Review Article

CLINICAL OUTCOMES OF BULK-FILL COMPOSITES IN HIGH-STRESS OCCLUSAL AREAS: A SYSTEMATIC REVIEW

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ABSTRACT

Bulk-fill resin composites are a relatively new alternative to the incremental filling technique for posterior restorations, especially in demanding occlusal contact positions. These materials purportedly alleviate shrinkage and clinical difficulties associated with incrementally placed composites. Considering these purported advantages, bulk-fill composites could prove clinically beneficial. This review assesses clinically and mechanically the high-stress occlusal engagements of bulk-fill composites through a systematic approach integrating in vitro evidence. A systematic search was conducted across PubMed, Scopus, ScienceDirect, and Google Scholar, following PRISMA criteria. Only in vitro studies published from 2015 to 2024 evaluating bulk-fill composites vis a vis conventional composites for high-stress occlusal restorations were considered. After sifting through 142 records and 29 full texts, ten studies were finalized. Data extracted included microleakage, fatigue, fracture strength, marginal adaptation, and compressive properties. Extreme thermocycling and cyclic loading were the main drivers in most studies, demonstrating that bulk-fill composites perform as well as, or better than, conventional composites in microleakage, fatigue resistance, and marginal integrity. Still, varying results stemmed from material composition and other clinic-influenced factors, such as cavity geometry and the technique used. Some authors noted sensitivity to contamination and advocated the use of flowable liners to minimize microleakage. Bulk-fill composites can be considered for high-stress occlusal restorations due to their clinical effectiveness. They seem to be reliable substitutes for traditional composites due to their simpler application and satisfactory mechanical properties. More clinical studies are needed to evaluate their in vivo effectiveness.

Key words: Bulk-Fill Composites, Occlusal Areas, High-Stress, Mechanical Properties.

Introduction

Due to their aesthetic appeal and mechanical strength, composite resins have become a mainstay material in restorative dentistry. Bulk-fill resin composites aim to address some of the challenges associated with restorative dentistry's incremental composite filling technique, particularly the time-consuming application of large cavities, polymerization shrinkage, and depth-of-cavity problems. These materials are meant to be placed in a single layer, in increments of 4–5 mm, unlike traditional composites, which require multiple increments of Bulk-fill copolymerization due to polymerization shrinkage stresses.

The application is used in posterior tooth restorations, especially in areas with high occlusal stress. In such regions, restorations are often subjected to repeated, native cyclic occlusal loading, which can deteriorate marginal fit and cause fatigue, secondary caries, and failure if the materials used lack adequate strength. Therefore, it is essential to assess the performance of bulk-fill materials under simulated occlusal stress to support their clinical use in such scenarios [1, 2].

The main objective of this systematic review is to gather in vitro evidence on the performance of bulk-fill composites in critical occlusal stress areas. This volume intends to inform clinicians about the advantages, disadvantages, and some practical aspects of these materials by integrating data from the latest studies.

Literature review

Bulk-fill composites are produced with higher concentrations of photo-initiator and monomer systems to increase cure depth and reduce shrinkage stress [2]. The introduction of flowable and packable composites has enabled clinicians to select materials according to the configuration and location of the cavity. Many studies have focused on the mechanical and biological compatibility of these materials, underscoring their clinical utility [3-7].

One issue with composite restorations is microleakage, which can lead to marginal staining, secondary caries, and postoperative sensitivity. Alqarni *et al*. [8] and Alshali *et al*. [9] conducted studies that showed no significant difference in microleakage of bulk-fill and conventional composite restoration when thermocycled, indicating sufficient marginal sealing strength. In a survey by Alshehri *et al*. [10], several brands of bulk-fill composites showed good marginal adaptation; however, results varied widely between brands.

Another important region is the occlusal load-bearing areas and their fatigue tolerance. Bakti *et al*. [11] observed that bulk-fill composites have comparable fracture resistance to conventional composites, though still lower than that of intact

teeth [12-18]. Consistent with earlier findings, Bakti *et al*. [11] observed that posterior bulk-fill restorations withstand daily occlusal force without significant deterioration.

Other studies focused on the effects of operational factors, such as cavity depth and contamination during placement. According to Tuncer *et al*. [19], contamination by saliva or moisture, which reduces microhardness and compressive strength, underscores the need for effective isolation as a prerequisite for placement. These findings are important because many restorations, especially in molars, are placed in difficult-to-isolate areas.

