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FRACTURE RESISTANCE OF ENDODONTICALLY TREATED TEETH RESTORED WITH DIFFERENT COMPOSITE RESINS: THE EFFECT OF FIBER REINFORCEMENT

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ABSTRACT

Background: This study evaluated the fracture resistance and fracture modes of endodontically treated maxillary premolars restored with different composite resins, focusing on the effect of fiber reinforcement.Stunting is defined as short stature for the age group, with a Z score less than −2 SD (standard deviation).

Materials and Methods: Sixty extracted maxillary first premolars were divided into six groups (n=10): intact control, conventional nanohybrid, bulk-fill (SDR), short-fiber-reinforced (EverX Posterior and EverX Flow), and Ribbond fiber. After standardized endodontic treatment and MOD cavity preparation, restorations were placed per the manufacturer's instructions. Specimens were loaded to fracture under compressive force using a universal testing machine. Data were analyzed by one-way ANOVA and Fisher's LSD test ($p<0.05$), and fracture modes were examined under magnification.

Results: Significant differences were found among groups ($p < 0.0001$). Intact teeth showed the highest fracture resistance (1047 ± 170 N). Among restorative materials, EverX Posterior achieved the greatest strength (624 ± 138 N), followed by EverX Flow (550 ± 80 N), Ribbond (548 ± 94 N), SDR (491 ± 119 N), and conventional composite (401 ± 76 N). EverX Posterior outperformed SDR ($p = 0.014$) and conventional composite ($p = 0.001$). Restorable fractures occurred mainly in intact teeth (80%) and EverX Flow (40%), with minimal repairable outcomes in other groups.

Conclusion: Fiber-reinforced composites notably improved fracture resistance compared with bulk-fill and conventional composites. EverX Posterior exhibited the highest reinforcement capability, whereas conventional composites showed the weakest performance. However, fiber reinforcement did not always yield more favorable (restorable) fracture patterns.

Keywords: *Neutrophil elasatase, polycystic ovarian syndrome, periodontit*

INTRODUCTION

Endodontically treated teeth (ETT) are structurally weakened and more prone to fracture due to hard tissue loss, canal instrumentation, and restorative interventions. Premolars with mesio-occluso-distal (MOD) cavities are particularly vulnerable due to their anatomy and functional load.

Clinical studies report that 11%–13% of teeth extracted after endodontic treatment exhibit cracks or fractures, highlighting the need for effective post-treatment restorations[1]. Inadequate coronal sealing and the use of certain irrigants may compromise dentin integrity, promoting collagen degradation, brittleness, and fatigue-induced cracking[2]. The number of remaining marginal ridges significantly influences post-treatment fracture resistance. Plotino et al. reported that losing one ridge reduces tooth stiffness by 46%, and loss of both leads to a 63% reduction[3]. Fracture risk is further affected by cavity design, preparation depth, and remaining wall structure[4].

Conventional composite resins (CCRs) are widely used for restoring posterior teeth due to their aesthetic and mechanical properties[5]. However, when applied to large posterior cavities, CCRs are limited by polymerization shrinkage and relatively low fracture toughness, contributing to marginal failure or restoration debonding[6]. To address these concerns, bulk-fill composites were introduced. Designed for placement in 4 mm increments, they simplify the clinical workflow and improve curing depth due to advancements in filler technology and photoinitiator systems[7,8].

Fiber-reinforced composites represent an innovative approach to restoring structurally compromised teeth by reinforcing the restoration and mimicking dentin's biomechanical behavior. EverX Posterior and EverX

Flow, composed of short E-glass fibers within a resin matrix, are designed to improve fracture resistance and inhibit crack propagation, providing a promising restorative option for endodontically treated teeth[9,10,11,12].

Additionally, Ribbond (A high-strength polyethylene fiber ribbon) is employed in restorative dentistry for its excellent stress distribution and reinforcement properties. Plasma treatment enhances its adhesion to resin-based materials, and its integration into restorations may further reduce crack propagation and enhance fracture resistance[13].

