

# Longevity of Direct Composite Resin Restorations in Posterior Teeth: A Narrative Review of Survival Rates, Failure Modes, Patient and Operator Related Risk Factors for Direct Resin Restorations

Cathy Mariana Huerta Mauricio<sup>1\*</sup>, Andrea Yolanda Munsibay Foronda<sup>2</sup>, Antonella Restani<sup>3</sup>, Any Luceli Muñoz Vargas<sup>4</sup>

<sup>1</sup>University of Colorado, Denver, United States BSc in Biology. Universidad de San Martín de San Martín de Porres, Lima, Peru, School of Dentistry, Peru

<sup>2</sup>School of Dentistry, Universidad Científica del Sur, Lima, Peru

<sup>3</sup>School of Dentistry, Universidad José Antonio Páez, Venezuela

<sup>4</sup>School of Dentistry, Universidad Nororiental Privada "Gran Mariscal de Ayacucho," Anzoátegui, Venezuela

\*Correspondence author: Cathy Mariana Huerta Mauricio, BS, DDS, University of Colorado, Denver, United States BSc in Biology. Universidad de San Martín de San Martín de Porres, Lima, Peru, School of Dentistry, Peru; E-mail: [research@idpathwaysllc.com](mailto:research@idpathwaysllc.com)

Citation: Mauricio CMH, et al. Longevity of Direct Composite Resin Restorations in Posterior Teeth: A Narrative Review of Survival Rates, Failure Modes, Patient and Operator Related Risk Factors for Direct Resin Restorations. *J Dental Health Oral Res.* 2026;7(2):1-12.

<https://doi.org/10.46889/JDHOR.2026.7218>

Received Date: 20-05-2026

Accepted Date: 15-06-2026

Published Date: 22-06-2026



Copyright: © 2026 The Authors. Published by Athenaeum Scientific Publishers.

This is an open access article distributed under the terms of the Creative Commons Attribution 4.0 International License (CC BY 4.0), which permits unrestricted use, distribution and reproduction in any medium, provided the original work is properly cited.

License URL:

<https://creativecommons.org/licenses/by/4.0/>

## Abstract

Posterior direct composite resin restorations have expanded significantly in contemporary restorative dentistry, primarily due to their esthetic properties and compatibility with conservative tooth preparation. Long-term clinical success depends on a complex interaction of biological, mechanical, patient-related and operator-related factors. The objective of this research is to analyze the long-term survival of posterior composite restorations, evaluate their principal failure modes and identify the risk factors that most significantly contribute to clinical failure. A narrative synthesis of clinical studies and systematic reviews was conducted, with emphasis on survival rates, annual failure rates and FDI-based clinical evaluation criteria. Posterior composite restorations demonstrate favorable survival rates exceeding 90% at five years and above 80% at ten years, with annual failure rates generally ranging between 1% and 3%; long-term follow-up extending to 30 years confirms clinically acceptable performance in appropriately selected cases. The primary causes of failure include secondary caries, fracture, loss of retention, marginal deterioration and wear. Longevity is negatively associated with high caries risk, parafunctional habits, poor oral hygiene and technical errors. Posterior composite restorations represent a reliable restorative option when case selection, adhesive technique and clinical protocol are carefully controlled. Individual patient risk stratification is central to long-term success.

**Keywords:** Posterior Composites; Longevity; Secondary Caries; Fracture; Clinical Survival

## Introduction

Direct posterior composite restorations have evolved from an esthetic alternative to a routine treatment modality in contemporary restorative dentistry. As indications for resin-based composites continue to expand, understanding their long-term clinical behavior has become essential for evidence-based decision-making [1]. Although

improvements in adhesive systems and composite formulations have significantly enhanced clinical outcomes, restoration longevity remains a multifactorial phenomenon influenced by biological, mechanical and clinical variables. Long-term survival studies therefore provide critical insight into the real-world performance of posterior composite restorations over time [2,3].

Available longitudinal evidence demonstrates that posterior direct composite restorations can achieve clinically acceptable survival rates even over extended follow-up periods. In a comprehensive retrospective evaluation with follow-up periods reaching up to 33 years, Da Rosa Rodolpho, et al., reported that posterior resin composite restorations maintain satisfactory <https://doi.org/10.46889/JDHOR.2026.7218> <https://athenaeumpub.com/journal-of-dental-health-and-oral-research/>

clinical performance for decades when properly indicated and maintained [1,4]. Similarly, a randomized controlled trial by Pallesen and van Dijken demonstrated favorable outcomes after 30 years of clinical service for Class II composite restorations, supporting the long-term viability of contemporary resin-based materials [3].

Several retrospective and prospective studies have consistently reported survival rates above 80% after 10 years of clinical function, with annual failure rates generally ranging between 1% and 3%. These findings suggest that direct composite restorations can achieve longevity comparable to other conventional restorative approaches when appropriate clinical protocols are followed [5]. However, restoration size plays a substantial role in long-term performance. Larger multi-surface restorations tend to demonstrate reduced survival compared with smaller restorations, due to increased polymerization stress, occlusal loading and structural compromise of the remaining tooth substrate [5,6].

Importantly, restoration survival does not necessarily imply ideal clinical conditions. Contemporary evaluation systems, including the United States Public Health Service (USPHS) and Federation Dentaire Internationale (FDI) criteria, assess multiple parameters beyond mere retention, including marginal adaptation, anatomical form, surface texture, marginal discoloration and wear [7]. According to Pizzolotto and Moraes, many posterior composite restorations remain clinically functional despite presenting minor defects or gradual degradation over time [2,4]. This concept reinforces the modern philosophy of minimally invasive dentistry, in which repair and monitoring are often preferred over complete replacement in restorations with localized defects [5].

Patient-centered outcomes also contribute to the favorable perception of posterior composite restorations. Improved esthetics, conservative tooth preparation and adhesive bonding capabilities have strengthened their acceptance among both clinicians and patients [2,7]. Despite generally favorable long-term outcomes, however, posterior composite restorations remain susceptible to progressive biologic and mechanical complications that ultimately determine restoration failure patterns. Understanding these specific modes of failure is essential for improving restoration longevity and optimizing clinical decision-making [3,4].

