

Comparative Evaluation of Modern Restorative Materials in the Treatment of Dental Caries: Clinical Outcomes and Patient Satisfaction

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Abstract

Background: Restorative treatment should balance structural durability, biological compatibility, appearance, and patient experience. Comparisons are complicated by differences in cavity dimensions, caries activity, isolation, and outcome definitions. This article presents a synthetic clinical comparison, not findings from recruited patients.

Objective: To illustrate a framework for comparing nanohybrid resin composite, bulk-fill resin composite, and high-viscosity glass-ionomer cement in posterior caries treatment.

Methods: A hypothetical parallel-group dataset comprised 120 adults, each receiving one restoration in a small, single-surface permanent posterior cavity. Forty restorations were assigned to each material. Outcomes at 12 months included retention without repair or replacement, secondary caries, persistent sensitivity, and satisfaction. Satisfaction was defined as a rating of four or five on a five-point scale. All observations were constructed for methodological illustration; no clinical recruitment, institutional approval, or actual treatment occurred.

Results: Restoration survival was 95.0% for nanohybrid composite, 92.5% for bulk-fill composite, and 87.5% for glass-ionomer cement. Corresponding satisfaction proportions were 90.0%, 87.5%, and 75.0%. Secondary caries affected one, one, and two restorations, respectively. Persistent sensitivity was uncommon across groups. These descriptive contrasts were not subjected to significance testing and cannot establish superiority.

Conclusions: The constructed example demonstrates how technical performance and patient-reported outcomes can be evaluated together. Material selection in practice should remain individualized and evidence-based. Real prospective trials with concealed allocation, standardized operative protocols, longer follow-up, and validated patient questionnaires are necessary before comparative clinical recommendations can be justified.

Keywords: dental caries, restorative materials, resin composite, bulk-fill composite, glass-ionomer cement, patient satisfaction

1. Introduction

Dental caries remains a major challenge in oral healthcare, affecting individuals across the life course and contributing to pain, impaired chewing, aesthetic concerns, and reduced quality of life. Although prevention and nonoperative management are central to contemporary caries care, restorative intervention remains necessary when cavitated lesions cannot be adequately controlled through biofilm management and remineralization alone. In these circumstances, treatment aims extend beyond replacing lost tooth structure to preserving pulp vitality, restoring function, and supporting long-term tooth retention. The choice of restorative material is therefore an important component of individualized clinical decision-making.

Modern restorative dentistry offers several tooth-colored materials with distinct mechanical, adhesive, and biological characteristics. Conventional resin-based composites are widely used because of their aesthetic versatility and capacity for conservative placement, although their performance can be influenced by polymerization shrinkage, moisture control, and operator technique. Bulk-fill composites have been developed to simplify placement in selected clinical situations, but their suitability depends on factors such as cavity depth, curing conditions, and product-specific recommendations. Glass ionomer and resin-modified glass ionomer cements provide chemical interaction with dental tissues and fluoride release, although their wear resistance and aesthetic properties may limit their use in some stress-bearing sites. These differences suggest that no single material is necessarily optimal for every carious lesion.

Clinical success is commonly assessed through restoration retention, marginal adaptation, anatomical form, surface quality, postoperative sensitivity, and the occurrence of caries adjacent to restorations. However, these outcomes arise from interactions among material properties, lesion characteristics, patient behavior, and treatment delivery. Cavity size and location, occlusal loading, baseline caries risk, oral hygiene, and the quality of isolation can all influence restoration performance. Consequently, laboratory measurements of strength, wear, or fluoride release cannot independently establish comparative clinical effectiveness. Evaluations conducted under clearly defined clinical conditions are needed to determine whether proposed material advantages translate into meaningful benefits for patients.

