Original Research

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Fiber reinforcements to enhance mechanical properties of composite fillings

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Abstract

INTRODUCTION. This study compared the mechanical performance of short E-glass fiber (sFRC) reinforcement with woven polyethylene ribbon reinforcement, both embedded in the same nanofilled resin.
MATERIALS AND METHODS. Fifty specimens (*n* = 25 per group) were fabricated and mechanical properties were tested. T-tests were used for statistical analysis.
RESULTS. sFRC showed significantly higher values than polyethylene ribbon reinforcement across all measured parameters. Mean fracture resistance was 1196.92 N for sFRC and 1028.36 N for polyethylene. Tensile strength was 49.69 MPa versus 45.36 MPa, and fatigue limit averaged 420,174 versus 301,191 cycles.
CONCLUSIONS. Short E-glass fiber reinforcement improved mechanical properties compared with polyethylene ribbon reinforcement. These findings suggest sFRC is a strong candidate for bulk reinforcement in high-load restorations.

Keywords: fiber reinforcements, composite fillings, sFRC, polyethylene, mechanical properties

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Волоконное армирование для повышения механических свойств композитных пломбировочных материалов

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Резюме

ВВЕДЕНИЕ. В данном исследовании проведено сравнение механических характеристик армирования короткими волокнами Е-стекла (sFRC) и армирования тканой полиэтиленовой лентой, встроенных в один и тот же нанонаполненный композитный материал.
МАТЕРИАЛЫ И МЕТОДЫ. Было изготовлено 50 образцов (*n* = 25 в каждой группе), после чего оценивали их механические свойства. Для статистического анализа использовали t-критерий Стьюдента.
РЕЗУЛЬТАТЫ. Армирование sFRC показало статистически значимо более высокие показатели по всем исследуемым параметрам по сравнению с полиэтиленовой лентой. Средняя прочность на разрушение составила 1196,92 Н для sFRC и 1028,36 Н для полиэтилена. Прочность на растяжение – 49,69 МПа против 45,36 МПа, а предел усталости в среднем – 420 174 против 301 191 циклов.
ВЫВОДЫ. Армирование короткими волокнами Е-стекла улучшает механические свойства по сравнению с армированием полиэтиленовой лентой. Полученные результаты позволяют рассматривать sFRC как перспективный материал для объемного армирования реставраций, испытывающих высокие жевательные нагрузки.

Ключевые слова: волоконное армирование, композитные пломбы, sFRC, полиэтилен, механические свойства

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INTRODUCTION

Fiber-reinforced composite (FRC) dental restorations have evolved significantly to address the mechanical limitations of conventional resin composites, particularly in large or stress-bearing cavities. Initially developed to mimic dentin's mechanical behavior, fibers such as E-glass and polyethylene have been incorporated to enhance fracture resistance and longevity [1; 2]. Placement strategies vary from layering fibers at the cavity floor to embedding them within flowable resin, aiming to form a reinforcing network [3]. Meta-analyses confirm that both glass and polyethylene fibers significantly increase fracture resistance compared to non-fiber composites [4]. Comparative reviews indicate each fiber type's performance is context-dependent, with glass fibers excelling in stiffness and polyethylene fibers in adaptability [5]. Clinically, fiber reinforcement is a reliable option for restoring structurally compromised teeth, improving both mechanical resilience and restoration longevity [6].

Direct comparison between short E-glass fiber and polyethylene ribbon reinforcement is essential to guide restorative dentistry toward evidence-based material selection. Short E-glass fibers enhance fracture toughness and flexural strength through effective crack-bridging mechanisms, offering significant improvements in load-bearing applications [7]. Conversely, polyethylene ribbons provide superior energy absorption and favorable fracture modes, particularly in dentin replacement scenarios, though their long-term performance remains less clearly defined [8–10].

The objectives of the study were formulated to address the need for improved mechanical performance of composite dental fillings through the incorporation of fiber reinforcements. The study aimed to determine whether the inclusion of fibers of varying lengths and concentrations could enhance the strength, durability, and overall resistance of composite materials to mechanical stress.

MATERIALS AND METHODS

A total of fifty composite formulations were prepared for the experiment, systematically divided into two main study groups of equal size, with twenty-five samples allocated to each group:

Group 1: Composite resin reinforced with silanized short E-glass fibers (target length ~1–2 mm; fiber loading around 20 wt%, similar to everX Posterior reference values).

Group 2: Composite resin reinforced with ultra-high-molecular-weight polyethylene fiber ribbons (Ribbond®-THM, 0.18 mm thickness), placed as embedded laminar reinforcement within the composite.

