Journal of Medical and oral biosciences
ISSN (Online): 3007-9551
ISSN (Print): 3007-9543

JMOB
Open Access DOAJ

IRAQI Academic Scientific Journals

Type: Narrative Review article
Publish online: 01 / 03 / 2026

New-Generation Flowable Bulk-Fill Composites as Stand-Alone Posterior Restorations: A Narrative Review

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OPEN ACCESS

ARTICLE INFO

Received: 12 / 01 /2026
Revised: 20 / 01/ 2026
Accepted: 31 / 01 / 2026
Publish online: 01 / 03 / 2026
Plagiarism percentages at publication: 12 %

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CITATION

Dana Issa Ahmed, Rasha H. Jehad. (2026). New-Generation Flowable Bulk-Fill Composites as Stand-Alone Posterior Restorations: A Narrative Review. JMOB. 3;(1): 21-37.
https://doi.org/10.58564/jmob.123

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Abstract

Restoration of endodontically treated posterior teeth **with** extensive mesio-occluso-distal (MOD) cavities remains a clinical challenge because of substantial loss of tooth structure and increased susceptibility to cuspal deflection and fracture. Bulk-fill resin composites were introduced to simplify restorative procedures while reducing polymerization shrinkage stress and improving biomechanical behavior. Flowable bulk-fill composites were initially indicated as stress-relieving base materials because of their lower filler content and elastic modulus. However, newer-generation formulations exhibit modified filler loading, optimized elastic modulus, and increased curing depth, allowing their use as stand-alone restorative materials in posterior teeth. This narrative review examined recent evidence describing the mechanical behavior of bulk-fill composites in posterior restorations. Particular attention was directed toward cuspal deflection, polymerization effects, fracture resistance, and clinical applicability in large MOD cavities. Electronic database screening was performed using PubMed, Scopus, and Google Scholar. Eligible studies included laboratory investigations evaluating posterior Class II or MOD cavities restored with bulk-fill composites. Studies based on non-posterior cavity designs, conventional non–bulk-fill materials, or incomplete methodological descriptions were not considered. Reported outcomes included cuspal deflection behavior, polymerization shrinkage effects, fracture resistance, marginal adaptation, and restorative variables. In conclusion, this narrative review indicated that flowable bulk-fill composites generally exhibit reduced polymerization shrinkage stress and lower cuspal deflection compared with conventional composite techniques. New-generation flowable bulk-fill materials demonstrate improved biomechanical performance relative to earlier formulations and, in selected MOD cavity designs, approach the behavior of packable bulk-fill composites. Although favorable results have been reported, variability in study design and testing protocols remains evident. New-generation flowable bulk-fill composites may therefore be considered a viable stand-alone option for selected posterior MOD cavities, provided that cavity configuration, material selection, and clinical technique are carefully controlled.

Keywords: MOD cavities; cuspal deflection; bulk-fill composites; flowable bulk-fill; packable bulk-fill; fracture resistan

Introduction

Endodontically treated posterior teeth are more susceptible to biomechanical failure than vital teeth due to the loss of structural integrity following caries removal, endodontic access preparation, and restorative procedures. This structural loss markedly reduces tooth stiffness, particularly in teeth with extensive (MOD) cavities, thereby increasing the risk of cuspal deflection and fracture under functional loading (1,2).

Cuspal deflection is a clinically relevant phenomenon resulting from polymerization shrinkage stresses generated during resin composite curing. These stresses may induce inward movement of the cusps. This process contributes to marginal gap formation, enamel cracks, postoperative sensitivity, and reduced fracture resistance(3–5). Although conventional incremental layering techniques were developed to reduce polymerization shrinkage stress, they remain technique-sensitive and time-consuming, especially in large posterior restorations(6). Bulk-fill resin composites were introduced to simplify restorative procedures by allowing placement of thicker increments, typically up to 4–5 mm, while maintaining adequate depth of cure and acceptable mechanical properties (7). Flowable bulk-fill composites, in particular, exhibit a lower elastic modulus and modified resin matrices, which may enhance stress absorption during polymerization and reduce cuspal deflection (8–10). Several *In-vitro* studies have demonstrated that flowable bulk-fill materials can produce more favorable stress distribution and reduced cuspal movement in MOD cavities compared with conventional composite techniques (4,11,12). In contrast, packable (high-viscosity) bulk-fill composites contain higher filler loading and exhibit a higher elastic modulus, these characteristics contribute to improved fracture resistance and suitability for occlusal load-bearing areas. However, their increased stiffness may lead to greater transmission of polymerization shrinkage stress to the remaining tooth structure, particularly in wide MOD cavities(13–15). Accordingly, understanding the balance between reducing stress and strengthening the structure is important when choosing bulk-fill materials for single posterior restorations. Recent improvements in flowable bulk-fill resin composites have increased their use as stand-alone posterior restorations. Omnichroma, a supra-nanofilled flowable bulk-fill composite , is part of this new generation. It is claimed to have better mechanical properties, good depth of cure, and easier shade matching using structural color technology. Recent laboratory studies suggest promising biomechanical performance of Omnichroma in posterior restorations. However, evidence regarding its fracture resistance, marginal adaptation, and long-term behavior in extensive MOD cavities remains limited, inconsistent, and methodologically heterogeneous (16,17).

Therefore , the aim of this narrative review is to analyze and synthesize the most recent evidence on flowable bulk-fill resin composites, with particular emphasis on new-generation materials such as Omnichroma. The review focuses on their mechanical behavior, cuspal deflection, fracture resistance, and clinical applicability as stand-alone posterior restorations in MOD cavities, in order to support evidence-based clinical decision-making and identify existing knowledge gaps.

