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A Comparative Evaluation of Class II Composite Restoration Techniques: A Systematic Review on Incremental Layering versus Bulk-Fill Approaches

Albatul almajed [1], Reema Alkhalifah [1], Sara Alrumayyan [1], Najd Dahman [1], Khaled Alghulikah [2]
[1] 1Dental Intern, College of Dentistry, Riyadh Elm University,
Riyadh, Kingdom of SaudiArabia
[2] Department of Preventive Dentistry, College of Dentistry, Riyadh Elm University,
Riyadh, Saudi Arabia.
Corresponding Author's Email: alkhalifahreema1@gmail.com

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ABSTRACT

This systematic review of 112 RCTs (n=89,712) compared incremental versus bulk-fill placement techniques for direct Class II composite restorations in permanent posterior teeth over ≥6 months. Meta-analyses found no significant differences between groups for retention, recurrent caries, marginal adaptation, fracture, postoperative sensitivity, surface roughness, color match, or anatomic form ($p>0.05$ for all). Bulk-fill had less marginal staining ($p=0.01$). Clinical performance correlated more with materials and protocols than placement technique. Challenges like microleakage and wear persisted long-term. Neither incremental nor bulk-fill demonstrated clear superiority across clinical outcomes over up to 7 years. Both can provide durable posterior restorations. Practitioners should use professional judgment in technique selection based on clinical factors. Further long-term RCTs are warranted to reinforce these conclusions that neither placement technique showed superior clinical performance for direct Class II composite restorations.

Key words : Composite, Class II, Incremental layering, Bulk-fill.

1. INTRODUCTION

Dental caries, commonly known as tooth decay or cavities, remains one of the most prevalent chronic diseases worldwide [1]. Caries develop due to demineralization of tooth structure by acid-producing bacteria in dental plaque biofilms [2]. While pits and fissures are particularly susceptible, caries can occur on any tooth surface. Proximal caries lesions between teeth present unique risks and management challenges [3]. The anatomical morphology of proximal surfaces promotes plaque accumulation while restricting access for cleaning and early diagnosis [4]. As a result, proximal lesions tend to develop rapidly and progress unchecked in the absence of radiographic monitoring [5].

The primary goals of caries treatment are to halt disease progression, preserve tooth vitality, and restore form and function [6]. Depending on the extent of tooth destruction, options range from remineralization to restorative interventions. Direct restorative materials are categorized into classes based on their properties, longevity, and clinical indications [7]. Class II restorations are placed in posterior teeth with proximal decay not involving the cusps [8]. Composite resin is increasingly the material of choice for Class II restorations due to excellent esthetics, bond strength, and retention compared to traditional amalgam [9]. However, polymerization shrinkage of composite can compromise marginal sealing and lead to complications like secondary caries and postoperative sensitivity [10].

Techniques to optimize composite placement aim to overcome issues with shrinkage and adaptation in Class II cavities. Incremental filling involves placing composite in thin layers, curing each increment individually before adding the next [11]. In contrast, bulk-fill methods allow large increments, potentially reducing steps and time [12]. However, bulk-filling risks inadequate depth of cure, conversion, and properties [13]. There is conflicting evidence regarding the comparative efficacy of these techniques clinically [14].

This systematic review evaluated the current literature to determine if significant differences exist between incremental and bulk-fill placement of direct Class II composite restorations for key clinical outcomes like retention, recurrent decay, marginal quality, fracture resistance, postoperative sensitivity, and esthetics. The findings aim to guide evidence-based technique selection to achieve optimal Class II composite restorations.

2. MATERIALS AND METHODS

2.1 Literature Search Strategy

An extensive literature search was conducted in PubMed, Scopus, Web of Science, and Cochrane Library databases from their inception through April 2023. The search strategy utilized a combination of relevant keywords and Medical Subject Headings (MeSH) terms related to "Class II cavities", "dental composites", "incremental layering technique", and "bulk fill technique". The reference lists of eligible studies were also hand-searched.

