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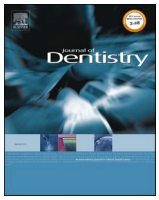

Review article

Direct resin composite restorations in decayed molars: a scoping review

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ABSTRACT

Objectives: The aim of this scoping review was to summarize and discuss the direct resin composites used to reconstruct decayed molars with minimal class II cavities as described in the literature.
Data: The study protocol has been registered on the Open Science Framework platform and can be accessed at the following link: https://doi.org/10.17605/OSF.IO/2D45H. This scoping review was developed according to the PRISMA-ScR guidelines.
Sources: A literature search of 3 electronic databases was performed in MEDLINE (PubMed), SCOPUS and EMBASE with the last search in March 2024. Study selection was completed by two reviewers independently using the collaboration software platform Covidence (Covidence systematic review software, Veritas Health Innovation, Melbourne, Australia).
Study selection: Of 8591 studies initially identified, full-text analysis was conducted in 82 studies. Any prospective clinical study conducted in adults involving an evaluation of composites on decayed molars with at least one proximal surface affected was included. Finally, 23 studies were included in this analysis.
Conclusions: Clinical studies on decayed molars with class II cavities show that direct composites are reliable restorations over the long term. Success rates are excellent, even after several years. However, further clinical studies on severely decayed molars with one or more missing cusps are needed to evaluate the effectiveness of these materials in direct techniques for even more complex cases.
Clinical significance: Direct resin composites are reliable materials for restoring decayed molars with Class II cavities.

1. Introduction

Resin-based composites are commonly used for the direct restoration of posterior cavities [1,2]. Dental composites enable the use of additive techniques and minimally invasive dental treatments [1]. Direct composite resin restoration can typically be completed in a single visit, often requiring minimal or no removal of healthy tooth structure, making them a cost-effective alternative [3].

Recent advancements in adhesive dentistry have minimized the need for posts and cores in the restoration of endodontically treated posterior teeth with significant coronal tissue loss [4]. Such damaged teeth can now be restored using either direct or indirect techniques. Even in this clinical situation, direct restorations can be applied in minimally invasive conditions, as they often require no specific cavity preparation. Partial indirect restorations such as inlays, onlays and overlays offer aesthetics, improved adaptation to natural tooth morphology, and a low shrinkage factor [5–7]. However, the procedure requires multiple appointments and is associated with higher material costs compared to direct resin composite restorations [5,8].

The emergence of adhesive dentistry and the minimally invasive restorative approach have challenged this perception. While indirect restorations are often associated with more extensive cavity preparation [9–11], recent approaches advocate for a conservative strategy whereby the cavity configuration is first optimized using resin composites [8]. This additive technique allows for the preservation of sound tooth structure prior to proceeding with the indirect restoration, thereby aligning with the principles of minimally invasive dentistry.

These considerations are in line with the major concern which is the longevity of the restoration itself. Today, it is generally accepted that it is more crucial to preserve the underlying tooth and ensure the overall functioning of the dentition. A successful restorative concept must take future restoration options into account, as the solution used today will

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eventually fail and will require replacement, repair, or adjustment. This is the essence of the biomimetic approach: not to create the strongest restoration, but to design one that is in harmony with the mechanical, biological, and optical properties of the surrounding tissues [8].

Traditionally, indirect restorations have been considered superior in terms of longevity compared to direct restorations [8]. Direct composite restorations have demonstrated acceptable survival rates, with annual failure rates averaging between 1 % and 3 % [12,13]. However, the technique is still considered to have significant sensitivity [14]. Direct restorations on carious molars present several challenges, including anatomy and occlusal function, in addition to polymerization shrinkage and contraction stresses. Shrinkage can result in distortion of cusps and fissures in the enamel at the base of the cusps. When choosing direct techniques, it is crucial to reduce contraction stresses [15,16].

For deep posterior cavities, the integration of fiber-reinforced composite resins as dentin substitutes represents a significant advancement in biomimetic minimally invasive dentistry [17]. A recent systematic review and meta-analysis [18] concluded that, under laboratory conditions, the use of glass fiber-reinforced composites such as everX® Posterior (GC, Tokyo, Japan) has shown promising mechanical properties in structurally compromised molars [16]. This glass fiber-reinforced material is designed to replace missing dentin and is intended to be completely covered by a micro-hybrid composite, thereby maintaining anatomical integrity, in accordance with the biomimetic approach [18]. However, the available clinical evidence remains limited.

In recent years, the popularity of direct restorations, which are more financially accessible, has increased due to inflation and economic difficulties. The use of composite resins for direct restorations, as well as short fiber-reinforced composite resins (SFRC) as dentin substitutes in large-scale restorations, represents a promising approach to meet this demand [16]. These materials aim not only to replicate the structure of the tooth but also to emulate its mechanical properties, thus reducing the risk of restoration-related fractures. Also, the fibers incorporated into SFRCs play a crucial role in limiting crack initiation and propagation, which strengthens the structure of direct restoration and enhances its long-term durability [17].

