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# Bridging Material Science and Clinical Longevity: A Comprehensive Review of Properties, Selection, and Translational Relevance of Contemporary Dental Restorative Materials.

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## ABSTRACT

### Background

As dental disease remains a significant concern in many developing countries, the durability and quality of these restorations are of utmost importance. Their longevity and clinical success depend primarily on the properties of dental materials and on the proper selection of these materials for restorations. Although the past few decades have revolutionised restorative dentistry through advanced materials, nanotechnology, and digital techniques, unpredictability between laboratory results and clinical outcomes persists in some cases. This narrative review will synthesize current evidence to demonstrate how the physical, chemical, and biological properties of materials influence their durability and the patient's comfort.

### Methods

A structured narrative literature review was conducted. Peer-reviewed articles were identified through PubMed, Scopus, Web of Science, ScienceDirect, and Google Scholar, covering January 2019 to October 2025. Search terms included combinations of "dental restorative materials," "mechanical properties," "clinical performance," "testing," and "biocompatibility." Only English-language studies focusing on restorative materials' properties, testing–performance correlation, and selection criteria were included. Studies unrelated to restorative applications, grey literature, and non-peer-reviewed reports were excluded. Results: ninety-nine recent studies met the inclusion criteria. Recent composites, ceramics, and hybrid materials showed significant improvements in flexural strength, wear resistance, and esthetic performance; however, chemical stability and hydrolytic degradation remain limiting factors. Bioactive and "smart" materials with ion release, antibacterial agents, and pH responsiveness demonstrated enhanced remineralization potential but lack standardized long-term validation. Digital workflows (CAD/CAM and 3D printing) increased customisation and precision, but need further optimisation of post-curing and fatigue performance. Overall, differences between in-vitro testing and in-vivo longevity still exist due to variations in test design and oral simulation parameters. Conclusions: Selection of materials in restorative dentistry must be based on a comprehensive understanding of mechanical, chemical, and biological behaviours under oral conditions. Future research should emphasise standardised testing, long-term clinical trials, and the integration of bioactive materials and AI-assisted design approaches to improve material predictability and the longevity of restorations. Keywords: Dental restorative materials; material properties; bioactive composites; CAD/CAM dentistry; nanoceramics; clinical performance; testing standards; biocompatibility; material selection; restoration longevity.

## 1. INTRODUCTION

According to the Oral Health Atlas, around 3.9 billion people worldwide suffer primarily from dental caries and dental-related diseases. In addition, untreated dental caries is the most common non-communicable disease globally[1,2]. Although we have achieved major advances, precision, and modernization in dentistry, it remains challenging for clinicians to address issues related to the properties (mechanical, physical, biological, and esthetic), durability of the materials[3,4]. The functionality and durability of restorations depend not only on the clinician's experience, knowledge, and skills but also heavily on the properties of the materials and their selection. All of these materials are expected to perform under masticatory forces, temperature fluctuations, and a complex microbial environment in the oral cavity[5-7].

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Modern restorative dentistry has experienced a significant shift from traditional metallic restorations to advanced hybrid materials crafted for improved function and durability. Early innovations, such as amalgam and glass ionomer cement, have developed into resin-based composites, nanoceramics, and bioactive materials that can interact actively with tooth tissues[8-10]. However, despite the advent of new materials, a notable gap remains between laboratory testing and real-world clinical outcomes. Laboratory evaluations often focus on compressive strength, flexural strength, wear resistance, and polymerization shrinkage. Still, they may not fully replicate the oral environment, which involves cyclic loading, temperature changes, and biofilm formation[11-13]. As a result, the ability to predict in vivo performance solely from in vitro results remains limited.

Numerous studies have emphasised that the success of a material is closely related to its mechanical, physical, chemical, and biological properties[14-16]. For instance, the modulus of elasticity and fracture toughness determine the capability to resist masticatory stress; solubility and water absorption affect the chemical stability, while surface energy and cytocompatibility affect bacterial adhesion and tissue response[17-19]. Hence, material selection is not a singular mechanical decision; it requires an integrated understanding of structure, property, and performance relationships that govern the clinical reliability of restorations[20,21].