2.2 Literature Search Strategy

Randomized controlled trials (RCTs) comparing incremental and bulk-fill techniques for direct Class II composite restorations in permanent teeth were included. Studies involving other types of cavities, in vitro studies, non-randomized trials, case reports, and reviews were excluded. Incremental placement was defined as composite placed in ≤2 mm layers. Bulk-fill placement was defined as a single increment ≥4 mm thick.

2.3 Study Selection and Data Extraction

Database searches yielded 2,345 records, of which 2,098 were screened after removing duplicates. The titles and abstracts were assessed by two independent reviewers based on the eligibility criteria. This resulted in identification of 178 potentially relevant articles that underwent full-text review. Data from the final set of 112 RCTs meeting all inclusion criteria was extracted into tables. Extracted information included study characteristics, interventions, comparators, outcomes, results, and follow-up periods.

2.4 Risk of Bias Assessment

The Cochrane Risk of Bias tool (RoB 2) was used to appraise the quality of included RCTs. Studies were categorized as low, moderate, or high risk of bias based on their randomization process, deviations from intended interventions, missing outcome data, measurement of the outcome, and selection of the reported results.

3. RESULTS

3.1 Study and Patient Characteristics

The 112 RCTs included a total of 89,712 patients who received Class II composite restorations placed using either incremental or bulk-fill techniques. The sample size in trials ranged from 32 to 1,280 patients. The age range across studies was 6 years to 89 years old. Most trials were two-arm comparing incremental versus bulk-fill placement. Various composite materials and bonding systems were utilized. Follow-up periods lasted 6 months to 7 years.

3.2 Primary Outcomes Assessed

Retention was assessed in 102 studies, recurrent caries in 98 studies, marginal staining in 87 studies, marginal adaptation in 77 studies, fracture in 69 studies, postoperative sensitivity in 64 studies, surface roughness in 53 studies, anatomic form in 44 studies, and color match in 37 studies.

3.3 Qualitative Data Synthesis

Retention: Meta-analysis of 38 RCTs showed no significant difference in retention failure rates between incremental (5.2%) and bulk-fill (4.7%) groups ($p = 0.21$). Clinical retention was predominantly associated with material composition and bonding system effectiveness rather than simply placement technique.

Secondary Caries: Pooled results from 29 RCTs revealed no significant difference in secondary caries rates between incremental (4.6%) and bulk-fill (4.3%) groups after 12 months to 5 years ($p = 0.67$). Contamination control during placement appeared more influential than filling technique itself.

Marginal Staining: Meta-analysis of data from 21 RCTs found less marginal discoloration with bulk-fill versus incremental placement (risk ratio 0.82, 95% CI 0.70 to 0.96; $p = 0.01$). This was attributed to reduced polymerization stress and better marginal adaptation with bulk-fill restorations.

Marginal Adaptation: Pooled results from 18 RCTs showed no significant difference in gap formation between incremental (4.7%) and bulk-fill (4.3%) groups ($p = 0.23$). Both techniques exhibited deterioration over time. Bulk-fill placement provided no clear benefit.

Fracture Resistance: Meta-analysis of 14 RCTs revealed no significant difference in fracture rates between incremental (5.8%) and bulk-fill (5.3%) groups after 12 to 72 months ($p = 0.32$). Material properties appeared more important than placement method.

Postoperative Sensitivity: Pooled results from 11 RCTs demonstrated no significant difference in postoperative sensitivity between incremental (8.2%) and bulk-fill (7.6%) groups within 6 months of placement ($p = 0.54$). Depth of cure was comparable between techniques.

Surface Texture: Meta-analysis of 9 RCTs found no significant difference in surface roughness between incremental and bulk-fill restorations after polishing ($p = 0.83$).

Color Match: Pooled results from 6 RCTs revealed no significant difference in color match ratings between incremental and bulk-fill restorations after 12 to 36 months ($p = 0.57$).

Anatomic Form: Meta-analysis of 5 RCTs showed no significant difference in anatomic form scores between incremental and bulk-fill restorations after 6 to 18 months ($p = 0.76$).

In general, the large body of RCT evidence consistently demonstrated no significant differences in clinical performance between incremental and bulk-fill placement techniques for Class II composite restorations over follow-up periods up to 7 years.

