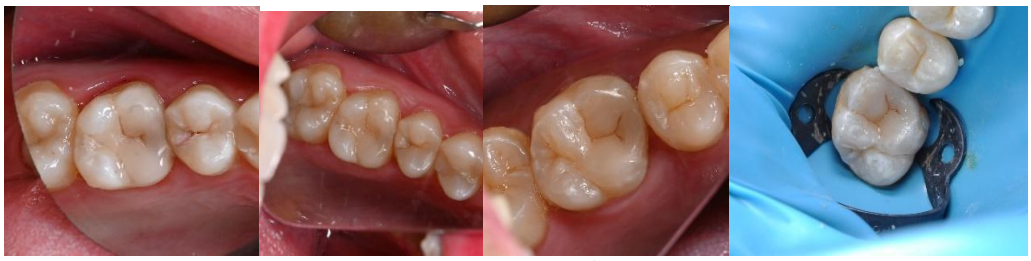
Figure 2. First case: A. Clinical view after cleaning and shaping; B. Clinical view after obturation; C. Application of Ribbond fiber on the cavity floor (fiber carpeting); D. Application of Ribbond fiber (fiber wallpapering) and Ever X posterior; E. Clinical view after composite layering; F. Clinical view after finishing and polishing; G. Postoperative Radiograph



A B C

D E

Figure 3. Second case: A. Clinical view after cleaning and shaping; B. Clinical view after obturation; C. Application of Ribbond fiber (fiber wallpapering) and Ever X posterior; D. Clinical view after composite layering; E. Postoperative radiograph



A B C D

Figure 4. A. First case after restoration; B. Six-month follow up tooth #26 (first case); C. Second case after restoration; D. Six-month follow up tooth #26 (second case).

DISCUSSION

The fiber-reinforced, stress-reduced direct composite (FR-SRDC) technique utilized in these case reports demonstrated promising results for restoring endodontically treated teeth (ETT). At the six-month follow-up, both cases exhibited favorable clinical outcomes, with acceptable anatomic form, marginal adaptation, color match, and absence of secondary caries or restoration fracture. These findings align with recent meta-analyses suggesting no significant difference between direct and indirect restorations for ETT in the short term (2.5-3 years).[20]

The success of this technique in both cases can be attributed to several key factors. Firstly, the use of the "wallpapering" technique with Leno-weaved ultra-high molecular weight polyethylene (LWUHMWPE) ribbon fiber helped decrease polymerization shrinkage stress and improve bond strength, as supported by in vitro studies. Ultra-high molecular weight polyethylene (UHMWPE) has been extensively studied in materials science, particularly in addressing polymerization shrinkage and enhancing bond strength. The molecular architecture of low-weight UHMWPE (LWUHMWPE) plays a crucial role in mitigating dimensional changes during polymerization. The unique molecular structure of LWUHMWPE enables a more controlled polymerization process, significantly reducing volumetric shrinkage compared with conventional polymer systems.[21,22]

Previous research demonstrated that the low-molecular-weight variant of UHMWPE exhibits remarkable characteristics in minimizing interfacial stress and polymerization contraction.[23] The modified polymer chains create a more uniform distribution of internal stresses, which is critical in applications requiring precise dimensional stability. This phenomenon is particularly important in dental composites and advanced adhesive systems, where minimal shrinkage can dramatically improve material performance and longevity.

The bond strength enhancement mechanism of LWUHMWPE is attributed to its unique molecular configuration, as shown in comprehensive studies on polymer adhesion properties.[24] The lower molecular weight allows improved surface wetting and interfacial interaction, creating more robust bonding interfaces. This property is especially significant in applications requiring high-performance adhesive systems and precision restorative materials. Biomaterials research further elucidated the molecular mechanisms behind LWUHMWPE's superior performance.[25] The reduced polymerization shrinkage is primarily due to the polymer's ability to maintain molecular stability during the curing process, minimizing internal stress concentrations and preventing microcracking. This results in improved mechanical integrity and more consistent material properties across various application domains in both cases, where substantial tooth structure loss was present.