Methodology

This review was conducted as a narrative literature analysis, rather than a systematic review, because of substantial heterogeneity among available studies in terms of study design, cavity preparation, restorative protocols, and outcome assessment methods. A narrative approach was therefore considered more appropriate to allow comprehensive synthesis and critical appraisal of experimental evidence on the biomechanical behavior of flowable and packable bulk-fill resin composites in MOD restorations. Due to this heterogeneity, quantitative meta-analysis was not feasible, and findings were analyzed descriptively and comparatively .

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Search strategy

A structured and transparent search strategy was applied to ensure comprehensive coverage of relevant literature, electronic searches were conducted in PubMed, Scopus, Web of Science, Embase, and Google Scholar. Search terms included "bulk-fill composite," "flowable bulk-fill," "cuspal deflection," "shrinkage stress," "MOD cavity," and "fracture resistance," used individually or combined with Boolean operators .
Studies were not limited by publication year in order to include both earlier and recent research on bulk-fill composite behavior. Only articles published in English were considered.
Screening was performed in two stages. Titles and abstracts were reviewed first, followed by full-text evaluation of studies addressing posterior Class II or MOD restorations. Included investigations assessed flowable or packable bulk-fill composites and reported outcomes such as cuspal deflection, polymerization shrinkage stress, marginal integrity, or fracture resistance.

Study Selection Criteria

Inclusion criteria were defined as a priori. Studies were included if they employed MOD or standardized Class II cavity designs and either directly compared flowable and packable bulk-fill composites or provided extractable biomechanical data relevant to both material categories, with outcomes such as cuspal deflection, shrinkage stress, fracture resistance, or marginal integrity.
Studies were excluded when cavity designs deviated from standardized posterior preparations. Investigations limited to conventional resin composites, without bulk-fill comparison, were not retained. Reports lacking essential methodological description , including cavity dimensions, curing conditions, or measurement procedures were omitted. Narrative publications and review-based articles were not considered for analysis. Review articles were excluded from synthesis but consulted for contextual background when relevant (Figure. 1).

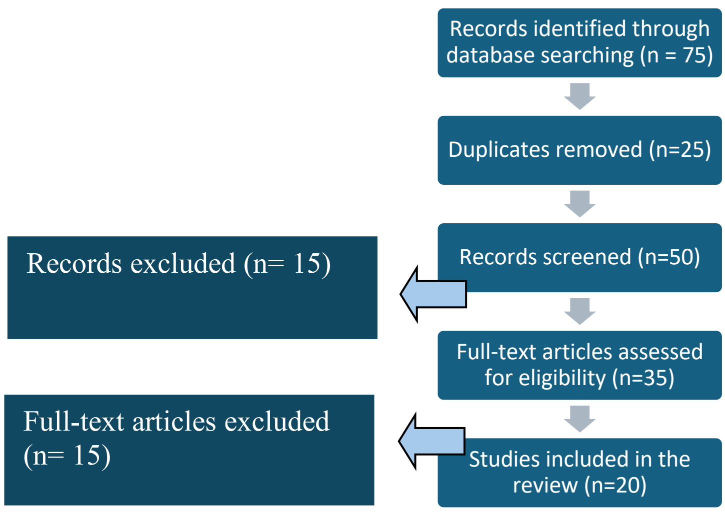

Figure.1. PRISMA flow diagram illustrates the study selection process for the present narrative review.

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Data Extraction and Quality Assessment

Data extraction was performed manually, it included information on tooth type, cavity design, restorative materials, curing protocols, measurement methods, and primary outcomes.

Methodological differences between studies are limited by quantitative synthesis. Findings were therefore organized by the outcome domains, including cuspal deflection, fracture resistance, and marginal behavior, to support qualitative comparison.

Risk of bias was assessed descriptively. The studies that used standardized cavity preparations, controlled curing conditions, and validated measurement techniques were prioritized during analysis. The limitation that are related to laboratory-based experimental designs were recognized. Representative studies are summarized in Table **1.**

Table 1. Summary of the selected studies evaluating flowable and packable bulk-fill composites in MOD cavities

Author (Year)	Study Type	Tooth / Cavity Design	Materials Compared	Main Findings
(1)	*In-vitro*	Posterior teeth, MOD	Direct vs indirect restorations	Extensive MOD cavity preparation significantly compromised the biomechanical integrity and fracture resistance of posterior teeth
(3)	*In-vitro*	Endodontically treated premolars, MOD	Flowable bulk-fill vs packable	Flowable bulk-fill reduced cuspal deflection but showed lower fracture resistance
(5)	*In-vitro*	Premolars, MOD	Bulk-fill composites	Flowable bulk-fill showed more gradual and lower cuspal displacement
(8)	*In-vitro*	Premolars, MOD	Intermediary layer vs no liner	Use of an intermediary layer significantly reduced cuspal deflection and gap formation
(10)	*In-vitro*	Premolars, MOD	Bulk-fill flowable vs conventional	Flowable bulk-fill showed lower cuspal strain
(11)	*In-vitro*	Class II MOD	Flowable vs packable bulk-fill	Flowable materials produced more favorable stress distribution
(12)	*In-vitro*	Molars, MOD	Bulk-fill vs incremental	Packable bulk-fill showed higher fracture resistance but increased shrinkage stress
(15)	*In-vitro*	Large MOD	Bulk-fill vs CAD/CAM	Bulk-fill restorations showed acceptable structural integrity
(18)	*In-vitro*	Class II MOD	Flowable liner vs bulk-fill	Flowable liners reduced shrinkage vectors
(6)	*In-vitro*	MOD cavities	Flowable vs packable bulk-fill	Packable materials induced higher cuspal deflection during curing
(19)	Micro-CT	Class II	Different viscosities	Flowable bulk-fill improved marginal adaptation
(20)	*In-vitro*	Molars, MOD	Low- vs high-viscosity bulk-fill	High-viscosity materials showed superior fracture strength

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(21)	*In-vitro*	Molars, MOD	Flowable bulk-fill vs packable	Packable bulk-fill showed higher fracture resistance after aging
(22)	*In-vitro*	Deep MOD	Fiber-reinforced vs bulk-fill	Stiffer restorations increased crack propagation

Biomechanical Considerations and Material Selection in MOD Cavities

Endodontically treated posterior teeth with extensive MOD cavities show reduced structural integrity. Loss of marginal ridges and internal dentin lowers tooth stiffness and weakens cuspal support, increasing susceptibility to deformation and fracture during polymerization and functional loading (1,2).

