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COMPARATIVE EVALUATION OF BULK-FILL AND INCREMENTAL TECHNIQUES ON MICROLEAKAGE AND MARGINAL ADAPTATION OF COMPOSITE RESTORATIONS: A SYSTEMATIC REVIEW

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Abstract

Background: Polymerization shrinkage remains a challenge in resin composite restorations, potentially compromising marginal adaptation and leading to microleakage. Bulk-fill resin composites have been developed to allow placement in thicker increments to save clinical time, but their performance compared to conventional incremental layering techniques remains debated.

Objective: To systematically review and synthesize current evidence comparing bulk-fill and incremental layering techniques in terms of microleakage, marginal adaptation, internal gap formation, and depth of cure in Class I, II, and V dental restorations.

Methods: Following PRISMA 2020 guidelines, electronic searches of PubMed, Scopus, Web of Science, Embase, and Google Scholar were conducted from January 2006 to July 2025. Eligible studies included in vitro experiments, randomized controlled trials, and systematic reviews comparing bulk-fill and incremental techniques in human teeth. Data were extracted on study design, composite type, cavity class, testing methods, and main outcomes.

Results: Fourteen studies met the inclusion criteria, encompassing various cavity types and composite viscosities. Findings indicate that incremental layering generally provides lower microleakage scores and better internal adaptation than bulk-fill placement, especially in deep proximal restorations. However, no significant differences were reported in some studies when high-quality bulk-fill composites and optimized curing protocols were applied.

Conclusions: While bulk-fill composites can reduce procedural time, incremental layering remains a reliable method for minimizing shrinkage-related gaps and ensuring optimal marginal seal. Clinical decisions should consider cavity configuration, material properties, and curing technique to achieve durable restorations.

Keywords: Bulk-fill composite; Incremental layering; Microleakage; Marginal adaptation; Resin composite restorations; Polymerization shrinkage; Systematic review.

INTRODUCTION

Dental resin composites have steadily replaced amalgam as the primary material for direct posterior restorations due to their superior aesthetics, adhesive properties, and the shift towards minimally invasive dentistry. Yet, despite decades of advancement, the challenge of polymerization shrinkage remains a critical limitation that can compromise the marginal seal and overall longevity of restorations. Even modern nanohybrid composites can undergo volumetric contraction during light curing, generating internal stress that may cause gap formation at the tooth–restoration interface, leading to marginal leakage, discoloration, and recurrent caries if not adequately controlled (Van Ende et al., 2017).

To minimize these shrinkage-related problems, incremental layering techniques have long been advocated as the gold standard in restorative practice. By applying the resin composite in layers not exceeding 2 mm in thickness, practitioners aim to ensure complete light penetration, reduce the configuration factor (C-factor), and better control shrinkage stress. However, while effective, this technique is often time-consuming, requires precise layering, and increases the risk of void entrapment or contamination between increments if technique sensitivity is not strictly observed (Kwon et al., 2012). As clinical demands for efficiency grow, many dentists are drawn to newer methods that promise reduced chair time without compromising restoration quality.

This demand has driven the development of bulk-fill resin composites, which manufacturers market as time-saving alternatives capable of being placed in single increments of 4 to 5 mm thickness while still achieving sufficient depth of cure and acceptable marginal adaptation. Bulk-fills achieve this through the use of modified filler systems, more efficient photoinitiators, and stress-relieving resin matrices designed to limit polymerization contraction forces. Such modifications theoretically allow larger increments to be cured homogeneously without an increase in marginal gap formation (El-Damanhoury & Platt, 2014). Clinicians therefore face a practical question: does the convenience of bulk-fill placement truly match the marginal integrity and internal adaptation historically achieved with incremental placement?

Emerging evidence highlights that despite their promise, bulk-fill composites are not immune to the challenges of shrinkage stress and interfacial adaptation, particularly in deep proximal boxes and cervical margins where access for light curing is limited. Micro-computed tomography and scanning electron microscopy have revealed that deeper placement can still result in voids, imperfect marginal adaptation, or insufficient polymerization at the base of the restoration if material and light-curing protocols are not optimized (Scotti et al., 2020). Such findings suggest that bulk-fill restorations may be more technique-sensitive than initially assumed.