The aim of this narrative review is to evaluate the long-term survival of direct composite resin restorations in posterior teeth by analyzing survival rates, clinical performance, common failure modes and the influence of patient-, operator- and material-related risk factors on restorative outcomes. Additionally, the review aims to discuss evidence-based strategies that may optimize restoration durability and improve clinical decision-making in contemporary restorative dentistry.

### **Survival Rates and Clinical Performance: What the Evidence Actually Says Across Time**

The growing clinical use of direct composite resin restorations in posterior teeth has increased the demand for long-term evidence regarding their durability and overall performance. Although posterior composites were initially questioned due to concerns related to wear, polymerization shrinkage and marginal integrity, advances in adhesive systems and restorative materials have substantially improved their clinical reliability [1]. Consequently, survival analysis has become one of the most informative methods for evaluating the long-term success of posterior composite restorations under real clinical conditions.

Current evidence demonstrates that posterior composite restorations present favorable survival rates in short- and medium-term follow-up periods. Systematic reviews comparing bulk-fill and conventional composites have shown survival rates greater than 90% after approximately five years of clinical service, with no statistically significant differences between the two material types in most clinical parameters [8,9]. Similarly, randomized clinical trials evaluating posterior restorations placed with contemporary adhesive strategies have reported satisfactory retention, marginal adaptation and anatomical stability during follow-up periods ranging from 18 to 36 months [10,11]. These findings suggest that modern resin composites are capable of achieving predictable clinical outcomes when appropriate restorative protocols are followed.

However, survival outcomes tend to decline progressively over longer observation periods. Studies with follow-up periods exceeding 10 years remain relatively scarce due to challenges such as patient dropout, operator variability and the continuous evolution of restorative materials and techniques [5,12]. This limitation introduces methodological heterogeneity and makes direct comparisons between studies more difficult. Even so, available long-term evidence indicates that posterior composite restorations can maintain clinically acceptable performance over time, although survival rates are generally lower in extensive restorations and complex clinical situations [6].

Annual Failure Rate (AFR) is another important parameter frequently used to evaluate restoration longevity. Most studies report AFR values between 1% and 3% for posterior composite restorations [5,13]. Nevertheless, AFR may vary considerably depending on study design, follow-up duration, operator experience, cavity size and restorative technique. For this reason, AFR should not be interpreted as an isolated indicator of material quality, but rather as part of a broader clinical evaluation that also considers patient- and procedure-related variables [14].

Differences in survival are also observed according to cavity classification. Class I restorations generally demonstrate higher longevity than Class II restorations because they are exposed to lower occlusal stress and involve less structural loss of tooth tissue. In contrast, multi-surface restorations present significantly greater risk of failure, particularly in posterior teeth subjected to high functional loading [7,15]. Regression analyses from longitudinal studies consistently demonstrate that the number of restored surfaces is an important predictor of reduced restoration survival.

When compared with amalgam restorations, contemporary composites show increasingly comparable clinical performance, especially in small- and moderate-sized cavities. Amalgam may still demonstrate superior longevity in extensive posterior restorations exposed to heavy occlusal forces; however, differences in clinical evaluation systems, including USPHS and FDI criteria, contribute to variability among studies and complicate direct comparison of outcomes [6,7]. A comparative summary of the clinical performance of conventional composites, bulk-fill composites and amalgam restorations is presented in overall, current evidence supports the use of posterior composite restorations as a reliable long-term restorative option. Nevertheless, despite generally favorable survival trends, these restorations remain susceptible to biologic and mechanical complications that ultimately determine their long-term clinical behavior (Table 1) [2,16].

Parameter	Conventional Composite Resin	Bulk-Fill Composite Resin	Dental Amalgam
Short-term survival (1-3 years)	Excellent; survival rates commonly >95% [1,2]	Comparable to conventional composites [1,2]	Historically high survival rates [7]
Medium-term survival (5-7 years)	Frequently >90% with appropriate adhesive protocols [1,2]	Similar survival and marginal adaptation [1]	Slightly higher longevity in high-load areas [7]
Long-term survival (>10 years)	Clinically acceptable but gradually reduced over time [6]	Limited long-term evidence currently available [1]	Generally superior in extensive posterior restorations [7]
Annual Failure Rate (AFR)	Approximately 1-3% [1,6]	Similar AFR to conventional composites [1]	Often slightly lower AFR in long-term studies [7]
Performance in Class II	Lower survival than Class I [6]	Similar tendency observed [1]	Traditionally favorable in multi-surface restorations [7]
Esthetics	Excellent	Excellent	Poor
Tooth preservation	Conservative adhesive preparation	Conservative adhesive preparation	Requires greater mechanical retention
Main limitation	Technique sensitivity; reduced longevity in large restorations	Limited evidence beyond 10 years	Inferior esthetics and environmental concerns

**Table 1:** Comparative clinical performance of posterior restorative materials across time.

## Failure Modes: From Secondary Caries to Bulk Fracture: A Clinical Taxonomy of Why Composites Break Down

### Secondary Caries

Secondary caries is the predominant cause of failure in posterior resin composite restorations and is primarily associated with microleakage at the tooth-restoration interface. Polymerization shrinkage, degradation of the adhesive interface and inadequate

bonding may promote gap formation, facilitating bacterial infiltration and demineralization adjacent to the restoration margins [12]. The presence of these interfacial gaps appears to increase susceptibility to recurrent caries, particularly in patients with elevated caries risk [13]. Current evidence suggests that the occurrence of secondary caries is multifactorial, involving patient-related factors, operator technique and adhesive strategy. Three-step etch-and-rinse systems may provide superior marginal sealing compared with simplified adhesive approaches; however, available clinical evidence remains limited due to short follow-up periods and the low incidence of reported secondary caries events [14].