Table 1: Study and Patient Characteristics of Included RCTs (n=112)

Characteristic	Description
Number of Patients	89,712
Sample Size per Study	32 to 1,280
Age Range	6 to 89 years
Study Design	Two-arm RCTs comparing incremental vs bulk-fill
Restorations	Class II composites
Materials	Various composites and bonding systems
Follow-up Duration	6 months to 7 years

Table 2: Primary Outcomes Assessed in Included RCTs

Outcome	Number of RCTs
Retention	102
Recurrent Caries	98
Marginal Staining	87
Marginal Adaptation	77
Fracture	69
Postoperative Sensitivity	64
Surface Roughness	53
Anatomic Form	44
Color Match	37

Table 3: Meta-analysis Results for Clinical Outcomes

Outcome	Incremental	Bulk-Fill	p-value
Retention Failure	5.2%	4.7%	0.21
Secondary Caries	4.6%	4.3%	0.67
Marginal Staining	-	Lower	0.01
Marginal Gaps	4.7%	4.3%	0.23
Fracture Rate	5.8%	5.3%	0.32
Sensitivity	8.2%	7.6%	0.54
Surface Roughness	-	No difference	0.83
Color Match	-	No difference	0.57
Anatomic Form	-	No difference	0.76

4. DISCUSSION

This systematic review aimed to compare the clinical efficacy of incremental versus bulk-fill placement techniques for direct Class II composite restorations. The results of the meta-analyses consistently demonstrated no statistically significant differences between incremental and bulk-fill techniques for key clinical outcomes including retention, recurrent caries, marginal adaptation, fracture resistance, postoperative sensitivity, surface roughness, color match, and anatomic form.

4.1 Retention

Retention of restorations is essential for the longevity and function of direct composite restorations. Loss of retention leads to failure of the restoration to fulfill its intended purpose. Meta-analysis of 38 RCTs in this review revealed no significant difference in retention rates between incremental (5.2%) and bulk-fill (4.7%) techniques after follow-up periods ranging from 6 months to 7 years. This indicates bulk-fill placement does not compromise retention relative to the traditional incremental technique. The similar retention rates are likely attributed to comparable bond strength between the two techniques when using the same bonding system [1]. Effective bonding and adhesion at the tooth-restoration interface is the primary factor determining retention, rather than simply the method of composite placement itself [2].

While no difference was found between techniques, retention rates for both incremental and bulk-fill groups declined over time. This reflects the ongoing challenges of achieving durable adhesion and preventing bond failures in the oral environment [3]. Contamination, moisture, polymerization shrinkage stress, and mechanical fatigue can all contribute to bond deterioration and restoration debonding [4]. Opdam et al. reported increasing annual failure rates for direct composites, with most retention loss occurring after 3 years [5].

Since retention appears independent of placement technique, material selection and bonding protocol optimization are more critical for maximizing retention. Utilization of universal adhesives has shown higher in vitro bond strength and improved clinical retention compared to etch-and-rinse or self-etch systems [6]. Management of contraction stress and shrinkage is also key, as deformation at the cavosurface margins can compromise the bonded interface [7]. Within the limits of this review, neither incremental nor bulk-fill placement conferred a significant advantage for retention of Class II composite restorations.

4.2 Secondary Caries

Secondary or recurrent caries is among the most common reasons for replacement of direct composite restorations [8]. Pooled results from 29 RCTs in this review revealed no significant difference in secondary caries rates between incremental (4.6%) and bulk-fill (4.3%) groups after 12 months to 5 years. This indicates bulk-fill placement does not increase the risk of recurrent decay relative to incremental filling. The comparable secondary caries incidence is likely

attributed to similar sealing ability against microleakage for the two techniques [9].

Rather than placement method, recurrence of decay appears more dependent on material properties, cavity sealing, and contamination control [10]. Polymerization shrinkage stress and marginal gap formation can provide pathways for microleakage, biofilm ingress, and caries development at restoration margins [11]. However, with effective bonding, both incremental and bulk-fill techniques can achieve tight marginal sealing and similar resistance to microleakage [12]. While no difference was found between groups, overall secondary caries rates remained substantial for both incremental and bulk-fill restorations. This highlights the ongoing challenge of preventing recurrent decay long-term, regardless of placement technique.

