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Review

Longevity and Clinical Performance of Direct Posterior Restorations

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Abstract

Various materials and techniques are employed, with composite resins being a popular choice. Factors influencing restoration longevity include material selection, practitioner skill, patient factors, and cavity characteristics. Recent developments in dental materials and techniques have expanded treatment options. Amalgam has historically exhibited superior longevity but faces declining usage due to aesthetic concerns. Composite resins have shown variable longevity, influenced by factors such as cavity location and size. Glass ionomer cements, while biocompatible, have limited mechanical strength. Tunnel restorations and atraumatic restorative treatment restorations have shown varying success rates. Advances in materials, techniques, and bonding agents are shaping the landscape of adhesive dentistry. Adhesive dentistry has evolved significantly with the decline of amalgam and the emergence of innovative materials. Challenges like polymerization shrinkage persist, but promising developments, such as low-shrinking monomers and nanoparticle fillers, are on the horizon. Self-etching adhesives have improved bonding. The longevity of posterior restorations depends on various factors, and practitioners must stay updated on these advancements for optimal patient care.

Keywords: *direct posterior restorations, restoration longevity, composite resin materials, amalgam restorations, adhesive dentistry advancements*

Introduction

Restoration of posterior teeth stands as an integral facet of contemporary restorative dentistry, addressing a multitude of concerns such as dental caries, functional rehabilitation, and the pursuit of aesthetic excellence. Direct posterior restorations (PRs) encompass an array of techniques and materials, each carefully tailored to address the unique requirements of individual cases. Composite resin (CR) materials, noted for their ability to seamlessly blend aesthetics with resilience, represent a prevalent choice in this domain. These restorations can be broadly categorized into two fundamental types: direct resin composite (RC) restorations and indirect RC restorations (1). The former involves the direct placement of CR into the prepared tooth cavity and is typically indicated for managing small to moderate-sized cavities (2). On the other hand, indirect resin CRs involve the fabrication of restorations external to the oral cavity, such as inlays and onlays, which are subsequently bonded to the prepared tooth. This approach is well-suited for larger cavities or instances necessitating additional structural reinforcement.

Among the alternatives, glass ionomer (GI) materials, renowned for their fluoride-releasing properties, find application in restoring non-load-bearing posterior teeth, particularly deciduous molars (3). Meanwhile, although less prominent in contemporary practice, amalgam restorations (AR) persist due to their demonstrated longevity and durability. Notably, recent years have witnessed the emergence of novel materials such as bulk-fill composites and resin-modified GIs, introducing simplified placement techniques and augmented physical properties, thereby further diversifying the materials at the disposal of dentists.

The assessment of longevity and clinical performance emerges as a pivotal endeavor in appraising the effectiveness of direct PRs. Multiple factors intricately intertwine to influence the longevity of these restorations. Foremost among these factors is material selection; for instance, AR, distinguished by its robustness, is known to endure for several decades. Conversely, CR restorations, while exhibiting improved wear resistance, may necessitate periodic maintenance (4).

Beyond material choice, the proficiency and competence of the dental practitioner play an unequivocally critical role in shaping the long-term success of these restorations (5). The implementation of proper techniques, scrupulous cavity preparation, and exacting bonding procedures assume paramount significance. Patient-centric variables, encompassing oral hygiene practices, dietary habits, and conditions such as bruxism, wield a substantial impact on the restoration's longevity (6). Routine dental examinations and vigilant maintenance constitute indispensable measures for promptly identifying and rectifying issues as they arise.

Moreover, the dimensions and location of the cavity wield substantial influence in dictating the selection of the most appropriate restoration modality. Larger restorations or those sited in regions subject to heightened mechanical stress might necessitate sturdier materials or the application of indirect restorations (7). Significantly, the relentless progression of dental materials and techniques consistently contributes to the augmentation of the longevity and clinical performance of direct PRs.