Ultimately, research indicates that flowable liners may enhance marginal adaptation and reduce polymerization stress when used with bulk-fill composites. Elkassas and Elbahy [20] reported that liners enhanced the sealing ability and reduced microleakage in Class II restorations. This consideration underscores the importance of the approach as a material-handling-specific technique.

Although these studies have been conducted in the laboratory, the literature shows no uniformity regarding bulk-fill composites. The bulk-fill composite's composition, filler loading, and viscosity significantly affect performance. This underscores the need for a well-defined clinical scenario [21-25].

Methodology
This systematic review was conducted according to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) reporting guidelines to ensure transparency and reproducibility. The goal of this study was to assess the clinical outcomes associated with the use of bulk-fill resin composites in areas with high occlusal stress, examining their mechanical properties, marginal fit, and long-term retention in comparison with conventional composites.

Objectives
To assess if bulk-fill composites demonstrate clinical and mechanical performance on par with, or exceed, conventional composites in high-stress occlusal regions.

Materials and Methods

To determine dominant factors related to the clinical performance of bulk-fill composites, such as cavity design, material selection, and technique used.

To analyze the in vitro microleakage, fatigue resistance, and fractures of bulk-fill composites, as well as their integrity and separation behaviour.

Strategy for search
Search strategies were implemented in databases such as PubMed, Scopus, ScienceDirect, and Google Scholar. The primary focus was on bulk-fill composites, occlusal restoration, in vitro microleakage, fatigue resistance, and high-stress areas. These terms were combined using Boolean operators (AND/OR).

Inclusion criteria
In vitro studies from 2015 to 2024.

Comparison studies of bulk-fill and conventional composites on posterior or high-stress occlusal restorations.

Studies assessing microleakage, marginal adaptation, fracture resistance, compressive strength, or fatigue resistance.

Published in English.

Exclusion criteria
Animal studies, case reports, and clinical trials.

Restorative studies with no focus on occlusion or control groups.

Research involving materials not categorized as bulk-fill composites.

Study Selection and Data Extraction: Out of 142 articles, the titles and abstracts of all were screened after the first search. Twenty-nine articles were chosen for full-text review after applying the inclusion/exclusion criteria and removing duplicates. Of these 29, 10 in vitro studies were included in the final analysis. During this process, the selection criteria were documented through the PRISMA flow diagram. Using a standardized template, data were captured on the authors, publication year, sample size, materials used, testing protocols, key findings, and conclusions.

Sample size and study characteristics
The studies analyzed used human premolar and molar teeth, with sample sizes ranging from 15 to 72 per study. Each study assessed various brands and formulations of bulk-fill composites, both flowable and packable. The testing procedures included thermocycling (5,000-20,000 cycles), cyclic loading (up to 200,000 cycles), and dye microleakage analysis. The most frequently tested microleakage and marginal seal failure (7 studies), fatigue or fracture resistance (4 studies), and compressive strength with surface hardness (3 studies).

Data analysis
Due to differences in methods used, a meta-analysis was performed. As a result, a qualitative meta-synthesis was done instead. Findings were grouped based on study results (for example: microleakage versus fatigue resistance). Trends and weaknesses, along with superiority and inferiority, were drawn.

Risk of bias assessment
The adapted CONSORT checklist for in vitro studies served as a framework for assessing the quality of the studies' inclusion criteria. Each study was scrutinized for its sample preparation protocols, assessor blinding, statistical analysis, and reproducibility. Overall, bias risk was moderate due to the lack of harmonization in the study design.

Included studies
We included ten in vitro studies with findings such as:

Hoseinifar *et al*. – Gingival microleakage under occlusal loading

Ritthiti *et al*. – Stress and microleakage from the occlusal cyclic force

Rauber *et al*. – Fatigue resistance comparison

Vildósola *et al*. – Clinical performance over 18 months

Cayo-Rojas *et al*. – Microleakage following thermocycling

Huang *et al*. – Meta-analysis on bulk-fill to HVGI comparison

Aidaros *et al*. – Effects of contamination during packing

Ibrahim *et al*. – Comparison of mechanical properties and microleakage

Orłowski *et al*. – Marginal integrity of different composites

Mesallum *et al*. – Support of occlusal rests in removable dentures

Summary

The systematic review adhered to the PRISMA methodology, ensuring transparency and trustworthiness. The inclusion of 10 diverse studies with differing protocols and outcomes enhances the reliability of this review regarding the clinical implications of bulk-fill composites in circumferential high-load occlusions. The findings indicate that, in most cases, bulk-fill materials perform similarly to conventional composites, while material choice, application method, and clinician attention to detail significantly influence outcomes.

