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Polyethylene fiber reinforcement in resin composite restorations: A systematic review of clinical trials

Rim Bourgi [a,b,c], Ahmed A. Holiel [c,d], António HS Delgado [e], Abigailt Flores-Ledesma [f], Souheir Khafaja [c,g], Carlos Enrique Cuevas-Suárez [f,h,*]

[a] Department of Biomaterials and Bioengineering, INSERM UMR_S 1121, University of Strasbourg, Strasbourg, France
[b] Department of Restorative and Esthetic Dentistry, Faculty of Dental Medicine, Saint-Joseph University of Beirut, Beirut, Lebanon
[c] Department of Restorative Sciences, Faculty of Dentistry, Beirut Arab University, Beirut, Lebanon
[d] Department of Conservative Dentistry, Faculty of Dentistry, Alexandria University, Alexandria, Egypt
[e] Center for Interdisciplinary Research Egas Moniz (CiiEM), Egas Moniz School of Health & Science, Campus Universitario, Quinta da Granja, Monte de Caparica, Almada, Portugal
[f] Dental Materials and Biomaterials Laboratory Faculty of Stomatology, Meritorious Autonomous University of Puebla, Puebla, Mexico
[g] Department of Esthetic and Restorative Dentistry, School of Dentistry, Lebanese University, Lebanon
[h] Dental Materials Laboratory, Academic Area of Dentistry, Autonomous University of Hidalgo State, San Agustín Tlaxiaca, Mexico

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ABSTRACT

Purpose: To synthesize evidence from randomized controlled trials (RCTs) on the clinical performance of ultra-high-molecular-weight polyethylene (UHMWPE) fiber-reinforced direct composite restorations compared to conventional composites in posterior teeth and non-carious cervical lesions. Methods: A systematic review was conducted following PRISMA guidelines (PROSPERO: CRD420251178877). Databases were searched up to November 2025 for RCTs evaluating fiber-reinforced versus non-reinforced direct composite restorations in Class I, II, or V cavities. Grey literature and trial registries were not searched, framing this as a restricted-source systematic review of peer-reviewed published evidence. The primary outcome was restoration failure/survival; secondary outcomes included marginal adaptation, discoloration, and postoperative sensitivity. Risk of bias was assessed using RoB 2, and certainty of evidence was evaluated with GRADE. Results: Four RCTs (404 patients, 494 restorations) with 12–24 month follow-up were included. All trials reported 100% restoration survival in both fiber-reinforced and control groups. No statistically significant differences were found in any clinical performance parameter. The evidence was of moderate certainty for primary outcomes in adults but low to very low for secondary outcomes and pediatric/NCCL indications, limited by short follow-up, imprecision, and risk of bias. Conclusions: Within the limited observation period of up to 24 months, UHMWPE fiber reinforcement did not demonstrate a measurable clinical advantage over contemporary non-reinforced composite protocols for posterior teeth. The uniformly high survival rates and comparable performance indicate excellent short-term outcomes for both approaches under controlled conditions. Absence of observed benefit should not be interpreted as equivalence; long-term RCTs are required to determine if fiber reinforcement mitigates late complications such as fracture in structurally compromised teeth.

1. Introduction

Direct resin composite restorations are central to contemporary minimally invasive dentistry, enabled by adhesive techniques and continuous advances in formulation and curing chemistry [1]. Long-term clinical evidence shows that posterior composites can perform predictably for many years [2], with failures influenced strongly by patient- and tooth-level factors rather than material choice alone. Although composites are undoubtedly the most popular direct choice, there are still shortcomings to address [3,4]. Polymerization shrinkage and shrinkage-stress development remain inherent to resin-based materials and can challenge the bonded interface. In fact, these phenomena may result in marginal microleakage, post-operative discomfort, secondary caries, and, ultimately, failure of the

* Corresponding author.
E-mail address: cecuevas@uaeh.edu.mx (C.E. Cuevas-Suárez).

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restoration, particularly in extensive Class I/Class II stress-bearing restorations [5].

Diverse stress-management and reinforcement concepts, such as strategic fiber placement or fiber-reinforced increments, have been advocated for structurally demanding posterior scenarios. These are intended to act as stress breakers and improve damage tolerance [6,7]. In dentistry, commercially available fiber reinforcements fall into distinct material classes with different interfacial chemistries and clinical use concepts: continuous ribbon/strip systems based on polyethylene fibers, most commonly ultra-high molecular weight polyethylene (UHMWPE) in woven architectures (e.g., Ribbond®), and glass-fiber reinforcements, typically supplied as pre-impregnated or resin-gel systems (e.g., everStick®) or braided glass tapes (e.g., Interlig®) [8,9]. Although numerous in vitro investigations have demonstrated improvements in fracture toughness and flexural performance when composites are fiber-reinforced, it remains uncertain whether these laboratory advantages translate into superior clinical outcomes [7]. The clinical translation of these in vitro benefits may in fact be attenuated by intraoral aging, hydrolytic degradation of adhesive interfaces, cyclic fatigue, and operator-dependent variables, which are difficult to replicate under laboratory conditions [10]. Most importantly, it remains unclear whether current generation resin-based materials, whose chemical formulations have been in constant optimization over the last decades, already deliver a performance that limits any additional clinical benefit from polyethylene fiber reinforcement.