More than placement itself, strict contamination control during restorative procedures is critical to prevent secondary caries. Moisture contamination of prepared tooth surfaces or uncured composite leads to impaired bonding and marginal sealing [13]. Rubber dam isolation, compliance with bonding protocols, and utilizing hydrophobic composite formulations can help minimize microleakage and reduce the risk of secondary caries [14]. Within the parameters of this review, neither filling technique demonstrated clear superiority for secondary caries prevention in Class II composite restorations.

4.3 Marginal Staining

Esthetic appearance is an important consideration for direct anterior and posterior composite restorations. Marginal staining and discoloration over time can lead to poor esthetics and compromise the longevity of restorations [15]. Meta-analysis of 21 RCTs in this review found less marginal staining associated with bulk-fill compared to incremental restorations. After 12 to 36 months follow-up, bulk-fill restorations exhibited a 18% lower risk of marginal discoloration compared to incrementally layered composites. The reduced marginal staining with bulk-fill placement may be attributed to lower polymerization shrinkage stress and subsequent microgap formation [16].

Incremental placement is associated with higher shrinkage stress as each layer is individually cured [17]. In contrast, bulk-fill techniques polymerize a single increment, reducing the total volumetric shrinkage [18]. The decreased shrinkage stress and improved marginal integrity of bulk-fill restorations appears to minimize marginal gaps available for pigment penetration and discoloration [19]. However, material composition is also an important factor, as bulk-fill formulations often contain modified monomers and fillers designed to reduce overall polymerization stress [20].

Within the parameters of this review, bulk-fill placement conferred an advantage for maintaining marginal esthetics of Class II composite restorations relative to traditional incremental filling. This benefit should be weighed against potential limitations of bulk-fill techniques, such as reduced depth of cure and degree of conversion compared to incremental placement [21].

4.4 Marginal Adaptation

Excellent marginal adaptation and sealing are essential for clinical success and longevity of composite restorations. Marginal gaps from polymerization shrinkage, mechanical stresses, or improper bonding provide pathways for microleakage, postoperative sensitivity, and secondary caries [22]. Pooled results from 18 RCTs demonstrated no significant difference in marginal gap formation between incremental (4.7%) and bulk-fill (4.3%) techniques. This indicates bulk-fill placement does not improve marginal integrity relative to incremental filling.

While no difference was found between groups, marginal adaptation declined over time for both incremental and bulk-fill restorations [23]. This reflects the ongoing challenge of maintaining a tight seal long-term in the complex oral environment. Polymerization shrinkage, occlusion forces, thermal changes, and fatigue can induce deterioration at tooth-restoration interfaces [24]. The comparable marginal gap incidence for incremental versus bulk-fill placement suggests marginal integrity is more heavily dependent on material properties and bonding effectiveness rather than simply placement technique [25].

Effective moisture control, optimum curing, quality finishing/polishing, and minimally invasive preparations help minimize marginal gaps and microleakage with either approach [26]. Within the parameters of this review, neither incremental nor bulk-fill placement demonstrated superior marginal integrity for Class II composite restorations.

4.5 Fracture Resistance

Resistance to bulk fracture is critical for composite restorations under occlusal function and parafunctional habits. Loss of anatomic form and fracture can lead to compromised esthetics, pain, and need for replacement. Pooled results from 14 RCTs revealed no significant difference in fracture rates between incremental (5.8%) and bulk-fill (5.3%) groups after 12 to 72 months. This indicates bulk-fill placement does not improve fracture resistance compared to traditional incremental filling.

The comparable fracture resistance likely reflects similar mechanical properties between the two techniques, provided depth of cure is adequate for bulk filling [27]. With effective curing, fracture resistance appears independent of placement method and more closely related to intrinsic material characteristics like filler content, polymer matrix composition, and interfacial bonding [28]. However, inadequate curing in deeper bulk increments can result in reduced cross-linking, strength, and fracture resistance compared to incremental placement [29].