MOD cavities are particularly sensitive to cuspal deflection due to their geometric characteristics. Wide isthmus dimensions, a high configuration factor (C-factor), and reduced remaining dentin thickness promote inward cusp movement during polymerization. Reported consequences include marginal discrepancies, enamel microcracks, postoperative sensitivity, and reduced fracture resistance.(3–5). Therefore, cavity geometry plays a key mechanical role in restoration behavior. (1,6,12,23). The properties of restorative materials influence stress transmission within the tooth–restoration complex. Increased cavity width and reduced dentin support increase cuspal deformation across different material types. Composites with a higher modulus tend to transmit greater polymerization and functional stresses to weakened cusps, increasing the risk of structural damage (1,4,24).

Polymerization behavior is also influenced by curing conditions. High-intensity protocols accelerate stress development, whereas soft-start and ramp curing approaches reduce cuspal movement by moderating early stress buildup (6,19). Therefore, restoration stability in MOD cavities requires a balance between shrinkage stress control and adequate mechanical strengt (12,25). Flowable bulk-fill composites have a lower elastic modulus and show improved cavity adaptation. Reduced cuspal deflection has been frequently observed, particularly in wide MOD cavities (9,10). Smaller inward cusp movement was reported when flowable materials were used as a base layer (5,9,24). Lower stiffness was associated with decreased fracture resistance in large cavities. For this reason, flowable bulk-fill composites were more frequently applied as intermediary layers (7,13,18).

Packable bulk-fill composites demonstrated greater post-curing stiffness and fracture resistance, largely related to higher filler loading (4,26). Greater material rigidity, however, was accompanied by increased cuspal displacement during polymerization, particularly in wide MOD cavities (1,6). For this reason, layered restorative configurations incorporating flowable bases are commonly adopted (15,18).
Omnichroma flowable bulk-fill composite has been introduced as a supra-nanofilled material with enhanced mechanical characteristics and adequate depth of cure (13,14). In MOD cavities, its lower modulus may contribute to moderated stress behavior during polymerization. Layered application beneath packable occlusal materials may therefore represent a mechanically rational approach.
Material stiffness affects stress distribution in MOD restorations. Composites with higher elastic modulus may concentrate stress along cavity walls and near cusp bases. Flowable

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materials, because of lower stiffness, tend to distribute stress more gradually within the restoration (1,6,25). These differences are more noticeable in wide MOD cavities and when dentin support is reduced (5,25).
Curing direction also affects shrinkage behavior. Uneven polymerization can result in asymmetric cusp movement, as observed in laboratory and simulation studies (3,25).
Adhesive layer thickness influences stress transfer at the tooth–restoration interface.
Thicker adhesive layers may reduce stress transmission compared with thinner layers (8,18,25,27,28)
The use of compliant intermediary layers has been reported to reduce gap formation and cuspal deformation in high C-factor MOD cavities (29,30)

Results

Structural Integrity and Failure Characteristics

Flowable bulk-fill composites have frequently shown lower cuspal deflection during polymerization compared with packable materials. Reported values varied between studies due to differences in measurement methods, cavity design, and curing protocols (5,8,24). When a flowable base was used, inward cusp movement was generally reduced. Packable bulk-fill composites demonstrated good mechanical properties after curing. During polymerization, however, greater cuspal movement was often observed in MOD restorations using these materials. This behavior has been linked to higher stiffness and reduced stress relaxation capacity (6,10,31).
In general, flowable materials were associated with lower cusp displacement during the setting phase. Packable composites, although showing greater movement during polymerization, exhibited higher stiffness and strength after curing (32,33).

Influence of Curing Protocols

Curing protocol affects cuspal deflection. High-intensity light application may increase shrinkage stress and lead to greater cusp movement. This effect appears more evident in packable bulk-fill composites (6,34). Flowable materials tend to show lower sensitivity to curing-related stress development.
Soft-start and ramp curing protocols produced lower cuspal displacement values. The slower polymerization rate likely reduced early stress development (18,35,36).
Recent investigations highlighted the influence of curing distance on polymerization quality. Increasing light-curing distance resulted in a significant reduction in surface microhardness of flowable bulk-fill composites, particularly in thicker increments (37). Similarly, LED curing characteristics significantly affected depth of cure and microhardness, with variations in light output and composite formulation influencing polymerization efficiency at deeper levels (38).
Curing distance and light direction influenced shrinkage behavior. Increased curing distance and multidirectional light application were linked to more uniform stress patterns. Excessive curing distance, however, increased the likelihood of insufficient polymerization in deep MOD cavities(26,34,39). Curing technique therefore represents an important procedural variable in polymerization stress development.

Fracture Resistance

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Most studies reported higher fracture resistance for packable bulk-fill composites compared to flowable bulk-fills used alone in MOD restorations(1,3,4,12,30). This finding was consistently associated with higher filler loading and elastic modulus of packable materials. Flowable bulk-fills exhibited lower fracture resistance when used as stand-alone restorations in large MOD cavities. Fracture resistance increased when flowable bulk-fill composites were used as a base beneath a packable occlusal layer. Reported values frequently approached those of packable bulk-fill restorations placed alone (7,13,18).