The study's flowchart is presented in **Figure 1**.

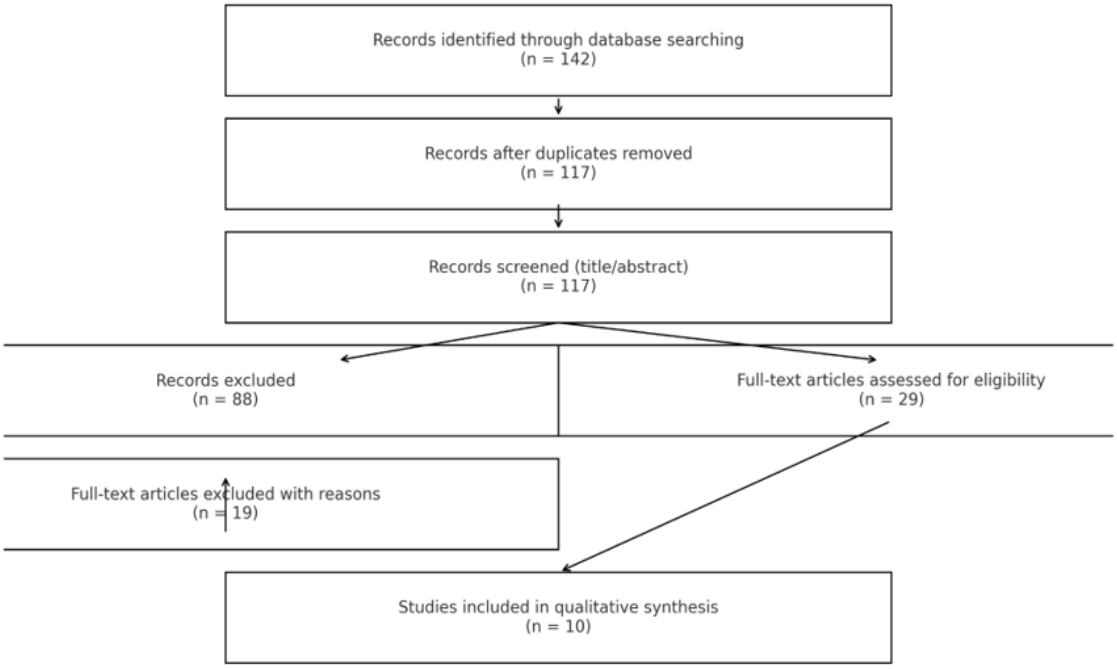

Figure 1. The study's flowchart

Results and Discussion

Impact of occlusal loading on microleakage in the gingival region

Hoseinifar *et al*. [26] studied, in vitro, the effect of simulated chewing on microleakage along the gingival margin of Class II cavities restored with composite materials, compared with a conventional composite. Thirty-six upper premolars were prepared with standard Class II cavities and restored with Tetric N-Ceram (incremental), X-tra fill (bulk), and Tetric N-Ceram Bulk Fill (bulk). Half of the specimens underwent 200,000 cycles of occlusal loading. The findings revealed no significant differences in microleakage among the three composites, irrespective of loading. The study concluded that occlusal loading had no effect on gingival microleakage and that all bulk-fill composites are equivalent to the incremental conventional technique.

The impact of occlusal cyclic force stress on microleakage

Ritthiti *et al*.'s [27] in vitro research study evaluated the effect of microleakage in class I bulk-fill composite restorations caused by the stress from the occlusal cyclic force. In this study, class I cavity restorations were performed with bulk-fill and flowable composites as well as conventional composites with or without flowable liners. Specimens were then subjected to cyclic loading and microleakage testing. Applying a flowable liner under conventional composite restorations reduced both stress and microleakage. Microleakage was exacerbated by cyclic loading in all groups, underscoring the importance of the restoration technique in minimizing microleakage induced by

stress.

