



GRADUATION PROJECT

Degree in Dentistry

COMPOSITE ONLAYS VS PORCELAIN ONLAYS. INDICATIONS AND CLINICAL EFFICACY

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RESUMEN

Introducción: Las restauraciones indirectas de cobertura parcial, como los onlays, se utilizan ampliamente para restaurar dientes posteriores con pérdida estructural extensa, preservando al mismo tiempo la estructura dental. Los materiales compuestos y cerámicos son los más utilizados, aunque sus indicaciones y su rendimiento clínico siguen siendo objeto de debate; **Objetivo:** Analizar y comparar los onlays de resina compuesta y cerámica en términos de indicaciones y eficacia clínica; **Material y métodos:** Se realizó una revisión sistematizada de la literatura siguiendo principios estructurados de búsqueda y selección. Las búsquedas en MEDLINE Complete y Dentistry & Oral Sciences Source identificaron 231 registros. Tras la eliminación de duplicados y el proceso de cribado, 24 artículos fueron evaluados a texto completo, de los cuales 7 estudios cumplieron los criterios de inclusión. Solo se incluyeron estudios clínicos in vivo publicados en los últimos 10 años. La extracción de datos se centró en las características de los estudios, los materiales, el seguimiento y los resultados clínicos; **Resultados:** Los estudios incluidos presentaron periodos de seguimiento de 1 a 6 años. Las tasas de supervivencia oscilaron entre el 95,8% y el 100%, con solo cinco fallos. La adaptación marginal fue, en general, clínicamente aceptable, aunque se observaron ligeros signos de deterioro y un aumento de la tinción marginal con el tiempo. No se encontraron diferencias significativas consistentes entre los materiales. Los materiales cerámicos mostraron un comportamiento clínico estable, mientras que los materiales basados en resina y los híbridos presentaron una menor incidencia de fractura y patrones de fallo más favorables; **Conclusiones:** Tanto los onlays de resina compuesta como los cerámicos representan opciones fiables con alta tasa de éxito clínico. La selección del material debe basarse en las indicaciones clínicas, las demandas funcionales y la posibilidad de reparación, ya que la evidencia actual no demuestra una superioridad clara de un material sobre otro dentro de los periodos de seguimiento disponibles.

PALABRAS CLAVE

Odontología, onlays, resinas compuestas, cerámica dental, CAD/CAM

ABSTRACT

Introduction: Indirect partial coverage restorations, such as onlays, are widely used to restore posterior teeth with extensive structural loss while preserving tooth structure. Composite and ceramic materials are commonly used, although their indications and clinical performance remain debated; **Objective:** To analyse and compare composite and ceramic onlays in terms of indications and clinical efficacy; **Material and Methods:** A systematised literature review was conducted following structured search and screening principles. Searches in MEDLINE Complete and Dentistry & Oral Sciences Source identified 231 records. After duplicate removal and screening, 24 articles underwent full-text assessment, and 7 studies met the inclusion criteria. Only in vivo clinical studies published within the last 10 years were included. Data extraction focused on study characteristics, materials, follow-up, and clinical outcomes; **Results:** The included studies reported follow-up periods from 1 to 6 years. Survival rates ranged from 95.8% to 100%, with only five failures. Marginal adaptation was generally clinically acceptable, although minor deterioration and increased marginal discoloration were observed over time. No consistent significant differences between materials were reported. Ceramic materials showed stable clinical performance, while resin-based and hybrid materials demonstrated a lower incidence of fracture and more favourable failure patterns; **Conclusions:** Both composite and ceramic onlays are reliable options with high clinical success. Material selection should be based on clinical indications, functional demands, and reparability, as current evidence does not demonstrate clear superiority of one material over the other within the available follow-up periods.