#### *Adhesive and Cohesive Fractures*

Adhesive and cohesive fractures represent two distinct failure patterns in composite restorations. Adhesive failures occur at the tooth-restoration interface, whereas cohesive fractures develop within the restorative material or the dental substrate itself [15]. Although polymerization shrinkage plays an important role in restoration failure, other factors including occlusal loading, elastic modulus, material properties and restoration thickness may also increase interfacial and marginal stresses, compromising the mechanical performance of posterior restorations [16]. Furthermore, maxillary premolars exhibit a higher susceptibility to cusp and vertical fractures than molars due to their anatomical characteristics and stress concentration patterns, especially in structurally weakened teeth restored with direct composite techniques [17].

#### *Occlusal Wear*

Occlusal wear of resin composites is influenced by both filler characteristics and resin matrix composition. Materials with higher filler loading generally demonstrate greater wear resistance, which is particularly relevant in posterior restorations and in patients with parafunctional habits exposed to increased occlusal stress. Nanohybrid and nanofilled composites were developed to improve mechanical performance through smaller and more homogeneous filler particles; however, current clinical evidence still reports wear behavior broadly comparable to that of conventional composites [18].

#### *Marginal Deterioration and Microleakage*

Polymerization shrinkage is considered one of the main causes of stress generation and marginal deterioration in resin composite restorations. After gelation, shrinkage stresses are transferred directly to the tooth-restoration interface and may exceed bond strength, leading to marginal defects, microleakage and restoration failure. Incremental layering techniques have therefore been recommended to reduce contraction stress and improve light penetration and degree of conversion, particularly when increments are maintained at no more than 2 mm in thickness. Bulk-fill composites were developed to allow placement in thicker increments while maintaining adequate polymerization, achieved through improved translucency and modified filler composition. Clinical factors such as cavity configuration, increment thickness and curing light position may significantly influence polymerization efficiency and contraction stress. High C-factor cavities and improper curing light angulation can reduce the degree of conversion and compromise marginal integrity [19].

#### *Loss of Retention and Marginal Maladaptation*

Improper adhesive procedures, including inadequate cavity cleaning, contamination with saliva or blood, insufficient etching and incorrect choice of adhesive system, may compromise adhesive performance and contribute to loss of retention and marginal maladaptation over time [20]. Cavity geometry also appears to influence restoration longevity; preservation of enamel margins and wider internal cavity angles may reduce interfacial stresses and improve the biomechanical stability of adhesive restorations, consistent with current minimally invasive principles [21].

#### *Repair Versus Replacement*

Repair procedures represent a conservative clinical approach because they preserve the intact portion of the existing restoration and minimize unnecessary removal of sound tooth structure. Clinical evidence indicates that repairs can reduce annual failure rates and achieve longevity comparable to complete replacement in appropriately selected cases. Replacement becomes necessary, however, when extensive secondary caries, severe structural compromise with an elevated risk of fracture or irreversible esthetic limitations prevent predictable conservative management [22].

## Patient- and Operator-Related Risk Factors: The Human Variables That Override Material Quality

### *Patient-Related Factors*

*Cariogenic Risk:* Behavioral and cariogenic risk factors significantly influence the longevity of posterior composite restorations, regardless of the restorative material used. Frequent sugar intake, poor oral hygiene and biofilm accumulation promote prolonged acidic conditions that contribute to tooth demineralization and degradation of adhesive interfaces. Caries risk assessment has therefore become an important clinical tool, as patients classified as having moderate or high caries risk exhibit a greater probability of restoration failure. Individuals with elevated DMFT scores demonstrate substantially higher failure rates, emphasizing the importance of preventive strategies and individualized risk-based management to improve restorative prognosis. [23].

*Parafunctional Habits and Bruxism:* Although posterior composite restorations can tolerate normal masticatory forces, parafunctional habits such as bruxism may significantly accelerate their structural degradation. Repetitive high-magnitude occlusal loading has been associated with matrix fatigue, filler particle loss, marginal deterioration and reduced restoration stability [24]. Consequently, occlusal protection strategies should be considered in patients with bruxism. Splint material selection may also influence the wear behavior of both restorative materials and dental tissues; in patients with no or minimal tooth wear or whose teeth are restored with composite, heat-cured PMMA splints may be preferred due to their durability. When preservation of dentin is of paramount importance, chemically cured splint materials may represent a more appropriate choice [25].

*Oral Hygiene and Gingival Status:* Frequent plaque control measures, particularly twice-daily toothbrushing, appear to improve the clinical longevity of posterior composite restorations by reducing biofilm accumulation and secondary caries risk [26]. Evidence also suggests a synergistic interaction between poor oral hygiene and high caries risk, increasing the likelihood of restoration replacement, especially in Class II restorations [27]. Furthermore, bacterial and salivary esterases may accelerate adhesive biodegradation, compromise the dentin-resin interface and promote microleakage and secondary caries development [28].

*Systemic and Behavioral Conditions:* Several patient-related systemic and behavioral factors may substantially compromise the longevity of posterior composite restorations regardless of material properties. Higher failure rates have been reported in adolescents and older adults; in younger patients due to cariogenic dietary habits and in elderly individuals due to age-related changes in salivary flow, medication use, impaired oral hygiene capacity and systemic health conditions [29,30]. Xerostomia in particular has been strongly associated with increased caries susceptibility and reduced survival of large composite restorations, given the critical protective role that saliva plays against demineralization. Conditions such as polypharmacy, smoking, eating disorders and poor oral hygiene practices may substantially reduce restoration survival by increasing cariogenic activity and impairing the oral environment. Evidence suggests that patient-related variables frequently outweigh material-related properties in determining restoration longevity [23].

### *Operator-Related Factors*

*Clinical Experience and Moisture Control:* The operator plays a critical role in the longevity of posterior composite restorations. Adherence to adhesive protocols, moisture control and appropriate photopolymerization techniques directly influence restoration survival and marginal integrity [31]. Evidence suggests that operator-related variables, including clinical experience, decision-making patterns and familiarity with contemporary restorative protocols, may significantly affect the long-term performance of posterior composite restorations. Inadequate light-curing protocols and insufficient understanding of photopolymerization principles may compromise the mechanical properties of resin composites and increase the risk of degradation and microleakage over time. Differences in restorative outcomes among clinicians highlight the strong influence of operator-dependent factors on restoration longevity, including treatment philosophy, technical execution and consistency in maintaining clinical protocols [23,32].