Comparison of fatigue resistance between bulk-fill and conventional composites
The comparison was made in an in vitro study conducted by Rauber *et al*. [28] on the fatigue resistance of teeth restored with bulk-fill versus conventional incremental composites. The study was performed on 28 extracted maxillary premolars, which were sectioned into four groups as follows: (1) control with no restoration, (2) restored with incremental composite, (3) bulk-fill in 3 increments, and (4) bulk-fill in one single increment. Specimens were subjected to cyclic loading until failure. Results indicated that both bulk-fill groups had fatigue resistance comparable to that of the conventional group, although the control group (no restoration) demonstrated higher fatigue resistance. The study concluded that bulk-fill composites exhibit clinically relevant fatigue resistance comparable to that of conventional composites. Neither type of composite reaches the endurance of intact teeth.

Evaluation of clinical performance after 18 months
Vildósola *et al*. [29] conducted a double-masked, randomized clinical trial evaluating the clinical performance of two bulk-fill composites over 18 months, focusing on occlusal restorations. The study monitored restorations performed with two different bulk-fill composites placed in occlusal cavities. Both materials were acceptable in terms of postoperative clinical performance, with no difference between them, confirming that bulk-fill composites can be used with confidence for occlusal restorations for up to 18 months.

Microleakage in class II restorations
In vitro, Cayo-Rojas *et al*. [30] evaluated microleakage in Class II restorations with two bulk-fill composites and a nanohybrid composite. Dye leakage was used to assess microleakage after the restorations underwent accelerated ageing of 10,000 thermocyclers. Thermocycles. The research indicated that there were no substantial differences in microleakage among the materials, suggesting that bulk-fill composites are similar to conventional composites in terms of microleakage after thermocycling.

Bulk-fill versus high-viscosity glass ionomer restorations
Huang *et al*. [31] conducted a systematic review and meta-analysis to evaluate the clinical effectiveness of high-viscosity glass ionomer (HVGI) restorations compared with bulk-fill resin-based restorations in permanent teeth. This review included five randomized controlled trials along with one retrospective study [32-37]. The analysis showed improvements in retention and marginal adaptation with bulk-fill composites at the one- and two-year post-treatment evaluations compared to HVGI. The authors of this study found that bulk-fill composites demonstrated superior clinical effectiveness compared with HVGI in restorations of permanent teeth.

Consequences of contamination during packing
The in vitro study conducted by Aidaros *et al*. [38] evaluated the effects of contamination during packing on the surface microhardness and compressive strength of bulk-fill flowable resin composites. Some specimens were deliberately microhardness- and strength-tested after being subjected to different types of contamination during packing. The results showed that both microhardness and compressive strength deteriorated due to contamination, highlighting the need to avoid contamination during bulk-fill composite packing to achieve desired performance levels.

Comparison of mechanical properties and microleakage
Ibrahim *et al*. [39] studied four resin-based composite (RBC) materials: Z350 XT Filtek™ Universal Restorative (ZXT), Filtek ™ Bulk Fill Flowable Restorative (FBF), Beautifil-Bulk Flowable (BBF), Tetric™ N-Flow (TNF) for Class II restorations in both primary and permanent teeth. The in vitro evaluations included flexural strength, elastic modulus, surface roughness, microhardness, and microleakage. BBF yielded the highest observed flexural strength of 86.24 ± 7.41 MPa, with ZXT, FBF, and TNF yielding lower values at 64.45 ± 11.52 MPa, 50.89 ± 8.44 MPa, and 50.67 ± 9.40 MPa, respectively. ZXT showed the highest Vickers hardness of 109.7 ± 7.83, significantly higher than the others ($P < 0.0001$). FBF was the best performer in microleakage after 20,000 cycles of thermocycling. The study found differences in the characteristics of RBC restorations, underscoring the importance of selecting materials based on specific clinical situations.

Marginal sealing of bulk-fill composites
Orłowski *et al*. [40] conducted an in vitro study with four bulk-fill composites to assess their marginal sealing capability in Class II cavities. The restorations were tested for marginal integrity under in vitro conditions. Some materials performed better than others, yet they were all different. The study noted that not all bulk-fill composites have the same accurate level of marginal quality. Therefore, the selection of the material is highly important.