There are few clinical studies that address direct composite restorations on damaged molars. Most clinical studies focus on Class I or II cavities without damage to the cusps. Studies show that direct composite restorations involving a greater number of surfaces have an increased risk of failure [1]. Some clinical studies have reported a lower survival rate for larger restorations [19–21], although evidence suggests that restoration size does not systematically affect survival rates [5,22].

The literature on direct composite techniques is extensive, but studies involving severely decayed molars are relatively scarce. The extent of most restorations in studies examining the longevity of direct composites is small to moderate [5]. The purpose of this scoping review is to evaluate the clinical performance of direct composite restorations in carious molars with at least one proximal surface affected. Specifically, the review aims to map the types of resin composites employed, restorative techniques, clinical conditions, operator variability and the reported outcomes in terms of restoration longevity and failure patterns and to synthesize the data gathered.

The research question guiding this scoping review was: “What resin composites and clinical restoration strategies are reported in the literature for the direct restoration of structurally compromised molars, and what are their reported clinical outcomes?”

2. Methods

The proposed scoping review was conducted in accordance with the JBI methodology for scoping review [23]. The reporting process adheres to the preferred reporting items for systematic reviews and meta-analyses extension for scoping reviews (PRISMA-ScR) guidelines [24], ensuring transparency and methodological rigor. The review protocol was registered on the Open Science Framework platform and is publicly accessible at: https://doi.org/10.17605/OSF.IO/2D45H.

2.1. Search strategy

A preliminary search was conducted in Medline (interface PubMed), the Cochrane Database of Systematic Reviews, and JBI Evidence Synthesis, which revealed no existing scoping or systematic reviews on the topic.

To develop a comprehensive search strategy, a multi-step approach was implemented collaboratively by a librarian (SV) and the lead author (MB). In the first step, an exploratory search was performed in PubMed to identify relevant records. The titles, abstracts, author keywords, and subject descriptors (e.g.; MeSH terms) were analyzed to extract potentially relevant search terms. These terms were then refined and expanded through consultation with the broader research team.

In the second step, the identified terms were tested in PubMed in various combinations to ensure that the search strategy adequately captured the breadth of the available literature. A draft search strategy was prepared and subsequently reviewed by MB before being finalized.

Finally, in the third step, the validated search strategy was adapted and applied to 3 databases: Medline (PubMed), Embase (Elsevier) and Scopus (Elsevier), covering studies published up to March 2024, which corresponds to the date of the final query in the selected databases.

The complete search equations for all databases are available in Table 1.

2.2. Eligibility criteria

This scoping review considered peer-reviewed published studies involving adult humans (18 years or older). Studies were eligible if they (1) were prospective clinical studies; (2) were published in English or French; (3) involved the use of conventional or bulk-fill resin composites; (4) included vital and/or non-vital molars; (5) applied a direct restorative technique; and (6) focused on Class II or large posterior cavities. Only studies published within the last 15 years, regardless of geographical location, and available up to March 20, 2024, were included. A 15-year publication timeframe was chosen to reflect contemporary clinical protocols, materials, and adhesive strategies.

2.3. Information sources and search strategy details

The literature search was developed using subject headings (as

Table 1
Search terms used in Pubmed, Embase and Scopus.

Bibliographic databases	Concept	Search
Medline (PubMed)	Decayed molar	("Molar"[Mesh] OR molar OR "posterior tooth" OR "posterior teeth") AND (caries OR carious OR decay*)
	AND	
	Resin composites	"Composite Resins"[Mesh] OR composite OR "bulk-fill*" OR "bulk fill*" OR restoration OR restorative OR "everx posterior" OR resin
Embase (Elsevier)	Decayed molar	('molar tooth'/exp OR molar OR 'posterior tooth' OR 'posterior teeth') AND (caries OR carious OR decay*)
	AND	
	Resin composites	'resin'/exp OR composite OR 'bulk fill*' OR restoration OR 'everx posterior' OR restorative
SCOPUS (Elsevier)	Decayed molar	TITLE-ABS-KEY ((molar OR "posterior tooth" OR "posterior teeth") AND (caries OR carious OR decay*))
	AND	
	Resin composites	TITLE-ABS-KEY (composite OR "bulk fill*" OR restoration OR "everx posterior" OR restorative)

appropriate per database) and free-text terms to composite resins and posterior teeth. Three bibliographic databases were searched: Medline (PubMed interface, 1946 onwards), Embase (Elsevier interface, 1974 onwards) and Scopus (Elsevier interface, 1974 onwards). No restrictions were placed on study design or language during the search phase.