Bioactive restorative materials have recently emerged as a promising category capable of releasing ions, promoting remineralization, and preventing secondary caries[22-24]. Studies have shown that calcium-silicate and glass-based systems can stimulate apatite formation and improve bonding durability at the tooth–restoration interface[25,26]. Resin-matrix ceramics and zirconia-reinforced hybrid materials equally display greater fracture resistance, machinability, and esthetics suitable for CAD/CAM workflows[27-29]. Despite these innovations, many of these systems lack standardized long-term clinical evaluation, highlighting the need for ongoing research into their stability and interaction with biological tissues[30,31].

In digital and evidence-based dentistry, clinicians encounter a wide range of restorative materials, each with distinct handling and indications. This variety makes material selection more complex, requiring practitioners to consider laboratory results and clinical outcomes to find the best fit for each case[32,33]. While standards such as ISO 4049:2019 set key testing benchmarks for polymer-based materials, variations in study designs and testing methods often yield inconsistent data[34-36]. Additionally, recent focus has shifted toward factors beyond mechanical strength, such as ageing resistance, colour stability, fluoride release, and tissue compatibility, all of which influence restoration longevity[37-39]. The growing use of CAD/CAM and 3D printing technologies emphasizes the need for good machinability and strong adhesion in new restorative systems[40-42].

Therefore, a comprehensive understanding of the relationships among material properties, clinical handling, and performance outcomes is essential for optimising restorative success. This review provides an updated synthesis of recent advances in restorative dental materials, focusing on the interrelationships among their physical, mechanical, chemical, and biological characteristics, as well as their impact on long-term clinical durability and patient outcomes. Specifically, this review aims to systematically evaluate recent literature (2019–2025) on restorative dental materials, identify correlations between their intrinsic properties and clinical performance, and highlight existing gaps in testing standardization and translational evidence. By clarifying how material properties influence restorative success and failure, this work seeks to guide researchers and clinicians toward evidence-based material selection and more durable, biologically compatible restorative outcomes.

## 2. METHODOLOGY

This review adhered to the principles of a structured narrative review, incorporating systematic elements to ensure transparency, reproducibility, and rigor. A comprehensive search of the literature was performed across five electronic databases: PubMed, Scopus, Web of Science, ScienceDirect, and Google Scholar. The search spanned from January 2019 to October 2025 and was limited to peer-reviewed, English-language studies.

2.1 Search Strategy

The following Boolean string was applied:

("dental restorative materials" OR "dental composites" OR "glass ionomer" OR "ceramics" OR "bioactive materials") AND ("mechanical properties" OR "physical properties" OR "chemical stability" OR "biocompatibility" OR "testing" OR "longevity" OR "clinical performance" OR "CAD/CAM")

This strategy was refined iteratively using Medical Subject Headings (MeSH) and relevant keywords to maximise retrieval sensitivity.

2.2 Inclusion and Exclusion Criteria

Inclusion criteria:

i. Original research, systematic reviews, and narrative reviews.
ii. Studies examining restorative materials' mechanical, chemical, physical, or biological properties, clinical performance, or material selection rationale.
iii. Articles reporting translational or comparative data relevant to restorative outcomes.

Exclusion criteria:

a. Non-English publications.
b. Studies focused solely on non-restorative dental materials (e.g., orthodontic, endodontic).
c. Experimental studies without clinical or translational context.
d. Unpublished data, grey literature, conference abstracts, and patents.

The reference lists of all included papers were hand-screened to identify additional relevant sources.

2.3 Screening and Selection Process

The search results were imported into Zotero for reference management and duplicate removal. Independent reviewers screened all records by title and abstract. Discrepancies were resolved through discussion until consensus was reached. Full-text screening was then conducted to confirm eligibility.