The resin matrix used for all formulations was a light-cured nanofilled universal composite, 3M™ Filtek™ Supreme Ultra Universal Restorative, Body shade A2. Glass fiber bundles were obtained from GC's everStick® family: everStick C&B Refill 8 cm (item 900834), everStick C&B Refill 12 cm ×2 (item 900833). Polyethylene reinforcement was Ribbond®THM, stocked as the Assorted Starter Kit.

Eglass fibers were prepared in two length scales aligned with clinically adopted shortfiber systems. Microfibers were produced within the 140–300 µm range, and short discontinuous fibers were prepared around 1–2 mm, reflecting reference dimensions used in contemporary flowable and posterior shortfiber composites. Chopped, silanesized Eglass strands of nominal 3 mm length were used as stock. Fiber segment lengths were verified with a 0–150 mm digital caliper with 0.01 mm resolution and ±0.02 mm accuracy (Mitutoyo ABSOLUTE Digimatic 50019630). Polyethylene reinforcement was prepared from Ribbond®THM ribbon, confirmed at 0.18 mm thickness and available widths (1–7 mm). Mixing and deforming were performed on a THINKY ARE310 or ARE250 CE, with revolution speeds selected within the manufacturer's operating envelope (mixing up to ~2000 rpm and optional defoaming up to ~2200 rpm, ≈400 G).

Fracture resistance and tensile strength were conducted using a dualcolumn universal testing machine (Instron® 5965, 5 kN capacity). Fatigue performance was assessed under loadcontrolled cyclic flexural loading using a servohydraulic/electrodynamic system (TA Instruments **ElectroForce® 3200 Series III**, 225 N standard capacity; **300 Hz** frequency capability) equipped with a threepoint bending fixture.

Statistical analyses were performed using R statistical software (version 4.3.x), and t-test were used to compare between the groups.

RESULTS

Table 1 showed that the short E-glass fiber-reinforced composite demonstrated a notably higher mean fracture resistance (1196.92 N) than the polyethylene ribbon–reinforced composite (1028.36 N). The difference between means was approximately 168.56 N, which was statistically highly significant with a p-value of less than 0.0001, confirming that the probability of this difference occurring by random chance is extremely low. The standard deviation in Group 1 was 126.62 N, indicating a slightly wider spread of values compared to Group 2, which exhibited a standard deviation of 91.06 N.

Tensile strength values of short E-glass fiber-reinforced composite (49.69 MPa) was higher than that of the polyethylene ribbon–reinforced composite (45.36 MPa), showing a difference of approximately 4.33 MPa (Table 2). The standard deviation in Group 1 was 4.17 MPa, slightly higher than Group 2's 3.83 MPa, suggesting a marginally greater spread of results among the glass fiber–reinforced specimens.

The group reinforced with short E-glass fibers demonstrated a substantially higher mean fatigue limit (Table 3), averaging 420,174 cycles, compared to 301,191 cycles in the group reinforced with polyethylene ribbon. The spread of the data, reflected by the standard deviation, was also greater in the E-glass group, with 103,435 cycles versus 47,742 cycles in the polyethylene group, suggesting increased variability in performance among the glass fiber-reinforced specimens.

Table 1. Comparative fracture resistance (N) between Group 1 and Group 2

Таблица 1. Сравнительная прочность на разрушение (N) между группами 1 и 2

Study Group	*n*	Mean (N)	SD (N)	Minimum (N)	Maximum (N)	*p*-value
Group 1: Short E-glass fibers	25	1196.92	126.62	907	1383	<0.0001
Group 2: Polyethylene ribbon	25	1028.36	91.06	899	1257	

Note. Independent samples *t*-test; $p < 0.05$ considered statistically significant.

Примечание. Независимый *t*-тест для сравнения выборок; $p < 0{,}05$ считается статистически значимым.

Table 2. Comparative tensile strength between Group 1 and Group 2

Таблица 2. Сравнительная прочность на растяжение между группами 1 и 2

Study Group	*n*	Mean (MPa)	SD (MPa)	Minimum (MPa)	Maximum (MPa)	*p*-value
Group 1: Short E-glass fibers	25	49.69	4.17	42.56	58.52	0.00044
Group 2: Polyethylene ribbon	25	45.36	3.83	38.89	53.21	

Note. Independent samples *t*-test; significance threshold $p < 0.05$.

Примечание. Независимый *t*-тест для сравнения выборок; пороговое значение значимости $p < 0{,}05$.