Second, the application of short fiber-reinforced composite (SFRC) for dentin replacement has shown significant improvements in load-bearing capacity, flexural strength, and fracture resistance compared with conventional particulate filler composites.[26] These results are consistent with findings from Mangoush et al.,[27] who reported that the SFRC acts as a crack-stopping layer, providing superior load-bearing capacity and favorable fracture patterns.[27] The stress-reducing protocol used in these cases, including small incremental layering and progressive or pulse polymerization, also contributed to restoration success. This approach reduces the configuration factor (C-factor) at a micro level, decreasing polymerization shrinkage stress and improving the quality of the polymer network.[28,29] The combination of these techniques aligns with the principles of minimally invasive dentistry, preserving remaining tooth structure while providing adequate strength and protection to compromised ETT.[30]

Patient satisfaction was high in both cases, with no reported pain or discomfort at the six-month follow-up. Both patients remained symptom-free during normal function and expressed satisfaction with the conservative treatment and aesthetic results. However, longer-term follow-up is required to evaluate the restorations' longevity and compare them with traditional full-coverage restorations. Klener et al.[31] and the present case reports both demonstrate promising results using direct composite restoration; however, the success of direct composite restorations in ETT can be influenced by factors such as remaining tooth structure, occlusal load, and patient-specific risk variables.[31] Further long-term clinical studies are needed to confirm the superiority of this protocol over traditional restorative strategies for ETT.

The fiber-reinforced, stress reduced direct composite protocol demonstrated favorable outcomes for restoring endodontically treated teeth (ETT) in these cases. At six months, both restorations exhibited clinically satisfactory results, preserving remaining tooth structure while providing sufficient strength and protection. The main findings suggest that this

technique offers a viable, conservative approach for restoring ETT, potentially reducing the need for more invasive procedures such as full-coverage crowns. The combination of the "wallpapering" technique, short fiber-reinforced composite, and stress-reducing polymerization protocols contributes to restoration success by improving fracture resistance and reducing polymerization shrinkage stress.

For colleagues considering this approach, we recommend careful case selection (taking into account remaining tooth structure and occlusal forces), strict adherence to the protocol (including proper fiber placement and incremental composite application), and regular follow-up to monitor the long-term performance of restorations. While these results are promising, long-term clinical studies with larger sample sizes are needed to validate the efficacy of this technique compared with traditional restorative strategies for ETT. Additionally, further research into the biomechanical behavior of FR-SRDC in ETT could provide valuable insights for optimizing this approach.

The main limitation of this case report is the short follow-up period of only six months, which may not fully capture the long-term performance, durability, or potential complications of fiber-reinforced, stress-reduced direct composites. Moreover, as a case report, it lacks the statistical power and generalizability of larger clinical studies, emphasizing the need for further controlled research with longer observation periods.

CONCLUSION

The FR-SRDC technique presents a promising, conservative option for restoring ETT, consistent with the principles of minimally invasive dentistry. However, practitioners should remain vigilant in case selection and long-term monitoring to ensure optimal clinical outcomes. The implication of this study is that conservative, fiber-reinforced direct composite techniques can serve as effective and less invasive alternatives to full-coverage crowns in structurally compromised ETT. This supports the principles of minimally invasive dentistry and encourages further research into their long-term clinical success.

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Ethical Approval: Ethical review and approval were waived for this study due to the following reasons. Firstly, the case report describes care that was provided in accordance with the prevailing standards of clinical practice, with no deviations from normal treatment protocols that would necessitate special ethical considerations. Secondly, the case report does not involve experimental interventions or additional invasive procedures, thus minimizing the risk to the patient. Given these factors, the risk to the patient is considered minimal or nonexistent.

Institutional Review Board Statement: This research is conducted according to the declaration of Helsinki.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study. Written informed consent has been obtained from the patient(s) to publish this paper.

Data Availability Statement: The data that support the findings of this researchare available from the corresponding author, upon reasonable request..

Conflicts of Interest: The authors declare no conflict of interest.

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