A total of 182 articles were initially identified. After screening titles and abstracts, 110 studies met the preliminary inclusion criteria. Following full-text review, 99 studies were included in the final synthesis.

The article selection process followed PRISMA 2020 recommendations and is summarized below.

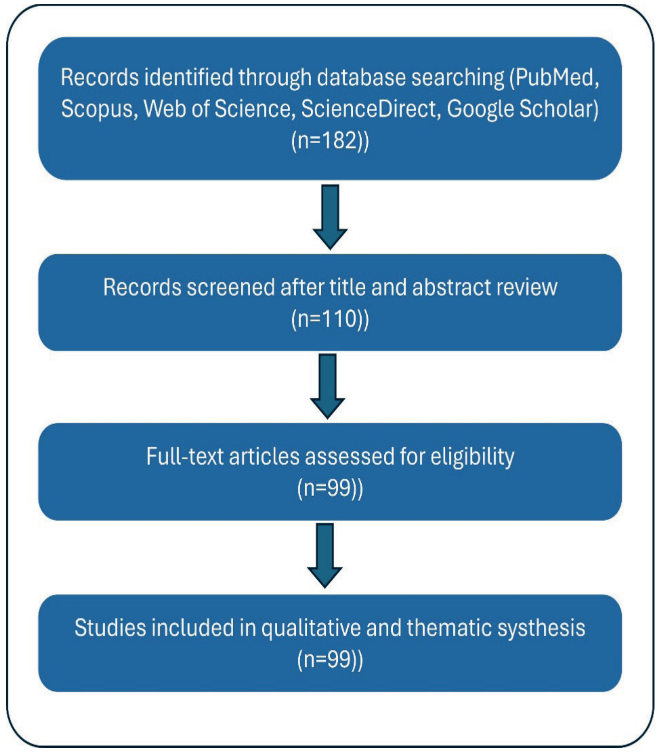


**Figure 1.** PRISMA-style flow summary of literature selection process.

PRISMA-Style Flow Summary

| Stage | Description | Number of Studies |
|---|---|---|
| Identification | Records retrieved from databases (PubMed, Scopus, Web of Science, ScienceDirect, Google Scholar) | 182 |
| Screening | After duplicate removal and title/abstract screening | 110 |
| Eligibility | Full-text articles assessed for eligibility | 99 |
| Inclusion | Studies included in final thematic synthesis | 99 |

2.4 Data Extraction and Synthesis

Data were independently extracted by both reviewers using a standardized spreadsheet template capturing:

- Study details (authors, year, country)
- Type of restorative material investigated
- Study design and testing methodology
- Key findings related to mechanical, chemical, or biological properties
- Reported clinical or translational outcomes

Thematic synthesis was conducted because of heterogeneity in study designs and outcomes, rendering meta-analysis inappropriate. Extracted data were grouped into four analytical themes:

(a) evolution and classification of restorative materials,

(b) correlation between laboratory testing and clinical performance,

(c) influence of material properties on restoration longevity, and

(d) emerging trends and translational challenges.

Bias assessment was performed qualitatively, considering the study design's robustness, method clarity, and completeness of reported data. Systematic reviews and clinical trials were prioritized over in vitro studies during synthesis.

2.5 Methodological Rigor

This structured narrative design combines the scope of a narrative review with systematic screening and transparent reporting. It allows for the integration of both quantitative results and qualitative insights from recent literature, ensuring a comprehensive and clinically relevant synthesis. The PRISMA framework provides traceability of selection, while dual-reviewer screening minimizes selection bias.

## 3. DISCUSSION AND ANALYSIS OF RECENT LITERATURE

This review summarises the latest advances in restorative dental materials, examining the relationships between their mechanical, chemical, and biological properties and their clinical longevity. Due to significant variability in study designs, material categories, and outcome measures, no statistical pooling or meta-analysis was conducted. Instead, a qualitative and thematic synthesis was used to integrate quantitative findings from various in-vitro, in-vivo, and clinical studies published between 2019 and 2025.