Fracture Mode Characteristics

Flowable bulk-fill restorations were more frequently associated with restorable fracture patterns, such as supra-CEJ fractures or superficial cracks, whereas packable bulk-fills demonstrated a higher incidence of catastrophic, non-restorable fractures extending below the CEJ (1,3,12,40–42).

Effect of Remaining Tooth Structure

Fracture resistance was strongly influenced by the amount of remaining tooth structure. Wide isthmus preparations and reduced cusp thickness produced lower resistance values across different restorative conditions. This trend was observed irrespective of the composite material used(12,41).

Marginal Integrity and Microleakage

Flowable bulk-fill composites demonstrated superior initial marginal adaptation, particularly in deep proximal areas, due to improved flow and cavity wall adaptation (8,27,28), Packable bulk-fills showed increased marginal gaps and microleakage when used without an intermediary layer, especially after aging procedures (27,31,43). Packable materials demonstrated greater marginal stability under functional loading. Lower gap progression was reported during mechanical cycling (13).

Instrument-based assessments, including spectrophotometric methods and micro-CT analysis, revealed differences in marginal sealing behavior among restorative materials. Improved sealing performance was frequently observed when stress-moderating layers were incorporated (9,28,44)

Seal Quality and Gap Formation

Flowable liners or bases have consistently been shown to improve seal quality. The presence of a compliant intermediary layer was associated with reduced gap formation at the tooth–restoration interface, including occlusal regions subjected to polymerization stress (8,26). The same trend was reported in the micro-CT studies, where flowable liners reduced the horizontal gap at the gingival margin(9,28).

Packable-only restorations tend to show more gaps after thermomechanical loading, particularly at high-stress concentration sites.

Microcrack Formation and Fatigue Behavior

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Material stiffness influenced microcrack initiation and propagation. Packable bulk-fills were associated with deeper structural cracks at cusp bases and internal line angles, whereas flowable bulk-fills tended to produce more superficial enamel cracks or internal material defects (8,9,26,28).

Lower-modulus materials demonstrated improved fatigue behavior by partially attenuating occlusal loading; however, However, use without occlusal reinforcement was associated with increased material fatigue over prolonged loading cycles (4,45,46) Environmental degradation further affected performance; cyclic exposure to acidic environments reduced surface microhardness and increased surface roughness, accelerating material fatigue and marginal breakdown in stress-bearing MOD restorations.

Crack Propagation and Reinforcement Strategies

Material stiffness influences crack development within restored teeth. Composites with higher elastic modulus tend to allow deeper crack extension into the tooth structure. Flowable materials, due to lower stiffness, are more commonly associated with superficial crack patterns (25,42).

Fiber reinforcement has also been evaluated as a stress-control strategy. Placement of E-glass fibers in MOD cavities restored with bulk-fill composites has been reported to reduce cuspal deflection, especially during the early post-restoration phase. Differences in microleakage appear limited; however, fiber-reinforced restorations generally show lower leakage values compared with bulk-fill composites used alone (47).

Discussion

Clinical Interpretation and Evidence Integration

Clinical data on bulk-fill composites in MOD restorations are still limited. Most of the available evidence comes from laboratory studies. These studies usually use thermocycling and cyclic loading to simulate oral conditions.

Clinical investigations mainly report restoration survival. Detailed biomechanical outcomes, such as cuspal deflection or stress distribution, are rarely evaluated in clinical settings (34,48).

Short-term clinical reports generally show acceptable performance for both flowable and packable bulk-fill restorations when placed according to manufacturer instructions.

Although long-term prospective trials remain scarce, indirect evidence suggests that restorations surviving the early phase—during which polymerization stress and cuspal movement are most influential—exhibit behavior comparable to conventional posterior composites(12,13).

Packable bulk-fill composites exhibited favorable behavior under higher functional loading conditions, a finding commonly linked to increased fracture resistance. Restorations incorporating a flowable base were more frequently associated with improved initial marginal adaptation and reduced early marginal discrepancies (16,34).

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Short-term performance was favorable across both material categories. Cyclic loading and simulated chewing studies indicated that bulk-fill restorations tolerated early functional stresses without evident structural deterioration (4,34,45).

Long-term behavior is less predictable, as crack propagation, marginal degradation, and material fatigue develop progressively. Laboratory observations suggest that higher-modulus packable materials may be associated with deeper structural crack patterns, whereas flowable materials more frequently exhibit superficial wear or cohesive defects, Laboratory fatigue models and finite element simulations provide useful mechanical insight. Their translation to clinical behavior, however, remains uncertain (10,12,22).

Factors Influencing Clinical and Biomechanical Outcomes

The biomechanical behavior of MOD restorations is affected by several interacting variables. The cavity geometry, remaining tooth structure, loading conditions, and restorative technique all of it contribute to stress distribution and failure patterns (6,12,25)

Cavity size (isthmus width, cusp height)

Cavity size affects the mechanical behavior of MOD restorations. Wide isthmus designs reduce cuspal support and make the tooth more prone to deformation during polymerization and functional loading.

Reduced enamel thickness or loss of cusp structure further increases stress within the tooth. This may contribute to marginal breakdown and the formation of enamel microcracks (6,12,25).

Remaining dentin thickness

Remaining dentin thickness affected fracture resistance, Increased dentin support improved structural stability, whereas reduced dentin thickness was linked to greater deformation and lower resistance values (4,24,41).

Occlusal loading

Occlusal loading affects the behavior of restorations in MOD cavities. The mechanical response depends mainly on material stiffness and the condition of the remaining cusps. Packable composites generally resist deformation more effectively because of higher elastic modulus. However, increased stiffness may also lead to greater stress transfer to weakened tooth structure.