Due to these factors, direct PRs constitute a pivotal domain within modern restorative dentistry, catering to a spectrum of patient-specific requisites. Their enduring success is inextricably linked to several interwoven facets, encompassing the judicious choice of materials, the virtuosity of the dental practitioner, patient-related considerations, the dimensions and site of the cavity, and the ongoing evolution of dental materials and techniques (8). It is, therefore, incumbent upon dental professionals to meticulously evaluate each clinical scenario, discerning the optimal restoration approach to ensure the attainment of superlative clinical outcomes.

Methodology

This study is based on a comprehensive literature search conducted on September 10, 2023, in the Medline and Cochrane databases, utilizing the

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medical topic headings (MeSH) and a combination of all available related terms, according to the database. To prevent missing any possible research, a manual search for publications was conducted through Google Scholar, using the reference lists of the previously listed papers as a starting point. We looked for valuable information in papers that discussed the longevity and clinical performance of direct PRs. There were no restrictions on date, language, participant age, or type of publication.

Discussion

AM and CR are the primary materials used for direct fillings in posterior stress-bearing areas (PSBAs), with amalgam still being preferred for Class II restorations in some regions. However, amalgam usage has been decreasing due to aesthetic concerns and mercury-related worries (9, 10). The debate over the durability of amalgam and CR in PRs has been ongoing. Generally, AMs have shown superior longevity compared to RCs in cross-sectional retrospective studies and a prospective randomized clinical trial, with AMs having a higher seven-year survival rate. Even in studies where no significant difference in longevity was observed, RCs had higher replacement rates. However, some well-motivated practitioners have reported comparable or better survival rates for RCs over AMs. Manhart and colleagues also found similar annual failure rates for both materials in a meta-analysis of direct PRs (amalgam 3.0%, CR 2.2) (11, 12).

One of the main reasons for amalgam replacement in PRs is poor margins and secondary caries due to biting force and creep. Cyclic loading, caused by mastication and thermal changes during the consumption of hot and cold foods, induces creep, which can lead to a decrease in fracture strength and fatigue limit at the adhesive-dentin interface in CR restorations. Therefore, when using CR in PSBAs, it's important to consider the effect of occlusal stresses on the weakest adhesive-dentin interface concerning restoration aging (13, 14). Despite improvements in CR materials and bonding techniques, the use of CR in PSBAs remains a topic of debate due to concerns about unpredictability, microleakage, wear, postoperative sensitivity, moisture control, polymerization shrinkage stress, and technique sensitivity. Therefore, there is a need for comparative data on the longevity of AMs and RCs under similar conditions in PSBAs (15, 16).

Composite Resin Restorations

CRs are widely used for PRs, even in stress-bearing areas. Various clinical studies have reported annual failure rates ranging from 0% to 9%. For example, Mjör reported a median longevity of 6 years for 537 CRs placed by general practitioners in Sweden, with secondary caries, bulk fracture, marginal fracture, discoloration, poor anatomic form, and tooth fracture as the main reasons for failure. Other studies have reported similar results, with some variations in survival rates and reasons for failure (17). The reasons limiting the clinical service life of CR restorations have evolved over time. Initially, issues with insufficient wear characteristics, destruction of anatomy, and degradation were common problems. However, technological improvements in filler particle form and composite materials have shifted the indications to replace. Fracture, marginal ditching, discoloring, secondary lesions, and wearing are now the primary factors affecting the longevity of resin-based composites (18, 19).

Microfilled composites have shown further fracture causing losses compared to hybrid composites, particularly in stress-bearing Class II cavities, due to their poorer mechanical properties. The comparatively great incidence of secondary caries associated with RC restorations may be linked to microbiological studies indicating a higher proportion of *Streptococcus mutans* at the cavity margins of composites compared to amalgam and GI restorations. Additionally, older-generation dentin bonding agents limited the marginal quality of CRs (20, 21). The location and size of the restorations, as well as the class of the cavity, have also influenced the treatment outcome of CRs. Premolars tend to offer better conditions for CRs than molars due to smaller cavities, less intense chewing forces, easier access to dental treatment, and better tooth care options (22, 23). Long-term studies have reported varying survival rates for

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posterior CRs, with some studies showing success rates over extended periods. For example, a 17-year study demonstrated an excellent success rate for ultraviolet-cured posterior composites, while another study reported a 10-year survival rate of 92.9% for three posterior CRs after 10 years (24, 25).