2.4. Study selection strategy

All identified records were imported into Covidence (Veritas Health Innovation, Melbourne, Australia), where duplicates were removed. To ensure consistency across reviewers, calibration exercises were conducted before starting the selection process. Following this pilot test, two independent reviewers (M.B. and A.G.) screened titles, abstracts, and full texts for inclusion based on the predefined eligibility criteria. Disagreements were resolved by consensus. Consistent with the JBI methodology for scoping reviews, no formal risk of bias or quality appraisal was conducted.

2.5. Data extraction

The two primary reviewers (M.B. and A.G.) independently extracted data on the Covidence platform. The following data was collected:

- Study characteristics: first author's last name, year of publication, country of study, and study design.
- Participant characteristics: number of participants, age, sex, and a description of the intervention and control population.
- Intervention characteristics: type and characteristics of teeth (e.g. vital or non-vital teeth) at time of care, number of treated surfaces, type of composite resin, adhesive system used, control treatment (if applicable), clinical conditions during restoration (e.g. use of rubber dam) and application technique used to place the materials (i.e. incremental technique or not), number and roles of operators and evaluators.
- Outcome measures: type of evaluation, evaluation criteria, and follow-up duration.

Any discrepancies were resolved through discussion between the two reviewers (M.B. and A.G.).

3. Results

3.1. Literature search and screening process

A total of 8591 potentially relevant records were initially identified through the literature search (Fig. 1). After duplicate removal using Covidence, 5157 records remained. Following title and abstract screening, 82 studies were considered for the full-text review. After these, 59 were excluded for not meeting the eligibility criteria. Finally, 23 studies were included in the scoping review.

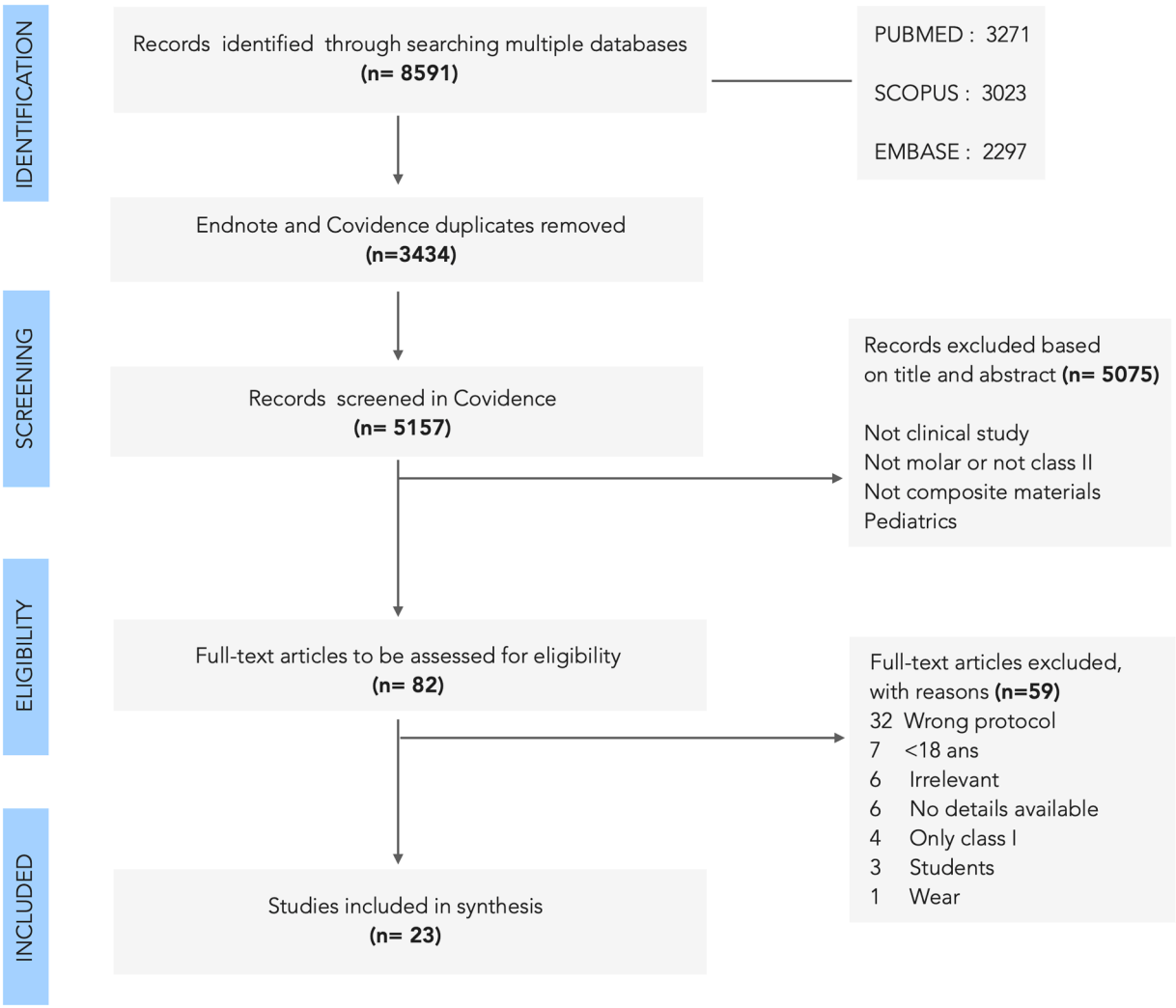

Fig. 1. Flow diagram for study selection according to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta- Analyses) guidelines.