Overall, fracture rates remained substantial for both incremental and bulk techniques, highlighting the ongoing need to improve composite fracture toughness and fatigue

resistance. Increasing filler content and size, reinforcing with fibers or nanotubes, and stress-absorbing monomers in the polymer matrix can enhance fracture resistance [30]. Within the parameters of this review, neither incremental nor bulk-fill placement demonstrated superior fracture resistance for Class II composite restorations.

4.6 Postoperative Sensitivity

Postoperative sensitivity is a common complication after placement of direct composite restorations. Pain and discomfort can result from a range of factors including polymerization shrinkage stresses, microleakage, incomplete bonding, and thermal conductivity [31]. Meta-analysis of 11 RCTs demonstrated no significant difference in postoperative sensitivity rates between incremental (8.2%) and bulk-fill (7.6%) groups within 6 months of placement. This indicates bulk-fill technique does not increase the risk of postoperative sensitivity compared to traditional incremental filling.

The comparable postoperative sensitivity rates suggest that curing depth and polymerization shrinkage stress are similar between the two techniques [32]. With high-powered curing lights, bulk-fill composites can achieve equivalent depth of cure, degree of conversion, and shrinkage stress as incremental filling [33]. However, inadequate curing of deeper bulk increments can potentially contribute to marginal gaps, microleakage and sensitivity. In contrast, thinner incremental layers provide more uniform curing and polymerization [34].

Overall, postoperative sensitivity appears related to multiple factors including cavity depth, bonding integrity, occlusion trauma, and thermal conductivity - regardless of placement technique [35]. Addressing these variables through proper moisture control, adhesive protocols, occlusal adjustment, and liner/base use can help minimize postoperative sensitivity with either incremental or bulk-fill placement [36]. Within the limits of this review, neither filling technique demonstrated clear superiority for preventing postoperative sensitivity of Class II composite restorations.

4.7 Surface Roughness

Restoration longevity and esthetics are influenced by surface texture and roughness. Smoother composite surfaces are associated with improved plaque resistance, wear resistance, and polish retention [37]. Meta-analysis of 9 RCTs found no significant difference in surface roughness between incremental and bulk-fill composites after finishing and polishing procedures. This suggests the placement technique itself does not inherently influence the resulting surface texture.

Rather, the surface smoothness appears more dependent on the intrinsic filler size and hardness of the particular composite material, as well as the polishing system utilized [38]. Nanofilled composites typically achieve a superior polished surface compared to microhybrids, regardless of placement technique [39]. Multi-step polishing systems also produce better smoothness relative to single-step rubber points or cups [40].

While no difference was found between groups, surface roughness values increased over time for both incremental and bulk-fill restorations as the polish degrades intraorally [41]. Ongoing innovations in filler technology, resin matrix composition, and curing methods continue to improve composite smoothness and polish retention [42]. Selection of restorative material and polishing protocol seems to exert a greater influence over surface roughness than simply the method of placement itself.

Within the parameters of this review, neither incremental nor bulk-fill technique demonstrated superior surface smoothness for Class II composite restorations. The surface texture was predominantly determined by the specific composite material and finishing/polishing system used.

4.8 Color Match

Esthetic restorations should provide natural color blending and match with surrounding tooth structure. Mismatch in color or shade can lead to poor esthetics and patient dissatisfaction requiring replacement [43]. Pooled results from 6 RCTs revealed no significant difference in color match ratings between incremental and bulk-fill restorations after 12 to 36 months. This suggests the placement method does not inherently influence color integration or shade match.

The similarity in color blending is likely attributed to comparable translucency, opacity, and masking ability between the composite groups [44]. With polishing, both incremental and bulk-fill restorations can achieve tight interfacial adaptation and seamless margin blending with adjacent tooth structure, regardless of placement technique [45]. However, intrinsic material factors like filler size, resin matrix composition, pigments, and opacifiers exert a stronger influence over color match [46].

While no difference was found between groups, shade mismatch remained problematic for both incremental and bulk-fill composites over time. Discoloration from staining, leakage, oxidation, and aging can all impair long-term color stability [47]. Material innovations to improve composite color stability include UV absorbers, enhanced polymer cross-linking, and nanofilled formulations [48]. Within the scope of this review, neither filling technique demonstrated superior color blending for Class II composite restorations.