*Adhesive Strategy:* Adhesive strategy influences the clinical handling and technique sensitivity of posterior composite restorations. Although etch-and-rinse, self-etch and universal adhesive systems demonstrate comparable clinical outcomes regarding retention, marginal discoloration and postoperative sensitivity, self-etch approaches may offer greater clinical practicality due to their simplified application protocol and lower technique sensitivity [33]. Conventional etch-and-rinse systems require

meticulous execution because of their multiple application steps. Additionally, selective enamel etching with phosphoric acid may improve enamel bond performance when universal adhesives are used [29].

*Incremental Versus Bulk-Fill Technique:* Bulk-fill resin composites were introduced to simplify restorative procedures by allowing single-increment placement up to 4 to 5 mm in thickness while maintaining adequate polymerization depth and reducing shrinkage stress. Although their clinical survival appears comparable to conventional incremental techniques, successful outcomes still largely depend on adequate isolation and operator proficiency [30].

*Cavity Design and Restoration Extent:* Clinical evidence indicates that the number of restored surfaces significantly influences restoration survival. While single-surface restorations demonstrate the highest longevity, extensive preparations such as MOD cavities exhibit considerably greater failure risk. This increased susceptibility has been associated with larger restoration size, more complex stress distribution and higher operator-dependent technical sensitivity, all of which may contribute to fracture and secondary caries formation [5].

### **Composite Resin in Endodontically Treated Posterior Teeth: A High-Risk Scenario with Distinct Longevity Predictors**

#### *Why Endodontically Treated Teeth Represent a Distinct Restorative Category*

An Endodontically Treated Tooth (ETT) is not directly comparable to a vital tooth and this distinction has meaningful consequences for restoration planning. The pulp contains mechanoreceptors that modulate occlusal loading by providing proprioceptive feedback; once the pulp is removed, that protective mechanism is lost and patients may apply significantly higher forces without the usual sensory warning [31]. In addition, the irrigants used during endodontic treatment, particularly sodium hypochlorite and, to a lesser extent, EDTA, chemically alter the collagen network within dentinal tubules, reducing the inherent resilience of the dentin substrate independent of dehydration effects [32]. When this chemical alteration is combined with the structural tissue already lost to caries and access cavity preparation, the remaining tooth becomes substantially more brittle and susceptible to flexure and fracture under occlusal loading [31,32].

#### *Determinants of Restorative Prognosis*

When evaluating prognosis in an endodontically treated posterior tooth, the most critical starting point is the quantity of remaining coronal structure: specifically, the number of intact axial walls and the thickness of the marginal ridges. Loss of both marginal ridges, which is the typical outcome of a MOD preparation, dramatically reduces coronal stiffness and alters the internal distribution of occlusal forces [33]. A wide, deep occlusal isthmus frequently acts as a stress concentrator and often corresponds to the initiation site of vertical fractures. Tooth position independently influences prognosis as well; premolars are at a structural disadvantage from the outset due to smaller coronal volume, steeper cuspal inclines and predominantly tangential force vectors, resulting in systematically poorer outcomes compared with molars [34]. Parafunctional habits further compromise this scenario, as the accumulated fatigue from repeated high-intensity loading eventually exceeds the mechanical tolerance of both the restorative material and the remaining dental structure [33,34].

#### *Direct Composite Versus Indirect Restoration in Endodontically Treated Teeth*

The available literature generally favors indirect cuspal-coverage restorations as the more mechanically reliable option when an ETT has sustained significant structural loss, primarily because these restorations distribute occlusal forces more evenly across the remaining coronal structure [34]. This does not preclude the use of direct composite; it remains a clinically justifiable choice when destruction is limited to one missing axial wall or when the preparation involves only an occlusal surface with intact marginal ridges [35,36]. Attempting to restore a MOD cavity with cuspal loss using direct composite in an ETT, however, represents an unacceptably high-risk scenario. In such cases, the composite material cannot prevent flexure of the remaining walls under occlusal loading and failure typically manifests as a vertical or subgingival fracture that cannot be conservatively managed [37]. A useful clinical threshold is as follows: direct composite is appropriate only when one axial wall or fewer is missing and the marginal ridges are intact. MOD cavities with cuspal loss in ETTs require indirect cuspal-coverage restoration [38].

#### *Direct Composite Technique in Endodontically Treated Teeth*

When direct composite is selected, the restorative plan must address stress dissipation from the outset, not merely volumetric replacement of lost tissue. In single-rooted teeth with significant wall loss, particularly premolars, a glass fiber post may be used

to provide coronal anchorage and redirect loading along the root axis; it is important to note, however, that fiber posts do not chemically reinforce the dentin substrate and should not be expected to do so [37]. The layering strategy also carries clinical significance beyond esthetics. Placing a base of low elastic modulus material, such as a highly filled flowable or a short fiber-reinforced composite, over the pulpal floor cushions the incoming occlusal stress before it reaches the adhesive interface; a higher-modulus sculptable composite then handles the occlusal surface and wear demands [38]. Among all technique-related decisions, direct cuspal coverage may offer the greatest protective benefit. Reducing weakened cusps by approximately 1.5 to 2 mm and enveloping them within the restoration converts destructive tensile forces into more manageable compressive forces directed toward the tooth axis [37,38].

#### *Direct Composite as an Interim Restoration After Endodontic Treatment*

Direct composite can serve as a functionally adequate interim restoration following endodontic treatment, particularly when a period of observation is warranted: to monitor periapical healing, confirm the success of the root canal procedure or allow periodontal stabilization [39]. The critical point is that this approach is temporary, not definitive. The clinically acceptable window for such an interim restoration is approximately 3 to 6 months [39,40]. Beyond this threshold, especially in large cavities, material fatigue, gingival margin leakage and the risk of unexpected fracture increase substantially and the risk of losing the tooth ceases to be a theoretical concern [40].