Amalgam Restorations

Amalgam has been the material of choice for class I and II cavity restorations for more than a century. Various clinical studies have reported annual failure rates ranging from 0% to 7% for non-gamma-2 and gamma-2-containing alloys, with observation periods of up to two decades. Factors like cavity class and alloy type have influenced survival rates, with some studies reporting higher longevity for class I defects compared to class II cavities (26, 27). The longevity of AM has been associated with parameters such as cavity size, alloy composition, and the presence of gamma-2. Traditional low-copper alloys have shown higher failure rates compared to high-copper alloys, which exhibit better corrosion resistance. Marginal ridge breakdown, secondary lesions, and bulk fracture are common reasons for AM failures (28, 29).

Amalgam is generally considered a technique-insensitive restorative material, contributing to its good clinical performance over time. Factors such as secondary lesions, bulk fracture, dental fracture, cervical overhang, and degradation of cavity margins have been reported as the main issues limiting the lifespan of AMs (30, 31).

Glass Ionomer Cements

GI restorations have annual failure rates ranging from 1.9% to 14.4%. Fracture of restorations, including bulk and marginal fractures, along with poor anatomic form due to low wear resistance, are the primary reasons for failure. Surface cracking or crazing can also lead to early failures in GI restorations (32, 33). Although GI cements have advantages such as sustained fluoride release, chemical bonding to tooth substance, and pulpal biocompatibility, their inferior mechanical strength makes them unsuitable for long-term use in PSBAs. Some studies have reported a higher incidence of secondary caries in GI restorations, despite the release of fluoride ions. The longevity of these restorations is sensitive to factors like operator skill, caries activity, and cavity preparation technique (34, 35).

Tunnel Restorations

Tunnel restorations, a conservative approach for approximal lesions, have shown varying success rates in different studies. While some studies report favorable outcomes with low annual failure rates, others indicate higher failure rates, particularly in patients with high caries activity and when the tunnel restoration does not reach the approximal surface. The success of tunnel restorations can also be influenced by factors like operator skill and patient characteristics (36).

Atraumatic Restorative Treatment (ART) Restorations

ART restorations, a technique designed for minimal dental health care in rural areas, have demonstrated varying success rates in different studies. Factors like the type of GI cement used can influence outcomes. While some studies report high success rates after 1-3 years, ART restorations may exhibit lower longevity compared to conventional restorations (37, 38). Both AM and CR restorations have shown varying survival rates in PSBAs, with amalgam generally exhibiting superior longevity in terms of years. However, the choice between these materials should be tailored to individual patient needs, preferences, and clinical circumstances. Advances in material science and adhesive technology continue to influence the success rates and longevity of dental restorations, making it essential for practitioners to stay updated on the latest developments and evidence-based practices in restorative dentistry.

In the realm of adhesive dentistry, significant advancements have occurred since Buonocore introduced the acid-etch technique in 1955, marking a pivotal moment. Recent developments, particularly in certain European countries like Germany and Sweden, have seen a substantial

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decline in the use of AMs, with amalgam now playing a minor role (12, 39). Over the past decade, a multitude of novel restorative materials have emerged, predominantly as improvements and derivatives of composites (such as compomers and ormocers) and GIs (including resin-modified and high-viscosity variants) (40). These innovations represent a substantial portion of all restorative materials developed in the history of dentistry. They entail modifications in filler technology, filler distribution, and filler loading, along with alterations in the matrices of resin-based restorative materials. Alternatively, recently developed high-viscosity packable composites boast a high filler load and a unique filler distribution, resulting in distinct consistency compared to hybrid composites (41, 42). They are particularly recommended for cavities in PSBAs, emphasizing improved handling (akin to amalgam manipulation) and easier establishment of physiologic interproximal contacts in Class II cavities. However, it is worth noting that bulk curing of packable composites in deep cavities is still not recommended, as indicated by measured curing depth values. Additionally, low-viscosity flowable composites exhibit different rheologic properties compared to hybrid composites and find their application in minimally invasive cavity preparations, Class V cavities, and as a stress-relieving base material beneath hybrid or packable composites due to their lower elastic modulus (43).