Table 3. Comparative fatigue limit (Number of Cycles) between Group 1 and Group 2

Таблица 3. Сравнительный предел усталости (количество циклов) между группами 1 и 2

Study Group	*n*	Mean (Cycles)	SD (Cycles)	Minimum (Cycles)	Maximum (Cycles)	*p*-value
Group 1: Short E-glass fibers	25	420,174	103,435	191,779	555,600	
Group 2: Polyethylene ribbon	25	301,191	47,742	202,926	411,769	0.0000002

Note. Independent samples *t*-test; significance threshold $p < 0.05$.

Примечание. Независимый *t*-тест для сравнения выборок; пороговое значение значимости $p < 0{,}05$.

DISCUSSION

The present study found that short E-glass fiber-reinforced composite exhibited significantly higher mean fracture resistance (1196.92 N) than polyethylene ribbon-reinforced composite (1028.36 N), with a difference of ~168.56 N ($p < 0.0001$). This aligns with recent findings where EverX Posterior outperformed Ribbond in fracture resistance in structurally compromised molars [11] and in MOD endodontically treated teeth [12]. Researchers also observed that polyethylene in a "wallpapering" technique outperformed other methods in premolar restorations [13]. The woven polyethylene may better absorb energy in certain geometries, while E-glass fibers offer higher stiffness in direct load-bearing restorations.

Short E-glass fiber-reinforced composites exhibited significantly higher tensile strength (49.69 MPa) compared to polyethylene ribbon-reinforced composites (45.36 MPa, $p = 0.00044$), suggesting enhanced load distribution and interfacial bonding. Recent findings by Hadianto et al. reported a similar trend, where E-glass fiber reinforcement showed superior tensile strength after prolonged exposure to artificial saliva, supporting its suitability in oral environments [14]. Patel and Jain also observed higher tensile values in E-glass composites compared to natural fiber counterparts [15]. Conversely, Miah et al. found that under weld-line conditions in polyethylene terephthalate matrices, short glass fibers could experience notable tensile strength reductions, indicating that processing factors may reverse the advantage seen in the current study [16].

Short E-glass fiber–reinforced composites also showed a markedly higher fatigue limit (420,174 cycles) than polyethylene ribbon–reinforced composites (301,191 cycles), indicating superior endurance under repeated loading. Molnár et al., reported that flowable short fiber–reinforced composites in endodontically treated molars demonstrated significantly higher fatigue survival compared to other restorative materials, reinforcing the durability advantage of short fiber systems [17]. Conversely, Volom et al. reported higher survival in polyethylene fiber systems with cuspal coverage, indicating that under specific configurations, polyethylene fibers may outperform glass fibers [18]. These discrepancies may be due to differences in fiber orientation, matrix composition, and load application mode.

CONCLUSIONS

Short E-glass fiber reinforcement consistently outperformed polyethylene ribbon reinforcement in all tested mechanical properties, including fracture resistance, tensile strength, and fatigue limit. Within the limits of this study, sFRC appears to be the preferred choice for reinforcing restorations subjected to high occlusal forces.