Patient satisfaction provides a complementary perspective that is not fully captured by technical assessments. Patients may judge restorative care according to appearance, comfort, perceived durability, chewing ability, treatment duration, and financial burden. A restoration that meets clinical acceptability criteria may nevertheless be considered unsatisfactory because of persistent sensitivity, visible discoloration, or unmet expectations. Conversely, favorable early patient impressions do not necessarily indicate sustained biological or mechanical success. Considering patient-reported experience alongside examiner-rated outcomes can therefore provide a more comprehensive assessment of restorative treatment, particularly when differences in clinical performance are modest.

Comparative research is complicated by variation in material formulations, restorative protocols, outcome definitions, and follow-up duration. Studies emphasizing a single technical endpoint may offer limited guidance when clinicians must balance preservation of tooth structure, procedural feasibility, aesthetics, and patient preferences. Moreover, findings from highly controlled settings may not apply uniformly to patients with differing caries activity or restorative needs. A balanced evaluation should acknowledge these sources of variability and distinguish short-term acceptability from evidence of longer-term durability.

Against this background, the present study aimed to compare selected modern restorative materials used in the treatment of dental caries, assessing clinical outcomes alongside patient satisfaction. By examining both perspectives within a common evaluative framework, the study sought to identify clinically relevant differences and inform material selection that reflects functional requirements and patient priorities.

2. Materials and Methods

A prospective, three-arm, parallel-group randomized controlled trial was designed to compare a conventional nanohybrid resin composite, a bulk-fill resin composite, and a surface-coated

glass-hybrid restorative system for posterior carious lesions. Recruitment was planned across three university dental clinics, with follow-up extending to 24 months. Institutional ethics approval and prospective trial registration would be obtained before recruitment, and written informed consent would be required from all participants. Reporting would follow CONSORT recommendations for randomized trials.

Eligible participants would be adults aged 18–70 years with one vital permanent premolar or molar requiring restoration of a cavitated, dentin-involving Class I carious lesion. Lesions would need to permit conservative preparation, with an anticipated isthmus width no greater than one-third of the intercusp distance and no cusp replacement. Eligibility would additionally require suitability for all three materials according to manufacturer instructions. Exclusion criteria would include spontaneous or lingering pain, signs of irreversible pulpitis or apical disease, cracked teeth, severe periodontal mobility, uncontrolled parafunctional activity, xerostomia, and known allergy to study materials. Only one tooth per participant would be enrolled; where multiple teeth qualified, one would be selected randomly.

The target sample would comprise 300 participants, allocated equally across treatment groups. This pragmatic calculation assumes 24-month restoration survival of 90% versus 70% for a clinically important pairwise difference, 80% power, and a two-sided significance threshold of 0.0167 to accommodate three comparisons. Approximately 82 evaluable participants per group would be required; recruitment of 100 per group would allow for attrition. These assumptions would not imply that smaller differences could be reliably excluded.

An independent statistician would generate allocation sequences using randomly varying block sizes, stratified by center and tooth type. Assignment would be concealed through a centralized electronic system and revealed after cavity preparation and confirmation of eligibility. Operators could not be blinded, and material appearance could compromise examiner masking. Nevertheless, follow-up examiners would not access treatment records, and participants would not routinely be informed of material identity. Standardized explanations would avoid suggesting that any material was superior.

Before treatment, clinicians would record demographic characteristics, smoking status, oral hygiene practices, caries experience, lesion characteristics, and baseline tooth sensitivity. Caries risk would be categorized using a standardized clinical assessment. Participating dentists would complete protocol training and perform supervised practice restorations. Local anesthesia would be administered when indicated, and rubber-dam isolation would be used throughout restorative treatment. Selective carious tissue removal would establish hard peripheral dentin while avoiding unnecessary pulpal exposure. Teeth with unexpected exposure would receive appropriate care and would not proceed to randomization.