KEYWORDS

Dentistry, onlay, composite resin, ceramic onlay, CAD/CAM

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1. INTRODUCTION

1.1. General concepts: Restorative Dentistry and Indirect Restorations.

1.1.1. Definition and purpose of indirect restorations.

Early loss of hard dental tissue can result from multiple aetiological factors such as caries, erosion, abrasion and fracture. However, several studies identify dental caries as the most prevalent cause, with some reports estimating its contribution to approximately 90% of cases (1). Delaying intervention in the early stages of hard dental tissue loss can lead to sensitivity, pain, pulpal involvement, periodontal complications, and secondary caries, ultimately necessitating restorative treatment (2,3). Partial restorations represent a minimally invasive alternative to conventional crowns, aligning with the increasing demand for tissue-preserving approaches. In contrast, full-coverage crowns typically require greater removal of healthy dental hard tissues during preparation (3). As alternatives to direct restorations with resin composites are indirect restorations, which are restorations done by a combination of intraoral and extraoral work. The tooth surface is prepared and before an impression or intra-oral scan is taken in order to replicate it extra-orally. The restoration is then made in the laboratory on the model, using different techniques such as metal casting or as tooth-coloured restorations using porcelain or composite resins. Depending on the material used, the restoration will be test-fitted on the tooth before cementation, with a provisional restoration usually being placed in the prepared site while the definite is being constructed (4).

1.1.2. Advantages and limitations compared to direct restorations.

Direct restorations are done with a technique with less steps than indirect restorations. Because of the multiple steps with clinical information transfer from mouth to laboratory and back to the mouth, this requires great care when indirect techniques are chosen in order to ensure maximum accuracy in every step to avoid errors (4). Secondary caries tends to be less frequent in indirect restorations, which theoretically should ensure longer lifespan. Polymerization shrinkage and improper polymerization are usually credited as the cause of secondary caries in direct techniques (5,6). Indirect techniques with resin composite should theoretically avoid these problems as the fit could be checked before cementation and as well be milled with CAD/CAM resin composite blocks. These materials are subjected to slower and more thorough polymerization by the dental technicians, and increases the monomer conversions, improving the mechanical properties (7,8). However, there is an elevated

cost for the patient when selecting the indirect technique, as well as a necessary waiting time between the first and second dental visit. Greater tissue removal during tooth preparation for indirect compared to direct technique is also considered a major disadvantage for indirect technique (9).

1.2. Onlays in Modern Restorative Dentistry.

1.2.1. Definition of onlays.

The tenth edition of The Glossary of Prosthodontic Terms (GPT-10) defines an onlay as “a partial-coverage restoration that restores one or more cusps and adjoining occlusal surfaces or the entire occlusal surface and is retained by mechanical or adhesive means” (10).

Examples of onlay restorations are illustrated in Figure 1 and Figure 1. This differs from inlays, which are intracoronal restorations without cusp coverage (Figure 1). Overlays represent a more extensive form of onlay restoration that involves complete cusp coverage and are typically bonded adhesively (Figure 1 and Figure 1).

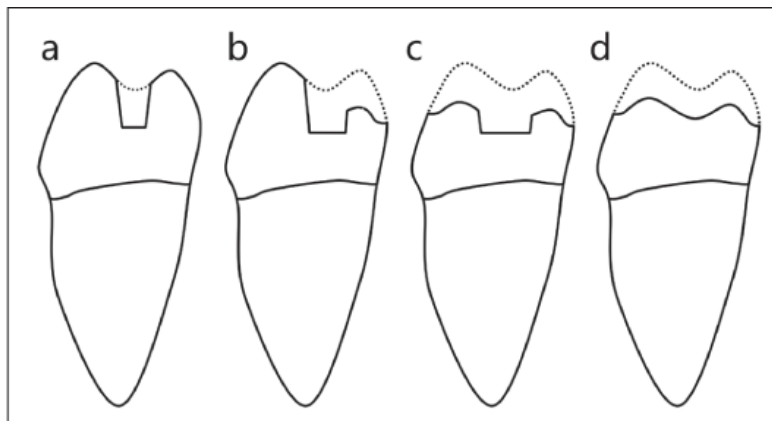


Figure 1. Inlay (A), onlay (B, C), overlay (C, D) (11).

1.2.2. Indications and contraindications.

Onlays are indicated in large class II cavities of molars and premolars with the need of partial cusp coverage where the lateral walls have some remaining enamel but with weakened or reduced thickness of the underlying dentine. Onlays are recommended when the isthmus width exceeds half the intercuspal distance between the lingual and buccal cusps, and/or when one or more cusps are structurally weakened (12). The dentine beneath the enamel must be structurally intact. Internal dentine cracks or craze lines, often seen in teeth with amalgam restoration or trauma, are indicated for overlays and are contraindicated for onlays. Endodontically treated teeth require at

least two axial walls which are well-supported and in continuation with one marginal ridge (13,14).