Clinical trials have begun to test polyethylene reinforcement in posterior and cervical direct composites and report generally favorable short-term outcomes [11–13], but the results are still very dispersed across indications and evaluated with non-uniform criteria, making it unclear whether fiber insertion adds value beyond traditional protocols. The heterogeneity in cavity configuration, tooth vitality and patient characteristics further complicates whether any observed differences reflect the reinforcement strategy in itself or other clinical factors. A focused systematic synthesis of randomized clinical evidence is required to quantify and interpret the incremental clinical effect of polyethylene fiber reinforcement on restoration survival and performance.

Therefore, this systematic review synthesizes controlled clinical trial evidence to determine whether ultra-high-molecular-weight polyethylene (UHMWPE) fiber reinforcement improves the clinical longevity and performance of direct resin composite restorations compared with conventional non-reinforced composites in posterior stress-bearing scenarios. We focused on restoration survival/failure as the primary endpoint and on standardized clinical performance domains. The a priori working hypothesis was that polyethylene fiber reinforcement does not confer clinically meaningful short-term advantages over conventional posterior resin composite restoration protocols.

2. Materials and methods

This systematic review was planned and reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement [14]. The protocol was registered prospectively in PROSPERO (CRD420251178877).

The following PICOS framework was used: Participants, patients with permanent teeth receiving direct resin composite restorations for Class I, Class II, and/or Class V (non-carious cervical lesion) defects; Intervention, direct resin composite restorations reinforced with commercially available polyethylene fiber systems, placed at any restorative layer according to the clinical protocol; Comparator, direct resin composite restorations placed under similar clinical conditions without fiber reinforcement; Outcomes, the primary outcome was restoration failure and/or survival using validated clinical criteria at the longest follow-up reported. Studies using either modified USPHS/Ryge criteria or the more recent FDI World Dental Federation criteria were eligible. Secondary outcomes included clinical performance parameters (e.g., marginal adaptation, marginal discoloration, fracture/anatomic form, wear, postoperative sensitivity, and secondary caries); Study design: randomized controlled trials (RCTs) only. Non-randomized controlled trials were listed a priori in the PROSPERO protocol but were not identified during screening; to eliminate methodological ambiguity and align reported methods with the executed review, the eligibility criteria were restricted to RCTs post hoc. Accordingly, no non-randomized studies were assessed or included. Accordingly, the core review question was: In permanent teeth restored with direct resin composite (Class I/II/V), does polyethylene-fiber reinforcement, compared with conventional resin composite restorations without fibers, improve clinical survival and overall clinical performance?

2.1. Information sources and search strategy

A comprehensive search was conducted in the following electronic databases from inception to 4 November 2025: MEDLINE (via PubMed), Embase, Scopus, Web of Science Core Collection, and SciELO. The search strategy combined controlled vocabulary and free-text terms for three conceptual domains: (1) the clinical condition or restoration class (e.g., Class I, Class II, Class V, posterior teeth, non-carious cervical lesion); (2) the intervention (e.g., polyethylene fiber, fiber ribbon, Ribbond, Construct); and (3) the study design (e.g., clinical trial). Search strategies were adapted for each database. Search strategies were adapted for each database. Grey literature sources and trial registries were not searched, thereby framing this review as a restricted-source systematic review of peer-reviewed published evidence. Search

Table 1
Search strategies used and adapted for each scientific database.

Database	Search strategy
PubMed	((molar OR bicuspid OR premolar OR dentition, permanent OR permanent dentition OR posterior teeth OR posterior tooth OR dental caries OR dental decay OR class i OR class ii OR class v OR non-carious cervical lesions OR non carious cervical lesions OR non-carious, cervical lesion OR non-carious cervical lesions) AND (Fiber reinforced composite OR Ribbond OR Polyethylene fibers OR Polyethylenefiber OR Polyethylene Fiber OR Fiber-Reinforced Composite)) AND (clinical efficacy OR clinical evaluation OR clinical study OR randomized clinical trial OR clinical trial OR controlled clinical trial)
Web of Science and Scielo	TS=(molar OR bicuspid OR premolar OR dentition, permanent OR permanent dentition OR posterior teeth OR posterior tooth OR dental caries OR dental decay OR class i OR class ii OR class v OR non-carious cervical lesions OR non carious cervical lesions OR non-carious, cervical lesion OR non-carious cervical lesions) AND TS=(Fiber reinforced composite OR Ribbond OR Polyethylene fibers OR Polyethylenefiber OR Polyethylene Fiber OR Fiber-Reinforced Composite) AND TS=(clinical efficacy OR clinical evaluation OR clinical study OR randomized clinical trial OR clinical trial OR controlled clinical trial)
SCOPUS	TITLE-ABS-KEY ("molar" OR "bicuspid" OR "premolar" OR "dentition, permanent" OR "permanent dentition" OR "posterior teeth" OR "posterior tooth" OR "dental caries" OR "dental decay" OR "class i" OR "class ii" OR "class v" OR "non-carious cervical lesions" OR "non carious cervical lesions" OR "non-carious, cervical lesion" OR "non-carious cervical lesions") AND TITLE-ABS-KEY ("Fiber reinforced composite" OR "Ribbond" OR "Polyethylene fibers" OR "Polyethylenefiber" OR "Polyethylene Fiber" OR "Fiber-Reinforced Composite") AND TITLE-ABS-KEY ("clinical efficacy" OR "clinical evaluation" OR "clinical study" OR "randomized clinical trial" OR "clinical trial" OR "controlled clinical trial")
Embase	(molar/ or bicuspid/ or premolar/ or exp tooth/ or (permanent dentition or posterior teeth or posterior tooth).ab,ti. or (class i or class ii or class v).ab,ti. or (non-carious cervical lesion* or non carious cervical lesion*).ab,ti.) AND (exp polyethylene/ or exp composite resin/ or (Ribbond or polyethylene fiber* or polyethylene fibre* or fiber reinforced composite* or fibre reinforced composite*).ab,ti.) AND (exp clinical trial/ or (clinical trial* or randomized controlled trial* or clinical efficacy or clinical evaluation).ab,ti.)

reporting with the full reproducible search strategies for each database provided in Table 1.