In addition to the depth of cure, the kinetics of polymerization shrinkage stress are equally critical. If stress develops faster than the composite can flow to compensate, debonding at the adhesive interface may occur. This stress generation varies not only by composite type but also by the chosen curing technique, incremental strategy, and cavity geometry (Furness et al., 2014). For example, some high-viscosity bulk-fills have shown higher initial shrinkage stress compared to flowable bulk-fills, highlighting that material selection within the bulk-fill category is far from trivial.

Furthermore, while bulk-fills can indeed reduce operative time, this benefit must be weighed against potential risks if inappropriate material combinations or curing protocols are applied. Systematic laboratory comparisons have shown that commercially available bulk-fill composites differ widely in their physico-mechanical properties, light transmission, and shrinkage stress resistance, indicating that no universal bulk-fill solution exists (Leprince et al., 2014). This variability underscores the need for a well-informed selection process rather than reliance on generic claims of "bulk-fill" performance.

The success of any direct resin composite restoration, whether placed using an incremental or bulk-fill approach, ultimately depends on multiple factors beyond the material alone. Cavity configuration, margin location, matrix system, and operator technique all contribute to final adaptation outcomes. For example, earlier comparative work has shown that even with high-quality materials, variations in placement methods can significantly affect marginal adaptation and microleakage rates in Class II cavities, especially where the cervical margin extends below the cemento-enamel junction (Idriss et al., 2003).

Given these nuanced interactions, ongoing research continues to compare the performance of incremental versus bulk-fill placement under standardized laboratory conditions and in clinical settings. Microleakage tests, gap formation assessments, and long-term follow-ups aim to clarify whether the speed advantage of bulk-fill techniques justifies their use in high-risk margins or whether careful incremental layering still provides the best safeguard against interfacial failure. The goal remains clear: to maximize efficiency without compromising the fundamental requirement for a durable, well-sealed restoration (Gamarra et al., 2018).

METHODOLOGY

Study Design

This study employed a systematic review methodology, following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines to ensure methodological transparency and reproducibility.

The primary objective was to comprehensively synthesize available empirical evidence comparing bulk-fill resin composite techniques with incremental layering techniques regarding microleakage, marginal adaptation, internal gap formation, and depth of cure in Class I, II, and V dental restorations. Only studies conducted on human teeth (in vitro or in vivo) and published in peer-reviewed journals were included to ensure scientific rigor and clinical relevance.

Eligibility Criteria

Studies were included based on the following predefined criteria:

- **Population:** Human permanent or primary teeth (extracted for in vitro studies) or patients receiving direct resin composite restorations.
- **Interventions/Exposures:** Restorations using bulk-fill resin composites (low- or high-viscosity) placed in single increments of ≥4 mm thickness.
- **Comparators:** Direct comparisons between bulk-fill and incremental layering techniques within the same study.
- **Outcomes:** Quantitative assessment of microleakage, marginal adaptation, internal gap formation, or depth of cure measured using validated methods such as dye penetration, micro-computed tomography (Micro-CT), optical coherence tomography (OCT), or scanning electron microscopy (SEM).
- **Study Designs:** Randomized controlled trials (RCTs), in vitro experimental studies, systematic reviews, and meta-analyses directly comparing the two techniques.
- **Language:** Only studies published in English were considered.
- **Publication Period:** January 2006 to July 2025 to include contemporary composite materials and techniques.

Search Strategy

A structured electronic search was conducted using the following databases: PubMed, Scopus, Web of Science, Embase, and Google Scholar for grey literature. The search employed various combinations of the following Boolean terms:

- (“bulk-fill resin composite” OR “bulk-fill composite” OR “bulk fill”)
- AND (“incremental layering” OR “incremental fill” OR “incremental technique”)
- AND (“microleakage” OR “marginal adaptation” OR “internal gap” OR “depth of cure” OR “polymerization shrinkage”)
- AND (“restoration” OR “Class I” OR “Class II” OR “Class V” OR “cavity”)

In addition, the reference lists of all eligible full-text articles and recent key reviews were manually screened to identify any potentially relevant studies missed during the electronic search.