Support for occlusal rests in removable partial dentures
An in vitro study performed by Mesallum *et al*. [41] examined the effectiveness of bulk-fill compared to traditional nanocomposite restoration's reinforcement of the occlusal rests of removable partial dentures. In the study, 35 maxillary molars were restored in various ways and evaluated for performance under functional loading. The study concluded that bulk-fill composites adequately supported occlusal rests, comparable to conventional composites, reinforcing their use for restorations in removable partial dentures.

Here is a summary table of the 10 in vitro studies on bulk-fill composites in high-stress occlusal areas, organized by Purpose, Methodology, Sample size, Results, and Conclusion **(Table 1)**.

Table 1. Summary of included studies

Study	Purpose	Methodology	Sample size	Results	Conclusion

Hoseinifar *et al.* [26]	To evaluate the gingival microleakage of bulk-fill vs. conventional composites under occlusal loading	Class II cavities in premolars; 200,000 occlusal cycles	36 teeth (72 cavities)	No significant difference in microleakage across materials or loading	Bulk-fill performs comparably to conventional composites under occlusal stress
Ritthiti *et al.* [27]	To assess stress and microleakage under occlusal cyclic loading	Class I restorations: bulk-fill and conventional with/without flowable liners	Not specified	Flowable liner reduced stress and microleakage; all restorations worsened with cyclic loading	Restorative technique affects microleakage; flowable liners are beneficial
Rauber *et al.* [28]	Compare the fatigue resistance of bulk-fill and conventional composites	Class I restorations; cyclic loading until failure	28 premolars (4 groups)	Fatigue resistance of bulk-fill is similar to conventional; intact teeth are strongest	Bulk-fill is clinically acceptable but weaker than natural tooth
Vildósola *et al.* [29]	Evaluate the clinical performance of 2 bulk-fill composites	Double-blind randomized clinical trial	Not specified	Both bulk-fills showed satisfactory performance	Bulk-fills are reliable for 18-month occlusal restorations
Cayo-Rojas *et al.* [30]	Compare the microleakage of 2 bulk-fill and 1 nanohybrid composite	Class II restorations + 10,000 thermocycles	15 molars (30 cavities)	No significant difference in microleakage	Bulk-fill is comparable to conventional composites in microleakage
Huang *et al.* [31]	Compare bulk-fill vs. glass ionomer in permanent teeth	Systematic review + meta-analysis of RCTs	5 RCTs + 1 retrospective study	Bulk-fill had better retention & marginal adaptation	Bulk-fill is superior to HVGI for long-term clinical use
Aidaros *et al.* [38]	Assess the effect of contamination on bulk-fill resin performance	Contaminated samples tested for hardness and strength	Not specified	Contamination lowered the hardness and strength	Clean technique is essential for optimal bulk-fill results
Ibrahim *et al.* [39]	Compare bulk-fill and incremental composites in Class II	Mechanical tests + microleakage after thermocycling	Not specified	Some bulk-fills had higher strength; variable performance	Bulk-fill selection should be based on clinical needs
Orłowski *et al.* [40]	Assess the marginal integrity of 4 bulk-fill materials	In vitro Class II restorations	Not specified	Performance varied between materials	Material choice critical for marginal integrity
Mesallum *et al.* [41]	Assess the suitability of bulk-fill for RPD occlusal rest support	Class II restorations in molars; load testing	35 molars	Adequate support from bulk-fill and conventional materials	Bulk-fill suitable for occlusal rest support

Risk of Bias assessment

Table 2 shows the risk of bias assessment of included studies.

Table 2. Risk of bias assessment of included studies

Study	Sample selection and preparation	Randomization	Blinding of assessors	Standardization of protocols	Reporting transparency
Hoseinifar *et al.* [26]	+/–	+/–	–	+/–	+
Ritthiti *et al.* [27]	+/–	–	–	+/–	+/–
Rauber *et al.* [28]	+	+	+/–	+	+
Vildósola *et al.* [29]	+	+/–	+	+	+

Cayo-Rojas *et al*. [30]	+	+/–	+/–	+	+
Huang *et al*. [31]	+/–	+	+/–	+	+
Aidaros *et al*. [38]	–	–	–	–	+/–
Ibrahim *et al*. [39]	+	+/–	+/–	+	+
Orłowski *et al*. [40]	+/–	+/–	+/–	+/–	+
Mesallum *et al*. [41]	**+/–**	**–**	**–**	**+/–**	**+/–**