Given the diversity of restorative approaches available and the critical role of fracture resistance in the long-term success of endodontically treated premolars, comparative clinical and in vitro studies are essential. This research aims to evaluate the fracture resistance and fracture modes of ETT premolars restored with different restorative materials: conventional composite, bulk-fill composite, short fiber-reinforced composite, and Ribbond (polyethylene fiber).

MATERIALS AND METHODS

This in-vitro study used 60 human maxillary first premolars selected from 130 orthodontic extractions (18–25 years)[14]. Periapical radiographs were obtained to exclude teeth with caries or internal/external resorption, ensuring only sound specimens are used[15]. Teeth were debrided and screened under a stereomicroscope (40×) to eliminate cracks, restorations, or fractures[16]. Only double-rooted premolars with standardized dimensions were included (MD 8 ± 0.5 mm, BL 9 ± 0.5 mm), measured with a digital caliper[17]. All specimens were stored in 0.1% thymol to prevent dehydration and microbial growth, preserving dentin's mechanical integrity and moisture[18,19].

An occlusal index was made for each tooth using a light-cured gingival barrier applied with a microbrush to standardize mounting[20]. To simulate the periodontal ligament, roots were coated in melted wax, leaving 2 mm apical to the CEJ exposed to create a 0.5 mm spacer. Teeth were embedded in self-curing acrylic within a plastic mold (16 mm × 20 mm) with the long axis perpendicular to the base. After polymerization, the wax was removed in boiling water, and the space was filled with light-body PVS before re-inserting the teeth into the mold[21]. After that, the specimens were randomly assigned to the designated experimental groups using a simple randomization method[16].

Ten specimens were left untreated as positive controls (Group I); the remaining 50 received standardized endodontic treatment. Access opening was prepared with a round diamond (Jota 801 FG 018), followed by a tapered cylindrical bur for de-roofing. Patency was established with a #10 K-file (FKG), and the working length was determined and confirmed by periapical radiographs[22]. For cleaning and shaping, ProTaper NEXT files up to X2 (#25) were used with 2 mL of 5.25% NaOCl between instruments[23]. The irrigation protocol comprised 5.25% sodium hypochlorite for 15 minutes, followed by 5 mL of 17% EDTA for 1 minute, a final 5ml of NaOCl rinse, and then a 5 mL distilled-water flush to eliminate residual chemicals[24]. Canals were dried with paper points and obturated using a single-cone gutta-percha matched to the master apical file in combination with an epoxy resin–based sealer (AH Plus, Dentsply); excess gutta-percha was removed 1 mm below the CEJ with a heated plugger, and the obturation was confirmed radiographically. Access cavities were cleaned with alcohol and sealed using a temporary eugenol-free material. All specimens were then stored in an incubator at 37 °C and 100% humidity for 7 days to ensure complete sealer setting [23].

After removing the temporary restoration, canal orifices were sealed with a self-etch universal adhesive (G-Premio Bond, GC) and light-cured for 20s using an LED unit (DENTMATE - Dental curing light LEDEX™ WL-090+) (Ramp mode), then covered with an injectable flowable composite (Essentia HiFlo, GC) and cured for 20s[23]. Standardized Class II MOD cavities were outlined in pencil and prepared with cylindrical diamond burs under water cooling, replacing the bur after every fourth preparation. Walls were kept parallel to the long axis; dimensions were standardized to 3 mm buccolingual width and 6 mm occluso-cervical depth using the cusp tip as reference, with no proximal steps. Cavosurface margins at 90° and rounded internal line angles were maintained, and final dimensions were verified with a digital caliper (Figure 1)[21,25].

The 50 treated specimens were restored using a disposable matrix band (Pro-Matrix) with low-fusing compound support for optimal adaptation[16]. A selective-etch protocol was used: 37% phosphoric acid on enamel for 30s, rinse for 20s, gentle air-dry; then G-Premio Bond was applied in two layers with 20s active rubbing, 5s mild air-dry, and 20s light-cure[14]. A 0.5 mm flowable composite liner was placed on the cavity floor and cured for 20s[26]. Interproximal walls were rebuilt with conventional composite (G-aenial Posterior, GC) (1.5 mm) measured by digital caliper and cured for 20s, after which the samples were restored using different studied materials according to the following groups[20].