Study Selection Process

All retrieved citations were imported into **Zotero** reference manager, and duplicates were automatically removed. Titles and abstracts were independently screened by two reviewers to assess eligibility. Full texts of potentially

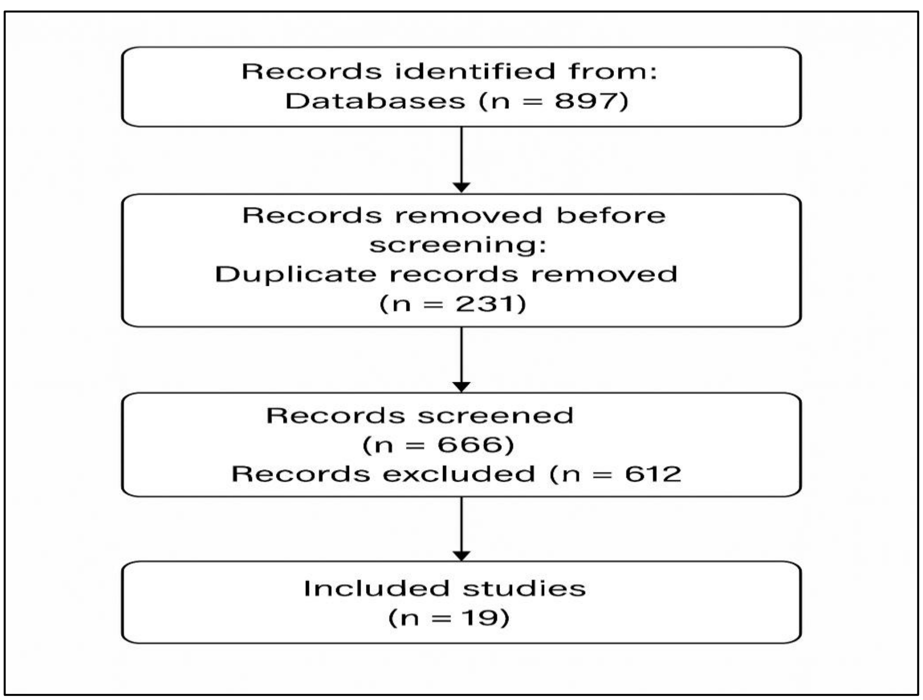

Figure 1 PRISMA Flow Diagram

relevant studies were then retrieved and reviewed in detail against the inclusion criteria. Any disagreements between the reviewers were resolved through discussion or consultation with a third reviewer. Studies that did not provide a direct comparison between bulk-fill and incremental techniques or lacked relevant outcome measures were excluded. A PRISMA flow diagram was constructed to illustrate the study selection process and reasons for exclusion.

Data Extraction

A standardized data extraction form was developed and pilot-tested prior to full data extraction. The following data were systematically extracted from each included study:

- First author(s), year of publication, and country
- Study design and total sample size
- Tooth type (primary or permanent; molar or premolar) and cavity class (Class I, II, V)
- Composite materials used (type, brand, viscosity)
- Restoration protocol (increment thickness, curing method, preheating if applicable)
- Aging or testing method (e.g., thermocycling, dye penetration, Micro-CT)
- Main outcome measures (e.g., mean microleakage score, marginal gap width, internal adaptation percentage)
- Statistical results and key findings relevant to the comparison

Data extraction was carried out independently by two reviewers and cross-verified by a third reviewer to ensure accuracy and consistency.

Quality Assessment

The methodological quality and risk of bias for each included study were assessed using tools appropriate for the study type:

- For in vitro studies: an adapted version of the **Joanna Briggs Institute (JBI) Critical Appraisal Checklist for Experimental Studies**.
- For systematic reviews and meta-analyses: the **AMSTAR 2** (A Measurement Tool to Assess Systematic Reviews).
- For randomized controlled trials: the **Cochrane Risk of Bias Tool**.