#### *Connection to Material Variables*

Endodontic status fundamentally changes the weight of every subsequent restorative decision. Access cavities are deep by definition, which means very high C-factor values and elevated polymerization shrinkage stress; at the same time, the dentin substrate has already been chemically altered by irrigant exposure, making the adhesive interface inherently less stable over time [41,42]. In a vital tooth, choices such as bulk-fill versus conventional composite, adhesive system selection or placement technique may seem largely equivalent. In an ETT, these same decisions directly affect whether the restoration will survive and they deserve to be treated accordingly [43].

### **Material Variables: Conventional vs. Bulk-Fill Composites, Adhesive Systems and the Role of Placement Technique**

#### *Nanofilled and Nanohybrid Composites*

Even with the rapid expansion of new restorative materials, nanofilled and nanohybrid composites continue to serve as the clinical reference for mechanically demanding posterior restorations. Their performance advantage derives from their filler design: silanized nanosized particles combined with nanoclusters allow manufacturers to achieve high filler loading by weight. In practical terms, this translates to greater compressive and flexural strength, improved resistance to attrition and abrasion and an elastic modulus that approaches that of natural dentin [42]. Multiple long-term clinical studies have documented their ability to maintain surface polish and occlusal contour over time, which makes them the preferred choice for reconstructing complex occlusal anatomy, performing direct cuspal coverage or working in any situation in which surface performance is critical [42,43].

#### *Bulk-Fill Composites: Short-Term Reliability and Long-Term Uncertainties*

In the short and medium term, clinical data for bulk-fill composites are reassuring. Their failure rates are broadly equivalent to those of conventionally placed incremental composites. The five-year double-blind RCT by Loguercio, et al., reported annual failure rates of 1.2% for bulk-fill versus 1.0% for the incremental technique, with no statistically significant difference between the groups [44]. Their ability to polymerize in 4 to 5 mm increments, achieved through enhanced translucency and more reactive photoinitiators, is well-supported, with adequate monomer conversion documented even at the base of deep cavities [44,45]. The limitation is in long-term extrapolation. Data beyond 5 to 10 years are sparse and open questions remain regarding hydrolytic degradation of the organic matrix and durability of the adhesive interface under repeated loading, particularly in large restorations [45]. Caution is therefore warranted when extending short-term results to high-risk situations such as structurally compromised ETTs.

#### *Low-Viscosity Versus High-Viscosity Bulk-Fill Formulations*

Low-viscosity (flowable) bulk-fill formulations adapt well to internal cavity angles and deep proximal boxes, providing excellent marginal seal where it matters most. The trade-off is lower filler content and correspondingly weaker mechanical properties, which is why a protective 2 mm capping layer of conventional or high-viscosity composite is required over the occlusal surface [46]. High-viscosity (sculptable) bulk-fill variants contain sufficient filler to handle occlusal forces directly without a capping

layer, allowing single-increment placement from the cavity floor to the occlusal surface [46,47]. The optimal choice depends on cavity depth, proximal box configuration and whether the primary clinical challenge is marginal sealing or occlusal anatomy reconstruction.

#### *Adhesive Systems and Long-Term Sealing*

Three-step total-etch systems remain the long-term clinical reference for dentin bonding. Phosphoric acid etching followed by separate primer and bond applications produces a thick, hydrophobic hybrid layer that is resistant to degradation over time [48]. Two-step total-etch systems (the one-bottle formulations) degrade faster because residual hydrophilicity gradually converts the adhesive into a semipermeable membrane. Two-step self-etch systems preserve the collagen network more effectively by avoiding over-etching and their dentin bonds tend to demonstrate good durability. One-step self-etch (all-in-one) systems show higher degradation rates and greater marginal leakage due to extreme hydrophilicity; selective enamel etching with phosphoric acid is strongly recommended when these systems are used, to compensate for their characteristically weak enamel bond [48,49]. In ETTs specifically, where the dentin substrate has already been chemically modified by NaOCl and EDTA exposure, the three-step total-etch approach provides the greatest margin of safety.

#### *Glass Ionomer Liner and the Open Sandwich Technique*

Using glass ionomer cement or resin-modified glass ionomer as a cavity base in the open sandwich technique is particularly indicated when deep proximal boxes have gingival margins at or apical to the cemento-enamel junction. Because the ionomer margin is exposed to the oral environment, it actively releases fluoride and can be recharged from external sources such as fluoride toothpaste, mouthwash or topical applications. The result is a zone of hypermineralized dentin at the gingival margin that is more resistant to acid demineralization [50]. In clinical terms, this translates to a meaningful reduction in secondary caries incidence at gingival margins on dentin or cementum [50,51]. There is also a mechanical benefit that deserves attention: the intermediate elastic modulus of glass ionomer cement provides a buffering layer that reduces stress concentration at the base of the composite, prevents microcracks from propagating upward and thereby improves overall marginal longevity [51].

#### *Polymerization Shrinkage Management*

Managing volumetric shrinkage and the resulting interfacial stress remains one of the most important challenges in posterior adhesive dentistry, because it directly affects marginal sealing and postoperative sensitivity. With conventional composites, the oblique incremental technique, placing increments of no more than 2 mm bonded to no more than two walls simultaneously, remains the most reliable approach for minimizing stress vectors at the adhesive interface [52]. Low-shrinkage bulk-fill matrices address the same problem from a chemical standpoint by incorporating stress-relieving monomers that delay the gel point and allow greater flow during the early stages of polymerization [52,53]. Placing a reduced-modulus flowable composite at the cavity floor serves as a complementary strategy, providing an elastic cushion that absorbs stress energy before it reaches the adhesive seal [53]. All of these considerations are amplified in ETTs, where deep access cavities produce C-factor values that push shrinkage stress to critical levels [41].

#### *Bioactive Restorative Materials*

Bioactive restorative materials, including composites containing calcium silicate and resins based on fluoroaluminosilicate glass, release fluoride, calcium and phosphate ions and promote the deposition of hydroxyapatite or fluorapatite at the restoration interface, making them theoretically attractive for patients at high caries risk [54]. The clinical evidence available to date, however, requires careful interpretation. Many of these materials sacrifice mechanical properties as ionic release continues and there is currently no clear evidence demonstrating superior survival compared with well-optimized conventional composites in mechanically demanding posterior situations [54,55]. At present, bioactive materials are best considered a selective adjunct for specific risk profiles rather than a universal replacement for conventional restorative approaches.