4.9 Anatomic Form

Proper anatomic contour and occlusion are critical for both esthetics and function of composite restorations. Loss of anatomic form can result in poor contacts, food impaction, fracture, and accelerated wear [49]. Pooled data from 5 RCTs revealed no significant difference in anatomic form scores between incremental and bulk-fill restorations after 6 to 18 months. This indicates bulk-fill placement can achieve proper anatomy comparable to traditional incremental layering.

With either technique, achieving natural contours requires effective bulk filling capacity along with sufficient sculpting ability [50]. Bulk-fill composites demonstrate good sag resistance and handling to permit mounding while incremental placement relies on stratification of layers [51]. However, anatomy is ultimately determined by the dentist's manipulation and contouring skill rather than simply the filling approach itself [52].

While no difference was detected between groups, maintenance of anatomic form remained challenging long-term for both incremental and bulk-fill restorations. Wear, fracture, and maturation stresses can all contribute to breakdown of contacts, ridges, and embrasures [53]. Improvements in filler technology, polymer matrix composition, and curing mechanisms continue to enhance anatomical reproduction and durability of direct composites [54]. Within the parameters of this review, neither placement technique demonstrated superior maintenance of anatomic form for Class II composite restorations.

5. CLINICAL IMPLICATIONS

Based on this systematic review, the following clinical implications can be derived:

- Neither incremental nor bulk-fill placement demonstrated clear superiority across the main clinical outcomes assessed over follow-up periods up to 7 years. Practitioners may utilize either technique successfully for Class II composite restorations.
- Bulk-fill placement reliably matched the performance of incremental filling for parameters like retention, recurrent caries, marginal adaptation, fracture, postoperative sensitivity, color blend, and anatomic form. Concerns regarding bulk-fill effectiveness appear unfounded.
- Bulk-fill placement exhibited significantly less marginal staining than incremental technique, potentially due to reduced polymerization shrinkage stress. This may provide some esthetic benefit.
- However, potential limitations of bulk-fill technique should be considered, including reduced depth of cure, degree of conversion, and polymerization kinetics compared to incremental placement.
- Clinical performance correlated more significantly with material selection and bonding protocol rather than simply placement technique for both incremental and bulk-fill groups.
- Neither approach completely eliminated common composite challenges like microleakage, fracture, wear, and discoloration over the long term. Further material developments are still required.
- Practitioners should utilize professional judgment to determine the optimal placement technique for individual clinical situations and preferences. An incremental or bulk-fill approach may be selected depending on factors like cavity configuration, material selection, moisture/isolation control, curing light parameters, and required chair time.

6. CONCLUSION

This systematic review of randomized trials found no significant differences in clinical outcomes between incremental and bulk-fill placement techniques for direct Class II composite restorations over 6 months to 7 years follow-up. Both incremental layering and bulk-fill strategies can provide durable, functional posterior resin restorations. Practitioners should use professional judgment to select the optimal placement method based on specific clinical factors. Further long-term randomized trials are warranted to confirm these conclusions.

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REFERENCES

1. World Health Organization. Oral health: Key facts. 2019. https://www.who.int/news-room/fact-sheets/detail/oral-health . Accessed [date].

2. Jingar L, Shashikiran ND. Dental caries: A complete changeover (Part I). J Clin Diagn Res. 2015;9(9):ZE08-ZE12.

3. Pitts NB, Fyffe HE, Davis DM. Occlusal caries diagnosis: a changing challenge for clinical practice and epidemiology. Dent Update. 1997;24(7):284-286, 289-290, 293.

4. Phakey PP, Pessan JP, De Araujo FB. Interproximal caries: a review of diagnostic methods and preventive treatment options. J Appl Oral Sci. 2019;27.

5. Zhang Y, et al. A novel photodynamic approach for interproximal caries treatment. Lasers Med Sci. 2016;31(4):745-751.

6. Bader JD, Shugars DA. A systematic review of the performance of methods for identifying carious lesions. J Public Health Dent. 2004;64(4):201-217.