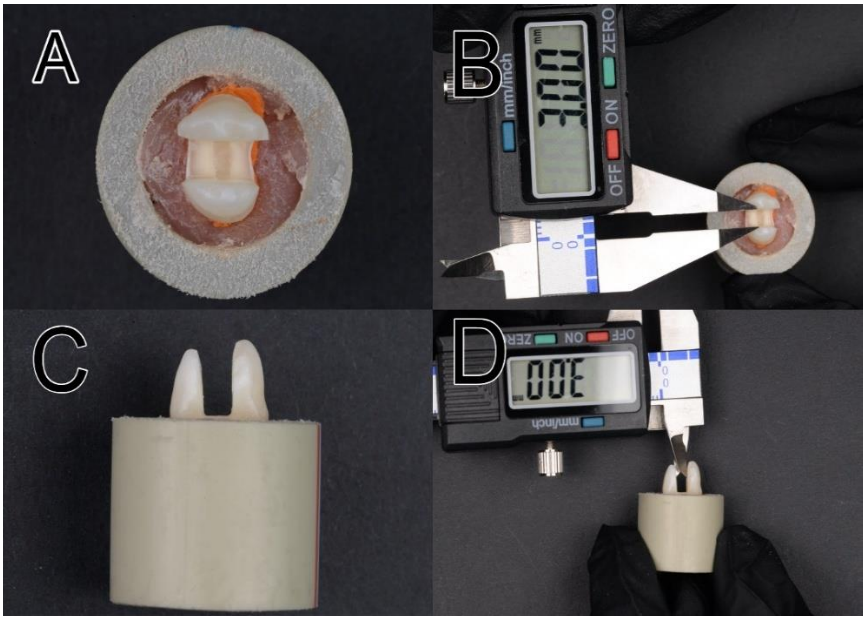

Figure 1. MOD cavity preparation: A.cavity preparation (occlusal view), B.bucco-lingual cavity width measured with digital caliper(occlusal view), C. cavity preparation (side view), D.bucco-lingual cavity width measured with digital caliper(side view).

Group II

In Group II, the cavities were restored with a posterior conventional composite (G-aenial Posterior, GC) using the oblique incremental technique with increments not exceeding 2 mm in thickness. The final occlusal layer of 1.5 mm thickness was shaped with the aid of an individual occlusal index, which was pressed against the uncured resin with a thin Teflon sheet interposed to prevent adhesion. After removal of the Teflon, the restoration reproduced the original tooth anatomy. Each increment was light-cured for 20 seconds[20].

Group III

In Group III, the cavities were restored using a bulk-fill flowable composite (SDR, Dentsply) placed in a single increment up to 4 mm in thickness and cured for 20 seconds (Figure 2). The remaining cavity volume was filled with posterior conventional composite resin, shaped with the aid of the occlusal index, as described in the previous group[27].