3.2. Study characteristics

Table 1 summarizes the key characteristics of the studies included in this review. The studies ranged from 2013 [25] to 2021 [26]. Geographically, most studies were conducted in Germany ($n = 8$), followed by Brazil ($n = 3$), Italy ($n = 3$), Egypt ($n = 2$), Sweden ($n = 2$), Turkey ($n = 2$), Finland ($n = 2$), Norway ($n = 1$). All the selected studies are clinical studies, including 12 randomized clinical trials and 6 split-mouth studies.

3.3. Results synthesis

The aim is to map the existing literature on direct composite restorations in decayed molars with minimum class II cavities. No statistical analysis was performed, in accordance with the scoping review methodology, which aims to map key concepts and identify knowledge gaps rather than to provide a quantitative summary. So, the factors analyzed in the included studies are therefore presented in a narrative format.

3.3.1. General information

The number of restorations at the beginning of the selected studies ranges from 35 [27] to 144 [28] (Table 2).

3.3.2. Rubber dam

In the 23 included studies, the use of a rubber dam was reported in various ways. In 13 studies [14,26–37], the rubber dam was systematically placed in all cases. In 5 studies, its use was not systematic: it was either determined by a randomization scheme [38] or adapted based on clinical judgment [39–41]. In 2 studies where the rubber dam was not used, cotton rolls and suction were employed [25,42]. In one study, the use of the rubber dam was not specified [43], and in 2 studies, the placement of the rubber dam was explicitly not used [44].

Table 2
: Characteristics of the selected studies, including country of study, study design and number of restorations at baseline.

Author	Year	Country	Study design	Restorations (n) Baseline
Barabanti et al. [29]	2013	Italy	Split-mouth	100
Cetin et al. [25]	2013	Turkey	Split-mouth	108
Delbons et al. [28]	2015	Brazil	RCT	144
Deliperi et al. [27]	2009	Italy	Pilot Clinical Study	35
Deliperi et al. [30]	2012	Italy	RCT	75
ElAziz et al. [31]	2020	Egypt	RCT	76
Frankenberger et al. [32]	2014	Germany	Split-mouth	68
Frankenberger et al. [14]	2020	Germany	Split-mouth	68
Garoushi et al. [38]	2012	Finland	Clinical	37
GianordoliNeto et al. [33]	2008	Brazil	Unspecified	70
Guney et al. [45]	2020	Turkey	RCT	120
Heck et al. [39]	2018	Germany	RCT	96
Kandil et al. [26]	2021	Egypt	RCT	56
Krämer et al. [34]	2011	Germany	Split-mouth	68
Krämer et al. [35]	2015	Germany	Split-mouth	68
Laegreid et al. [40]	2012	Norway	Prospective Clinical Study	74
Manhart et al. [41]	2009	Germany	RCT	96
Manhart et al. [42]	2010	Germany	RCT	96
Perdigão et al. [36]	2009	Brazil, USA	RCT	121
Schirrmeister et al. [37]	2009	Germany	RCT	86
Tanner et al. [43]	2018	Finland	Clinical	36
VanDijken et al. [44]	2014	Sweden	RCT	106
VanDijken et al. [46]	2014	Sweden	RCT	122

Legend : RCT : Randomized Controlled Trial.

3.3.3. Follow-up, success rate and failures

The included studies reported follow-up periods ranging from a minimum of 12 months [26,27,31,33,38] to a maximum of 12 years [14]. Among the 23 selected studies, only 8 reported no restoration failures during the follow-up period [26–30,33,34,38] (Table 3).

Among the eight studies reporting no failures, all used a rubber dam [26–30,33,34], except one [38], in which the placement of the rubber dam was determined by a randomization scheme. However, five studies that systematically used a rubber dam did report failures [14,31,32,35,37]. For instance, in the study by El Aziz in 2020, two patients exhibited signs of irreversible pulpitis [31]. Frankenberger's studies (2014 and 2020) reported one cusp fracture and one marginal fracture [14,32]. In Kramer's 2015 study, a cusp fracture occurred after 6.6 years [35]. In Schirrmeister's 2009 study, 2 teeth required root canal treatment after 9 and 40 months, respectively, in the same patient; both teeth had deep Class II cavities previously restored with amalgam. The patient also exhibited symptoms of bruxism and poor oral hygiene [37].