1.3. Materials Used for Onlays.

1.3.1. Overview of ceramic materials.

Ceramics has been a part of dentistry for more than 100 years, originally using the feldspathic form which naturally forms for anterior teeth for aesthetic crowns, denture teeth and partial coverage. Since the mid-1960s when John McLean introduced aluminous porcelain, ongoing advancements in aesthetics, strength, and fabrication techniques have led to the development of a wide range of ceramic materials. (15). Ceramics used in dentistry may be classified into three major groups based on their composition: glass-matrix ceramics, polycrystalline ceramics, and resin-matrix ceramics (Figure 2.). Glass-matrix ceramics are inorganic non-metallic ceramics which contains a glass phase and includes ceramics like feldspathic and synthetic ceramics like lithium disilicate. Polycrystalline ceramics are inorganic, non-metallic materials that lack a glass phase and include examples such as stabilised zirconia (16,17). Dental ceramics most used for onlays are lithium disilicate, which has main properties such as high flexural strength, wear resistance and excellent aesthetics. The ceramics have limitations like brittleness and risk of fracture under tension (18). CAD/CAM processing allows for precise, standardised fabrication and has been associated with increased adaptation of the margin and mechanical compared with earlier techniques (19).

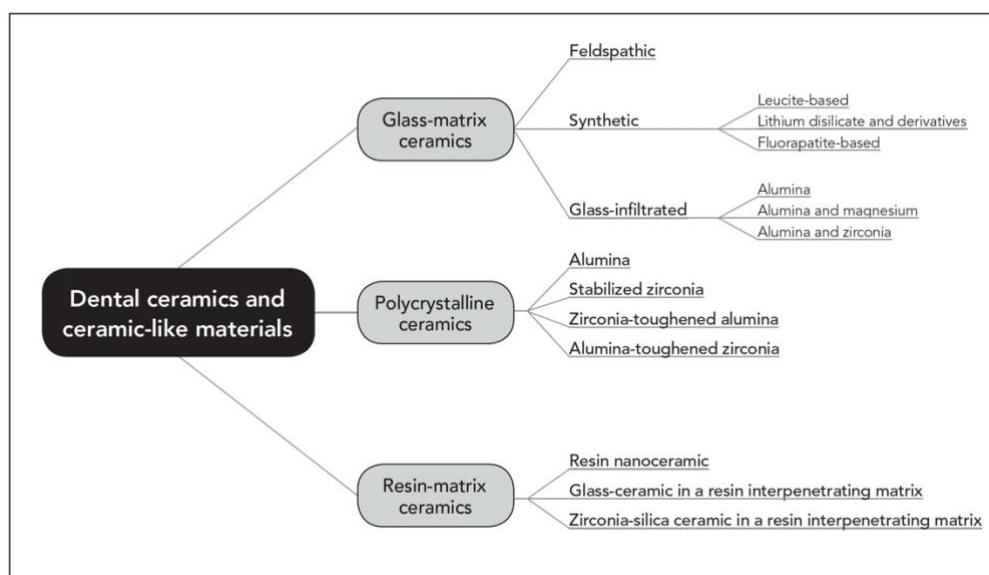


Figure 2. Classification system of all-ceramic and ceramic-like materials according to Gracis et al. (16).

1.3.2. Overview of composite resin materials.

Composite resin materials are typically composed of a mix of different types of matrixes (organic polymer) and fillers (combination of inorganic particles). The most famous type of matrix used in dentistry today is the Bis-GMA which was introduced to dentistry by Bowen in 1962. We may divide composite resin materials into direct resin composites and indirect. In the 1980s the first generation of indirect composite materials was introduced but they demonstrated poor performance in clinical studies. These materials contained over 50% resin matrix and exhibited greater wear compared to direct composites available at that time (20). In the early 1990s, a second generation was developed, consisting of microhybrid composites with roughly 66% filler content by volume, resulting in enhanced mechanical properties such as flexural strength and elastic modulus. Indirect composites are significantly stronger than direct composites, and the polymerization shrinkage is nearly eliminated (21). Composite resin materials used for indirect techniques may be made using blocks of composite resin with prefabricated computer aided designed and manufacturing (CAD/CAM), or a technician may craft the restoration using restorative resin composite (7,8). Composite resin materials for indirect restorations are cheaper than porcelain (22) and may be advantageous in patients with bruxism because of the lower rate of fractures (23). Milling time is reduced, as well as no post milling furnace is necessary (24), which means that they are highly efficient compared ceramic onlays. The major downside is that they rely more on technique and operator and technician skill, which increases the risk of microleakage (23,25).