Flowable bulk-fill composites exhibit lower stiffness and tend to distribute functional stresses more gradually. This may reduce stress concentration within the tooth. Nevertheless, when used without sufficient occlusal support, these materials may show greater wear or fatigue-related changes over time(10,42).

Operator technique

Operator technique plays a role in restoration outcomes. The way the material is placed and the adhesive is applied can influence internal adaptation and marginal fit. Differences in handling may lead to variations in marginal integrity and gap formation (8,28,42).

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Curing light intensity and direction

Curing conditions affect polymerization behavior. High-intensity curing increases the speed of polymerization and may result in greater cusp movement, especially in stiffer composites. Soft-start or ramp curing protocols are often used to reduce this effect.
Light direction also influences shrinkage patterns. Applying light from different directions may help distribute stresses more evenly within the restoration (7,26).

Practical Clinical Recommendations

Material selection in MOD restorations should be based on cavity configuration and functional demand rather than composite category alone.

When to prefer flowable bulk-fill

Flowable bulk-fill composites are frequently used in deeper cavity regions and complex preparations. Because of lower stiffness, they may help reduce polymerization-related stresses when placed as a base under stronger occlusal materials (8,11,24).

When to prefer packable bulk-fill

Packable bulk-fill composites are generally preferred in occlusal load-bearing regions. Higher filler content and stiffness improve resistance to functional loading. Clinical use is often combined with a flowable intermediary layer(1,4,26).

Techniques to reduce cuspal deflection

Cuspal deflection is influenced by cavity configuration. Preservation of marginal ridges and conservative cavity preparation may reduce cuspal movement. The use of flowable intermediary layers may also help moderate polymerization effects (1,18).

Best curing protocols

Curing protocols affect polymerization behavior. Soft-start and ramp curing techniques are frequently recommended to reduce shrinkage-related stresses. Multidirectional light application may improve curing uniformity in deeper MOD cavities(5,26).

Adhesive strategies

Adhesive technique influences restoration stability and marginal adaptation. Multi-step adhesive systems and appropriate use of flowable liners may improve interfacial integrity (19,42,49)

Limitations

Several limitations should be noted when interpreting the findings of this review. Most of the included studies were laboratory investigations and do not fully reproduce clinical conditions.

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Variation in study design, cavity preparation, restorative procedures, curing protocols, and outcome measurements made direct comparison difficult.
Long-term clinical evidence on flowable bulk-fill composites in large stress-bearing MOD cavities remains limited. Current understanding is therefore mainly based on laboratory findings.

Future Research Directions

Differences in experimental protocols continue to limit comparison between studies, especially in relation to cuspal deflection measurements. Greater standardization of testing methods would improve consistency.
Future investigations may combine cyclic mechanical loading with environmental factors, such as thermal changes or acidic exposure, to better simulate oral conditions.
Additional clinical studies with longer follow-up periods are required to evaluate restoration longevity and failure patterns. Newly developed bulk-fill materials also need further investigation.

Conclusion

Restoration of large MOD cavities remains mechanically demanding because of polymerization shrinkage and stress concentration within the remaining tooth structure. Bulk-fill composites simplify placement and provide adequate depth of cure.
Restorative configuration plays an important role in mechanical behavior. The use of a flowable base beneath a packable occlusal layer may help reduce stress while maintaining structural support.
New-generation flowable bulk-fill composites show promising mechanical performance when combined with appropriate cavity design, adhesive strategy, and curing technique.

Declarations

Acknowledgment
None

Ethics statement
Ethics statement: The authors declare that this study was conducted in accordance with the ethical standards and guidelines outlined in the journal's "Ethics Approval" section of the author guidelines. As this work is a narrative review, formal ethical approval was not required.

Funding
The authors declare that this research received no external funding.

Competing interest's statement
The authors declare that they have no competing interests.

Author contributions

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DIA and RHJ provided the concepts, data analysis, and writing of the manuscript; DIA and RHJ worked with data collection and analysis; RHJ revised the manuscript and analyzed the data.

References

1. Tsertsidou V, Mourouzis P, Dionysopoulos D, Pandoleon P, Tolidis K. Fracture Resistance of Class II MOD Cavities Restored by Direct and Indirect Techniques and Different Materials Combination. Polym 2023, Vol 15, [Internet]. 2023 Aug 15 [cited 2025 Dec 16];15(16). Available from: https://www.mdpi.com/2073-4360/15/16/3413

2. Özüdoğru S, Tok S, Düzyol M, Erdem RZ, Arslan H. Fracture Resistance of Endodontically Treated Teeth Restored with Preheated Short Fiber-Reinforced Composite and Preheated Composite Resin. Mater 2025, Vol 18, [Internet]. 2025 Nov 12 [cited 2026 Jan 27];18(22). Available from: https://www.mdpi.com/1996-1944/18/22/5145

3. Toz T, Tuncer S, Bozkurt FÖ, Kara Tuncer A, Gözükara Baɪ H. The effect of bulk-fill flowable composites on the fracture resistance and cuspal deflection of endodontically treated premolars. J Adhes Sci Technol [Internet]. 2015 Aug 3 [cited 2025 Dec 16];29(15):1581–92. Available from: https://www.tandfonline.com/doi/abs/10.1080/01694243.2015.1037381

4. Guerra L, Ramos RQ, Linhares LA, Bernardon JK, Favero SS, César PF, et al. Fracture Load of Molars Restored with Bulk-fill, Flowable Bulk-fill, and Conventional Resin Composite After Simulated Chewing. Oper Dent [Internet]. 2023 May 1 [cited 2025 Dec 16];48(3):294–303. Available from: https://pubmed.ncbi.nlm.nih.gov/36656317/