2.2. Study selection and data collection

Search results were imported into EndNote 20 (Clarivate Analytics, Philadelphia, PEN, USA) for duplicate removal and subsequently into Rayyan QCRI website for screening [15]. Two independent reviewers (R.B. and C.E.C.-S.) screened titles and abstracts against the eligibility criteria. Full texts of potentially relevant articles were then retrieved and assessed independently by the same reviewers. Any discrepancies were resolved through consultation with a third reviewer (A.D.) A standardized, pre-piloted data extraction form (Microsoft Excel for Mac, Version 16.108, Microsoft Corporation, Redmond, WA, USA) was used to collect details on study characteristics (author, year, design, setting), participant demographics, intervention and control protocols, follow-up period, outcome measures, and results. When multiple restorations were placed in the same patient, data were extracted at the restoration level, as reported in the original studies.

2.3. Risk of bias assessment

Because the eligibility criteria were restricted to randomized controlled trials (see Section 2), risk of bias was assessed using the revised Cochrane risk-of-bias tool for randomized trials (RoB 2). Non-randomized studies were not eligible and therefore no tool for non-randomized designs (e.g., ROBINS-I) was required. Risk of bias for each randomized clinical trial was assessed using the revised Cochrane risk-of-bias tool for randomized trials (RoB 2), in accordance with the guidance provided in the *Cochrane Handbook for Systematic Reviews of Interventions*, version 6.5, and the official RoB 2 guidance documentation [16]. Each study was judged across five domains: (1) bias arising from the randomization process; (2) bias due to deviations from intended interventions; (3) bias due to missing outcome data; (4) bias in measurement of the outcome; and (5) bias in selection of the reported result. Each domain was rated as "low risk of bias," "some concerns" or "high risk of bias," and an overall risk-of-bias judgement was derived using the RoB 2 decision rules. Assessments were performed at the outcome level (for the clinical performance outcomes at the longest follow-up) and informed the subsequent GRADE certainty-of-evidence ratings.

2.4. GRADE

The certainty of the evidence for each key outcome was assessed using the GRADE (Grading of Recommendations Assessment, Development and Evaluation) approach, following the guidance in the *Cochrane Handbook for Systematic Reviews of Interventions*, version 6.5 (2024), and current GRADE Working Group recommendations. Randomized controlled trials were rated down, when appropriate, for risk of bias, inconsistency, indirectness, imprecision and publication bias. Certainty ratings (high, moderate, low or very low) were assigned separately for each outcome and are summarized in the summary of findings tables.

2.5. Synthesis methods (SWiM guidance)

The primary synthesis was conducted narratively following the Synthesis Without Meta-analysis (SWiM) reporting guideline [17].

Studies were grouped by clinical indication to account for expected differences in baseline failure risk and stress profiles. The four pre-specified groups were: (1) Class II MOD restorations in vital posterior teeth of adults, (2) Class II restorations in endodontically treated molars; (3) Class II restorations in pediatric first permanent molars; and (4) Class V non-carious cervical lesions. No pooling across these heterogeneous indications was attempted.

The primary outcome was restoration failure/survival, defined as the need for repair or replacement due to any cause. For each outcome, the direction of effect (favoring intervention, favoring control, or no difference) and the reported statistical significance ($p < 0.05$) were extracted. Given the uniformly zero-event primary outcome and the absence of statistically significant between-group differences for any outcome across all studies, the synthesis was primarily descriptive. The rule of three was applied post hoc to provide quantitative context for the zero-event findings [18].

3. Results

3.1. PRISMA workflow and outcome data

A comprehensive search across multiple databases yielded a total of 516 documents. After meticulously removing duplicate entries, 326 unique articles were left for initial assessment based on their titles and abstracts. Subsequently, a thorough screening of titles and abstracts led to the identification of 6 studies that warranted a full-text examination. The inter-reviewer agreement during title/abstract screening and full-text assessment was high, and all disagreements were resolved by consensus. Upon closer examination, 2 of these studies were excluded for the following reasons: one article evaluated short-fiber resin-based composites [19], and the other one was a comment for an editor [20]. This process left a final number of 4 documents that eligible for qualitative analysis [21–24]. The study selection process followed the guidelines outlined in the PRISMA statement and is visually represented in Fig. 1.

Due to the nature of the extracted outcome data, specifically, the absence of failure events (zero events) in both intervention and control groups across all included studies within the reported follow-up periods, a standard meta-analysis calculating pooled odds ratios or risk ratios was not feasible or methodologically sound. Presenting such an analysis would yield non-informative results (e.g., OR=1, $p = 1$). Alternative statistical approaches for zero-event data, including continuity corrections or Peto odds ratios, were considered but deemed inappropriate because all studies reported zero events in both arms, precluding meaningful estimation of relative effects.