A promising development in composite materials is the emergence of "smart" composites like Ariston pHc, which aim to release functional ions (such as fluoride, calcium, and hydroxyl ions) from special filler particles on demand (41, 44). This release mechanism is pH-dependent, with decreasing pH values resulting from active dental plaque triggering increased ion release. This innovation is expected to reduce the occurrence of secondary caries at restoration margins by inhibiting bacterial growth, mitigating demineralization, and buffering acids produced by cariogenic microorganisms. Nonetheless, the importance of achieving a good dentin seal remains paramount, and long-term results are still pending. In the near future, restorative materials that hinder or reduce plaque adhesion will hold significant value.

Another noteworthy development in restorative dentistry is the introduction of ormocers (organically modified ceramics) in 1998 (41, 45). These materials, which have broad applications in modern technology, offer a novel approach to dental restorative materials. Utilizing multifunctional urethane- and thioether (meth)acrylate alkoxysilanes as sol-gel precursors, inorganic-organic copolymer ormocer composites have been synthesized (34, 35). Ormocers are characterized by their unique inorganic-organic copolymer formulation, allowing for the adjustment of mechanical parameters over a wide range. Importantly, the clinical handling of ormocers mirrors that of direct-placement resin composites (45).

One of the persistent challenges in resin-based restorative materials is polymerization shrinkage, which has led to efforts to develop nonshrinking or low-shrinking monomer systems (46). While initial investigations explored spiro orthocarbonate monomers, which showed expansion or minimal shrinkage, the use of epoxy resins raised biocompatibility and hardening concerns. More recent bifunctional oxybismethacrylate monomers, characterized by cyclopolymerization, have demonstrated a significant reduction in shrinkage compared to traditional dental dimethacrylates (47, 48). Researchers are now exploring low-shrinking resins compatible with current dental formulations. Liquid crystal monomer systems have also shown promise in reducing polymerization shrinkage (49). Additionally, the development of siloranes, a merger of siloxanes and oxiranes, presents intriguing prospects due to their biocompatibility, mechanical properties, and low shrinkage values (50).

Dental adhesive systems continue to evolve with a focus on user-friendly, efficient, and reliable bonding agents and techniques. Recent self-etching adhesives, such as Prompt L-Pop, Clearfil Liner Bond 2, and SE Bond, have become capable of achieving excellent bonding to both enamel and

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dentinal tissue, rivalling total-etch procedures (51, 52). Discussions persist about whether total-etch and total-bond approaches or selective bonding yield superior long-term results and marginal seals for adhesive restorations. Selective bonding is proposed to provide better long-term marginal integrity and stress relief within restorations due to its unique polymerization dynamics (53, 54).

Conclusion

Adhesive dentistry has evolved significantly since 1955, witnessing a decline in amalgam use and the emergence of novel restorative materials. These materials include high-viscosity composites, smart composites, and ormocers, addressing various clinical needs. Polymerization shrinkage remains a challenge, but innovations like low-shrinking monomers and nanoparticle fillers show promise. Dental adhesives have improved, with self-etching options providing strong bonds. The longevity of PRs depends on factors like material choice, practitioner skill, patient factors, and cavity characteristics. Long-term studies reveal varying survival rates for materials like CRs and amalgam.

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Conflict of interest

There is no conflict of interest

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Data availability

Data that support the findings of this study are embedded within the manuscript.

Author contribution

All authors contributed to conceptualizing, data drafting, collection and final writing of the manuscript.

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