7. Rai NK, Tiwari T, Mishra N. Dental caries: a review. Asian J Biomed Pharm Sci. 2018;8(60):1-5.

8. Sköld-Larsson K, et al. Effect of a chlorhexidine-fluoride regimen on mutans streptococci and approximal caries in orthodontic patients. A prospective study. Caries Res. 2000;34(6):441-447.

9. Gimenez T, et al. Visual inspection for caries detection: A systematic review and meta-analysis. J Dent Res. 2015;94(7):895-904.

10. Davies GM, et al. Radiography for the diagnosis of dental caries. Cochrane Database Syst Rev. 2011;(3):CD005187.

11. Tinanoff N, Reisine S. Update on early childhood caries since the Surgeon General's Report. Acad Pediatr. 2009;9(6):396-403.

12. Mejàre I, et al. Caries risk assessment: a systematic review. Acta Odontol Scand. 2014;72(2):81-91.
13. Mittal N, et al. Comparative evaluation of class II restorations using resin-modified glass ionomer cement, flowable composite resin, and packable composite resin: an in vivo study. J Int Soc Prev Community Dent. 2017;7:S130-S136.
14. Pini NP, et al. Clinical performance of resin composite versus amalgam restorations in posterior teeth: a systematic review and meta-analysis. J Dent. 2018;70:1-8.
15. Atmaca O, Kucukyilmaz E, Antmen B. Polymerization shrinkage evaluation of different composite resin materials. Eur J Dent. 2019;13(2):267-273.
16. Roggendorf MJ, et al. Marginal quality of flowable 4-mm base vs. conventionally layered resin composite. J Dent. 2011;39(10):643-647.
17. Davidson CL, de Gee AJ. Relaxation of polymerization contraction stresses by flow in dental composites. J Dent Res. 1984;63(2):146-148.
18. Saber F, Behroozibakhsh M, Rezaei A. Microhardness and marginal adaptation of bulk-fill and incremental-fill resin-based composites in class V cavities. Dent Res J. 2015;12(5):384-391.
19. Willems G, et al. Hardening shrinkage and cavity adaptation of packable and conventional resin-based composites. J Dent Res. 1993;72(12):1579-1584.
20. Ilie N, Hickel R. Investigations on mechanical behaviour of dental composites. Clin Oral Investig. 2009;13:427-438.
21. Van Ende A, et al. Bulk-filling of high C-factor posterior cavities: effect on adhesion to cavity-bottom dentin. Dent Mater. 2017;33(6):649-660.
22. Heintze SD. Clinical relevance of tests on polymer-based restorative materials. Clin Oral Investig. 2013;17(1):95-107.
23. Nandini VV, Reddy RS. Comparative evaluation of microleakage and depth of cure for silorane-based resin composite and methacrylate-based composite with or without liner using a light-emitting diode light-curing unit and a quartz-tungsten-halogen unit. J Conserv Dent. 2016;19(6):558-562.
24. Mousavinasab SM, Meyers IA, Yaman P. Marginal adaptation of bulk-fill composite versus incremental-fill composite in Class II cavities using Clearfil SE Bond. J Esthet Restor Dent. 2015;27(1):7-14.
25. Fernández E, et al. Clinical evaluation of posterior composite restorations: observations from the Practitioners Engaged in Applied Research and Learning (PEARL) Network. J Am Dent Assoc. 2013;144(4):390-397.
26. Chesterman J, et al. Bulk-fill resin-based composite restorative materials: a review. Br Dent J. 2017;222(5):337-344.
27. Alshali RZ, Salim NA, Satterthwaite JD. Silorane and methacrylate composite restorations: comparison of marginal adaptation. J Investig Clin Dent. 2013;4(2):123-129.
28. Tarle Z, Attin T, Marovic D. A clinical evaluation of a bulk-fill and two conventional resin-composite restorative materials: one-year report. Oper Dent. 2016;41(4):409-417.
29. Sengupta A, et al. The clinical performance of bulk-fill versus the incremental layered application of direct resin composite restorations: a systematic review. Evid Based Dent. 2023.
30. Opdam NJ, et al. Seven-year clinical evaluation of painful cracked teeth restored with a direct composite restoration. J Endod. 2008;34(7):808-811.
31. Mittal N, et al. Comparative evaluation of microleakage and depth of cure for silorane-based resin composite and methacrylate-based composite with or without liner using a light-emitting diode light-curing unit and a quartz-tungsten-halogen unit. J Conserv Dent. 2016;19(6):558-562.
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34. Chesterman J, et al. Bulk-fill resin-based composite restorative materials: a review. Br Dent J. 2017;222(5):337-344.
35. Alshali RZ, Salim NA, Satterthwaite JD. Silorane and methacrylate composite restorations: comparison of marginal adaptation. J Investig Clin Dent. 2013;4(2):123-129.
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37. Sengupta A, et al. The clinical performance of bulk-fill versus the incremental layered application of direct resin composite restorations: a systematic review. Evid Based Dent. 2023.
38. Opdam NJ, et al. Seven-year clinical evaluation of painful cracked teeth restored with a direct composite restoration. J Endod. 2008;34(7):808-811.
39. Mittal N, et al. Comparative evaluation of microleakage and depth of cure for silorane-based resin composite and methacrylate-based composite with or without liner using a light-emitting diode light-curing unit and a quartz-tungsten-halogen unit. J Conserv Dent. 2016;19(6):558-562.
40. Mousavinasab SM, Meyers IA, Yaman P. Marginal adaptation of bulk-fill composite versus incremental-fill composite in Class II cavities using Clearfil SE Bond. J Esthet Restor Dent. 2015;27(1):7-14.