1.3.3. Clinical considerations in selecting composite vs ceramic onlays.

When selecting the material for an onlay restoration, the amount and quality of the remaining tooth structure must strongly influence the choice. The more natural tooth structure that remains, less stress in the remaining dentine will be transmitted by the restoration, regardless of material selected. If the tooth has weakened dentine walls or there is minimal remaining enamel, composite is safer as it causes reduced stress on the tooth compared to ceramics. This is due to composite having an elastic modulus closer to dentine. However, in cases where there is sufficient enamel, ceramic restorations may perform better for predictable adhesive bonding and to replicate the stiffness of the remaining enamel (26). Occlusal factors are equally relevant. In cases where there is high occlusal load, ceramic is the more suitable option as it withstands the heavy load better with an increased fracture resistance (1,27). In cases with low-

to-moderate occlusal load, or with a delicate antagonist, composite restoration is more suitable as it is more elastic, causing less antagonist wear (27). However, one should also consider the type of tissue of the antagonist, for instance if the antagonist is mostly enamel, composite is the less abrasive alternative. If the lithium-disilicate ceramic restoration is well-polished, it may be less aggressive to the enamel (28). If the antagonist tooth already has a ceramic restoration, one should select ceramic with similar hardness and a good polish. For patients with bruxism, ceramic restorations have a risk of sudden fracture due to their brittle nature and the high forces if the patient does not wear a nightguard. Whereas composite restorations still fail in bruxist patients, the wear is more gradual, and the restoration is easier to adjust in addition to possessing the advantage of being chairside repairable. Ceramics show high compressive strengths and excellent aesthetics, which is why this material is preferred when colour stability, strength and aesthetics are the main priorities. Composites show lower hardness and strength, but more elastic. It is a material which is cheaper, easier to adjust, repair and bond, but has an inferior colour stability. Choosing composite is preferred when flexibility, conservativity, cost and repairability are more important (1). Both materials show comparable survival rates when the a correct case selection is done, the choice of material is ultimately depending on balancing biomechanical variables with clinical circumstances and individual patient needs (1,11,29).

1.4. Adhesion and Bonding Protocols.

1.4.1. Adhesive protocols for composite onlays.

Indirect partial-coverage crowns rely heavily on adhesive bonding because their retention and longevity are dependent on having a strong bond joining the tooth and the restoration. In contrast to full-coverage crowns that gain micromechanical retention from axial walls, partial-coverage crowns like onlays depend mainly on chemical and micro-mechanical adhesion for stability (30). As CAD/CAM composites are manufactured under high-temperature and high-pressure conditions that create a cross-linked, densely polymerised resin matrix with limited unreacted monomers become available for chemical bonding (25). Their high filler content and modified polymer-filler interface further reduce surface reactivity, meaning that adhesion cannot rely on co-polymerisation as in direct composites (31,32). As a result, successful bonding requires micromechanical surface conditioning, most commonly air-particle abrasion, to increase surface roughness and improve wettability (33,34). Since the indirect composite contains silica-based fillers, silanisation can provide an additional

chemical coupling effect, while in other systems a universal adhesive containing functional monomers may be used to enhance interaction with the conditioned surface (34–36). On the tooth substrate, a selective enamel etch is typically recommended to optimise enamel bonding, whereas dentine may benefit from mild self-etch or universal adhesives and immediate dentine sealing (IDS) to improve bond strength and reduce postoperative sensitivity (36,37). Overall, the adhesive success of composite onlays is determined by combining appropriate surface activation of the restoration, adhesive optimisation of the tooth, and the use of a compatible resin cement system, forming a durable bonded interface capable of supporting functional loads (34,35).