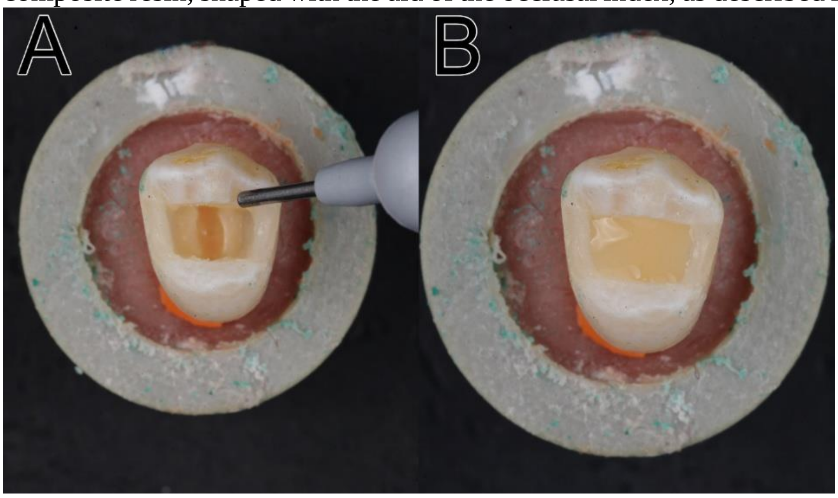

Figure 2. SDR Bulk-fill composite: A. placement of SDR in the cavity, B. polymerized SDR layer.

Group IV

In Group IV, a 4-mm layer of fiber-reinforced composite (EverX Posterior, GC Corp) was placed in the cavity, leaving sufficient space for the overlying composite. This layer was light-cured for 20 seconds. The remaining cavity volume was restored following the same procedure described in the previous groups[27].

Group V

In Group V, a 4-mm layer of fiber-reinforced composite (EverX Flow, GC Corp) was placed in the cavity, leaving adequate space for the overlying composite. This layer was light-cured for 20 seconds. The remaining cavity volume was restored following the same procedure described in the previous groups[27].

Group VI

In group VI, (Ribbond), A polyethylene fiber strip (3 mm × 10 mm) was cut and pre-wetted with Clearfil SE Bond 2 (SE2; Kuraray Noritake Dental, Tokyo, Japan) and left uncured. A thin flowable composite layer was placed, and the fiber was embedded in a U-shape from vestibular to palatal walls, leaving 1.5 mm occlusal space (Figure 3). The fiber–composite complex was light-cured for 30s, and the cavity was completed with conventional composite as in previous groups[20].

All restorations were finished using a fine-grit diamond finishing burs mounted on a high-speed handpiece with continuous air–water cooling. Polishing was subsequently performed with polishing discs (Tor VM) followed by an Eve Twist polisher[27].

Specimens were tested in a universal testing machine (TERCO MT-3037, Sweden). A 6-mm spherical steel indenter was centered on the occlusal surface so its long axis contacted both facial and lingual cusp inclines. Compressive loading at 1 mm/min continued until failure occurred; the maximum load (N) was recorded. Mean fracture resistance was computed for each group, and failure modes were classified visually and under magnification[28].

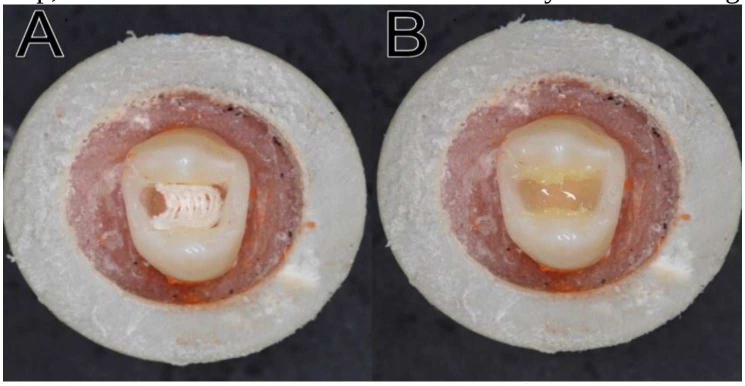

Figure 3. Ribbond: A. unwetted U-shape polyethylene fiber in the cavity, B. placement of wetted U-shape polyethylene fiber in the cavity.

RESULTS

The mean fracture resistance (±SD) values for all experimental groups are summarized in Table 1. For all statistical tests, the level of significance was set at $p < 0.05$.

Table 1. Fracture resistance (N) of all the study groups.

Material	Mean (SD)	p
Positive	**1047 (169.8)**	**<.001**
Ever x posterior	**624 (137.9)**	
Ever x flow	**550 (80.4)**	
Ribbond	**548 (94)**	
SDR	**491 (119.3)**	
Conventional	**401 (76.1)**	
One-way ANOVA, significance; P<0.05		

The descriptive statistics revealed distinct variations in the fracture resistance among the different groups. As expected, the positive control group (intact teeth) demonstrated the highest resistance to fracture, with a mean value of 1047.0 ± 169.8 N.