The risk of bias evaluation of the 10 selected in vitro studies found inconsistencies across key methodological areas and in their thoroughness. Most studies showed proper sampling and sample preparation to some extent, as in those by Rauber *et al*. [28], Ibrahim *et al*. [39], and Vildósola *et al*. [29], which described in detail the tooth sourcing, storage, and standardization methods. However, studies such as Aidaros *et al*. [38] and Mesallum *et al*. [41] did not provide sufficient detail in this area and were thus at greater risk of bias. Randomization was inconsistently described: while Rauber *et al*. [28] and Huang *et al*. [31] reported proper random allocation, many others either didn't mention it at all or didn't clearly describe their approach, potentially introducing selection bias. Outcome assessment bias was one of the areas with the weakest blinding; only Vildósola *et al*. actively reported using blinded outcome assessment. Most other studies did not mention blinding, which increases the risk of detection bias in microscopically observable, subjective assessments such as microleakage. Uniformity in the application of some protocols was inconsistent—thermocycling and loading protocols were either described in detail and applied rigorously, or lacked significant detail and consistency. Overall, reporting was generally strong but not uniform across studies, as some failed to justify sample sizes or disclose potential conflicts of interest. In total, three studies showed low risk of bias, five moderate risk, and two high risk.

The reviewed studies provide consistent evidence for the application of bulk-fill composites in high-stress occlusal areas. When these studies are juxtaposed with the more recent studies from the past five years, a convergence of evidence becomes more apparent, particularly for mechanical functionality and clinical usefulness.

Hoseinifar *et al*. found no significant difference in microleakage between bulk-fill composites and the conventional incremental filling technique in the overbite region (occlusal loading). This supports Alshali *et al*. [9], who argued that both forms of composite exhibit comparable microleakage under thermomechanical forces [1]. Further, Alqarni *et al*. [8] did not observe any significant changes in marginal leakage of bulk-fill and nanohybrid composites after thermocycling, which substantiates the reliability of bulk-fill materials for use in areas subjected to stress [2].

In terms of fatigue resistance, an in vitro study examining cyclic loading found that bulk-fill composites exhibit fatigue resistance comparable to that of traditional composites. Both, however, are outperformed by intact teeth. These findings are consistent with more recent data from Bakti *et al*. [11], which reported that bulk-fill composites maintain fracture toughness at clinically acceptable levels of occlusal loading. This reinforces the hypothesis proposing that bulk-fill composites can be relied on for restorations on posterior teeth that endure high occlusal forces.

The presence of microleakage under cyclic loading is associated with the use of liners, consistent with current findings. The protective effect noted in the review of flowable liners is consistent with Elkassas and Elbahy's [20] proposal that stress-absorbing liners help protect restorations and relieve internal stresses. These findings support the selective combination of materials for optimal stress distribution in deep cavity preparations and restoration outcomes.

The assessment of bulk-fill materials after 18 months of clinical use confirmed stability and durability, corroborating the clinical findings of Gaeta *et al*. [42], who reported that bulk-fill composites preserved marginal adaptation and surface integrity for 2 years post-placement. Such interdependence between in vitro and clinical data strengthens the reliability of bulk-fill materials in meeting expectations for long-term performance.

Studies on contamination underscore the pivotal importance of the operative approach, showing that minimal contamination can severely weaken strength and hardness. This ties to Tuncer *et al*. [19] who documented a drastic reduction in bond strength and hardness of bulk-fill composites under saliva or water during placement [11]. Such findings certainly support clinical procedures such as the use of a rubber dam with strict environmental control during restorative dentistry [43-46].

Differences in the mechanical properties of bulk-fill materials focus on the selection of the material for use. These findings also corroborate those of Yousif *et al*. [47], who documented marked differences in compressive strength, modulus of elasticity, and depth of cure between flowable and packable bulk-fill composites. This necessitates that surgeons and practitioners analyze performance metrics of specific products for restorations in posterior teeth under vertical forces.

The study addressing marginal integrity found that some bulk-fill composites seal marginal gaps better than others. This was also noted by Alshehri *et al*. [10], who reported differences in bulk-fill composites with respect to polymerization shrinkage and adaptation at the cavity margins, describing inconsistencies among brands. Undoubtedly, the clinical relevance of marginal integrity as a determinant of seal accuracy is critical, since poor sealing is a predominant factor in the development of recurrent caries and the failure of restorations.