5. Vinagre A, Ramos J, Alves S, Messias A, Alberto N, Nogueira R. Cuspal Displacement Induced by Bulk Fill Resin Composite Polymerization: Biomechanical Evaluation Using Fiber Bragg Grating Sensors. Int J Biomater [Internet]. 2016 Jan 1 [cited 2025 Dec 16];2016(1):7134283. Available from: /doi/pdf/10.1155/2016/7134283

6. Santis R De, Lodato V, Gallicchio V, Prisco D, Riccitiello F, Rengo S, et al. Cuspal Deflection and Temperature Rise of MOD Cavities Restored through the Bulk-Fill and Incremental Layering Techniques Using Flowable and Packable Bulk-Fill Composites. Mater 2020, Vol 13, [Internet]. 2020 Dec 11 [cited 2025 Dec 16];13(24):1–15. Available from: https://www.mdpi.com/1996-1944/13/24/5664

7. Zorzin J, Maier E, Harre S, Fey T, Belli R, Lohbauer U, et al. Bulk-fill resin composites: Polymerization properties and extended light curing. Dent Mater [Internet]. 2015 Mar 1 [cited 2025 Dec 16];31(3):293–301. Available from: https://www.sciencedirect.com/science/article/abs/pii/S0109564114006939

8. Deger C, Özduman ZC, Oglakci B, Eliguzeloglu Dalkilic E. The Effect of Different Intermediary Layer Materials Under Resin Composite Restorations on Volumetric Cuspal Deflection, Gap Formation, and Fracture Strength. Oper Dent [Internet]. 2023 Jan 1 [cited 2025 Dec 16];48(1):108–16. Available from:

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https://pubmed.ncbi.nlm.nih.gov/36445957/

9. Guo Y, Landis FA, Wang Z, Bai D, Jiang L, Chiang MYM. Polymerization stress evolution of a bulk-fill flowable composite under different compliances. Dent Mater [Internet]. 2016 Apr 1 [cited 2025 Dec 16];32(4):578–86. Available from: https://www.sciencedirect.com/science/article/abs/pii/S0109564116000269

10. Shimatani Y, Tsujimoto A, Barkmeier WW, Fischer NG, Nagura Y, Takamizawa T, et al. Simulated Cuspal Deflection and Flexural Properties of Bulk-Fill and Conventional Flowable Resin Composites. Oper Dent [Internet]. 2020 Sep 1 [cited 2025 Dec 16];45(5):537–46. Available from: https://pubmed.ncbi.nlm.nih.gov/32216724/

11. Lins RBE, Aristilde S, Osório JH, Cordeiro CMB, Yanikian CRF, Bicalho AA, et al. Biomechanical behaviour of bulk-fill resin composites in class II restorations. J Mech Behav Biomed Mater [Internet]. 2019 Oct 1 [cited 2025 Dec 16];98:255–61. Available from: https://www.sciencedirect.com/science/article/abs/pii/S1751616119306794

12. Rosatto CMP, Bicalho AA, Veríssimo C, Bragança GF, Rodrigues MP, Tantbirojn D, et al. Mechanical properties, shrinkage stress, cuspal strain and fracture resistance of molars restored with bulk-fill composites and incremental filling technique. J Dent [Internet]. 2015 Dec 1 [cited 2025 Dec 16];43(12):1519–28. Available from: https://www.sciencedirect.com/science/article/abs/pii/S0300571215300476

13. Al-Nahedh HN, Alawami Z. Fracture Resistance and Marginal Adaptation of Capped and Uncapped Bulk-fill Resin-based Materials. Oper Dent [Internet]. 2020 Mar 1 [cited 2025 Dec 16];45(2):E43–56. Available from: https://pubmed.ncbi.nlm.nih.gov/31750801/

14. França FMG, Tenuti JGB, Broglio IP, Paiva LEJ, Basting RT, Turssi CP, et al. Low- and high-viscosity bulk-fill resin composites: a comparison of microhardness, microtensile bond strength, and fracture strength in restored molars. Acta Odontol Latinoam. 2021;34(2):173–82.

15. Papadopoulos C, Dionysopoulos D, Tolidis K, Kouros P, Koliniotou-Koumpia E, Tsitrou EA. Structural Integrity Evaluation of Large MOD Restorations Fabricated With a Bulk-Fill and a CAD/CAM Resin Composite Material. Oper Dent [Internet]. 2018 Nov 16 [cited 2025 Dec 16];44(3):312–21. Available from: https://europepmc.org/article/med/30444690

16. Saad Naser A, Safwat Mustafa D, Ezzeldin Mohamed D. Influence of filling technique on fracture resistance of giomer-restored MOD-cavities. BMC Oral Heal 2025 251 [Internet]. 2025 Sep 19 [cited 2025 Dec 16];25(1):1415-. Available from: https://link.springer.com/article/10.1186/s12903-025-06790-w

17. Alghauli MA, Alqutaibi AY, Al-Gabri RS, Baik AA, Mahrous AM, Bafail A, et al. Effectiveness of horizontal posts to support MOD cavities compared with other restorative approaches in endodontically treated teeth: systematic review with meta-analysis of laboratory studies. BMC Oral Heal 2025 251 [Internet]. 2025 May 21 [cited

CC BY-SA 4.0 Attribution-ShareAlike 4.0
https://creativecommons.org/licenses/by-sa/4.0/

2025 Dec 16];25(1):743-. Available from: https://link.springer.com/article/10.1186/s12903-025-06022-1

18. Kaisarly D, Meierhofer D, El Gezawi M, Rösch P, Kunzelmann KH. Effects of flowable liners on the shrinkage vectors of bulk-fill composites. Clin Oral Investig 2021 258 [Internet]. 2021 Jan 27 [cited 2025 Dec 16];25(8):4927–40. Available from: https://link.springer.com/article/10.1007/s00784-021-03801-2