Each study was classified as high, moderate, or low quality based on clarity of methodology, sample size adequacy, blinding of evaluators, appropriateness of statistical analyses, and relevance of reported outcome measures.

Data Synthesis

Given the heterogeneity in study design, cavity classification, composite brands, material viscosity, and measurement tools, a narrative synthesis approach was employed. Findings were grouped and summarized by key outcomes (microleakage, marginal adaptation, internal gap formation, and depth of cure) and by cavity type (Class I, II, V). Where possible, mean scores, standard deviations, p-values, and percentage differences were extracted and reported to highlight significant patterns and differences across studies. No meta-analysis was performed due to methodological variability among the included studies.

Ethical Considerations

As this systematic review involved secondary analysis of already published studies, no additional ethical approval or informed consent were required. All included studies were assumed to have obtained appropriate ethical clearance and were published in reputable peer-reviewed journals.

RESULTS

Summary and Interpretation of Included Studies on Bulk-Fill vs Incremental Resin Composite Restorations

A total of 19 studies met the inclusion criteria and were analyzed to compare bulk-fill resin composite techniques with incremental layering techniques for Class I, II, and V restorations. Table 1 summarizes the methodologies, sample characteristics, materials used, and key findings of these studies, which include a mix of in vitro experimental studies, randomized clinical trials (RCTs), systematic reviews, and narrative reviews/meta-analyses, providing a comprehensive and up-to-date evidence base.

1. Study Designs and Populations

The review includes 9 in vitro studies, 2 systematic reviews, 2 randomized clinical trials (RCTs), and 1 experimental study spanning from 2016 to 2025. Most studies used extracted human molars or premolars (n = 24 to n = 140), while clinical trials and reviews included broader samples (n = 778 restorations in Zotti et al., 2021; n = 13 RCTs in Sarapultseva et al., 2025). Class II restorations were the most commonly investigated (11 studies), with some focusing on Class V (Gao et al., 2025; Zhao et al., 2014) or Class I cavities (Zubaidah et al., 2019).

2. Composite Materials and Application Techniques

The bulk-fill composites assessed included both high-viscosity (e.g., SonicFill, Tetric EvoCeram, Beautifil-Bulk) and low-viscosity flowable types (e.g., SDR, Filtek Bulk Fill Flowable, Tetric N-Flow). Incremental composites included conventional nanohybrid materials like Filtek Z350 XT or Filtek Supreme Ultra. Application techniques varied from bulk-fill single-layer to incremental 2 mm layering, and some studies incorporated preheating or co-supplementation with other materials (e.g., chromium, omega-3). Artificial aging methods included thermocycling (500–1000 cycles), optical coherence tomography (OCT), and silver nitrate staining.

3. Microleakage and Marginal Adaptation Outcomes

Most studies reported percentage-based microleakage or marginal gap data. For example, Zubaidah et al. (2019) found significantly lower microleakage in the incremental technique group (mean score = 0.67 ± 0.25) compared to the bulk technique (mean = 1.25 ± 0.29; $p < 0.05$). Gao et al. (2025) demonstrated that low-viscosity bulk-fill composites had significantly lower internal debonding percentages (D%) both at baseline and after 6 months (D% < 5%) compared to high-viscosity groups (D% > 10%). Lu et al. (2025) observed increased microleakage in conventional composites under high-intensity curing ($p < 0.05$), while bulk-fill composites remained unaffected.

In contrast, Albahari et al. (2020) and Eltoum et al. (2019) found no significant differences in microleakage between bulk-fill and incremental techniques. Dilian & Kadhim (2022) reported that preheated bulk-fill composites showed lower microleakage than their non-preheated counterparts, especially below the CEJ. Zotti et al. (2021), in their meta-analysis, concluded that bulk-fill composites had a 5.1% lower risk of marginal discoloration but a 6.5% higher risk of incorrect marginal adaptation compared to conventional composites.