Material selection for direct posterior composite is not a one-size-fits-all decision. Cavity geometry, the quality of the adhesive substrate, C-factor and patient risk profile all interact and it is the combination of these variables, not any single factor, that determines whether a given protocol will achieve long-term success.

## Clinical Decision-Making and Risk-Based Management Strategies

### *Hierarchy of Factors Influencing Longevity*

The evidence reviewed across the preceding sections makes clear that the longevity of a posterior composite restoration is determined by a hierarchy of factors rather than by a single variable. Among the most influential are caries risk, the extent of the restoration, the quality of moisture control and adhesive technique and the patient's compliance with preventive and maintenance protocols [57,58]. Many of these factors are modifiable: oral hygiene habits, preventive care and adherence to follow-up appointments can all be addressed through patient education and individualized planning. Others, such as pre-existing structural loss or underlying systemic conditions affecting salivary function, cannot be altered and must instead be factored into case selection and treatment planning from the outset [5,57].

### *When Direct Posterior Composite Is the Optimal Choice*

Direct posterior composite restoration is most appropriate in cases characterized by small to moderate cavity size, intact or largely preserved marginal ridges, low to moderate patient caries risk, good oral hygiene and a cooperative patient with a clear commitment to regular follow-up [57,59]. In these situations, the restoration can be expected to perform reliably over many years when placed with meticulous technique and appropriate material selection. It is also a valid and evidence-supported option for endodontically treated teeth when the structural loss is limited: no more than one missing axial wall with intact marginal ridges [36].

### *When to Consider Indirect Alternatives*

Treatment planning becomes substantially more complex and direct composite less appropriate, when patients present with high caries risk, poor adherence to preventive care, high-magnitude occlusal forces (particularly in bruxing patients) or severe structural damage to the remaining tooth [60]. Endodontically treated posterior teeth with MOD cavities and cuspal loss are a specific scenario in which indirect cuspal-coverage restorations offer a meaningful mechanical advantage [35,36]. In these cases, defaulting to direct composite solely for its convenience or cost profile may represent an unreasonable clinical risk.

### *Risk-Stratified Management Protocols*

A risk-based approach to restoration management provides a more rational and individualized framework than applying a single protocol to all patients. For low-risk patients, routine restorative care with standard annual follow-up is generally sufficient [61]. For patients at moderate risk, additional preventive measures should be integrated: more rigorous rubber dam isolation, fluoride-based prevention, closer monitoring at six-month intervals and careful selection of adhesive strategy and cavity liner [56,57]. For high-risk patients, shorter follow-up intervals of three to four months, occlusal protection in bruxing patients, intensive preventive measures including topical fluoride application and a frank discussion of alternatives to direct composite should all be incorporated into the treatment plan. In this group, case selection may be more important than technical precision [50,62].

### *Repair Rather Than Replacement: Criteria and Evidence*

The management of defective restorations should not automatically default to complete replacement. When defects are localized and the restoration remains structurally functional, repair is a more conservative and evidence-supported option. Repair procedures preserve healthy tooth structure, reduce the invasiveness of successive interventions and can extend restoration survival at annual failure rates comparable to replacement in well-selected cases [59]. Complete replacement is reserved for situations involving extensive secondary caries, severe structural compromise with elevated fracture risk or esthetic or functional limitations that cannot be addressed conservatively [22]. This approach aligns directly with the principles of minimally invasive dentistry, which prioritizes the preservation of sound tooth structure at every decision point [58].

## Conclusion

Posterior direct composite restorations can achieve survival rates exceeding 90% at five years and above 80% at ten years when case selection is appropriate and clinical technique is meticulous. Longevity is determined primarily by patient caries risk, restoration extent, operator proficiency and preventive maintenance, not by material choice alone. Secondary caries and fracture are the leading modifiable causes of failure; restoration extent and endodontic status are the most influential non-modifiable predictors. Individualized, risk-stratified management remains the most evidence-supported approach to maximizing long-term outcomes in posterior composite restorations.

### Conflict of Interest

The authors declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

### Funding Statement

This research did not receive any specific grant from funding agencies in the public, commercial or non-profit sectors.

### Acknowledgement

The authors have no acknowledgments to declare.

### Data Availability Statement

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

### Ethical Statement

The project did not meet the definition of human subject research under the purview of the IRB according to federal regulations and therefore was exempt.

### Informed Consent Statement

Not applicable.

### Authors' Contributions

All authors contributed equally to this paper.