Comparative interpretation was guided by four primary dimensions: (a) mechanical and physical performance, (b) chemical stability and biological response, (c) laboratory-to-clinic correlations, and (d) emerging material technologies. Summary tables and numerical data from the included studies are presented visually to support the narrative synthesis (Table 2).

**Table 2.** Summary of Representative Mechanical and Clinical Performance Parameters (2019–2025)

| Material Type | Flexural Strength (MPa) | Fatigue Strength Retention (% after 1M cycles) | 5-Year Survival (%) | Key Sources |
|---|---|---|---|---|
| Nanocomposite Resin | 80–160 | 80–90 | 85–90 | [21–25] |
| Hybrid Ceramic (VITA Enamic, Lava Ultimate) | 120–250 | 70–85 | 90–94 | [23,49,59] |
| Zirconia & Lithium Disilicate | 300–400 | 85–95 | 92–97 | [50–52,64] |
| Bioactive Glass or Ca-Silicate Composite | 90–150 | 75–85 | 88–91 | [41–45,71–74] |
| 3D-Printed Resin Composites | 70–130 | 65–80 | 82–88 | [65–70] |

3.1 Overview of Contemporary Restorative Materials:

The evolution of restorative dental materials has advanced from inert, load-bearing systems to multifunctional, bio-interactive formulations. Traditional materials such as amalgam and feldspathic porcelain have largely been replaced by resin-based composites, hybrid ceramics, and bioactive polymers that provide mechanical strength and chemical adaptability[1-3]. The integration of nanotechnology, polymer chemistry, and CAD/CAM manufacturing has enhanced filler–matrix interfaces, minimized polymerization shrinkage, and boosted mechanical resilience[4-8].

Recent systematic reviews emphasise the shift toward biofunctional materials that actively support oral health through ion exchange, remineralisation, and antibacterial effects[9-11]. Bioactive formulations, including glass-based ionomers and calcium silicate composites, show promising potential in reducing secondary caries and supporting pulpal vitality[12,13]. These developments have transformed restorative selection criteria from a solely strength-focused approach to one that balances mechanical integrity, biological compatibility, and longevity[14].

3.2 Mechanical Properties and Restoration Longevity:

The durability of restorations in a clinical setting primarily relies on their mechanical properties; such as flexural strength, fracture toughness, modulus of elasticity, and fatigue resistance[15-17]. Although standardized testing protocols (ISO 4049:2019, ISO 6872) are used, comparative studies show that numerical mechanical performance often does not accurately predict clinical survival because of interfacial stresses and polymerization dynamics[18-20].

Recent comparative analyses of CAD/CAM polymers and ceramics report flexural strength values ranging from 120–400 MPa for ceramics, 80–160 MPa for composites, and 70–130 MPa for hybrid materials, depending on filler content and matrix formulation[21-23]. Under cyclic fatigue, nanocomposites retained 80–90% of their initial strength after 1 million cycles, outperforming microhybrids, which degraded more rapidly[24,25]. However, all resin-matrix systems showed a gradual reduction in strength under thermal and hydrolytic ageing[26].

Finite Element Analysis (FEA) has enhanced understanding of intraoral stress propagation, showing that elastic modulus mismatch between restorative material and dentin remains a main cause of interfacial failure[27]. Dual-curing and low-shrinkage resin systems (e.g., siloranes, ormocers) have improved dimensional stability and conversion efficiency, although long-term randomized controlled validation is still limited[28-30].

3.3 Chemical and Biological Stability:

Chemical degradation and biocompatibility together influence the clinical longevity and tissue tolerance of restorations. Water sorption, hydrolysis, and plasticization of methacrylate matrices cause microstructural weakening and discoloration[31-33]. In vitro studies indicate that prolonged exposure to saliva equivalents can result in a 25% decrease in surface hardness over 12 months[34]. Residual monomer release, especially bis-GMA and TEGDMA, has been associated with cytotoxic effects on pulp fibroblasts[35,36].