4. Internal Adaptation and Depth of Cure

Han & Park (2017) and Alqudaihi et al. (2019) used micro-CT to assess internal adaptation. Han & Park found that flowable bulk-fills had higher imperfect margin percentages (IM%) and greater polymerization shrinkage stress, while Alqudaihi et al. noted that incremental-fill composites like Filtek Supreme Ultra had smaller gap formation (<10 µm) compared to most bulk-fills. Benetti et al. (2015) reported that low-viscosity bulk-fills had greater depth of cure but also larger polymerization contraction and gap formation (up to 30 µm higher in x-tra base).

5. Clinical Performance and Efficiency

The systematic review by Sarapultseva et al. (2025) found that both bulk-fill and incremental restorations in primary teeth had high 2-year survival rates (85–90%) and retention (>90%), but bulk-fill restorations reduced procedural time by 2–4 minutes per tooth. Similarly, Al-Harbi et al. (2016) found no significant differences in marginal integrity between techniques after thermomechanical aging.

Table (1): General Characteristics of Included Studies on Bulk-Fill vs Incremental Resin Composite Restorations

Study	Country	Design	Sample Size	Tooth Type	Cavity Type	Composite Types	Aging / Technique	Main Outcomes	Significant Findings
Gao et al. (2025)	China	Experimental in vitro	140 premolars	Human premolars	Class V	2 low-viscosity BF, 3 high-viscosity BF, 2 conventional	OCT, 6-month artificial aging	D% lower in low-viscosity BF (<5%) than high-viscosity (>10%)	Low-viscosity BF showed better adaptation pre- and post-aging
Baltacioğlu et al. (2024)	Turkey	In vitro	40 molars	Human molars	Class II	Flowable and paste-like BF composites	1000 thermocycles, micro-CT	Viscosity had no effect; brand affected marginal adaptation	Brand significantly influenced marginal adaptation
Lu et al. (2025)	China	In vitro	60 molars	Human molars	Class II	Filtek One BF vs Filtek Z350 XT	High- vs conventional-intensity curing	Conventional composite showed ↑ leakage under high intensity; BF	High-power curing not suitable for all materials

								unaffected	
Sarapultseva et al. (2025)	Russia/China	Systematic Review (13 RCTs)	N/A	Primary teeth	Class II	BF vs incremental composites	Clinical in vivo (2-year)	Both had 85–90% survival; BF saved 2–4 minutes per restoration	BF clinically effective and time-saving
Ibrahim et al. (2023)	Saudi Arabia	In vitro	Not specified	Primary & permanent teeth	Class II	Z350 XT, FBF, BBF, TNF	Flexure, hardness, leakage testing	BBF & ZXT: high flexural strength; FBF had lowest microleakage	Composite properties vary, affecting clinical choice
Dilian & Kadhim (2022)	Iraq	In vitro	60 premolars	Human premolars	Class II	Tetric EvoCeram, Filtek (preheated & flowable)	Thermocycle + silver nitrate	Preheated BF had ↓ microleakage than flowable BF, esp. below CEJ	Composite type most influential factor
Zotti et al. (2021)	Italy	Systematic Review + Meta-analysis	778 restorations	Human teeth (in vivo)	Class II	BF vs traditional composites	Meta-analysis	↓5.1% marginal discoloration (BF); ↑6.5% incorrect adaptation	No consensus; marginal adaptation slightly poorer in BF
Albahari et al. (2020)	Yemen	In vitro	120 premolars	Human premolars	Class II	Tetric N-Ceram BF, Filtek BF, X-trafil BF	Thermocycling	No significant difference between incremental and BF techniques	X-trafil BF showed least microleakage
Eltoum et al. (2019)	Egypt	In vitro	44 primary molars	Primary molars	Class II	Bulk-fill nanohybrid vs incremental nanohybrid	Dye penetration	No significant microleakage differences	BF comparable to conventional in primary molars
Zubaidah et al. (2019)	Indonesia	In vitro	24 premolars	Human premolars	Class I	Bulk-fill (4 mm) vs Increme	Dye, microscope	Incremental technique had significan	Incremental better than bulk