The remaining 8 studies used a rubber dam selectively [38–42] or employed alternative methods such as cotton rolls and suction [25,45], and reported various types of failures, including secondary caries, sensibility, and fractures. One study did not specify whether the rubber dam was used, and reported 3 minor fractures [43].

3.3.4. Operators and evaluators

The number of operators involved in the studies ranged from 1 to 5. A single operator was reported in 12 studies [14,25–27,31–35,37,44,45], two operators were reported in one study [40], three operators in four studies [29,39,41,42], four operators in one study [43], and five operators in one study [36]. In four studies, the number of operators was not reported [28,30,38,46].

As for the evaluators, the number ranged from 1 to 2. A single evaluator was reported in four studies [37,39,40,45], while two evaluators were reported in 13 studies [14,25–27,29–36,41,42]. In five studies, the number of evaluators was not specified [28,38,43,44,46].

3.3.5. Participants : inclusion or exclusion criteria

As mentioned above, an inclusion criterion common to all the studies selected is that all patients included in these clinical trials must be over 18 years of age. All other inclusion or exclusion criteria are listed in Table 4.

Laegreid (2012) included only teeth without suspected endodontic complications [40]. Van Dijken (2014), in one study, reported that no participants were excluded due to high caries activity, periodontal condition, or parafunctional habits [46]. In another publication from the same year, Van Dijken (2014) emphasized that no exclusion criteria were applied regarding caries activity, periodontal status, or parafunctions, in order to reflect the general patient population [44].

For all the other studies listed in Table 4, the inclusion and exclusion criteria considered the patient's oral hygiene status, thereby ensuring a minimum level of oral health among participants. In contrast, the remaining studies applied variable criteria. Barabanti (2013) excluded individuals with active periodontal or pulpal diseases [29], and Cetin (2013) avoided extremely large restorations [25]. Delbons (2015) excluded non-vital teeth and patients with bruxism, periodontal disease, a history of tooth sensitivity, or fractured/cracked teeth [28]. Deliperi (2009) excluded patients with occlusal parafunction, severe internal discoloration (e.g., tetracycline staining or fluorosis), smoking habits, poor compliance with recall appointments, or a gingival index score greater than 1 [27]. Kandil (2021) excluded participants with failed endodontic treatment, missing opposing teeth, parafunctional habits, advanced periodontal disease, or temporomandibular joint disorders [26]. Perdigão (2009) excluded patients with a history of tooth sensitivity, periodontal disease, bruxism, visible wear facets, or visibly cracked teeth [36].

Table 3
: Follow-up duration, success rate, and restoration failures reported by included studies.

Author	Follow up duration	Success Rate	Restoration failures
Barabanti et al. [29]	5 y	Not specified	No failure
Cetin et al. [25]	5 y	97,5 % (indirect) 98,4 % (direct)	1 tooth required canal treatment and replacement after 2 years 1 tooth required replacement after 3 years due to secondary caries
Delbons et al. [28]	18 m	Not specified	No failure
Deliperi et al. [27]	1 y	Not specified	No failure
Deliperi et al. [30]	2 y	100%	No failure
ElAziz et al. [31]	1 y	Not specified	1 postoperative hypersensitivity
Frankenberger et al. [32]	8 y	98,5%	1 restoration was lost due to bulk fracture 1 restoration suffered drop out due to cusp fracture having been not related to the restoration itself
Frankenberger et al. [14]	12 y	97.1 %	1 cusp fracture 1 marginal fracture
Garoushi et al. [38]	1 y	Not specified	No failure
GianordoliNeto et al. [33]	1 y	Not specified	No failure
Guney et al. [45]	2 y	Not specified	2 teeth required canal treatment Loss of 3 restorations
Heck et al. [39]	10 y	76.9 % (QuiXfil) 86.7 % (Tetric Ceram)	2 restoration fractures, 2 tooth fractures, 5 secondary caries, 1 postoperative sensitivity and 1 marginal integrity issue
Kandil et al. [26]	1 y	Not specified	No failure
Krämer et al. [34]	6 y	100%	No failure
Krämer et al. [35]	10 y	96,9%	1 restoration have marginal fracture 1 restoration failed due to cusp fracture
Laegreid et al. [40]	3 y	Not specified	2 restoration fractures 1 endodontic treatment
Manhart et al. [41]	3 y	QuiXfil (92,5 %) Tetric Ceram (97,8 %)	3 restorations failed because of bulk fracture, partial tooth fracture, or postoperative symptoms 1 restoration was lost due to problems with tooth integrity
Manhart et al. [42]	4 y	Quixfil (89.2 %) Tetric Ceram (97.8 %)	4 restorations failed because of bulk fracture, partial tooth fracture (2x), or postoperative symptoms 1 restoration was lost due to problems with tooth integrity
Perdigão et al. [36]	2 y	Not specified	Not specified
Schirrmeister et al. [37]	4 y	Not specified	2 restorations was removed for root canal treatment in the same patient
Tanner et al. [43]	30.6 m (16.2 to 51.3)	88.9 %	3 fillings had minor fractures
VanDijken et al. [44]	3 y	Not specified	1 cusp fracture and 1 resin composite fracture
VanDijken et al. [46]	10 y	80,7%	Failures are caries, fracture, pain, lost of restoration