Restorations would be placed using one prespecified commercial product per material category. Conventional composite would be inserted in increments not exceeding 2 mm; bulk-fill composite would be placed within its specified curing-depth limit. Both composite groups would use the same compatible adhesive protocol. Glass-hybrid restorations would receive the recommended conditioner and protective surface coating. Mixing, placement, curing, finishing, and polishing would follow manufacturer instructions. Light output would be checked regularly with a radiometer. Cavity dimensions, operative duration, isolation difficulties, and protocol deviations would be documented.

Assessments would occur at baseline after placement and at 6, 12, and 24 months. The primary outcome would be restoration survival at 24 months, defined as retention without repair, replacement, or tooth extraction attributable to restorative failure. Secondary outcomes would include marginal adaptation, fracture, retention, recurrent caries, anatomical form, and postoperative sensitivity, assessed using prespecified FDI criteria. Two calibrated examiners would independently evaluate a subset of restorations to estimate interexaminer agreement. Radiographs would be obtained only when clinically indicated.

Patient satisfaction would be measured at each follow-up using separate 0–10 numerical scales for overall satisfaction, appearance, chewing comfort, and perceived sensitivity. Responses would be collected before clinical examination by staff uninvolved in treatment. Adverse events and additional dental treatment would be recorded throughout follow-up.

Analyses would follow randomized assignment. Survival would be estimated using Kaplan–Meier methods and compared using Cox models adjusted for center, tooth type, and baseline caries risk, with proportional-hazards assumptions checked. Repeated satisfaction scores would be analyzed using mixed-effects models. Pairwise primary comparisons would receive multiplicity adjustment; secondary analyses would be considered exploratory. Effect estimates would be presented with confidence intervals. Missing-data patterns would be examined, with multiple imputation and sensitivity analyses used where assumptions were defensible.

3. Results

The results presented below describe a simulated dataset constructed for this manuscript, rather than findings from an actual clinical investigation. The study population comprised 240 adults receiving one posterior restoration each, with 60 participants allocated to nanohybrid resin composite, bulk-fill resin composite, resin-modified glass ionomer cement, or glass-hybrid restorative material. All treated teeth had cavitated dentinal caries considered suitable for direct restoration. Follow-up examinations were completed by 234 participants at 6 months, 228 at 12 months, and 220 at 24 months. Final assessment attendance ranged from 90.0% to 93.3% across groups. The principal reasons for missing final assessments were relocation, scheduling difficulties, and withdrawal from follow-up; restoration status could not be established for these participants.

Baseline characteristics were broadly comparable between treatment groups. The overall mean age was 38.6 years, with a standard deviation of 12.4 years, and 132 participants (55.0%) were women. Group mean ages ranged from 37.8 to 39.5 years. Molars accounted for 156 restorations (65.0%), while premolars accounted for 84 (35.0%). There were 144 Class I and 96 Class II cavities, distributed equally across groups. Baseline caries risk was categorized as high in 92 participants (38.3%), with group proportions ranging from 35.0% to 41.7%. Mean baseline pain scores ranged from 3.0 to 3.3 on a 0–10 numerical rating scale. No substantial descriptive imbalance was apparent in tooth location, cavity classification, or baseline symptoms.

At 24 months, 204 of 220 assessed restorations (92.7%) met the prespecified clinical success criterion, defined as retention without recurrent caries or fracture requiring repair or replacement. Observed success was highest in the bulk-fill composite group, although its proportion was almost identical to that of nanohybrid composite. Both ionomer-based materials showed numerically lower success proportions, with absolute differences of fewer than four percentage points relative to either composite group. These differences were small in relation to the limited number of events and should not be interpreted as establishing material superiority. Clinical outcomes, treatment duration, and patient-reported measures are summarized in Table 1. Percentages for final outcomes use the number assessed at 24 months as the denominator.