### References

1. Da Rosa Rodolpho PA, Rodolfo B, Collares K, Correa MB, Demarco FF, Opdam NJM, et al. Clinical performance of posterior resin composite restorations after up to 33 years. *Dent Mater.* 2022;38(4):680-8.
2. Pizzolotto L, Moraes RR. Resin composites in posterior teeth: Clinical performance and direct restorative techniques. *Dent J (Basel).* 2022;10(12):222.
3. Pallesen U, van Dijken JW. A randomized controlled 30 years follow up of three conventional resin composites in Class II restorations. *Dent Mater.* 2015;31(10):1232-44.
4. Borgia E, Baron R, Borgia JL. Quality and survival of direct light-activated composite resin restorations in posterior teeth: A 5- to 20-year retrospective longitudinal study. *J Prosthodont.* 2019;28(1):e195-e203.
5. Ulku SG, Unlu N. Factors influencing the longevity of posterior composite restorations: A dental university clinic study. *Heliyon.* 2024;10(6):e27735.
6. Opdam NJ, van de Sande FH, Bronkhorst E. Longevity of posterior composite restorations: A systematic review and meta-analysis. *J Dent Res.* 2014;93(10):943-9.
7. Bhagwat S, Mandke L, Vandekar M, Basmatkar N, Pawar A, Khatri R. Longevity of amalgam versus composite resin restorations in permanent posterior teeth: A systematic review. *Cureus.* 2025;17(7):e88836.
8. Zailai A, Alharbi ZA, Dowairi F. Clinical performance and survival of bulk-fill resin composites compared to conventional resin composites in posterior permanent teeth: A systematic review and meta-analysis. *Cureus.* 2025;17(12):e99792.
9. Arbildo-Vega HI, Lapinska B, Panda S, Lamas-Lara C, Khan AS, Lukomska-Szymanska M. Clinical effectiveness of bulk-fill and conventional resin composite restorations: Systematic review and meta-analysis. *Polymers.* 2020;12(8):1786.
10. Naupari-Villasante R, Falconi-Paez C, Castro AS. Clinical performance of posterior restorations using a universal adhesive over moist and dry dentin: A 36-month double-blind split-mouth randomized clinical trial. *J Dent.* 2024;147:105080.
11. Mohammed MAEG, Hassan MA, Morsy KES. Clinical evaluation of different bi-layer biomimetic strategies of composite resin in large class I cavities: An 18-month randomized clinical trial. *BMC Oral Health.* 2026;26(1):862.
12. Hussein KJ. Prevalence of secondary caries around posterior restoration. *Acta Sci Med Sci.* 2022;6(2):3-10.
13. Fatiny FI, Alyahya F, Alfuways F. Secondary caries formation in aged restorations: A clinical review. *Int J Community Med Public Health.* 2025;12(9):4242-6.
14. Askar H, Krois J, Goestemeyer G, Schwendicke F. Secondary caries risk of different adhesive strategies and restorative materials in permanent teeth: Systematic review and network meta-analysis. *J Dent.* 2021;104:103541.
15. Yin H, Kwon S, Chung SH, Kim RJY. Performance of universal adhesives in composite resin repair. *Biomed Res Int.* 2022;2022:7663490.
16. Weimann D, Fleck C, Razi H. Marginal integrity in minimally invasive molar resin composite restorations: Impact of polymerization shrinkage. *J Mech Behav Biomed Mater.* 2024;155:106554.

17. Ibrahim RH, ElKassas DW, Nabih SM, Salem MN, Haridy R. The impact of different fiber placement techniques on the fracture resistance of premolars restored with direct resin composite: An *in-vitro* study. *J Funct Biomater*. 2025;16(6):225.
18. Dionysopoulos D, Gerasimidou O. Wear of contemporary dental composite resin restorations: A literature review. *Restor Dent Endod*. 2021;46(2):e18.
19. Bardocz-Veres Z, Miklos ML, Biro EK, Kantor EA, Kantor J, Dudas C, et al. New perspectives in overcoming bulk-fill composite polymerization shrinkage: The impact of curing mode and layering. *Dent J (Basel)*. 2024;12(6):171.
20. Gheorghiu IM, Perlea P, Iliescu AA, Onu MS, Scarlatescu S. The causes of adhesive direct dental restorations failures. *Rom J Stomatol*. 2023;69(2):52-60.
21. Babaei B, Cella S, Farrar P, Prentice L, Prusty BG. The influence of dental restoration depth, internal cavity angle and material properties on biomechanical resistance of a treated molar tooth. *J Mech Behav Biomed Mater*. 2022;133:105305.
22. Uma M, Nallagatla VK, Sekhar MC, Kumar CS, Kumar SS, Babu KC, et al. Repair or replacement of direct restorations: Clinical guidelines. *SADJ*. 2025;80(10):545-9.
23. Santos MJMC, Zare E, McDermott P, Santos GC Jr. Multifactorial contributors to the longevity of dental restorations: An integrated review of related factors. *Dent J (Basel)*. 2024;12(9):291.
24. Boitor AA, Objelean A, Gasparik C, Burde AV, Colosi HA, Dudea D. Bruxism simulation in aligner therapy: Effects on restored posterior teeth. *J Clin Med*. 2025;14(21):7877.
25. Osiewicz MA, Werner A, Roeters FJM, Kleverlaan CJ. Effects of occlusal splint therapy on opposing tooth tissues, filling materials and restorations. *J Oral Rehabil*. 2021;48:1129-34.
26. Saleem S, Idrees S, Nazir U, Ali Darvesh S, Lalita J, Nasir Z. Association between oral hygiene practices and restoration longevity in children: A cross-sectional study. *J Popul Ther Clin Pharmacol*. 2024;32(4):1089-93.
27. Rashid Noaman B, Dawood Fattah L. The relationship of caries risk and oral hygiene level with placement and replacement of dental restorations. *Acta Med Acad*. 2021;50(3):406-13.
28. Guo X, Yu Y, Gao S, Zhang Z, Zhao H. Biodegradation of dental resin-based composite: A potential factor affecting the bonding effect. *Biomedicines*. 2022;10(9):2313.
29. Polesso Patias M, Fernandes-e-Silva P, Carreno NLV, Lund RG, Piva E, da Silva AF, et al. Comparative clinical performance of universal adhesives versus etch-and-rinse and self-etch adhesives: A meta-analysis. *Clin Oral Investig*. 2025;29(7):352.
30. Sarapultseva M, Hu D, Sarapultsev A. Clinical performance of bulk-fill versus incremental composite restorations in primary teeth: A systematic review of *in-vivo* evidence. *Dent J (Basel)*. 2025;13(7):320.
31. Maravic T, Comba A, Mazzitelli C. Finite element and *in-vitro* study on biomechanical behavior of endodontically treated premolars restored with direct or indirect composite restorations. *Sci Rep*. 2022;12(1):12671.
32. Pushpa S, Sathyajith N, Kumar A. Effect of irrigation protocols on the biomechanical and structural properties of radicular dentin: A systematic review. *J Endod*. 2023;49(4):372-84.
33. Silva-Sousa YT, Teixeira R, Butler S. Structural loss and stiffness reduction in posterior teeth under endodontic and restorative steps. *Int Endod J*. 2024;57(2):189-98.
34. Zhang Y, Hughes J, Sadr A. Fracture resistance of endodontically treated premolars versus molars restored with direct resin composites. *Clin Oral Investig*. 2022;26(8):5431-42.
35. Govas A, Suksaphar W. Direct versus indirect restorations for endodontically treated posterior teeth: A systematic review and meta-analysis. *J Prosthodont*. 2023;32(4):301-11.
36. Al-Nuaimi M, Burke FJ. Survival rates and failure modes of direct composite restorations in endodontically treated posterior teeth: A systematic review. *J Dent*. 2021;112:103741.
37. Scotti N, Comba A, Gambino A. Fiber post usage in single-rooted endodontically treated teeth: structural and clinical indications. *Int J Prosthodont*. 2022;35(3):321-30.
38. Frater M, Forster A, Kereszturi M. *In-vitro* fracture resistance of endodontically treated premolars restored with different combinations of fiber-reinforced and bulk-fill composites. *Dent Mater*. 2021;37(2):266-74.
39. Suksaphar W, Banomyong D, Jirathanyanatt T. Survival rates of endodontically treated posterior teeth restored with direct composite resin: A 5-year retrospective study. *J Conserv Dent*. 2021;24(1):62-7.
40. Dias M, Fonseca B, Santos M. Medium-term survival of interim direct restorations in root-canal-treated teeth. *Oper Dent*. 2023;48(3):241-50.
41. Taha AA, Al-Zubail A. C-factor challenges in deep endodontic access cavities restored with composite resin. *J Adhes Dent*. 2024;26(1):45-53.
42. Ilie N, Hilton TJ, Heintze SD, Hickel R, Watts DC, Silikas N, et al. Academy of Dental Materials guidance: Resin composites. Part I: Mechanical properties. *Dent Mater*. 2017;33(8):880-94.
43. Balkaya V, Arslan S. Long-term clinical performance of nanofilled versus nanohybrid composite restorations in posterior teeth. *Clin Oral Investig*. 2023;27(5):2145-55.
44. Loguercio AD, Naupari-Villasante R, Gutierrez MF, Gonzalez MI, Reis A, Heintze SD. Five-year clinical performance of posterior bulk-filled resin composite restorations: A double-blind randomized controlled trial. *Dent Mater*. 2023;39(12):1159-68.

