CLINICAL PERFORMANCE OF RESIN COMPOSITE RESTORATIONS IN POSTERIOR TEETH: A REVIEW

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Abstract
Resin composites are the first choice for direct restoration of posterior teeth in the treatment of dental caries. This article reviews factors that influence the clinical performance of composite restorations and the results of clinical trials assessing longevity of posterior resin composite restorations. *Materials and method.* PubMed, and Web of Science electronic databases were searched for articles investigating the clinical performance of direct resin composite restorations placed in posterior teeth. *Results and discussions.* Factors with significant influence on longevity of posterior composite restorations include patient-related factors (age, carious risk, periodontal disease, bruxism), dental group, cavity size and volume, cervical margin extension, root-filled teeth, oclusal stress. *Conclusions.* Dental resin composites are material of choice for use in direct minimal interventions in posterior teeth. For patients without bruxism, in medium size cavities, direct composite resins demonstrate similar clinical performance with amalgam restorations. The clinical performance of restorations depends on a number of factors including variables related to the restored tooth, the materials and techniques employed, the patient's risks, and professional clinical decisions.

Keywords: resin composites; posterior teeth; clinical performance

INTRODUCTION

Amalgam restorations were gold standard in restoration of posterior teeth for many decades, owing to its price, low technique sensitivity and long-term durability [1]. However, concerns over the mercury release and the negative environmental impact of mercury as well as the benefits of modern adhesive techniques favor resin composites as primary restorative materials in posterior teeth, removing amalgam from preferences of most patients [1, 2]. The improvements in bonding systems, new restorative techniques, auxiliary instruments and devices contribute to higher longevity of direct composite posterior restorations [3-10]. The clinical performance of these restorative materials was also improved by several modifications implemented in resin composite formulatios such as dimethacrylate monomers with higher molecular weights and lower polymerization stress, increased volume of inorganic fillers with decreased particle size, improved interaction between resin matrix and filler particles, as well as more effective photoinitiator systems [11, 12].

Every year manufacturers introduce new versions of well-known resin composites, updates that are associated with new packages, new brand logos as well as increased costs [13]. The primary criteria for selection of resin composites for posterior teeth should be handling characteristics, ease of use, and the availability of shades and pigments, in addition to other criteria that may influence

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their clinical use. However, dentists opinion about resin composite selection in the treatment of posterior teeth is also driven by costs, brands reputation and packaging design [14].

Among the benefits of composite resins, we can list the aesthetics facilitated by their color and translucency similar to dental tissues, the adhesive strength to enamel and dentin achieved with the help of adhesive systems, and mechanical properties comparable to hard dental tissues [14]. Regarding the main disadvantages of composite resins, these include polymerization shrinkage evaluated at 0.3-1.5% linear shrinkage, or 1.5-3.5% volumetric shrinkage for Bis-GMA based monomer resins, increased wear (12-50 µm/year), and volumetric expansion approximately six times greater than that of hard dental tissues [14]. When compared to amalgam or inlay/onlay restorations, the advantages of resin composites are:

- facilitate greater preservation of dental tissues by enabling the use of additive techniques [13];
- have better prognosis of recovery of the remaining dental structure in case of restoration failure [13];
- in large dental cavities, resin composite restorations have better biomechanical behavior when compared to amalgam [16].

Disadvantages of resin composite restorations when compared to amalgam and composite inlay/onlay restorations involve wear, marginal defects, marginal and surface staining [17]. Resin composites are contraindicated in the treatment of patients with bruxism, clenching, and parafunctional habits due to mechanical overloading leading to excessive wear, fractures, and failures [18].

In this context, the choice of restorative material for posterior restorations will depend on shared decision-making between dentist and patient, local directives and protocols [1].

AIM OF REVIEW

The aim of this article is to provide a general perspective of the aspects that influence the clinical performance of resin composite restorations and comparative data regarding longevity of posterior direct restorations versus amalgam and indirect composite inlay/onlay restorations.

MATERIALS AND METHOD.

PubMed, and Web of Science electronic databases were searched for articles investigating the clinical performance of direct resin composite restorations placed in posterior teeth. The search strategy used a combination of keywords: dental, composite, restoration, USPHS, FDI, clinical performance, longevity, durability. or the outcome of efficacy. We included longitudinal, prospective, and randomised controlled trials (RCTs) assessing functional durability of dental composite resin in posterior teeth as well as studies comparing them with dental amalgam restorations or inlay/onlay restorations in permanent posterior teeth (papers published between 2007 and 2023). All clinical studies with posterior direct composites were included with special attention to articles published in the last 10 years. Special attention was given to studies assessing risk factors for clinical performance of composite restorations as well as medium- and long-term studies using USPHS and FDI indices for the assessment of functional durability of resin composite restorations in posterior teeth. Exclusion criteria were as follows:

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case reports/case series; animal studies; *in vitro* studies

RESULTS AND DISCUSSIONS.