REFERENCES / СПИСОК ЛИТЕРАТУРЫ

1. Neri H., Aripin D., Muryani A., Dharsono H.D.A., Yolanda Y., Mahyuddin A.I. Stress Analysis on Mesiolingual Cavity of Endodontically Treated Molar Restored Using Bidirectional Fiber-Reinforced Composite (Wallpapering Technique). *Clin Cosmet Investig Dent*. 2024;16:75–89. https://doi.org/10.2147/CCIDE.S450325
2. Saravia-Rojas M.A., Espinoza-Jiménez G., Huanambal-Tiravanti V.A., Geng-Vivanco R. Restoration of a vital tooth with extensive crown destruction using glass fiber and polyethylene fiber-reinforced composite resin: A clinical case. *Oper Dent.* 2023;48(5):476–482. https://doi.org/10.2341/22-127-S
3. Soto-Cadena S.L., Zavala-Alonso N.V., Cerda-Cristerna B.I., Ortiz-Magdaleno M. Effect of short fiber-reinforced composite combined with polyethylene fibers on fracture resistance of endodontically treated premolars. *J Prosthet Dent*. 2023;129(4):598.e1–598.e10. https://doi.org/10.1016/j.prosdent.2023.01.034
4. Escobar L.B., Pereira da Silva L., Manarte-Monteiro P. Fracture resistance of fiber-reinforced composite restorations: A systematic review and meta-analysis. *Polymers*. 2023;15(18):3802. https://doi.org/10.3390/polym15183802
5. Mangoush E., Garoushi S., Lassila L., Vallittu P.K., Säilynoja E. Effect of fiber reinforcement type on the performance of large posterior restorations: A review of in vitro studies. *Polymers*. 2021;13(21):3682. https://doi.org/10.3390/polym13213682
6. Bijelic-Donova J., Bath A.K., Rocca G.T., Bella E.D., Saratti C.M. Can fiber-reinforced composites increase the fracture resistance of direct composite restorations in structurally compromised teeth? A systematic review and meta-analysis of laboratory studies. *Oper Dent*. 2025;50(1):E1–E29. https://doi.org/10.2341/24-032-LIT
7. Tanaka C.B., Ershad F., Ellakwa A., Kruzic J.J. Fiber reinforcement of a resin modified glass ionomer cement. *Dent Mater*. 2020;36(12):1516–1523. https://doi.org/10.1016/j.dental.2020.09.003
8. Mohamed M.H., Abouauf E.A., Mosallam R.S. Clinical performance of class II MOD fiber reinforced resin composite restorations: an 18-month randomized controlled clinical trial. *BMC Oral Health*. 2025;25(1):159. https://doi.org/10.1186/s12903-025-05521-5
9. Ferrando Cascales Á., Andreu Murillo A., Ferrando Cascales R., Agustín-Panadero R., Sauro S., Carreras-Presas C.M., Hirata R., Lijnev A. Revolutionizing restorative dentistry: The role of polyethylene fiber in biomimetic dentin reinforcement-insights from in vitro research. *J Funct Biomater*. 2025;16(2):38. https://doi.org/10.3390/jfb16020038
10. Psarri C., Kourtis S. Effect of fiber-reinforcement on the strength of polymer materials for provisional restorations: An in vitro study. *J Esthet Restor Dent*. 2020;32(4):433–440. https://doi.org/10.1111/jerd.12586
11. Mohammadipour H.S., Farajzadeh M., Toutouni H., Gazerani A., Sekandari S. Fracture resistance of fiber-reinforced vs. conventional resin composite restorations in structurally compromised molars: An in vitro study. *Int J Dent*. 2025;2025:5169253. https://doi.org/10.1155/ijod/5169253
12. Selvaraj H., Krithikadatta J. Fracture resistance of endodontically treated teeth restored with short fiber reinforced composite and a low viscosity bulk fill composite in class ii mesial-occlusal-distal access cavities: An ex-vivo study. *Cureus*. 2023;15(8):e42798. https://doi.org/10.7759/cureus.42798
13. Abdulamir S.W., Majeed M.A. Fracture resistance of endodontically treated maxillary premolar teeth restored with wallpapering technique: A comparative in vitro study. *Int J Dent*. 2023;2023:6159338. https://doi.org/10.1155/2023/6159338
14. Hadianto E., Santoso L.A., Ratnawati I.D., Suhartono B. The effect of immersion duration of non-dental glass fiber reinforced composite in artificial saliva on tensile strength. *Odonto: Dental Journal*. 2024;11(2):259–265. https://doi.org/10.30659/odj.11.2.259-265
15. Patel N., Jain P. To study and evaluate the tensile strength, impact strength and flexural strength of randomly oriented short banana and e-glass fiber composite materials. *Nanotechnol Percept.* 2024;20(S14):2007–2022. https://doi.org/10.62441/nano-ntp.vi.3064
16. Miah S., Yu J., Yang Y., Pang Y., Wang X., Yu L., Yang Y. Time-temperature-dependent mechanical durability analysis of short (glass) fiber-reinforced polyethylene terephthalate injection molding composites with weld line. *Text Res J*. 2022;92(11-12):1923–1939. https://doi.org/10.1177/00405175211069877
17. Witzgall C., Gadinger M., Wartzack S. Fatigue behaviour and its effect on the residual strength of long-fibre-reinforced thermoplastic PP LGF30. *Materials*. 2023;16(18):6174. https://doi.org/10.3390/ma16186174
18. Volom A., Vincze-Bandi E., Sáry T., Alleman D., Forster A., Jakab A. et al. Fatigue performance of endodontically treated molars reinforced with different fiber systems. *Clin Oral Investig*. 2023;27(6):3211–3220. https://doi.org/10.1007/s00784-023-04934-2

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AUTHOR'S CONTRIBUTION

The author made a substantial contribution to the preparation of the manuscript, including the conception and design of the study, data collection, analysis and interpretation of data, critical revision of the article for important intellectual content, and final approval of the version to be published.

ВКЛАД АВТОРОВ

Автор внес существенный вклад в подготовку рукописи, включая разработку замысла и дизайна исследования, сбор, анализ и интерпретацию данных, критический пересмотр статьи с точки зрения значимого интеллектуального содержания и окончательное одобрение версии для публикации.