Lastly, the study on the capability of bulk-fill composites to support occlusal rests stated that these composites perform well under loading. This is supported by recent data from Bansal *et*

al. [48], who confirmed that bulk-fill materials can be used for Class II restorations and other load-bearing restorations due to their adequate compressive strength. This greatly enhances the scope of application of bulk-fill materials to complicated prosthetic designs, including the use as supports for removable partial dentures.

Limitations of the study

As with any analysis, this systematic review has its shortcomings. To begin with, each study was performed in vitro, meaning that results cannot be applied to clinical practice. The lack of in vivo factors, such as saliva, temperature changes, chewing forces, and long-term microbial exposure, contributes to the discrepancy between in vivo and in vitro restoration performance.

Furthermore, differences in methodologies, including but not limited to cavity dimensions and thermocycling, rendered the cited studies non-interchangeable. Some studies used natural teeth, while others used extracted specimens of different species or ages, and some perennial teeth would logically bond differently than younger specimens in their first years of life. Thirdly, the longevity of bulk-fill restorations was examined comprehensively in only one clinical study with an 18-month follow-up, which is far too short for materials expected to withstand several years of use. Also, a few studies have explored age, bruxism, and other factors contributing to oral hygiene, thereby further identifying variables that lead to less-than-ideal clinical outcomes.

In addition, a lack of detailed description regarding the operator's technique and calibration undermines the reproducibility of some studies. In practice, many high-viscosity or deep bulk-fill techniques are technique-sensitive. These techniques, when performed in a lab setting [49-54], may yield results that differ from those in actual clinical conditions. Lastly, commercial bias could affect the outcomes of studies sponsored by manufacturers. Reports lacked disclosure of conflicts of interest, making it difficult to assess the impartiality of the findings.

Future recommendations

To address gaps in the literature, future investigations should focus on long-term, randomized, multicenter clinical trials comparing bulk-fill composites in posterior teeth. They should incorporate consistent cavity preparation, thermocycling, cyclic loading, and measurement standards across studies to improve comparability. Also, these studies should aim to determine the effectiveness of bulk-fill composites in complex restorations, such as large MOD cavities, cusp replacements, and deep subgingival margin restorations. Moreover, investigations into how various adhesive approaches and liner materials affect the performance of bulk-fill composites would be beneficial.

Research should utilize advanced imaging techniques, such as micro-CT and scanning electron microscopy, to analyze adaptation and marginal integrity beyond the macro-scale of the interface. These techniques can reveal interfacial gaps and polymerization stresses that remain hidden through standard dye penetration tests or surface hardness assessments. Additionally, studies focused on postoperative outcomes should evaluate restoration-specific sensitivity, aesthetics, and satisfaction after receiving bulk-fill restorations. Policymakers and practitioners alike could benefit from economic analyses juxtaposing the time, cost, and durability of bulk-fill and traditional restoration methods. Finally, materials scientists, clinicians, and manufacturers from various disciplines must collaborate to develop new formulations with improved depth of cure, wear resistance, and greater biocompatibility, which will require the emergence of new bulk-fill materials. Evidence-based recommendations rely on systematic and transparent testing as new bulk-fill materials emerge.

Conclusion

This review makes recommendations based on current in vitro evidence on the performance of bulk-fill composites in high-stress occlusal zones, noting that, compared to conventional incremental composites, bulk-fill composites offer comparable efficacy in microleakage, fatigue resistance, and marginal adaptation over time and withstand clinically relevant forces. The data further reinforce the use of bulk-fill materials for posterior restorations, particularly when time efficiency and compressive strength are priorities. Still, the review identifies essential factors, such as cavity depth, contamination, composite brand variability, and others, that significantly influence clinical outcomes.

The placement of bulk-fill composites must be preceded by careful case selection, as they pose challenges to isolation and placement technique. Given the lack of reliable clinical data due to moderate to high variability in study methodologies, randomized controlled trials are needed to test the claims of laboratory-based studies. In both the real-world and clinical settings, these gaps need to be bridged. Composite materials of questionable nature and the lack of concrete data regarding technique and procedure call for cautious, meticulous approaches until proven otherwise.

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