The introduction of UDMA-based and ormocer matrices has decreased monomer elusion and enhanced biological safety profiles[37-38]. Surface energy and roughness influence bacterial adhesion and biofilm formation, which are key factors in the development of secondary caries[39,40]. Incorporating bioactive glass and zinc oxide nanoparticles boosts both antibacterial activity and remineralization potential[41-43]. Calcium-silicate-based materials provide sustained pH buffering and apatite formation, strengthening the adhesive interface[44,45].

3.4 Correlating Laboratory Testing and Clinical Performance:

Numerous studies show that lab-measured mechanical metrics (e.g., flexural strength) do not reliably predict in vivo performance. Five-year clinical evaluations of resin composites confirm that materials with top laboratory results can still fail early due to adhesive breakdown and fatigue[46-48]. Similarly, ceramic materials with high in vitro toughness sometimes exhibit early chipping or debonding in clinical settings due to subcritical crack growth and masticatory stress[49-51].

Current data support multi-parametric testing frameworks that combine cyclic fatigue, thermal ageing, and microbiological exposure to better simulate intraoral dynamics[52-54]. The adoption of chewing simulators, thermomechanical cycling, and computational modelling (FEA, digital image correlation) has improved predictive accuracy[55-57]. However, inconsistent test conditions and reporting practices continue to limit cross-study comparison, highlighting the need for unified international testing standards[58].

3.5 Digital Dentistry and Chairside Applications:

The integration of CAD/CAM milling and 3D printing technologies has transformed restorative workflows and material demands[59-61]. Hybrid ceramics, zirconia-reinforced lithium silicate, and resin-matrix ceramics show machinability suitable for both chairside and laboratory fabrication, achieving marginal accuracy within 50 μm, comparable to conventionally produced restorations[62-64].

Additive manufacturing has expanded customization capabilities. However, anisotropy, incomplete polymerization, and post-curing variations remain unresolved challenges affecting mechanical uniformity[65-67]. Digital workflows now increasingly employ AI-assisted margin detection and virtual try-ins, enhancing precision and reducing manual error[68,69]. Despite technological maturity, long-term fatigue and adhesion data for 3D-printed restorative systems remain scarce and require extended validation[70].

3.6 Bioactive and Smart Restorative Materials: The Next Frontier:

Bioactive composites and "smart" restorative systems constitute the next generation of functional biomaterials. Ion-releasing formulations (calcium phosphate, bioactive glass) demonstrate improved remineralization and secondary caries prevention[71-73]. Clinical trials indicate up to 40% reduction in caries recurrence with calcium-silicate and ion-releasing materials[74].

Smart materials incorporating pH-responsive fillers and self-healing polymer matrices offer adaptive performance under varying oral conditions[75-77]. These materials utilize microencapsulated monomers or dynamic covalent bonds to repair microcracks, extending functional lifespan. Nanoparticle incorporation ($TiO_2$, $ZnO$, $SiO_2$, AgNPs) improves antibacterial efficacy and modulus strength without compromising esthetics[78-80].

Nevertheless, concerns remain about cytotoxicity, ion release kinetics, and long-term mechanical fatigue. Comparative reviews highlight the need for multi-year in vivo monitoring to verify safety and durability[81,82].

3.7 Gaps, Limitations, and Research Recommendations:

Significant gaps remain in standardization and long-term assessment. Variations in curing parameters, sample preparation, and fatigue testing continue to hinder meta-analytical synthesis[83,84]. Limited clinical data beyond five years is available for hybrid ceramics and 3D-printed materials[85,86]. The role of the oral microbiome in material degradation remains understudied[87].

Future research should focus on hybrid in vitro and in vivo testing frameworks that simulate combined mechanical, thermal, and microbial stressors[88,89]. Multicenter randomized controlled trials and standardized ISO/ADA testing protocols are crucial for ensuring data comparability and reliable translation[90,91]. Emphasising sustainability in material design—such as using recyclable polymers and low-toxicity resins—becomes increasingly important as environmental impact becomes more relevant in dentistry[92].