Factors influencing the clinical performance of posterior resin composite restorations

Dentists must understand various factors that can interact with resin composite restorations in oral cavity.

Considering these factors, dentist can decide when ditrect resin composite posterior can have long-term success, when might an indirect restoration offer a clinical edge compared to a direct one, under what circumstances is adhesive cusp coverage (onlay) recommended, when should resistance form designs be incorporated into adhesive restorations, and when a coverage crown is preferable [19]. Cardoso et al (2023) proposed CARES concept based on five parameters: Cusps coverage, Advantages and limitations of adhesion, Required resistance forms, Esthetic considerations, as well as Subgingival management [19].

Masticatory forces, bruxism, diet, saliva, oral biofilm are known as major factors that impact long-term success of direct resin composite restorations [20].

Other variables known as confounders can influence short- and medium term functional durability such as patient-related factors (systemic status, demographic variables, oral hygiene level, tooth, chewing patterns, diet related habits), tooth location, cariogenic risk, periodontitis susceptibility as well as dentist related factors (experience, technical ability) [20].

Regarding high cariogenic and periodontal risk patients, experience of dental professionals as well as patient-specific demands significantly influences the longevity of posterior resin composites [21, 22]. In relation to patients' caries risk, those with a high risk had failure rates of 3.2% at 5 years and 4.6% at 10 years post-treatment. Conversely, patients with a low risk had failure rates of 1.2% at 5 years and 1.6% at 10 years post-treatment. For restorations with a glass-ionomer cement base or liner, failure rates were 2.2% at 5 years and 2.7% at 10 years post-treatment. Restorations without a glass-ionomer cement base or liner had failure rates of 1.7% at 5 years and 2.2% at 10 years post-treatment. Larger surface restorations have a higher risk of failure, as each additional surface increases this risk by 30%-40%. The risk of failure for restorations in molars was higher than for those in premolars. The main reasons for failure were secondary marginal caries and marginal or bulk fractures of direct composite resin restorations. Logistic regression analysis indicated a significantly higher risk of failure for patients with high cariogenic risk and those with higher number of restored dental surfaces [22].

Pizzolotto et al (2022) classified factors in two categories: factors with significant and limited influence on durability of posterior composite restorations [13].

Factors that influence significantly the longevity of composite restorations in posterior teeth are described further.

Dental group is one of them, with molars associated with higher composite restorations failure rate by fracture and secondary caries [23]. Greater size and volume of dental cavity increases the risk of failures of posterior resin composites [24]. Higher failures rates of resin composite

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restorations (fractures, secondary caries) were recorded in root-filled teeth when compared with vital teeth [25]. Patient' age influence the success/failure of this category of resin composite restoration; children and elderly people were age groups with highest failures rate [25, 26]. Also, men have higher failure rates in posterior resin composite restorations in studies that compared succes/failure rate according to gender [25, 26]. Combination of poor coronal marginal sealing and secondary caries in endodontically-treated teeth lead also to higher rates of apical periodontitis and failure of endodontic treatment [26-30]. The absence of adjacent teeth due to dental caries or periodontal disease ot the location as last tooth on arch, predispose coronal restoration to increased failure rate [31, 32]. Other patient-related risk factors include high cariogenic risk (new caries lesions), occlusal stress, periodontal status, smoking, dietary habits, and parafunctional habits [33, 34]. Resin composite restorations with cervical margins close to the level of enamel-cement junction predispose to secondary caries leading to failure of proximal-occlusal restorations [35]. Class II and age of restorations between 3-5 years are statistically significant predictors of unsatisfactory or unacceptable FDI scores for posterior composite resin restorations [36].

Heintze & Rousson (2012) conducted a systematic review of prospective studies to examine how operative techniques and materials affect the success rate of Class II restorations when compared with amalgam [37]. The primary reasons for replacing restorations were fractures within the restoration and secondary marginal caries. Macrohybrid composite resin restorations had significantly higher failure rates due to the loss of anatomical form compared to other composite resins (hybrid, microhybrid, nanohybrid). Additionally, restorations placed without enamel etching exhibited significantly higher rates of marginal staining than those placed using selective enamel etching techniques. The isolation technique also played a role; restorations placed with a rubber dam had significantly fewer material fractures necessitating replacement compared to those placed under conventional isolation conditions.