1.4.2. Adhesive protocols for porcelain onlays.

Adhesive bonding to porcelain onlays is fundamentally determined by the ceramic's microstructure, as glass-based ceramics such as feldspathic porcelain and lithium disilicate exhibit a silica-rich, etchable glass matrix that allows for strong chemical and micromechanical adhesion (38,39). Effective bonding begins with hydrofluoric acid etching, which selectively dissolves the glassy phase and creates a micro-retentive surface pattern that enhances resin infiltration (39,40). This is followed by applying a silane coupling agent, which facilitates chemical bonding between the silica in the ceramic and the methacrylate groups of the resin cement (38,41). On the tooth side, bonding to enamel and dentine follows the same principles as for other indirect restorations, typically involving selective enamel etching and the application of a compatible adhesive system to optimise the hybrid layer. The final bond strength for porcelain onlays is therefore highly dependent on appropriate ceramic surface conditioning, the use of chemical coupling agents, and the selection of a resin cement capable of forming a stable interface under occlusal loading (38,40).

1.4.3. Influence of surface treatments and luting cements.

The quality of adhesion in indirect restorations is strongly influenced by the interaction between surface conditioning methods and the selected luting cement. Surface treatments modify the substrate to enhance mechanical retention, chemical bonding, or both. Airborne-particle abrasion increases surface roughness and improves wettability across many material types, while hydrofluoric acid etching creates a microporous surface in silica-based ceramics (40,42,43). Chemical treatments such as silane coupling agents promote covalent bonding to glass-containing substrates (44).

These substrate modifications determine how effectively resin-based cements can infiltrate and polymerise within the conditioned surface. Resin cements themselves vary in their adhesive capabilities: adhesive and universal resin cements rely on a separate bonding agent, while self-adhesive resin cements attempt to simplify the process but may offer reduced bond performance to certain materials (45). The choice of luting cement therefore must align with both the material characteristics of the restoration and the surface treatment applied. Ultimately, the durability of indirect restorations depends on achieving compatibility between surface conditioning, adhesive chemistry, and the resin cement's polymerisation behaviour, ensuring a stable and mechanically resilient bonded interface under functional loading.

1.5. Justification of the Study

1.5.1. Current trends and scientific gap

In recent years, adhesive onlay restorations have become an important part of conservative posterior rehabilitation. Both composite and porcelain onlays are widely studied, with favourable results reported for fracture resistance, marginal adaptation, wear behaviour, and survival. At the same time, advances in materials and adhesive systems have improved their clinical performance.

Despite the large amount of available research, the evidence is often fragmented. Many studies focus on a single material, specific variables, or short-term outcomes, making it difficult to obtain a clear overview. In addition, important outcomes such as failure types, survival rates, and long-term performance are not always clearly compared. Therefore, an updated synthesis of the literature is necessary to enhance the understanding of the clinical performance and indications of composite and porcelain onlays.

1.5.2. Justification of my comparative approach

A comparison between composite and porcelain onlays is justified because both are commonly used for similar clinical situations. Although both provide a minimally invasive approach, they differ in mechanical properties, wear behaviour, cost, treatment time, and reparability.

For clinicians, the key challenge is to understand when one material is more suitable than the other. Factors such as occlusal load, parafunctional habits, remaining tooth structure, aesthetics, and cost may influence this decision.

This comparative approach follows the PICO framework of the study and focuses on differences in clinical performance, longevity, and complications. By presenting the evidence in a clear and comparative way, this study aims to support more informed clinical decision-making.

2. OBJECTIVE

2.1. General Objective

To compare composite and porcelain onlays with regard to their clinical performance and indications based on available scientific literature.

2.2. Specific Objectives

- To analyse the types of failures associated with composite and porcelain onlay restorations.
- To assess the clinical longevity and survival of composite and porcelain onlays reported in the literature.

3. MATERIAL AND METHODS

3.1. Type of Study

This study was conducted as a systematised literature review aimed at analysing and comparing the clinical performance and indications of composite and ceramic onlay restorations based on current scientific literature. The methodology followed principles similar to those used in systematic reviews, including a structured search strategy, predefined inclusion and exclusion criteria, and a systematic screening process.