Table 1. Clinical outcomes and patient-reported assessments in the simulated study population

Outcome	Nanohybrid composite	Bulk-fill composite	Resin-modified glass ionomer	Glass hybrid
Allocated participants, n	60	60	60	60
Assessed at 24 months, n	55	56	54	55
Clinical success, n (%)	52 (94.5)	53 (94.6)	49 (90.7)	50 (90.9)
Recurrent caries requiring intervention, n (%)	1 (1.8)	1 (1.8)	2 (3.7)	2 (3.6)
Fracture requiring intervention, n (%)	1 (1.8)	1 (1.8)	2 (3.7)	2 (3.6)
Complete restoration loss, n (%)	1 (1.8)	1 (1.8)	1 (1.9)	1 (1.8)
Placement time, minutes, mean ± SD	31.2 ± 6.4	24.6 ± 5.8	26.8 ± 6.1	25.9 ± 5.9

Satisfaction at 24 months, 0–10, mean $\pm$ SD	8.8 $\pm$ 1.1	8.7 $\pm$ 1.2	8.1 $\pm$ 1.5	8.2 $\pm$ 1.4
Would choose the same material again, n (%)	50 (90.9)	51 (91.1)	45 (83.3)	47 (85.5)

The 16 unsuccessful restorations comprised six with recurrent caries, six with clinically consequential fracture, and four with complete loss. Each unsuccessful restoration was assigned one primary failure category, preventing duplicate counting. Ten failures were managed by localized repair and six by replacement. No treated tooth required extraction during observed follow-up. Failures were more frequent descriptively among Class II restorations, accounting for 10 events, compared with six among Class I restorations. Because this comparison involved few events and was not adjusted for cavity dimensions or caries risk, it did not establish an independent association between cavity classification and failure.

Minor marginal and surface changes were also recorded in restorations that remained clinically successful. Marginal staining without an indication for operative intervention occurred in five nanohybrid, six bulk-fill, eight resin-modified glass ionomer, and eight glass-hybrid restorations. Mild surface roughness was documented in four, five, nine, and eight restorations, respectively. These findings occasionally overlapped within individual restorations and were therefore not summed as separate failures. Color matching was descriptively more favorable for composite restorations, whereas clinically acceptable anatomic form was maintained in most restorations across all four groups.

Early postoperative sensitivity was reported by eight nanohybrid composite recipients, seven bulk-fill recipients, five resin-modified glass ionomer recipients, and six glass-hybrid recipients. Most episodes were mild and associated with cold stimulation or chewing. At the one-month review, persistent sensitivity was reported by two, two, three, and three participants, respectively. All reported episodes had resolved by six months without endodontic treatment. No serious treatment-related adverse event was recorded. Mean placement time was shortest with bulk-fill composite and longest with nanohybrid composite, representing a descriptive difference of 6.6 minutes between these groups.

Patient satisfaction remained favorable across materials, although mean scores were numerically higher for both composites. The composite groups also had higher proportions willing to select the same material again. Among participants expressing reservations, appearance and surface feel were more commonly reported concerns than chewing comfort. Satisfaction distributions nevertheless overlapped substantially across groups. Missing outcomes introduced uncertainty: when all 20 participants without final assessments were conservatively classified as unsuccessful, overall success decreased from 92.7% among attendees to 85.0% among all allocated participants. Corresponding group estimates were 86.7%, 88.3%, 81.7%, and 83.3%. This sensitivity analysis preserved the descriptive ordering but did not resolve uncertainty about outcomes among participants lost to follow-up.

4. Discussion

The comparative findings suggest that modern restorative materials can provide satisfactory clinical outcomes in the treatment of dental caries, while differing in characteristics that influence their suitability for individual patients. No material should therefore be regarded as universally preferable. Clinical performance must be interpreted alongside lesion location, cavity extent, moisture control, caries activity, and patient priorities. The relationship between technical outcomes and patient satisfaction is particularly important: a restoration that meets clinical acceptability criteria may not fully satisfy expectations concerning appearance, comfort, or the treatment experience.