Among the restored groups, notable differences were observed. The EverX Posterior group recorded the highest mean fracture resistance (624.0 ± 137.9 N), outperforming all other restorative materials. Followed by the EverX Flow group and the Ribbond group, which demonstrated approximate mean values (550.0 ± 80.4 N and 548.0 ± 94.0 N, respectively). The SDR bulk-fill composite group achieved a mean fracture resistance of 491.0 ± 119.3 N, ranking slightly below the fiber-reinforced groups but still substantially higher than the conventional composite. Finally, the conventional composite group recorded the lowest resistance among the restored teeth, with a mean of 401.0 ± 76.1 N.

Taken together, these descriptive results establish a clear hierarchy in performance: intact teeth remain the strongest, followed by fiber-reinforced composites (EverX Posterior, EverX Flow, and Ribbond), then bulk-fill SDR, and finally conventional composite as the least resistant.

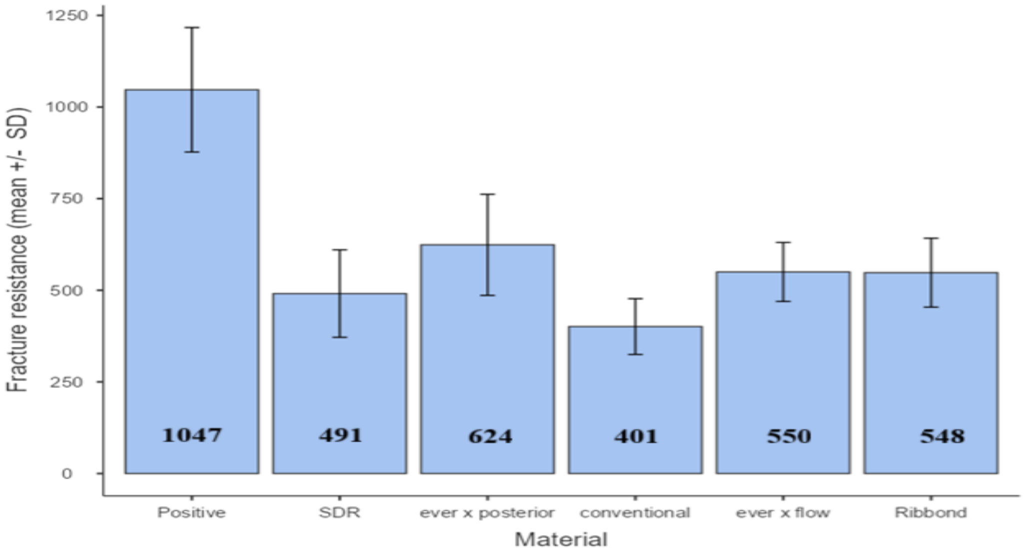

Figure 4. The overall fracture resistance across all six study groups.

The distribution of fracture resistance across the study groups is also illustrated in Figure 4, which clearly shows the superior performance of the intact control group compared with all restored groups, as well as the higher resistance values recorded for EverX Posterior, EverX Flow, and Ribbond compared with SDR and conventional composite.

One-way ANOVA revealed a statistically significant difference in fracture resistance among all groups ($p < 0.0001$). Therefore, Tukey LSD post-hoc analysis was performed to identify specific intergroup differences.

The LSD test was conducted to evaluate pairwise comparisons among the different restorative materials used in the study (Table 2). The positive control group (intact teeth) showed statistically significant differences ($p < 0.001$) when compared to all other groups, including EverX Posterior, EverX Flow, Ribbond, SDR, and Conventional composite.

Table 2. Fisher's Least Significant Difference (LSD) post hoc comparisons among study groups.