Legend : "Not specified" indicates that the study did not report an explicit success rate. "No failure" denotes that no restoration failure was observed during the reported follow-up period, "y" (years), "m" (months).

Table 4
Inclusion and exclusion criteria.

Author	Inclusion criteria
Deliperi et al. [30]	Dental prophylaxis 2 weeks prior to the start of the study
Frankenberger et al. [32]	High level of oral hygiene
Frankenberger et al. [14]	Good level of oral hygiene
GianordoliNeto et al. [33]	Appropriate oral hygiene
Guney et al. [45]	Good general health and oral hygiene
Heck et al. [39]	Patients with a high level of oral hygiene
Krämer et al. [34]	High level of oral hygiene
Krämer et al. [35]	Good level of oral hygiene
Manhart et al. [41]	High level of oral hygiene
Manhart et al. [42]	High level of oral hygiene Exclusion criteria
ElAziz et al. [31]	Poor oral hygiene, heavy smokers
Garoushi et al. [38]	Patients with extremely poor oral hygiene
Guney et al. [45]	Poor oral hygiene
Tanner et al. [43]	Patients with extremely poor oral hygiene

3.3.6. Failure types and knowledge gaps

Commonly reported failure types included secondary caries, fractures, and postoperative sensitivity [14,25,31,32,35,39–44,46]. Although these complications are widely known in clinical practice, our review shows that the way they were recorded and reported varies considerably across studies. For example, while some authors clearly defined their failure criteria, others used vague or inconsistent terminology. Similarly, oral hygiene was an inclusion criterion in some studies [14,30,32–35,39,41,42,45], whereas others did not mention it. This lack of standardization limits the comparability of results and highlights important gaps in current research, particularly in terms of defining clinical endpoints and inclusion criteria.

3.3.7. Materials

Among the 23 studies included in this review, conventional nanohybrid composites were by far the most commonly used materials. In contrast, the short-fiber reinforced composite everX® Posterior (GC Corp., Tokyo, Japan) was specifically evaluated in three clinical studies. These reported generally favorable outcomes: El Aziz [31] observed one case of postoperative hypersensitivity, Kandil [26] reported no failures after one year of follow-up, and Tanner [43] recorded three minor fractures over a follow-up period ranging from 16.2 to 51.3 months.

Furthermore, El Aziz concluded that complex proximal restorations, whether performed with direct SFRCs or via the indirect technique (Grandioso inlay system; VOCO, Cuxhaven, Germany), exhibited acceptable clinical performance after a one-year follow-up [31]. Also, Kandil observed that both types of restorations—fiber-reinforced resin composites and conventional resin composites—maintained clinical acceptability over the same observation period [26]. Tanner also reported favorable short-term results, indicating that posterior restorations incorporating a bulk-fill base of fiber-reinforced composite demonstrated good clinical behavior [43]. Collectively, these findings support the use of SFRCs materials (everX® Posterior, GC, Japan) as a relevant option for reinforcing complex posterior restorations, particularly in high-stress-bearing areas.

More broadly, the studies included in this review primarily evaluated a wide variety of resin composites. Among the most frequently reported materials, the Tetric range (EvoCeram and Ceram, Ivoclar Vivadent, Schaan, Liechtenstein) was used in several studies [14,25,29,32,34,35,39,41,42,45,46]. Filtek composites (Supreme XT, Z350XT, Z250, P60; 3 M ESPE, Saint Paul, Minnesota) were also widely represented [25,28,33,36,38,40]. Grandio (Voco, Cuxhaven, Germany) was employed in the studies by Frankenberger (2020) [14] and Krämer (2011, 2015) [34,35], while Quixfil (Dentsply, Charlotte, USA) was notably used by Manhart (2009, 2010) [41,42] and Heck (2018) [39]. Some studies focused on fiber-reinforced composites, such as everX® Posterior (GC Corp., Tokyo, Japan) combined with G-aenial Posterior (GC Corp., Tokyo, Japan), as

reported in the works of El Aziz (2020) [31], Guney (2020) [45], Kandil (2021) [26], and Tanner (2018) [43]. Other composites, including Vit-l-escence (Ultradent, South Jordan, USA) [27,30], Ceram.X Mono (Dentsply, Charlotte, USA) [37,44,45], Estelite (Tokuyama, Shunan, Japan) [38,43], Clearfil Majesty Posterior (Kuraray, Tokyo, Japan) [38, 43], Synergy (Coltene, Altstäten, Suisse) [38,43], and Aelite Aesthetic (Bisco, Schaumburg, USA) [25], were also reported.