Therefore, the primary synthesis was narrative and descriptive, conducted in accordance with the SWiM (Synthesis Without Meta-analysis) guidance as prespecified in Section 2.5. Study characteristics, patient and restoration details, follow-up times, and clinical performance outcomes were tabulated and summarized qualitatively. The restoration survival rate for each study arm was calculated and reported. For secondary continuous outcomes (if reported, e.g., quantitative marginal gap measurements), a narrative synthesis was performed. The implications of the uniformly high short-to-medium-term survival in both groups are discussed in the context of follow-up duration and clinical relevance.

3.2. Characteristics of included studies

The four included studies were randomized controlled trials published between 2023 and 2025, with a total of 494 restorations in 404 patients. Two trials evaluated Class II MOD restorations in vital posterior teeth [21,22], one evaluated with Class II restorations in molars with previous endodontic treatment [24]. and one assessed non-carious cervical lesions (Class V) [23]. The follow-up periods ranged from 12 to 24 months. In all trials, the intervention consisted of intra-restorative reinforcement with an ultra-high-molecular-weight polyethylene (UHMWPE) ribbon system (Ribbond® system) applied using a circumferential/peripheral fiber-lining design within the composite increment. The comparator in each trial was a direct resin composite restoration placed under identical clinical conditions without fiber reinforcement. Clinical performance was assessed using modified USPHS/Ryge criteria across all studies. Notably, although FDI World Dental Federation criteria were eligible for inclusion, none of the identified trials employed the FDI system [25,26]. Key study characteristics and outcome reporting

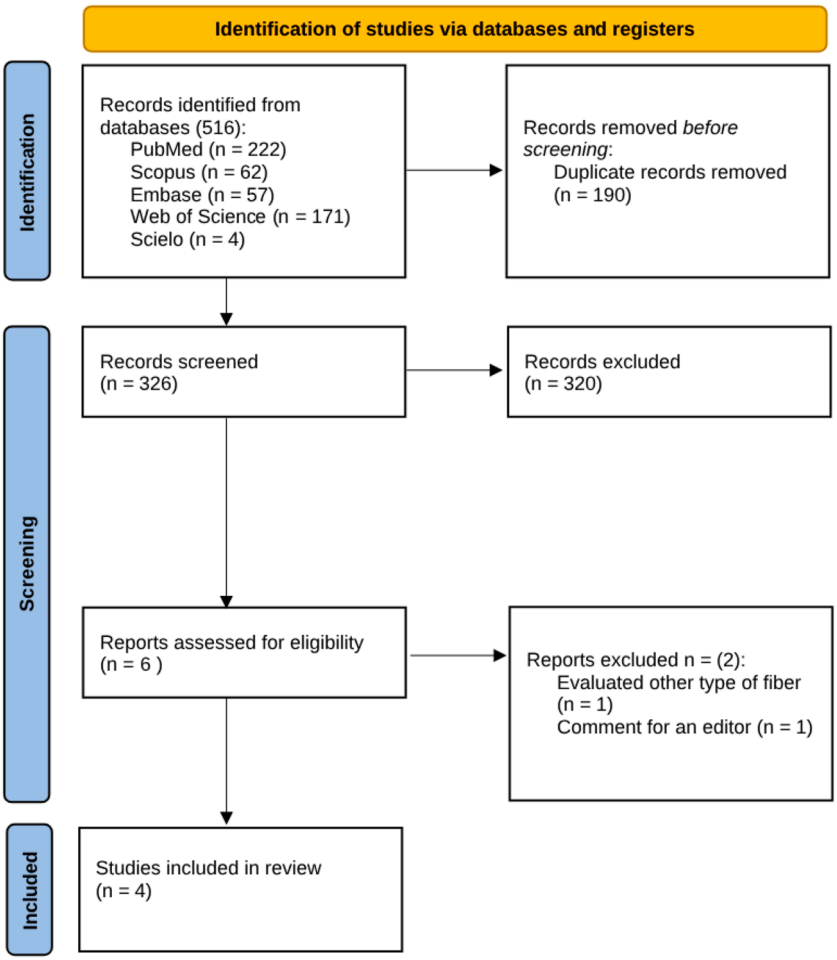

Fig. 1. PRISMA 2020 flow diagram of the selection process.

are summarized in Table 2.

3.3. Risk of bias assessment

Overall, two trials were judged at low risk of bias, while two were judged as having some concerns and they are summarized in Fig. 2. The trials by Metwaly et al. (2024) and Mohamed et al. (2025) were rated as low risk of bias across all RoB 2 domains. Both reported adequate random sequence generation and allocation concealment, used blinded and calibrated examiners for outcome assessment, had minimal or well-explained loss to follow-up, and presented the prespecified clinical performance outcomes according to the modified USPHS criteria at all time points.