The generally favorable performance of resin-based composite restorations is consistent with their capacity to support conservative cavity preparation and reproduce natural tooth appearance. Their aesthetic advantages may help explain favorable patient perceptions, particularly when restorations involve visible surfaces. Nevertheless, such benefits depend on careful adhesive procedures, adequate

polymerization, and appropriate finishing. Small differences in marginal adaptation or postoperative sensitivity should not automatically be interpreted as intrinsic material effects, because isolation quality, cavity depth, and operator technique may contribute substantially. Where differences between materials are modest, their clinical importance deserves as much attention as their statistical significance.

Glass-ionomer-based materials offer a different balance of properties. Chemical interaction with dental tissues and fluoride release provide a rationale for their use in selected clinical situations, including cervical lesions and patients with elevated caries risk. These characteristics, however, should not be equated with demonstrated prevention of recurrent caries. Any protective effect is likely to depend on plaque control, dietary exposure, fluoride availability, and continued preventive care. Potential disadvantages in surface smoothness, wear resistance, or color stability may become more relevant in highly visible or heavily loaded restorations. Material selection should therefore distinguish between biological plausibility and benefits directly supported by clinical follow-up.

Hybrid restorative approaches, including resin-modified glass ionomers and fluoride-releasing resin-based materials, aim to combine desirable handling, mechanical, and biological characteristics. Their practical appeal does not establish equivalent performance across all indications. Differences in composition, curing requirements, and surface treatment can produce variation within the same broad material category. Consequently, findings for a particular product should not be generalized uncritically to every material with a similar label. The present comparison is best understood as informing specific treatment choices rather than establishing a definitive hierarchy of restorative technologies.

Patient satisfaction adds a complementary perspective to conventional clinical assessment. Appearance and perceived smoothness may be especially salient to patients, whereas marginal defects identified during examination may remain unnoticed. Conversely, transient sensitivity or an uncomfortable occlusal contact can reduce satisfaction despite an otherwise acceptable restoration. Satisfaction should thus be interpreted as a multidimensional outcome rather than a surrogate for restoration longevity. Expectations, previous treatment experiences, and communication about likely benefits and limitations may also influence reported ratings independently of material performance.

Taken together, these considerations support an individualized, minimally invasive approach to restorative care. For visible lesions under favorable isolation conditions, aesthetic performance may appropriately carry greater weight. In situations involving difficult moisture control or substantial caries activity, handling characteristics and integration with preventive management may become more influential. These decisions should remain grounded in the actual cavity conditions and the patient's preferences. Successful caries treatment ultimately requires both a technically appropriate restoration and sustained management of the disease processes that made restoration necessary.

Beyond restoration-centered outcomes, patient satisfaction should be interpreted as a complementary measure of treatment success rather than a substitute for clinical assessment. Perceptions of appearance, comfort, and chewing ability may differ from professional evaluations of marginal integrity or surface quality. A restoration can therefore remain clinically acceptable while failing to meet an individual patient's expectations. Conversely, high satisfaction does not exclude early deterioration or recurrent caries. Considering both perspectives supports a more comprehensive evaluation of restorative care and highlights the importance of discussing expected benefits and limitations before treatment.

Differences between restorative materials are unlikely to reflect material composition alone. Cavity size, tooth position, occlusal loading, moisture control, and remaining tooth structure can influence performance. Resin-based composites offer aesthetic advantages but depend on appropriate isolation and adhesive technique. Glass-ionomer-based materials may be useful where chemical adhesion or fluoride release is desirable, although these properties should not be interpreted as evidence of superior long-term caries prevention. Their suitability also depends on mechanical demands and the specific formulation used. These considerations argue against identifying a universally preferred material without accounting for the clinical indication.

Postoperative sensitivity also requires contextual interpretation. Early discomfort may relate to cavity

depth, pre-existing pulpal irritation, adhesive procedures, or occlusal discrepancies rather than an intrinsic material effect. Persistent or worsening symptoms warrant reassessment, whereas isolated early reports should be evaluated alongside subsequent clinical findings. Similarly, changes in surface roughness or marginal staining do not necessarily indicate restoration failure. Distinguishing findings suitable for monitoring, polishing, or localized repair from those requiring replacement can reduce unnecessary loss of sound tooth tissue and better align treatment decisions with minimally invasive principles.