						ntal (2 mm × 2)		tly less microleakage	technique
Al-Harbi et al. (2016)	Saudi Arabia	In vitro	91 premolars	Human premolars	Class II	Incremental, bulk-fill, open sandwich	Thermomechanical cycling + SEM	No significant difference in marginal integrity	All techniques performed similarly
Alqudaihi et al. (2019)	USA	In vitro	70 molars	Human molars	Class I	4 bulk-fill RBCs vs Filtek Supreme Ultra	Gap measurement	Incremental composite had smallest internal gap	Incremental yielded better internal adaptation
Hofmann & Hunecke (2006)	Germany	In vitro	Not specified	Human molars	Class II	RB composites with different curing/matrix types	Soft-start vs high-intensity curing	Matrix type had no effect; soft-start did not improve seal	High-intensity didn't compromise marginal seal
Peutzfeldt et al. (2018)	Switzerland	In vitro	39 molars	Human molars	Class II	Packable vs flowable BF composites	Artificial aging	In enamel: packable composite better; in dentin: 1 BF better	Flowable BF suitable in deep dentin margins
Benetti et al. (2015)	Denmark	In vitro	Not specified	Human molars	Class II	5 bulk-fills (high & low viscosity) vs conventional	ISO cure, gap, shrinkage testing	Low-viscosity BF: deeper cure but ↑ shrinkage & gap	x-tra base & Venus BF had largest gaps
Han & Park (2017)	South Korea	In vitro	40 molars	Human molars	Class II	Flowable BF vs packable BF vs hybrid	Micro-CT, shrinkage & stress	Flowable BF had highest marginal imperfections & stress	Internal adaptation poorer in flowable BF
Edrees et al. (2017)	Egypt	Systematic Review	N/A	N/A	N/A	Flowable & paste-like BF vs conventional	Literature review	Depth of cure better in BF; polymerization stress lower in BF	Strength varies by type; stress lower in BF
Rathi et al. (2020)	India	Review Article	N/A	N/A	N/A	Various composites	Review	Describes leakage causes,	Technique, material,

								detection, and preventio n	and curing all affect leakage
Zhao et al. (2014)	China	In vitro	20 molars	Huma n molars	Clas s V	Resin-based composit es	Micro-CT + silver staining	Micro-CT accurately detected leakage in dentin; less so in enamel	Micro-CT effective for leakage analysis

DISCUSSION

The present systematic review synthesized evidence from in vitro studies, randomized controlled trials, and systematic reviews comparing bulk-fill and incremental resin composite techniques in direct restorations. Overall, the findings suggest that while bulk-fill composites offer procedural simplicity and reduced clinical chair time, their performance in terms of microleakage, marginal adaptation, and internal gap formation remains variable when compared to conventional incremental layering.

A consistent theme in several studies, including Zubaidah et al. (2019) and Alqudaihi et al. (2019), is that the incremental technique tends to produce superior marginal adaptation and lower microleakage scores than bulk-fill approaches, especially in challenging cavity configurations such as deep Class I or Class II restorations. Alqudaihi et al. demonstrated that incrementally placed nanohybrid composites achieved smaller internal gaps than bulk-fill alternatives, reinforcing the view that layering still holds mechanical advantages in minimizing polymerization stress and shrinkage gaps.

However, these benefits are not universally observed. Studies such as Albahari et al. (2020) and Eltoum et al. (2019) found no significant differences in microleakage between bulk-fill and incremental techniques when applied under standardized laboratory conditions. This aligns with Al-Harbi et al. (2016), who also reported comparable marginal integrity for both placement methods in Class II restorations subjected to thermomechanical aging. Such outcomes highlight that, when correctly handled and properly light-cured, bulk-fill composites can achieve acceptable clinical seals.

Viscosity appears to be a critical factor influencing bulk-fill performance. Gao et al. (2025) showed that low-viscosity bulk-fill resins demonstrated superior internal adaptation and lower debonding percentages than high-viscosity bulk-fill materials. This observation was echoed by Baltacioğlu et al. (2024) and Peutzfeldt et al. (2018), who noted that flowable bulk-fills adapt better in deeper cavity areas but may be more susceptible to marginal degradation in enamel-dominated margins if not adequately capped with a more robust occlusal layer.