In contrast, the trials by Manjunath et al. (2025) and Özüdoğru et al. (2023) were judged as having some concerns overall. For Manjunath et al., concerns related mainly to limited detail on the randomization and allocation procedures, unclear reporting of follow-up completeness, and restricted transparency regarding pre-specification of outcomes and analyses. For Ozüdoğru et al., the main issues were moderate attrition at 24 months with exclusion of dropouts from the analyses and the absence of a publicly accessible protocol or trial registration, raising some concerns about selective reporting. In all four trials, outcome measurement bias was considered low because the same modified USPHS criteria were applied in a blinded manner across groups; however, the exclusive use of modified USPHS, rather than the FDI criteria which supersede USPHS (1), should be acknowledged as a methodological limitation due to its

Table 2
Characteristics of included randomized controlled clinical trials evaluating polyethylene fiber reinforcement in direct resin composite restorations.

Study	Design	Cavity Type (sample size)	Intervention (Fiber)	Follow-up (Months)	Outcomes Report	Restoration Survival (Failure Events)
Manjunath et al. (2025) [23]	RCT	NCCLs in premolars (n = 66)	Ribbond + biomimetic protocol	12	Retention, marginal adaptation, anatomic form, sensitivity	0% failure (0/132 restorations)
Metwaly et al. (2024) [24]	RCT	Class II preparations in endodontically treated molars (n = 120)	Ribbond THM + bulk fill composite	24	Retention, gross fracture, marginal adaptation, staining, secondary caries	0% failure (0/240 restorations)
Mohamed et al. (2025) [22]	RCT	Class II MOD in vital posterior teeth (n = 22)	Ribbond Ultra + nanohybrid composite	18	Marginal adaptation, color match, marginal discoloration, gross fracture, recurrent caries	0% failure (0/45 restorations)
Özüdoğru & Tosun (2023) [21]	RCT	Class II in first permanent molars (n = 38)	Ribbond THM + composite	24	Retention, color match, marginal discoloration, adaptation, secondary caries, sensitivity	0% failure (0/75 restorations)

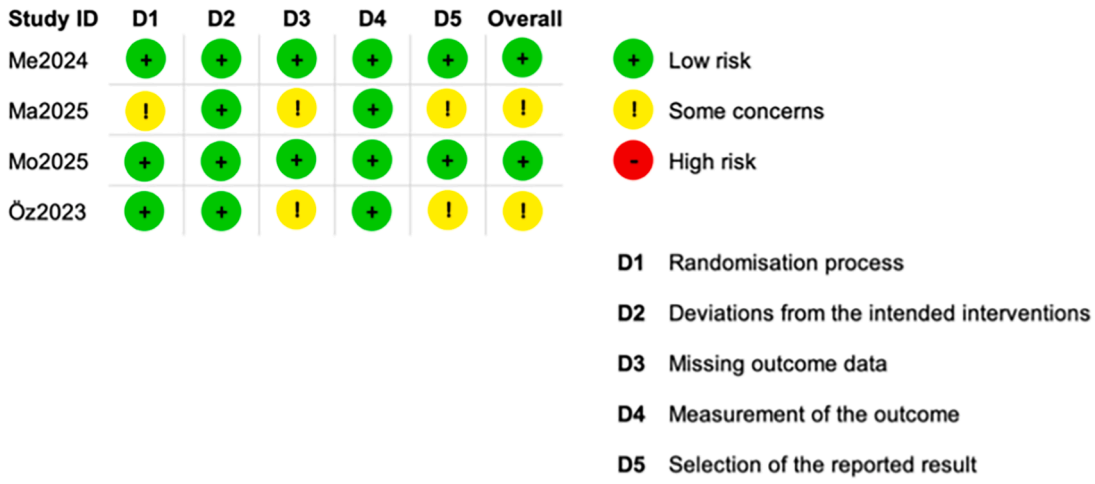

Fig. 2. Risk of bias assessment for the included randomized clinical trials using the Cochrane RoB 2 tool. Each row represents one study and each column a bias domain (D1–D5). Green circles indicate low risk of bias, yellow circles indicate some concerns, and red circles (none present) would indicate high risk of bias.

lower discriminative capacity.

3.4. GRADE

For adult posterior teeth, evidence from two randomized clinical trials provided moderate-certainty evidence that fiber-reinforced composites have comparable short- to medium-term clinical performance (clinical failure/retention, marginal adaptation and marginal discoloration at 18–24 months) to non-fiber composites (Table 3). Certainty was mainly downgraded for imprecision due to modest sample sizes and few events. For secondary caries and postoperative sensitivity in adults, the certainty was low, reflecting the very low event rates and wide plausible ranges of effect.

For pediatric first permanent molars, the single available trial contributed low-certainty evidence for all clinical outcomes at 24 months because of some concerns regarding risk of bias and serious imprecision (Table 4) [21]. Similarly, for non-carious cervical lesions (Class V), the single randomized trial comparing three restorative/adhesive protocols provided low-certainty evidence for retention, marginal adaptation and other clinical criteria at 12 months, mainly due to study limitations and imprecision (Table 5) [23]. Overall, the body of evidence suggests that fiber reinforcement and alternative protocols may influence clinical performance, but the confidence in these estimates is limited and further high-quality, adequately powered trials are required. No outcome across any clinical indication reached high-certainty evidence.

3.5. Quantitative interpretation of zero-event survival data

Because all included studies reported zero restoration failures in both intervention and control groups across follow-up periods of 12 to 24 months, standard meta-analysis was not feasible. To provide interpretable quantitative context despite the absence of events, the "rule of three" was applied [18]. For a study with zero events in n restorations, the upper bound of the 95% confidence interval for the true failure rate is approximately 3/n.