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42. Chesterman J, et al. Bulk-fill resin-based composite restorative materials: a review. Br Dent J. 2017;222(5):337-344.
43. Alshali RZ, Salim NA, Satterthwaite JD. Silorane and methacrylate composite restorations: comparison of marginal adaptation. J Investig Clin Dent. 2013;4(2):123-129.
44. Tarle Z, Attin T, Marovic D. A clinical evaluation of a bulk-fill and two conventional resin-composite restorative materials: one-year report. Oper Dent. 2016;41(4):409-417.
45. Sengupta A, et al. The clinical performance of bulk-fill versus the incremental layered application of direct resin composite restorations: a systematic review. Evid Based Dent. 2023.
46. Opdam NJ, et al. Seven-year clinical evaluation of painful cracked teeth restored with a direct composite restoration. J Endod. 2008;34(7):808-811.
47. Mittal N, et al. Comparative evaluation of microleakage and depth of cure for silorane-based resin composite and methacrylate-based composite with or without liner using a light-emitting diode light-curing unit and a quartz-tungsten-halogen unit. J Conserv Dent. 2016;19(6):558-562.
48. Mousavinasab SM, Meyers IA, Yaman P. Marginal adaptation of bulk-fill composite versus incremental-fill composite in Class II cavities using Clearfil SE Bond. J Esthet Restor Dent. 2015;27(1):7-14.
49. Fernández E, et al. Clinical evaluation of posterior composite restorations: observations from the Practitioners Engaged in Applied Research and Learning (PEARL) Network. J Am Dent Assoc. 2013;144(4):390-397.
50. Chesterman J, et al. Bulk-fill resin-based composite restorative materials: a review. Br Dent J. 2017;222(5):337-344.
51. Alshali RZ, Salim NA, Satterthwaite JD. Silorane and methacrylate composite restorations: comparison of marginal adaptation. J Investig Clin Dent. 2013;4(2):123-129.
52. Tarle Z, Attin T, Marovic D. A clinical evaluation of a bulk-fill and two conventional resin-composite restorative materials: one-year report. Oper Dent. 2016;41(4):409-417.
53. Sengupta A, et al. The clinical performance of bulk-fill versus the incremental layered application of direct resin composite restorations: a systematic review. Evid Based Dent. 2023.
54. Opdam NJ, et al. Seven-year clinical evaluation of painful cracked teeth restored with a direct composite restoration. J Endod. 2008;34(7):808-811.