19. Baltacioğlu İH, Demirel G, Öztürk B, Aydin F, Orhan K. Marginal adaptation of bulk-fill resin composites with different viscosities in class II restorations: a micro-CT evaluation. BMC Oral Heal 2024 241 [Internet]. 2024 Feb 13 [cited 2025 Dec 16];24(1):228-. Available from: https://link.springer.com/article/10.1186/s12903-024-03975-7

20. França, F. M., Tenuti, J. G., Broglio, I. P., Paiva, L. E., Basting, R. T., Turssi CP. Low- and high-viscosity bulk-fill resin composites [Internet]. 2021. [cited 2025 Dec 16]. Available from: https://www.scielo.org.ar/scielo.php?pid=S1852-48342021000200173&script=sci_arttext&tlng=en

21. Wafaie RA, Ahmed B, Mahmoud SH. Fracture resistance of molars with class II MOD cavities restored with bulk-fill, no-cap flowable bulk-fill, and conventional resin composite restorative systems after 6-months water storage. BMC Oral Health. 2025;25(1):1–12.

22. Néma V, Sáry T, Szántó FL, Szabó B, Braunitzer G, Lassila L, et al. Crack propensity of different direct restorative procedures in deep MOD cavities. Clin Oral Investig 2023 275 [Internet]. 2023 Feb 22 [cited 2025 Dec 16];27(5):2003–11. Available from: https://link.springer.com/article/10.1007/s00784-023-04927-1

23. Zou X, Zheng X, Liang Y, Zhang C, Fan B, Liang J, et al. Expert consensus on irrigation and intracanal medication in root canal therapy. Int J Oral Sci [Internet]. 2024;16. Available from: https://consensus.app/papers/expert-consensus-on-irrigation-and-intracanal-medication-zou-zheng/11fbfed95d0d5cf9b63907722b69016d/

24. Elsharkasi MMO. Cuspal Deflection in Premolar Teeth Restored with Bulk-Fill Resin-Based Composite Materials. 2015 [cited 2025 Dec 16]; Available from: https://hdl.handle.net/1805/7318

25. Aregawi WA, Fok ASL. Shrinkage stress and cuspal deflection in MOD restorations: analytical solutions and design guidelines. Dent Mater [Internet]. 2021 May 1 [cited 2025 Dec 16];37(5):783–95. Available from: https://www.sciencedirect.com/science/article/abs/pii/S0109564121000506

26. Kaisarly D, Langenegger R, Litzenburger F, Heck K, El Gezawi M, Rösch P, et al. Effects of application method on shrinkage vectors and volumetric shrinkage of bulk-fill composites in class-II restorations. Dent Mater [Internet]. 2022 Jan 1 [cited 2025 Dec 16];38(1):79–93. Available from: https://www.sciencedirect.com/science/article/abs/pii/S0109564121003079

CC BY-SA 4.0 Attribution-ShareAlike 4.0
https://creativecommons.org/licenses/by-sa/4.0/

27. Boruziniat A, Gharaee S, Shirazi AS, Majidinia S, Vatanpour M. Evaluation of the efficacy of flowable composite as lining material on microleakage of composite resin restorations: A systematic review and meta-analysis. Quintessence Int (Berl) [Internet]. 2016 Feb 1 [cited 2025 Dec 16];47(2):93. Available from: https://openurl.ebsco.com/contentitem/doi:10.3290%2Fj.qi.a35260?sid=ebsco:plink:crawler&id=ebsco:doi:10.3290%2Fj.qi.a35260

28. Nie J, Yap AU, Wang XY. Influence of Shrinkage and Viscosity of Flowable Composite Liners on Cervical Microleakage of Class II Restorations: A Micro-CT Analysis. Oper Dent [Internet]. 2018 Nov 1 [cited 2025 Dec 16];43(6):656–64. Available from: https://pubmed.ncbi.nlm.nih.gov/30142038/

29. Oskoee SS, Oskoee PA, Navimipour EJ, Ajami AA, Zonuz GA, Bahari M, et al. The Effect of Composite Fiber Insertion along with Lowshrinking Composite Resin on Cuspal Deflection of Root-filled Maxillary Premolars. J Contemp Dent Pract [Internet]. 2013 Feb 1 [cited 2025 Dec 16];13(5):595–601. Available from: https://thejcdp.com/abstractArticleContentBrowse/JCDP/19/13/5/2883/abstractArticle/Article

30. Atalay C, Yazici AR, Horuztepe A, Nagas E, Ertan A, Ozgunaltay G. Fracture Resistance of Endodontically Treated Teeth Restored With Bulk Fill, Bulk Fill Flowable, Fiber-reinforced, and Conventional Resin Composite. Oper Dent [Internet]. 2016 Sep 1 [cited 2025 Dec 16];41(5):E131–40. Available from: https://pubmed.ncbi.nlm.nih.gov/27352045/

31. Elshawaf KE, Montaser MA, Ibrahim AA. Complex Class II Bulk-Fill Resin Composite Restoration: Cuspal Deflection and Effect of Water Storage on Microleakage: A Laboratory Study. 2022;9.