3.3.8. Secondary caries

Out of the 23 included studies, 13 explicitly considered good oral hygiene as either an inclusion criterion [14,30,32–35,39,41,42,45] or an exclusion criterion [31,38,43,45] (Table 4). This is consistent with the existing literature, which has shown that the incidence of dental caries is associated with poor oral hygiene, potentially promoting plaque accumulation on tooth surfaces [47,48]. In four studies [30,33,34,38], no failures were observed, while eight studies reported failures unrelated to secondary caries [14,31,32,35,41–43,45]. Among the three studies reporting failures due to secondary caries—Cetin (2013), Heck (2018), and VanDijken (2014)—only Heck explicitly included patients with good oral hygiene [39]. In contrast, Cetin (2013) and VanDijken (2014) did not specify oral hygiene as an inclusion or exclusion criterion [25,46].

3.3.9. Restoration longevity

Moreover, several trends observed in the included studies suggest that variables such as operator expertise, use of rubber dam, patient oral hygiene, and the type of resin composite may influence restoration longevity.

4. Discussion

This scoping review maps the existing literature on direct resin composite restorations in damaged molars with at least one proximal surface affected by decay. A key limitation identified early in the analysis was the absence of a consistent or clinically explicit definition of what constitutes a ‘damaged molar.’ Most of the included studies involved Class II restorations, often with moderate tissue loss, and did not provide detailed classification of the structural extent of decay. As is common in the literature, most restorations in studies assessing the longevity of composites are of small to moderate extent [5]. Our research focuses on Class II cavities, but a Class II cavity does not necessarily indicate a severely damaged tooth. A tooth decay classification scheme would be necessary to visualize the extent of the tissue loss [4].

In this scoping review, the clinical performance of composite restorations for this type of cavity is very satisfying. In the included studies, reported success rates ranged from 100 % after 2 years [30] to 97,1 % after 12 years [14], reflecting generally favorable long-term outcomes for direct resin composite restorations in Class II molars. However, another study with a 10-year follow-up, reports a less favorable but clinically acceptable success rate of 76.9 % [39].

All studies combined, the most common failures are fractures; additionally, studies report other failures such as recurrent caries, endodontic treatment, loss of restorations, and sensitivity issues. The study by Heck et al. also shows favorable results over 10 years of clinical service : ten restorations failed, mainly for secondary caries and marginal discoloration, followed by tooth fracture, restoration fracture, postoperative sensitivity, and deterioration of marginal integrity [39]. The results are consistent with the classification of failures according to Hickel et al., as secondary caries, tooth fractures, and restoration fractures primarily occur as late failures after more than two years [39,49].

The use of a rubber dam significantly enhances bond strength to enamel, regardless of the adhesive system used. Its application is therefore recommended for all adhesive procedures [50]. This scoping review examines whether the authors used a rubber dam or an alternative system when performing composite restorations. In 13 out of 23 studies, a rubber dam was used. In seven of these studies, no failures were reported [26–30,33,34], including the study by Kramer in 2011 [34], which had a six-year follow-up. In five studies, the rubber dam was used in some cases. Among the studies that did not report the use of a rubber dam, alternative isolation methods such as cotton rolls and saliva ejectors were employed. These studies also reported certain failures, including recurrent caries and postoperative sensitivity [25,45]. However, as no comparative analysis was performed, no causal association can be established between the isolation method and the observed outcomes. Further controlled studies are needed to explore the potential impact of isolation protocols on restoration success.

Several risk factors influence the durability of composite restorations. The longevity of posterior composite restorations depended on more than just the materials used [13]. While variations between composites have a limited impact on their longevity, this assumes the rigorous application of materials and techniques by dentists. The durability of direct resin composite restorations has been assessed in studies conducted both in clinical practice and university settings [5,19,20, 51–53]. University-based studies assess the performance of restorations and materials under controlled conditions, whereas practice-based studies are influenced by multiple factors, including patient and operator variability [20]. Reported mean annual failure rates (AFRs) in practice-based studies range from 1.5 % to 4.9 % over follow-up periods of 4.6 to 22 years [10,11,14]. According to two university-based studies on direct Class II composites, the annual failure rates were 1.1 % over 30 years and 1.6 % over 27 years [52,53]. In another study, the annual failure rate was below 1 % for Class II restorations [35].