Across all four studies (494 restorations, zero failures), the upper 95% confidence bound for the true failure rate at the reported follow-up (12–24 months) is 3/494 ≈ 0.6% per restoration. When disaggregated by clinical indication, Class II MOD in vital posterior teeth (Mohamed et al., 2025; 45 restorations, zero failures at 18 months): upper bound = 3/45 ≈ 6.7%; Endodontically treated molars (Class II) (Metwaly et al., 2024; 240 restorations, zero failures at 24 months): upper bound = 3/240 ≈ 1.3%; Pediatric first permanent molars (Class II) (Özüdoğru & Tosun, 2023; 75 restorations enrolled, 65 evaluated at 24 months, zero failures): upper bound = 3/65 ≈ 4.6%. Non-carious cervical lesions (Class V) (Manjunath et al., 2025; 132 restorations, zero failures at 12 months): upper bound = 3/132 ≈ 2.3%.

These upper bounds indicate that the observed zero failures are compatible with true failure rates as high as 0.6% to 6.7% within the

Table 3
GRADE summary of findings for RCTs referring to adult posterior teeth.

Outcome	No. of studies (lesions)	Study design	RoB	Inconsistency	Indirectness	Imprecision	Publication bias	Overall certainty of evidence (GRADE)
Clinical failure / loss of restoration / need for replacement (18–24 months)	2 RCTs (~285 teeth)	RCT	Not serious	Not serious	Not serious	Serious[a]	Not serious	⊕⊕⊕⊖ MODERATE
Marginal adaptation (USPHS; Bravo/Charlie vs Alpha, 18–24 months)	2 RCTs	RCT	Not serious	Not serious	Not serious	Serious[a]	Not serious	⊕⊕⊕⊖ MODERATE
Marginal discoloration (18–24 months)	2 RCTs	RCT	Not serious	Not serious	Not serious	Serious[a]	Not serious	⊕⊕⊕⊖ MODERATE
Secondary caries (18–24 months)	2 RCTs	RCT	Not serious	Not serious	Not serious	Very serious[b]	Not serious	⊕⊕⊖⊖ LOW
Postoperative sensitivity / symptoms (18–24 months)	1–2 RCTs	RCT	Not serious	Not serious	Possibly serious[c]	Serious[a]	Not serious	⊕⊕⊖⊖ LOW

[a] Serious imprecision: Total sample size is modest, the number of events is small, and the plausible confidence intervals around the effect estimate are wide enough to include both no important effect and a clinically relevant benefit or harm.
[b] Very serious imprecision: Events of secondary caries are extremely rare; any risk estimate is based on very few events and a small total sample, resulting in very wide plausible effect ranges.
[c] Possible indirectness: Definitions and measurement of postoperative sensitivity/patient-reported symptoms may vary slightly between trials and are not always the primary outcome.

Table 4
GRADE summary of findings for RCTs referring to pediatric first permanent molars.

Outcome	No. of studies (lesions)	Study design	RoB	Inconsistency	Indirectness	Imprecision	Publication bias	Overall certainty of evidence (GRADE)
Clinical failure / loss of restoration (24 months)	1 RCT (75 teeth; 65 evaluated)	RCT	Serious[d]	Not serious[e]	Not serious	Serious[f]	Not serious[g]	⊕⊕⊖⊖ LOW
Marginal adaptation (24 months)	1 RCT	RCT	Serious[d]	Not serious[e]	Not serious	Serious[f]	Not serious[g]	⊕⊕⊖⊖ LOW
Marginal discoloration, anatomical form, postoperative sensitivity (24 months)	1 RCT	RCT	Serious[d]	Not serious[e]	Not serious	Serious[f]	Not serious[g]	⊕⊕⊖⊖ LOW
Secondary caries (24 months)	1 RCT	RCT	Serious[d]	Not serious[e]	Not serious	Very serious[h]	Not serious[g]	⊕⊖⊖⊖ VERY LOW
Clinical failure / loss of restoration (24 months)	1 RCT (75 teeth; 65 evaluated)	RCT	Serious[d]	Not serious[e]	Not serious	Serious[f]	Not serious[g]	⊕⊕⊖⊖ LOW

[d] Serious risk of bias: The trial was judged as "some concerns" in RoB 2 due to ~14% attrition at 24 months and lack of a publicly available pre-specified protocol or analysis plan.
[e] No serious inconsistency: Only one study is available; inconsistency cannot be formally assessed and is not usually downgraded on this basis in GRADE.
[f] Serious imprecision: Single small trial with 65 restorations assessed at 24 months and few events; confidence intervals are expected to be wide and compatible with appreciable benefit or harm.
[g] Publication bias not downgraded: With only one study, publication bias cannot be reliably assessed; no specific signal justifying an additional downgrade, but the possibility should be acknowledged.
[h] Very serious imprecision: Very few or no secondary caries events were observed, making any effect estimate extremely uncertain.

Table 5
GRADE summary of findings for RCTs referring to NCCLs.