Material	Material	p
Positive	Ever X posterior	<.001
	Ever X flow	<.001
	Ribbond	<.001
	SDR	<.001
	Conventional	<.001
Ever X posterior	Ever X flow	0.166
	Ribbond	0.155
	SDR	0.014
	conventional	0.001
Ever x flow	Ribbond	0.97
	SDR	0.267
	Conventional	0.007
Ribbond	SDR	0.284
	Conventional	0.007
SDR	conventional	0.093

Note. Comparisons are based on estimated marginal means

When comparing EverX Posterior to other groups, statistically significant differences were found with SDR ($p = 0.014$) and the Conventional group ($p = 0.001$), while the differences with EverX Flow ($p = 0.166$) and Ribbond ($p = 0.155$) were not significant. EverX Flow showed no significant differences when compared to Ribbond ($p = 0.970$) or SDR ($p = 0.267$). However, the difference between EverX Flow and the Conventional group was statistically significant ($p = 0.007$). Regarding Ribbond, no statistically significant differences were found when compared to SDR ($p = 0.284$), but a significant difference was observed with the Conventional group ($p = 0.007$). Finally, the comparison between SDR and the Conventional group revealed no statistically significant difference ($p = 0.093$).

Table 3. Chi-Squared Test

Material	Fracture Type (%)		p
	Restorable	Un-restorable	
Positive	**8 (80)**	**2 (20)**	**< 0.00001**
EverX Posterior	**1 (10)**	**9 (90)**	
SDR	**0 (0)**	**10 (100)**	
EverX Flow	**4 (40)**	**6 (60)**	
Ribbond	**0 (0)**	**10 (100)**	
Conventional	**1 (10)**	**9 (90)**	
Total	**14 (20)**	**46 (80)**	

Note: Significance p < 0.05 ; Chi score (27.51)

DISCUSSION

The coronal restoration of ETT serves to prevent microbial leakage, restore function and form, protect remaining structure from fracture, preserve periodontal integrity, and provide satisfactory esthetics[29]. In this study, fracture resistance was tested using different materials (everX posterior, everX flow, Ribbond, SDR, and conventional composite) and compared to the sound intact teeth. standardized MOD cavities were prepared after endodontic therapy to simulate a clinically weakened condition and evaluate restorative performance in a worst-case scenario. The intact-tooth control group showed the highest fracture resistance owing to the presence of the pulp-chamber roof and marginal ridges, which maintain cuspal continuity and reinforce the tooth[30]. The arched roof configuration effectively resists occlusal pressure[31], and the dentino-enamel junction functions as a crack-arresting interface that reduces stress concentration between enamel and dentin[32]. Furthermore, the control teeth were not subjected to endodontic procedures, which are increasingly recognized to degrade dentin's mechanical integrity by altering its organic matrix and reducing its toughness and elasticity[33,34].

Unlike restored specimens, intact teeth are free from adhesive interfaces or polymerization shrinkage stresses that can weaken the tooth-restoration complex and act as potential crack initiation sites[35,36]. For the same biomechanical reasons discussed above, the positive control group also exhibited a more favorable fracture pattern, with 80% restorable and only 20% non-restorable fractures. The continuous enamel–dentin complex and intact marginal ridges directed stresses coronally, limiting crack propagation into the root dentin[37].In the present study, EverX Posterior exhibited a mean fracture resistance of 624 ± 137.86 N, representing the highest value among all restorative groups. Short-fiber-reinforced composites (SFRCs) such as EverX Posterior substantially enhance the strength of structurally compromised teeth. Kamath et al. (2023) reported that EverX Posterior exhibited significantly higher fracture resistance than the bulk-fill composite SDR[38]. This can be attributed to its E-glass fibers, which transfer stresses from the resin matrix to the fibers acting as crack stoppers[39]. The material's fracture toughness (2.9 MPa $m^{1/2}$), flexural strength (124 MPa), and modulus (9.5 GPa) surpass those of conventional composites[40]. The 3 mm fibers dispersed within the bisphenol A glycol dimethacrylate matrix further contribute to improved load distribution[39]. The EverX Posterior group exhibited mainly unfavorable, non-restorable fractures (1 / 10 restorable). This finding corresponds with reports that high stiffness and dense fiber packing concentrate stress at the tooth–restoration interface[41.12]. The rigidity of the EverX Posterior core strengthens the restoration but promotes deep crack propagation through dentin rather than deflection within the composite[41].