In contrast, patient-specific factors play a crucial role in the longevity of restorations. Therefore, clinicians should adopt a comprehensive approach to patient care and promote a healthy lifestyle to optimize restoration longevity [1]. Moreover, more than half of the studies listed in this scoping review included studies with good oral hygiene as an inclusion criterion, a sign that the presence of dental plaque directly linked to a lack of efficiency in patient hygiene techniques can have a detrimental influence on the longevity of composite restorations. In fact, a synergistic relationship has been identified between oral hygiene practices and individual caries risk, particularly in patients with a predisposition to secondary caries and the subsequent need for restoration’s replacement—especially in Class II cavity configurations. The selection criteria play a crucial role in determining the clinical success of restorations [26]. Behavioral factors that fall under the patient’s control, such as inadequate oral hygiene, have been directly associated with an increased incidence of caries and may significantly compromise the longevity of restorations [54]. In this scoping review, 3 studies [39,46, 55] reported cases of secondary caries after more than two years of follow-up. These findings are consistent with the failure classification proposed by Hickel et al., which considers secondary caries primarily as a late failure, typically occurring beyond the two-year mark [49,56,57].

The restoration of extensive and complex cavities frequently presents multiple clinical challenges, including limited accessibility and the need for advanced technical skills to reestablish the anatomical form accurately. Moreover, such restorations are often subjected to increased functional stresses, which may compromise their long-term performance [8,31]. Among recent developments in composite resin technology, the introduction of short-fiber-reinforced resin composites (SFRCs) represents a significant advancement, particularly in the context of complex clinical restorations. The incorporation of short E-glass fibers within the filler system enhances crack resistance by impeding crack propagation, thereby improving fracture toughness and reducing the risk of catastrophic failure. In high-stress-bearing areas, SFRCs—such as everX® Posterior (GC Corp., Tokyo, Japan)—are increasingly utilized as bulk-fill dentine substitutes, offering both mechanical reinforcement and clinical efficiency [31,58]. This scoping review identified three studies evaluating everX® Posterior (GC Corp., Tokyo, Japan). Clinical outcomes were generally favorable, with one study reporting a single case of postoperative hypersensitivity [31], while Kandil (2021) observed no

failures after one year [26], and Tanner (2018) reported three minor fractures over a follow-up of 16.2 to 51.3 months [43]. Although the three studies evaluating everX® Posterior (GC Corp., Tokyo, Japan) reported favorable short-term outcomes, this material was only marginally represented in the included literature. These findings suggest that short-fiber-reinforced composites may be a promising option for reinforcing posterior restorations, but further clinical research is needed to confirm their long-term performance.

Previous systematic reviews and meta-analyses have reported no significant difference in clinical longevity between direct and indirect resin composite restorations in posterior teeth [9,59]. In particular, the review by da Veiga et al. [59] concluded that both approaches offer comparable long-term outcomes, regardless of the tooth type. Given their lower cost, reduced chair time, and greater preservation of tooth structure, direct restorations may therefore be preferable in many clinical situations. However, as the present scoping review focused exclusively on direct restorations, no comparative conclusions can be drawn from the included data.

In the future, considering that most restorations in the studies included in this scoping review involved limited to moderate tooth structure loss [5,35,52,53], it would be necessary to develop clinical studies assessing direct composites in severely damaged teeth to evaluate their clinical performance in more complex cases.

4.1. Limitations

We did not find studies where the damage is truly significant. Most studies refer to class II without specifying the extent of the damage. Most studies focus on molars and premolars without clearly stating the results to differentiate between these two types of teeth. Premolars and molars not only differ significantly in the amount of residual tissue remaining after the removal of decay, but they are also subjected to distinct mechanical stresses. For future research, clinical studies evaluating direct composites on severely damaged molars, with one or more missing cusps, are necessary to assess their effectiveness in these more complicated cases.

Most studies originated from a limited number of countries, predominantly Germany, Brazil, and Italy. This geographic concentration may reflect research infrastructure disparities and could limit the generalizability of the findings. In addition, while the search was performed up to March 2024, most included studies were published between 2013 and 2021, suggesting a need for more recent prospective studies on this topic.

Given the scoping nature of this review, no critical appraisal of study quality was performed. This approach aligns with JBI guidelines, which emphasize breadth of coverage over methodological rigor in mapping existing evidence.

5. Conclusion

Prospective clinical studies on decayed molars with class II cavities show that direct composites are reliable restorations over the long term. Reported success rates remain high over time, ranging from 100 % after 2 years of follow-up [30] to 97,1 % after 12 years [14]. However, further clinical studies on severely decayed molars with one or more missing cusps are needed to evaluate the effectiveness of these materials in direct techniques for even more complex cases.

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Patient consent

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CRediT authorship contribution statement

Marcia Belleflamme: Writing – review & editing, Writing – original draft, Validation, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Sandrina Vandenput:** Writing – review & editing, Validation, Supervision, Methodology, Investigation. **Audrey Guéders:** Writing – review & editing, Validation, Supervision, Methodology, Investigation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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