Outcome	No. of studies (lesions)	Study design	RoB	Inconsistency	Indirectness	Imprecision	Publication bias	Overall certainty of evidence (GRADE)
Retention / clinical failure of restoration (12 months)	1 RCT (~132 lesions)	RCT	Serious[i]	Not serious[j]	Not serious	Serious[k]	Not serious[l]	⊕⊕⊖⊖ LOW
Marginal adaptation / anatomic form (12 months)	1 RCT	RCT	Serious[i]	Not serious[j]	Not serious	Serious[k]	Not serious[l]	⊕⊕⊖⊖ LOW
Marginal discoloration, secondary caries, sensitivity (12 months)	1 RCT	RCT	Serious[i]	Not serious[j]	Not serious	Serious to very serious[m]	Not serious[l]	⊕⊕⊖⊖ LOW (up to VERY LOW for very rare outcomes)

[i] Serious risk of bias: The trial was judged as "some concerns" with RoB 2 (uncertain details of random sequence generation and allocation concealment using a chit system; incomplete reporting of attrition and analysis population; limited transparency regarding pre-specification of outcomes).
[j] No serious inconsistency: Only one trial is available; inconsistency cannot be assessed but is not usually downgraded in such cases.
[k] Serious imprecision: Single small study with short follow-up (12 months) and few restoration failures; confidence intervals around any effect estimate are expected to be wide and compatible with both no effect and important differences.

observed timeframes. The data do not rule out clinically meaningful differences between fiber-reinforced and conventional composites, nor do they establish equivalence.

Substantial heterogeneity existed across the four included RCTs despite all evaluating polyethylene fiber reinforcement. Follow-up duration varied from 12 months (Manjunath et al., 2025) to 18 months (Mohamed et al., 2025) to 24 months (Metwaly et al., 2024; Özüdoğru & Tosun, 2023). Clinical indications differed markedly: two trials evaluated Class II MOD restorations in vital posterior teeth of adults (Mohamed et al., 2025) and endodontically treated molars (Metwaly et al., 2024); one assessed Class II restorations in pediatric first permanent molars (Özüdoğru & Tosun, 2023); and one examined Class V non-carious cervical lesions (Manjunath et al., 2025). Restorative protocols also varied in composite materials (bulk-fill vs. nanohybrid vs. conventional composite) and fiber placement techniques, though all used Ribbond® and rubber dam isolation. Outcome measurement was consistent in that all used modified USPHS/Ryge criteria, but reporting of secondary outcomes (marginal adaptation, discoloration, post-operative sensitivity) was not uniform across all time points, and no study used the more contemporary FDI criteria.

3.6. Deviations from the registered PROSPERO protocol

The following deviations from the registered protocol are reported transparently, in accordance with PRISMA 2020 guidance. Deviation 1, the registered protocol stated that both randomized and non-randomized controlled trials would be eligible. During the conduct of the review, no non-randomized studies were identified at any stage of screening. Deviation 2, the registered protocol did not explicitly exclude grey literature or trial registries. However, as implemented and transparently reported in Section 2.1, the search was restricted to peer-reviewed indexed databases. Deviation 3, the registered protocol did not prespecify the application of the rule of three for interpreting zero-event findings.

4. Discussion

This systematic review qualitatively synthesized evidence from four randomized clinical trials evaluating the clinical performance of polyethylene fiber-reinforced composite restorations versus conventional composites in posterior teeth over follow-up periods of 12 to 24 months. The included studies consistently reported no restoration failures and no significant differences in key clinical parameters between the two restorative approaches These findings indicate that within short-term follow-up under controlled clinical conditions, adding polyethylene fibers to direct composite restorations did not demonstrate a measurable clinical advantage over contemporary conventional composite protocols. Because no restoration failures occurred in any study arm, the data are subject to a ceiling effect: both groups show 100% survival, the available evidence cannot robustly distinguish superiority, non-inferiority, or equivalence. It is thus more accurate to state that no benefit was observed.

Modern posterior composite restorations placed under optimal conditions often show high short-term survival, with failures accruing

gradually over longer follow-up [2]. Large syntheses of posterior composite longevity report annual failure rates typically in the ~1–3% range, with patient, tooth-, and operator-related factors exerting stronger influence than material class alone [2–4]. Against this background, trials that are capped at 24 months, particularly those conducted under rubber dam isolation, well-experienced operators, and selective eligibility criteria, may simply be too short and over-optimized to reveal benefits of reinforcement, if such benefits exist.

All included trials reported 100% survival (retention) at final recall, even in scenarios with different stress profiles (e.g., Class II MOD cavities, endodontically treated molars, and Class V NCCLs). No restoration required repair or replacement due to loss of retention, fracture, or debonding. This suggests that, when executed under standardized protocols, both conventional and polyethylene fiber–augmented direct composites can achieve excellent short-term clinical stability. However, the observation of zero failures must be interpreted with caution. Applying the rule of three to the pooled sample of 494 restorations yields an upper 95% confidence bound of approximately 0.6% for the true failure rate at 12–24 months. When examined by individual study, the upper bounds range from 1.3% to 6.7% (see Section 3.5). These values are not trivial; they indicate that true failure rates of several percent cannot be excluded based on the current data. For context, large-scale longevity syntheses report annual failure rates for posterior composites in the range of 1–3% [2,3]. The present zero-event findings are therefore compatible with failure rates that would be considered clinically acceptable but also with failure rates that could favor one intervention over another.

Because failure events were not observed, the evidence does not yet clarify whether fiber reinforcement can reduce the incidence of late complications, such as bulk fracture, cusp fracture in structurally compromised teeth, or long-term debonding [27]. It is important to note that many clinically relevant degradative mechanisms tend to become more apparent over longer service times [28]. This reinforces the likelihood that 2 years is insufficient to test longevity claims.