45. Cidreira Boaventura JM, de Oliveira MR. Bulk-fill composite restorations in posterior teeth: A systematic review of long-term randomized clinical trials. *J Dent.* 2022;123:104163.
46. Ilie N. Characterization of low-viscosity versus high-viscosity bulk-fill composites: Rheology and mechanical stability. *Dent Mater.* 2021;37(9):1381-91.
47. Tomaszewska IM, Jarvis J. Marginal adaptation and sculpting advantages of regular versus flowable bulk-fill matrices. *Oper Dent.* 2022;47(2):154-65.
48. Breschi L, Maravic T, Cunha SR. Dentin bonding systems: from dentin collagen structure to bond preservation and clinical applications. *Dent Mater.* 2018;34(1):78-96.
49. Van Meerbeek B, Yoshihara K, Van Landuyt K. Active degradation patterns of one-step self-etch adhesives: A multi-year update. *J Adhes Dent.* 2021;23(4):287-99.
50. Koubi S, Oliver J. The open sandwich technique using glass ionomer liners: An update on secondary caries mitigation. *Clin Oral Investig.* 2022;26(3):1125-35.
51. Francois P, Attal JP. Base liners and mechanical buffering under posterior direct composites: A systematic review. *Dent Mater.* 2021;37(6):912-24.
52. Braga RR, Ballester RY. Polymerization shrinkage stress management strategies: Incremental versus bulk techniques. *J Dent Res.* 2022;101(8):891-901.
53. Baroudi K, Rodrigues JC. Flowable composites and reduced-modulus liners as stress-absorbing cushions: A review. *J Clin Med.* 2021;10(14):3150.
54. Vallittu PK, Boccaccini AR. Bioactive materials and ion release in restorative dentistry: Current evidence on clinical performance. *Dent Mater.* 2023;39(2):105-17.
55. Saunders SH, Al-Manei KK, Smith AJ. Bioactive resin-composites versus conventional composites in posterior restorations: 3-year randomized clinical trial and secondary caries risk. *J Dent.* 2024;141:104812.
56. Olegario IC, Moro BLP, Tedesco TK. Use of rubber dam versus cotton roll isolation on composite resin restorations' survival in primary molars: 2-year results from a non-inferiority clinical trial. *BMC Oral Health.* 2022;22(1):440.
57. Demarco FF, Cenci MS, Montagner AF. Longevity of composite restorations is definitely not only about materials. *Dent Mater.* 2023;39(1):1-12.
58. Alyahya Y. A narrative review of minimally invasive techniques in restorative dentistry. *Saudi Dent J.* 2024;36(2):228-33.
59. Vandekar M, Pendse G, Toprani N, Shitole N, Pannikar P, Chadchan P. Longevity of repair versus replacement of partially fractured direct composite restorations in permanent teeth: A systematic review and meta-analysis. *Cureus.* 2025;17(7):e88307.
60. Josic U, D'Alessandro C, Miletic V, Maravic T, Mazzitelli C, Jacimovic J, et al. Clinical longevity of direct and indirect posterior resin composite restorations: An updated systematic review and meta-analysis. *Dent Mater.* 2023;39(12):1085-94.
61. Laske M, Opdam NJM, Bronkhorst EM, Braspenning JCC, Huysmans MCDNJM. Risk factors for dental restoration survival: A practice-based study. *J Dent Res.* 2019;98(4):414-22.
62. Elgezawi M, Haridy R, Abdalla MA, Heck K, Draenert M, Kaisarly D. Current strategies to control recurrent and residual caries with resin composite restorations: Operator- and material-related factors. *J Clin Med.* 2022;11(21):6591.

## About the journal



Journal of Dental Health and Oral Research is an international, peer-reviewed, open-access journal published by Athenaeum Scientific Publishers. The journal publishes original research articles, case reports, editorials, reviews and commentaries relevant to its scope. It aims to disseminate high-quality scholarly work that contributes to research, clinical practice and academic knowledge in the field.

All submissions are evaluated through a structured peer-review process in accordance with established editorial and ethical standards. Manuscripts are submitted and processed through the journal's online submission system.

**Manuscript submission:** <https://athenaeumpub.com/submit-manuscript/>