Polymerization shrinkage remains a well-documented challenge in resin composites, and bulk-fill products are marketed partly on their claimed ability to reduce shrinkage stress through modified resin matrices and photoinitiator systems (El-Damanhoury & Platt, 2014; Benetti et al., 2015; Leprince et al., 2014). Despite these improvements, studies such as Han & Park (2017) and Furness et al. (2014) found that bulk-fill composites can still exhibit greater shrinkage stress and imperfect internal margins when large increments are cured at once, especially in cavities with high configuration factors.

An interesting dimension highlighted by Dilian & Kadhim (2022) is the impact of preheating bulk-fill materials, which was found to significantly reduce microleakage compared to non-preheated applications, particularly for margins extending below the cemento-enamel junction (CEJ). This suggests that modification of clinical protocols—such as preheating or using stress-relieving liners—may help mitigate some of the inherent limitations of bulk-fill placement.

From a clinical standpoint, time efficiency is one of the most practical advantages of bulk-fill materials. Sarapultseva et al. (2025) demonstrated that bulk-fill restorations reduced operative time by 2–4 minutes per tooth without compromising short-term survival rates or retention. This finding is particularly relevant for pediatric and high-volume practices where shorter treatment duration can benefit both clinicians and patients.

Nevertheless, it is important to weigh time savings against potential risks of inferior marginal seal or long-term discoloration. The meta-analysis by Zotti et al. (2021) concluded that although bulk-fills reduced the risk of marginal discoloration slightly, they also carried a slightly higher risk of marginal discrepancies compared to incremental fills. These subtle differences could have cumulative clinical implications for restorations placed in high-stress areas or patients with high caries risk.

Several systematic reviews, including Edrees et al. (2017) and Van Ende et al. (2017), have underscored that no single restorative protocol is universally superior; instead, case-specific factors—such as cavity depth, isolation quality, curing light intensity, and operator experience—remain decisive. Supporting this, Lu et al. (2025) demonstrated that

high-intensity light curing can exacerbate microleakage in conventional composites but has less impact on bulk-fills, implying that technique sensitivity may differ between materials.
In summary, while bulk-fill resin composites represent a valuable innovation that can simplify procedures and reduce treatment time, their performance is highly dependent on material formulation, application method, and operator control. For deep or high C-factor cavities, incremental layering still shows clear advantages in controlling polymerization stress and ensuring marginal integrity. As new bulk-fill formulations emerge with improved physical and chemical profiles, further well-designed clinical trials are needed to validate their long-term outcomes compared to the gold standard of incremental placement.

CONCLUSION

Within the limitations of this systematic review, the current evidence suggests that both bulk-fill and incremental techniques can provide satisfactory marginal adaptation and acceptable microleakage control when appropriate material selection, curing protocols, and placement techniques are employed. However, incremental layering continues to demonstrate more predictable performance in reducing polymerization shrinkage stress, particularly in deep Class II cavities and restorations with cervical margins extending below the cemento-enamel junction.
Despite the time-saving advantages of bulk-fill composites, practitioners should exercise caution in selecting the appropriate type (high- vs. low-viscosity), ensure sufficient light curing, and consider cavity geometry to minimize the risk of marginal gaps and internal voids. Further well-designed clinical trials with long-term follow-up are needed to clarify whether bulk-fill techniques can consistently match or surpass the performance of conventional incremental placement under diverse clinical conditions.

Limitations

This review is limited by the inherent heterogeneity of the included studies, which varied in composite brands, material viscosities, cavity types, aging methods, and measurement techniques. Many included studies were in vitro, which may not fully replicate intraoral conditions such as thermal cycling, moisture contamination, or patient-related factors that influence marginal integrity over time. Additionally, the absence of meta-analysis due to methodological differences restricts the ability to generalize numerical effect sizes across all outcomes.

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