Marginal adaptation and marginal discoloration showed similar performance in reinforced and control restorations. Only minor changes occurred over time, and no consistent between-group separation was observed. Mechanistically, polyethylene fibers are proposed to act as stress-modulating elements through crack deflection, energy dissipation, and stress redistribution [29]. The "wallpapering" or circumferential placement technique has been advocated to shield cavity walls and potentially reduce interfacial strain [30]. However, in the included clinical evidence, any potential shrinkage-stress advantage did not translate into measurable improvements in USPHS marginal scores within 24 months. It should be noted that all included trials relied exclusively on modified USPHS criteria, which have lower sensitivity for detecting early or subtle marginal changes compared with the more recently recommended FDI criteria [23]. The similar performance in marginal integrity may be attributed to the consistent use of flowable composite liners and incremental placement techniques in both groups across all studies, which likely mitigated polymerization stresses regardless of fiber presence.

For secondary caries, all restorations across all studies remained caries-free throughout the observation periods. This universal absence of recurrent caries must be interpreted cautiously within the context of the included studies. Recurrent caries is strongly influenced by patient risk profile and typically requires longer periods for lesion development and detection [31]. In broader longevity analyses, caries risk is consistently among the strongest predictors of restoration failure, often outweighing restorative material factors [32]. The caries-free findings here therefore likely reflect the short follow-up and controlled trial conditions, rather than a specific caries-preventive effect of fiber reinforcement.

Other evaluated parameters including anatomic form, color match, and postoperative sensitivity, also showed no statistically significant differences between groups when analyzed collectively. Su and Pan, 2024 observed better maintenance of anatomic form with fibers in younger patients, potentially related to higher reported masticatory forces in this demographic [33], but this finding did not reach statistical significance across the evidence base and was not replicated in other included studies. Color match challenges were specifically noted only with opaque glass fiber-reinforced composites in one comparative study, while translucent polyethylene fibers showed no significant color mismatch when properly covered with an adequate thickness of conventional composite [34]. Postoperative sensitivity was low and transient in both groups, suggesting that contemporary adhesive systems and placement techniques effectively minimize pulpal irritation regardless of fiber incorporation [35]. The theoretical advantage of fibers in reducing polymerization shrinkage stresses did not translate to clinically measurable reductions in postoperative sensitivity within the studied timeframes [36].

The current evidence is limited by a very short follow-up window ($\leq$24 months) with zero events, that restricts the inferential power of the findings. Heterogeneity in indications (Class II vs endodontically treated teeth vs Class V NCCLs), which complicates a simple pooled interpretation and the existing trials relied on the modified USPHS criteria without standardized FDI reporting, which supersedes it. All procedures were performed under ideal conditions by calibrated operators, which may not reflect routine clinical settings. The small number of studies and their uniformly positive results raise possible publication bias concerns. Importantly, because the present review explicitly excluded grey literature and trial registries to focus on peer-reviewed published trials, the risk of publication bias is further magnified: unpublished studies with negative, null, or inconclusive findings—which are less likely to be accepted for publication—would not have been captured by our search. Consequently, the uniformly favorable short-term outcomes reported here may overestimate the true clinical performance of both fiber-reinforced and conventional composites. In addition, several trials placed multiple restorations per patient without statistical adjustment for clustering, which may have led to underestimated variance and overly optimistic precision of reported outcomes.

Future randomized trials should prioritize $\geq$5-year follow-up, prespecified primary endpoints that are likely to occur (e.g., fracture/survival using time-to-event methods), FDI-based calibrated assessments, transparent reporting of attrition, and statistical approaches that account for clustered restorations within patients. Only with adequately long observation windows and rigorous outcome measurement it will then be possible to determine the true advantages of polyethylene fiber reinforcement.

Within the first two years, polyethylene fiber reinforcement appears to be clinically comparable to conventional direct composite approaches for the evaluated indications, without demonstrable short-term superiority. In routine posterior restorations placed under good isolation and adhesive protocols, these data suggest that the additional cost and technique sensitivity of fiber insertion may not be justified *solely* on the basis of short-term performance.

Within the limits of the available short-term clinical evidence, the routine use of polyethylene ribbon reinforcement for posterior or cervical direct composites may not be justified solely on the basis of short-term performance. Its use may be reserved for selected, structurally demanding cases where the clinical objective is improved damage tolerance and fracture control rather than early marginal outcomes; however, this remains a hypothesis requiring testing in long-term comparative trials. At present, the evidence does not support a strong recommendation for or against fiber reinforcement, and clinical decisions should be guided by the specific clinical context, operator experience, and patient factors.

5. Conclusion

Within the limitations of the available clinical evidence, polyethylene ribbon reinforcement did not demonstrate a measurable short-

term clinical advantage over contemporary non-reinforced direct resin composite restorations. Across four randomized controlled trials, no restoration failures occurred in either group and clinical performance outcomes were comparable to controls. However, the uniformly zero-event data and limited follow-up introduce substantial imprecision, meaning that absence of observed benefit should not be interpreted as proof of equivalence or as evidence against long-term effects. Well-powered randomized trials with longer follow-up and calibrated FDI-based outcome assessments are required. Readers should interpret the present findings with awareness that the exclusion of unpublished studies and trial registries may have introduced publication bias, and the results are therefore generalizable primarily to peer-reviewed published evidence rather than to the totality of completed but unreported research.

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Declaration of competing interest

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