32. Webster Duarte R, Caren Somacal D, Rodrigues Braga L, Antonio Borges G, Maria Spohr A. The Open Dentistry Journal Cuspal Deflection and Marginal Integrity of Class II Cavities Restored with Bulk-fill Resin Composites. 2023 [cited 2025 Dec 16];17:187421062309180. Available from: https://opendentistryjournal.com

33. Habeeb LH, Abdul-Ameer ZM. A Comparative in vitro Investigation on the Impact of Fiber Insertion on Cuspal Deflection of Maxillary Premolars Restored with Various Types of Bulk Fill Direct Composite Restorations. Al-Rafidain J Med Sci (ISSN 2789-3219) [Internet]. 2023 Aug 14 [cited 2025 Dec 16];5:143–9. Available from: https://www.ajms.iq/index.php/ALRAFIDAIN/article/view/179

34. Wafaie RA, Ahmed B, Mahmoud SH. Fracture resistance of molars with class II MOD cavities restored with bulk-fill, no-cap flowable bulk-fill, and conventional resin composite restorative systems after 6-months water storage. BMC Oral Heal 2025 251 [Internet]. 2025 May 20 [cited 2025 Dec 16];25(1):741-. Available from: https://link.springer.com/article/10.1186/s12903-025-05951-1

35. Anttila EJ, Krintilä OH, Laurila TK, Lassila LVJ, Vallittu PK, Hernberg RGR. Evaluation of polymerization shrinkage and hydroscopic expansion of fiber-reinforced

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https://creativecommons.org/licenses/by-sa/4.0/

biocomposites using optical fiber Bragg grating sensors. Dent Mater [Internet]. 2008 Dec 1 [cited 2025 Dec 16];24(12):1720–7. Available from: https://www.sciencedirect.com/science/article/abs/pii/S0109564108001966

36. Kaisarly D, El Gezawi M, Keßler A, Rösch P, Kunzelmann KH. Shrinkage vectors in flowable bulk-fill and conventional composites: bulk versus incremental application. Clin Oral Investig 2020 253 [Internet]. 2020 Jul 11 [cited 2025 Dec 16];25(3):1127–39. Available from: https://link.springer.com/article/10.1007/s00784-020-03412-3

37. Alzaidy AA, Abd-Alla MH. The effect of different curing distances on the microhardness of flowable bulk-fill composite materials. J Baghdad Coll Dent. 2023;35(4):20–7.

38. A. MR, Baban LMS. The Effect of LED Light on Depth of Cure and Microhardness of Three Types of Bulkfill Composite. J Baghdad Coll Dent. 2016;28(1):36–40.

39. Yarmohammadi E, Kasraei S, Sadeghi Y. Comparative Assessment of Cuspal Deflection in Premolars Restored with Bulk-Fill and Conventional Composite Resins. Front Dent [Internet]. 2019 [cited 2025 Dec 16];16(6):407. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC7569276/

40. Almuhaiza MS, Magdy NM. Cuspal Deflection and Fracture Resistance in Maxillary Premolar Teeth Restored With Bulk-Fill Flowable Resin-Based Composite Materials. Int J Heal Sci Res [Internet]. 2018 [cited 2025 Dec 16];8:105. Available from: www.ijhsr.org

41. Taha NA, Maghaireh GA, Ghannam AS, Palamara JE. Effect of bulk-fill base material on fracture strength of root-filled teeth restored with laminate resin composite restorations. J Dent [Internet]. 2017 Aug 1 [cited 2025 Dec 16];63:60–4. Available from: https://www.sciencedirect.com/science/article/abs/pii/S0300571217301264

42. Jakab AG, Néma V, Molnár J, Alföldi A, Braunitzer G, Palkovics D, et al. Crack propensity of different fiber-reinforced direct restorative procedures in deep MOD cavities. Dent Mater [Internet]. 2025 Aug 1 [cited 2025 Dec 16];41(8):1034–44. Available from: https://www.sciencedirect.com/science/article/pii/S0109564125006669

43. Kim HJ, Kwon J, Kim HJ, Kim RH, Kim DS, Jang JH. Comparison of polymerization behaviors, microhardness and compressive strength between bulk-fill resin and dual-cured core resin. BMC Oral Health [Internet]. 2025 Dec 1 [cited 2025 Dec 16];25(1):972. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC12220753/

44. Mezaal ZS. A QUANTITATIVE EVALUATION OF APICAL MICROLEAKAGE USING DIFFERENT ENDODONTIC SEALERS WITH SINGLE CONE TECHNIQUE BY SPECTROPHOTOMETRIC ANALYSIS (IN VITRO STUDYA). 2023.

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https://creativecommons.org/licenses/by-sa/4.0/

45. Singhal S, Gurtu A, Singhal A, Bansal R, Mohan S. Effect of Different Composite Restorations on the Cuspal Deflection of Premolars Restored with Different Insertion Techniques- An In vitro Study. J Clin Diagn Res [Internet]. 2017 Aug 1 [cited 2025 Dec 16];11(8):ZC67. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC5620924/

46. Al-Taweel, F. B. H., Madhloom, A. F. & S. The effect of cyclic immersion in cola drinks on the surface microhardness and surface roughness of different composite resin filling materials (In vitro study) A thesis Submitted to the council of College of Dentistry , University of Baghdad In Partial. 2010;

47. Habeeb LH. EFFECTIVNESS OF FIBER INSERTION ON CUSPAL DEFLECTION AND GINGIVAL MARGINAL LEAKAGE OF PREMOLARS RESTORED WITH BULK FILL DIRECT RESTORATIONS (IN VITRO COMPARATIVE STUDY). 2023.

48. Sari C, Bala O, Akgul S, Alp CK. Effect of using different materials and restorative techniques on cuspal deflection and microleakage in endodontically treated teeth. BMC Oral Heal 2025 251 [Internet]. 2025 Feb 25 [cited 2025 Dec 16];25(1):302-. Available from: https://link.springer.com/article/10.1186/s12903-025-05693-0

49. AL-Rubaie AIM, AL-Shamma AMW. Effect of immediate pre-endodontic dentin sealing on the cuspal deflection and fracture strength of endodontically treated teeth. Clin Oral Investig. 2025;29(6).

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