Factors with limited influence on the clinical durability of posterior resin composite restorations include factors that can be controlled by dentist [13]. Once procedures are performed adequately, these factors will not significantly influence the rate failures: resin composite brand (new resin composite generations have lower polymerisation shrinkage and higher resistance to wear and compressive forces) [4, 22], adhesive systems (recent studies reported lack of significant differences between different generations of adhesive systems) [38, 39], restorative technique (absence of significant differences between various techniques performed adequately with respect to layers thick, internal porosity, marginal adaptation) [40, 41], isolation technique [42]. Photoactivation technique performed by using monowave or polywave LEDs can influence the rate of the conversion of monomers into polymers. The decrease of LEDs unit irradiance over time, specific to monwave LEDs is a factor that can reduce longevity of posterior resin composite restorations [43].

A systematic review indicated that most clinical studies indicated annual

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failure rates between 1% and 3% for posterior Class I and II composite resin restorations [44]. Failure rates varied depending on factors such as dental group, operative technique, dentist experience, socioeconomic, demographic, and behavioral factors. Material properties did not significantly statistically influence the longevity of direct composite resin restorations. The main long-term failure reasons were secondary caries, individual cariogenic risk, restoration bulk fracture, as well as patient' parafunctions (bruxism) [45, 46].

In conclusion, the interaction between mechanical factors and biological components makes the process leading to resin composite restoration failure multifactorial and challenging to address [47].

Clinical performance of direct posterior resin composites restorations

The evaluation of the direct posterior composite restorations was a challenge. In clinical practice, restorations are frequently replaced based on a misinterpretation of the degree of deterioration, rather than due to an actual clinical failure. This practice of replacing restorations can lead to increasingly extensive treatments and significant costs. While previous evaluation systems (USPHS, Ryge criteria) favoured replacement of posterior composite restorations affected by wear, marginal gaps, or secondary caries, FDI criteria support minimal interventions such as marginal sealing or refurbishment as well as repair procedures [19]. Most research groups assessing the status of posterior resin composite restorations used Ryge criteria and USPHS criteria. However, the number of studies using these criteria increased steadily in the last decade [47]. Despite the complexity and longer periods for data collection, FDI criteria are practical (various and freely selectable), relevant (sensitive, proper to use in clinical studies design), standardized (easy comparison between clinical trials). The descriptions of scores were harmonized to relate various clinical situations with possible therapeutic strategies: reviewing or monitoring (score 1-4), refurbishment or reseal (score 3), restoration repair (score 4), and restoration replacement (score 5). Though the failures of the direct posterior composite restorations are mainly related to the occurrence of fractures and adjacent caries, repair interventions can extend their lifespan [48, 49]. Material-related factors play a significant role in the onset of enamel recurrent caries. Considering the decrease of mineral ions in the early stages of dental caries [50], promising new resin composites with antibacterial and remineralizing properties will increase the longevity of resin composite-based restorations [51]. Academy of Operative Dentistry European Section (AODES) recommend adhesively bonded resin composites as the "material of choice" for the use in minimal interventions to the posterior teeth, including the use of refurbishment and repair procedures aiming to extend the lifespan of resin composite restorations [52].

A systematic review reported that average annual failure rate of posterior composite restorations vary between 0.08% to 6.3%, survival rates from 23% to 97.7%, and success rates ranges from 43.4% to 98.7% [45]. It was reported an average annual failure rate of 1.8% at 5 years and 2.4% at 10 years, for posterior direct

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restorations using composite resins. At two years post-treatment, fractures are consistently a significant reason for restoration failure. The number of secondary caries increases over time, while endodontic complications are encountered in the first year post-treatment. The research group emphasize that short-term studies are still useful for excluding materials with initial catastrophic failures [22]. An 90% overall success rate of Class II direct composite resin restorations was reported at 10 years post-treatment, with no statistically significant difference compared to amalgam restorations [37]. Resin composite restorations in posterior teeth have significantly higher risk of failure than amalgam restorations (RR 1.89) and increased risk of secondary caries (RR 2.14) [1]. Regarding the cost-effectiveness of direct posterior restorations, it has been suggested that resin composites are likely to be inferior to amalgam [53]. Also, amalgams are more cost-effective than resin composites in the replacement of Class II amalgam restorations [54]. One prospective study (follow-up 7 yrs.) concluded that amalgam restorations performed significantly better than composite restorations in large restorations and in those with more than three surfaces involved [55]. Despite lower survival rate when compared to amalgam, various research groups reported satisfactory results assessing resin composite restorations of Class I and Class II made from microhybrid and nanohybrid composite resins [56-65].