Several methodological issues constrain the interpretation of comparative restorative research. Limited follow-up may capture early adaptation and patient acceptance more reliably than late fracture, wear, or recurrent caries. If multiple restorations are placed in the same patient, analyses should account for within-patient correlation. Operator experience and differences in cavity complexity can introduce confounding, particularly when allocation is not randomized. Patient-reported outcomes may also be influenced by expectations, treatment cost, and interactions with clinicians. Without standardized questionnaires and clearly specified assessment intervals, apparent satisfaction differences should be interpreted cautiously. Statistical significance alone does not establish a clinically meaningful advantage, particularly when estimates are imprecise.

Future investigations should prioritize longer follow-up, standardized failure definitions, and transparent reporting of repair and replacement separately. Stratification by baseline caries risk, lesion extent, and restoration location would help identify patients most likely to benefit from particular material characteristics. Economic evaluation should include treatment time, maintenance, retreatment, and patient expenses rather than acquisition cost alone. Consistent measurement of sensitivity, aesthetics, function, and oral-health-related quality of life would improve comparability across studies and clarify whether clinical differences translate into benefits that patients value.

Overall, comparative findings are best used to guide individualized selection rather than categorical claims of material superiority. Durable restorative care depends on appropriate case selection, careful placement, ongoing disease control, and realistic expectations. Shared decision-making can integrate clinical requirements with aesthetic preferences and affordability while acknowledging uncertainty about long-term performance. Restorative material choice should therefore remain one component of comprehensive caries management, accompanied by preventive support and follow-up tailored to the patient's risk profile.

5. Conclusion

Within the limitations of this comparative clinical evaluation, modern restorative materials appeared capable of providing satisfactory outcomes in the treatment of dental caries when selected according to lesion characteristics, functional demands, and patient priorities. The findings do not support a universally superior material across all clinical and patient-reported outcomes. Instead, they suggest that restorative success depends on balancing mechanical performance, marginal integrity, aesthetic acceptability, postoperative comfort, and the practical requirements of material placement.

Resin-based composites offered a favorable option where appearance and conservative cavity preparation were important, although their clinical performance remained dependent on appropriate isolation and adhesive technique. Glass ionomer-based materials represented a reasonable alternative in selected clinical circumstances, particularly where moisture control or caries susceptibility influenced treatment planning. However, potential benefits associated with fluoride release should not be interpreted as proof of reduced recurrent caries without longer observation and direct assessment of this outcome. Material selection should therefore reflect the demands of the individual restoration rather than assumptions based solely on material classification.

Patient satisfaction constituted an important complement to clinical assessment. Acceptable appearance, limited postoperative sensitivity, and comfortable function were relevant to patients' appraisal of treatment, but satisfaction alone cannot establish restoration durability or biological success. Conversely, technically acceptable restorations may not fully meet patient expectations. These considerations support incorporating clear preoperative communication and patient-reported outcome measures into routine restorative care and future comparative investigations.

Interpretation of the study should remain cautious because outcomes may be influenced by observation duration, operator technique, cavity size and location, baseline caries risk, and oral hygiene practices. Where treatment allocation does not fully account for these factors, observed differences cannot confidently be attributed to the restorative material itself. Longer-term, adequately powered studies using standardized outcome definitions are needed to assess restoration survival, recurrent caries, repair requirements, and changes in patient satisfaction.

Overall, an individualized, minimally invasive approach remains the most defensible basis for selecting modern restorative materials. Combining evidence-informed material choice with careful placement, preventive care, and scheduled review may improve the likelihood of durable, acceptable treatment while avoiding premature claims of superiority.

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