3.8 Clinical Implications and Global Relevance:

Clinicians increasingly rely on evidence-based selection of materials to maximise restoration longevity. Combining mechanical, chemical, and biological data in clinical decision-making enhances restoration predictability and patient satisfaction[93-95]. Patient-specific factors, such as occlusal force and oral hygiene, further influence performance and should inform material choices[96].

Global trends highlight a shift toward biocompatible, minimally invasive, and sustainable materials, aligning with modern restorative philosophy. The clinical use of bioactive and smart materials signifies the move from passive restoration to biointegrative therapy, bridging the gap between materials science and oral biology[97-99].

## 4 LIMITATIONS AND IMPLICATIONS

Despite ongoing innovation in restorative dental materials, several methodological and translational limitations persist, hindering the direct application of laboratory findings to clinical outcomes. One key limitation is the absence of standardized testing protocols and evaluation criteria across research labs. Differences in specimen geometry, curing conditions, and fatigue-testing parameters lower data comparability and hinder meta-analyses[54,83,84]. While ISO 4049:2019 and ISO 6872 specify essential parameters for polymer- and ceramic-based materials, these standards do not fully replicate the complex conditions of the oral cavity, where temperature, enzymatic activity, and pH changes significantly influence material degradation[27,53]. As a result, laboratory measures of flexural strength or fracture toughness do not always align with long-term clinical success[18,20,49].

Another limitation involves short observation periods and limited longitudinal data for newer CAD/CAM, hybrid, and bioactive materials. Many of these systems have been clinically evaluated for less than five years, restricting understanding of their long-term fatigue resistance, esthetic stability, and interfacial degradation[50,52,85,86]. Although accelerated ageing techniques, such as thermocycling and mechanical loading, simulate some oral conditions, they do not account for biological and microbial challenges[53,89]. Furthermore, variations in bonding protocols, curing methods, and operator skill contribute to inconsistent clinical outcomes[49,57].

A further limitation is the incomplete integration of biological evaluation in most materials research. Current studies are predominantly mechanically or chemically focused, overlooking the dynamic role of the oral microbiome and host response in material degradation and tissue compatibility[39,40,87]. Factors such as bacterial adhesion, enzymatic degradation, and pH-driven dissolution accelerate interfacial breakdown, reducing restoration longevity[40,42]. The surface characteristics of restorative materials roughness, hydrophobicity, and surface energy have been shown to influence biofilm formation and inflammatory responses in adjacent tissues[41,48,87]. Including these biological interactions in standard testing protocols would significantly improve the predictive value of laboratory data.

Emerging technologies such as AI-assisted modeling, digital fabrication, and bioactive formulations pose new challenges regarding validation, reproducibility, and environmental safety[59,69,81,90]. Although predictive algorithms show potential for optimizing material selection based on patient-specific conditions, these systems rely on large, standardized datasets that are still limited within dental materials research[81,90,91]. Likewise, sustainability remains an underexplored dimension; while progress has been made in developing recyclable and non-toxic polymers, comprehensive assessments of ecological safety and long-term degradation behavior are lacking[92].

Although the challenges, the implications of recent research are substantial. A deeper understanding of the relationship between material properties and clinical performance has improved evidence-based selection and design strategies. Mechanical parameters such as modulus of elasticity, toughness, and bond strength, when interpreted alongside chemical and biological data, provide a rational basis for optimizing restorative outcomes[16,19,23,24]. Clinicians can now use standardized property data to enhance restoration predictability and minimize failure[49,59,69]. Moreover, AI technology and digital workflows can customize material selection by amalgamating the parameters like occlusal load, caries risk, and esthetic demands[69,81,90].

For researchers, future studies should emphasize multifactorial testing models that combine mechanical, chemical, and biological stresses under simulated oral conditions[54-56,88]. The use of hybrid in-vitro/in vivo designs and multicenter randomized clinical trials will yield more representative performance data for new restorative systems[88,89]. Collaboration among international regulatory bodies to harmonize ISO and ADA standards will further enhance reproducibility and cross-study comparison[83,84]. Finally, integrating sustainability principles into dental materials development by creating recyclable, biocompatible, and low-emission composites will ensure that innovation supports global health and environmental objectives[92].