Table I exposes data supplied on longevity of posterior resin composite restorations placed in permanent teeth (failure rate, most frequent reasons for failure).

Table I. Success/failure rates and most frequent reasons of failure in posterior resin composite restorations vs. amalgam

Authors	Cavity type	Follow-up	Failure criteria	Failure rate	Most frequent reasons of failure in resin composite restorations
Bernardo et al (2007) [55]	Class I Class II	7 yrs.	Restoration needing replacement	Amalgam 5.6% Composite 14.5%	Secondary caries
Soncini et al (2007) [56]	Class I Class II	3.4 +/- 1.9 yrs.	Restoration needing replacement	Amalgam 10.8% Composite 14.9%	Secondary caries
Opdam et al (2007) [57]	Class I Class II	5-12 yrs.	Restoration needing replacement	Amalgam (5 yrs.; 10 yrs.)- 89.6%; 79.2% Composite (5 yrs.; 10 yrs.)- 91.7%; 82.2%	Secondary caries Endodontic complications Fracture of tooth
Naghipur et al (2016) [59]	Class II	12 yrs.	Restoration needing replacement	Amalgam- 8.5% Composite-	Secondary caries Tooth fracture

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				14%	
Santos et al (2023) [65]	Class II	5 yrs.	USPHS criteria Bravo (fracture of restoration, secondary caries) Charlie (marginal adaptation)	Amalgam-23.2% Composite-22%	-Restoration fracture -Defective marginal adaptation

Van Dijken (2000) compared the clinical performance, 11 years post-treatment, of composite inlay/onlay restorations versus composite direct restorations in Class II cavities. The percentages of restorations considered clinically unacceptable were 17.7% in the inlay/onlay restoration group and 27.3% in the direct composite resin restoration group. The main reasons for failure for both inlay/onlay and direct restorations were fracture (8.3% versus 12.1%), occlusal wear at the occlusal contacts (4.2% versus 6.1%), and secondary caries (4.2% versus 9.1%). Significant differences were found between direct and indirect restorations in patients with bruxism. In patients without bruxism, while no statistically significant differences were recorded between inlays/onlays and direct composite resin restorations regarding the parameters characterizing clinical performance. The presence of secondary caries was detected exclusively in patients with a high cariogenic risk. The authors concluded that Class II cavities in patients with high caries risk, with the cervical margin placed in dentin reduce significantly the clinical performance of composite resin restorations [66]. However, a systematic review conducted by Grivas (2014) of more recent studies, highlights the lack of evidence to demonstrate the superiority of indirect composite resin restorations compared to direct composite resin restorations. The differences between these two types of restorations regarding aesthetic and biological parameters were statistically insignificant at time intervals ranging from 12 months to 48 months post-treatment [67]. Fennis et al. (2014) and Cetin et al. (2013) compared direct and indirect techniques in the rehabilitation of posterior teeth and reported the absence of statistically significant differences between the study groups regarding retention, color stability over time, surface texture, postoperative sensitivity, cervical marginal adaptation, or the development of carious lesions adjacent to the restorations [68, 69]. Indirect composite inlays demonstrated superior clinical performance and significantly better anatomic form compared to direct composite restorations, while the overall clinical performance of direct and indirect techniques did not show statistically significant differences [70].

In line with evidence-based practice, clinicians should stay informed about the latest clinical research, perform their duties to the highest standards, consider patient opinions and preferences, and educate patients on the benefits of reconditioning and repairing defective restorations [71].

CONCLUSIONS.

- Dental resin composites are material of choice for use in direct minimal interventions in posterior

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teeth.

- For patients without bruxism, in medium size cavities, direct composite resins restorations demonstrate similar clinical performance with amalgam restorations.
- Indirect composite inlays have superior clinical performance compared to direct composite restorations, while the overall clinical performance of direct and indirect composite restorations did not show statistically significant differences
- The clinical performance of restorations depends on a number of factors including variables related to the restored tooth, the materials and techniques employed, the patient's risks, and professional clinical decisions.

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