EverX Flow, a flowable SFRC, achieved a mean resistance of about 550 ± 80 N—higher than conventional and SDR groups but slightly lower than EverX Posterior. Its short, randomly oriented E-glass fibers dispersed in a Bis-GMA matrix improve crack deflection and stress redistribution[23].The flowable consistency promotes superior adaptation to the cavity floor and homogenous fiber dispersion, enhancing internal stress transfer and load-bearing capacity[42]. EverX Flow's fiber-reinforced core is mechanically more compliant and energy-absorbing than the denser, stiffer EverX Posterior core, which helps explain the greater incidence of repairable fractures (40%) for the EverX Flow. In particular, EverX Flow incorporates very fine E-glass microfibers (≈6 µm diameter, 200–300 µm length at ~25 wt%) in a Bis-GMA matrix[11]. This "high aspect-ratio" fiber network yields a balanced elastic modulus (≈9 GPa) with high fracture toughness (≈2.8 MPa·m^½)[12]. Under load, the abundant, randomly-oriented fibers in EverX Flow promote crack deflection, fiber-pullout, and bridging, dissipating stress within the composite and preventing cracks from penetrating deeply into the tooth[43]. As a result, cracks tend to branch and arrest coronally, producing shorter cuspal fractures that remain restorable[26]. The present results align with Magne et al. (2023), who reported that EverX Flow exhibited high load-to-fracture values (≈1450–1500 N) and more repairable partial failures compared with EverX Posterior. Similarly, Garoushi et al. (2021) demonstrated that the incorporation of a flowable short-fiber-reinforced composite base beneath restorative materials improved both the fracture resistance and the incidence of restorable fractures in large posterior restorations[12,44].

Ribbond polyethylene-fiber reinforcement (mean = 548 ± 94 N) produced results comparable to EverX Flow and significantly higher than SDR and conventional composites, indicating a beneficial reinforcing effect[29]. High-tensile polyethylene fibers absorb and redistribute occlusal forces and act as crack bridges[39,40]. The adhesive coupling between Ribbond and the resin matrix allows stress transfer from the brittle composite to the ductile fibers, increasing energy absorption[30]. The present results align with Mavidi et al. (2025), who reported fracture loads of approximately 854 N for Ribbond, comparable to short-fiber composites and near the strength of intact teeth[29].The Ribbond group produced exclusively non-restorable fractures (0 / 10). Despite its U-shaped placement connecting buccal and palatal walls, the fibers did not prevent catastrophic root-level failures. Although this configuration provides horizontal reinforcement, it does not effectively control vertical stress transmission during compressive loading [29,39]. Polyethylene fibers mainly resist tensile stresses and may concentrate stress at the cavity base, directing occlusal forces apically[40]. Functioning as a two-dimensional reinforcement, Ribbond limits cusp flexure but lacks the capacity to absorb axial loads, resulting in deep subgingival fractures consistent with previous research[29]. Unlike the U-shaped splint used in our study, bucco-lingual occlusal splinting and circumferential 'wallpapering' of cavity walls have been associated with higher proportions of restorable fractures in MOD premolars restored with polyethylene fibers[45].