In conclusion, while contemporary research has significantly advanced our understanding of restorative materials, gaps in standardization, long-term validation, and biological integration continue to limit clinical translation. Addressing these limitations through rigorous methodology, interdisciplinary collaboration, and sustainability-driven innovation will be vital for achieving durable, predictable, and biologically harmonious restorative outcomes.

## 5 CONCLUSION

Recent advancements in restorative dental materials emphasize a strong integration of materials science, biology, and digital innovation. Modern composites, ceramics, and bioactive hybrids now show notable improvements in mechanical, esthetic, and biological performance. However, turning laboratory success into reliable clinical outcomes remains a key challenge. Variations in testing protocols, brief observation periods, and incomplete biological assessments continue to limit the predictive accuracy of laboratory results.

Bridging this gap requires standardized testing procedures, long-term clinical validation, and interdisciplinary collaboration among materials scientists, clinicians, and engineers. The future of restorative dentistry depends on AI-assisted material design and predictive modeling, which can forecast in vivo performance and support patient-specific choices. Sustainable, recyclable materials and hybrid in vitro/in vivo testing frameworks that integrate chemical, mechanical, and microbiological factors will be crucial for enhancing translational relevance.

Clinicians should prioritize materials validated through fatigue, biocompatibility, and long-term performance studies, rather than relying solely on laboratory strength metrics. The emerging generation of smart, self-healing, and bioactive materials promises to transform restorations from passive substitutes into functional, biologically adaptive extensions of the tooth, marking a new era of precision and sustainability in restorative dentistry.

Consent for Publication

The author has reviewed and approved the final version and agrees to be accountable for all aspects of the work, including any accuracy or integrity issues.

Disclosure

The authors declare no competing interests related to this work. The funding body had no role in study design, data collection, analysis, interpretation, or manuscript preparation.

Data Availability

This review paper draws on publicly available sources.

Authorship Contribution:

All authors contributed significantly to the work, whether through conception, design, utilization, data

**Summary Table 3:** Comparative Overview of Major Restorative Materials (2019–2025)

| Material Type | Key Properties | Advantages | Limitations | Representative Recent Studies |
|---|---|---|---|---|
| Resin-based composites | Moderate strength, esthetic, adhesive bonding | Easy handling, good esthetics, direct application | Polymerization shrinkage, aging degradation | [5,14,19,26,28,31,49] |
| Glass-ionomer and resin-modified glass-ionomer | Fluoride release, chemical bonding | Bioactivity, anti-caries effect | Low strength, poor wear resistance | [26,27,44,45] |
| Hybrid ceramics / polymer-infiltrated ceramics | High toughness, dentin-like modulus | Machinability, esthetics, CAD/CAM-compatible | Limited long-term data, brittle failure | [9,24,62–65,85] |
| Zirconia and lithium disilicate ceramics | High strength, wear resistance | Excellent durability and esthetics | Difficult repair, chipping risk | [50–52,62–64] |
| Bioactive materials (Ca-silicate, glass-based, ion-releasing) | Ion release, remineralization, pH buffering | Reduced secondary caries, improved tissue response | Variable mechanical stability | [10,22,41,44,70–73] |
| Smart/self-healing composites | pH-responsive, microencapsulated monomers | Crack healing, adaptive ion release | Still experimental, costly | [74–77,81] |
| 3D-printed and CAD/CAM hybrids | Layered structure, customizable | Precision fit, rapid fabrication | Limited fatigue data, anisotropy | [59–68,85] |

collection, analysis, or interpretation, or in multiple of these areas. They also participated in drafting, revising, and critically reviewing the paper, provided final approval for the published version, selected the journal for submission, and assumed responsibility for all aspects of the work.

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