The SDR bulk-fill composite group (mean = 491 ± 119 N) demonstrated moderate reinforcement but remained inferior to fiber-reinforced materials. SDR's polymerization-modulator technology improves adaptation and reduces polymerization shrinkage stress[46]; however, its homogeneous particle-filled matrix lacks reinforcing fibers capable of arresting or redirecting crack propagation, which explains its lower fracture resistance compared with SFRCs and Ribbond[39,47]. Although SDR provides excellent flow and adaptation, the absence of a fiber network limits its ability to dissipate occlusal stresses effectively. In accordance with this mechanical behavior, the SDR group showed non-restorable fractures (0 / 10), indicating an inability to dissipate or arrest crack propagation. The lower modulus of elasticity for SDR may accommodate more cusp deflection and focus vertical stresses resulting in deep subgingival fracture[47]. While the polymerization-modulator system minimizes polymerization stress, it does not mitigate functional compressive stress during loading[46]. Similar findings were reported by Ibrahim and Al-Azzawi (2017), who also observed non-restorable fractures in SDR restorations[48], and by other studies confirming that, although SDR enhances marginal integrity, it fails to resist vertical load transmission efficiently [49].

The nanohybrid composite restorative group had the minimum mean wear resistance of all restoration groups (401 ± 76 N). Such result is indicative of the brittle characteristics and low fracture toughness of particle filled composites without fiber reinforcement[9,50]. Under occlusal stress, cracks tend to initiate at internal line angles or along the dentin–restoration interface and propagate rapidly through the structure, resulting in cusp separation and catastrophic failure[51]. similarly, fracture mode analysis revealed that only 1 out of 10 specimens (10%) presented a restorable fracture, while 90% fractured below the CEJ, indicating a predominantly non-restorable pattern. This unfavorable behavior comes from the non-reinforced microstructure of traditional composites, where microcracks formed at stress concentration sites (particularly internal angles or adhesive interfaces) and extended apically into the root dentin[39,50,51]. Consistent with Monga et al. (2009) and Garoushi et al. (2018), conventional composites demonstrated abrupt, non-restorable fractures with minimal plastic deformation and limited capacity for energy absorption[30,40].

Limitations and Future Research

The present *in-vitro* study has inherent limitations that restrict the direct application of its findings to clinical conditions. The specimens were only tested under static loading without other adverse intraoral conditions such as cyclic fatigue, humidity, and thermal changes[44]. It should be noticed that only one tooth type (maxillary first premolars) and a single MOD cavity design were investigated, so results might not apply to different tooth morphologies or cavity sizes[34]. A unidirectional compressive loading cannot mimic the multi-directional occlusal forces in function and these may affect the initiation and propagation of a crack.
For further work, it would be advisable to include aging and cyclic loading being performed in different thermomechanical conditions so that the long-term performance of new materials can be simulated. Subsequent investigations on different cavity designs, tooth types, and fibre position techniques (ex, bucco-lingual splinting and circumferential “wallpapering” orientation) are suggested for successful reinforcement of the fiber-reinforced restoration[52]. Additionally, the application of finite element analysis (FEA) may provide deeper insights into internal stress distribution and complement experimental observations. Finally, there is a need to perform further in vivo and clinical long-term studies in order to generalize these findings under real mastication conditions and confirm their clinical stability over time.

CONCLUSION

In the confines of this in vitro study, fiber-reinforced composite yielded markedly higher fracture resistance levels than those with non-reinforced materials for endodontically treated maxillary premolars. The EverX Posterior showed the highest mean fracture resistance (624 ± 137.86 N), followed by EverX Flow (550 ± 80 N) and Ribbond (548 ± 94 N), whereas SDR (491 ± 119 N) and the conventional composite (401 ± 76 N) showed lower values. The intact control remained the strongest (1047 ± 169.77 N).

In relation to the fracture mode, most of the intact teeth presented repairable fractures (80%), and EverX Flow showed a higher number of restorable failures (40%) than all other restorative materials. These results indicate that incorporating reinforcing fibers (particularly in a flowable matrix) enhances stress distribution and promotes favorable fracture patterns.

Clinically, fiber-reinforced composites may offer improved biomechanical stability and greater predictability when restoring endodontically treated premolars. Further *in-vivo* and fatigue studies are needed to confirm these results under functional conditions.

DECLARATIONS

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

Ethical Approval: This study was conducted in accordance with the principles of the Declaration of Helsinki and was approved by the Institutional Medical Ethics Committee.

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