The literature search was carried out using selected electronic databases, and only primary studies providing clinical data were considered for inclusion. The selection process involved the identification of records, removal of duplicate articles, screening of titles and abstracts, and full-text assessment of potentially relevant studies. The study did not involve clinical experimentation or patient data, relying exclusively on published scientific literature.

3.2. Research question (PICO Framework)

The research question was structured according to the PICO framework as follows:

- Population (P): Posterior teeth requiring indirect restorative treatment
- Intervention (I): Composite onlays
- Comparison (C): Porcelain/ceramic onlays (including lithium disilicate restorations)
- Outcome (O): Clinical performance, longevity, survival rate, and reported complications

Based on this framework, the following research question was formulated:

In posterior teeth requiring indirect restorations, how do composite onlays compare with porcelain onlays in terms of clinical performance and longevity?

3.3. Eligibility criteria

Eligibility criteria were defined according to the elements of the research question structured using the PICO framework. These criteria were applied during both the title and abstract screening and the full-text assessment in order to ensure that only relevant studies were included in the review.

Inclusion criteria

Studies were included if they met the following criteria:

- Clinical studies evaluating composite or ceramic onlay restorations
- Studies reporting clinical outcomes, such as survival rate, longevity, complications, or restoration performance
- In vivo studies, including randomized controlled trials, prospective studies, and retrospective clinical studies.
- Articles published in peer-reviewed scientific journals.
- Studies published within the last 10 years
- Articles written in English

Exclusion criteria

Studies were excluded if they met any of the following criteria:

- Studies evaluating restorations other than onlays or where onlay results could not be identified separately.
- Studies that did not evaluate composite or ceramic restorative materials.
- In vitro studies, laboratory studies, or studies without clinical outcomes.
- Case reports, case series, or technical reports without analytical clinical data.
- Non-scientific texts such as blogs, opinion pieces, or non-peer-reviewed content.
- Articles not accessible in full text
- Articles published in languages other than English.

3.4. Sources of information

The literature search was conducted using the electronic databases MEDLINE Complete and Dentistry & Oral Sciences Source, accessed through the online library of the Universidad Europea de Madrid. The chosen databases were selected due to the wide availability of publications in dentistry and oral health sciences that are peer-reviewed.

The search was limited to peer-reviewed scientific articles in order to ensure the inclusion of primary research studies with reliable clinical data. A publication date filter was then applied to include studies published within the last ten years. The database searches were performed using predefined keywords and Boolean operators related to the research question.

3.5. Search strategy

The search strategy was developed based on the key elements of the research question defined using the PICO framework. Keywords related to the type of restoration, restorative materials, and indirect restorations were identified and combined using Boolean operators.

The following search equation was used in both databases:

(onlay OR "partial coverage restoration") AND (composite OR "resin composite") AND (ceramic OR porcelain OR "lithium disilicate")

The Boolean operator OR was used to combine synonyms within the same concept, while the operator AND was used to combine the different concepts of the research question.

The search was conducted in MEDLINE Complete and Dentistry & Oral Sciences Source. Filters were applied to limit the results to peer-reviewed articles published within the last 10 years. No restrictions regarding study design were applied during the initial search in order to obtain a comprehensive set of results.

The search identified 132 records from MEDLINE Complete and 99 records from Dentistry & Oral Sciences Source, resulting in a total of 231 records. These records were exported and then screened according to the predefined eligibility criteria.

3.6. Study selection process

The study selection process was conducted out in multiple stages in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Figure 3) (46). The purpose of this process was to systematically identify, screen, and simplify the selection of the studies that met the predefined eligibility criteria.

First, all records identified through the database search were exported and compiled into a single dataset. A total of 231 records were identified through the database searches. Duplicate articles appearing in both databases were identified and removed before the screening process. After removing 40 duplicate records, 191 articles remained for evaluation.

In the second stage, the titles and abstracts of the remaining records were screened to determine their relevance to the research question. During this stage, 167 articles were excluded because they did not meet the inclusion criteria. The majority of these excluded records corresponded to in vitro or laboratory studies that did not evaluate clinical outcomes. A study design filter was not applied during the database search because the classification of study types in the databases used was not always consistently reported. Therefore, the studies were screened by title and abstract to identify and exclude laboratory studies while avoiding the exclusion of potentially relevant clinical studies.

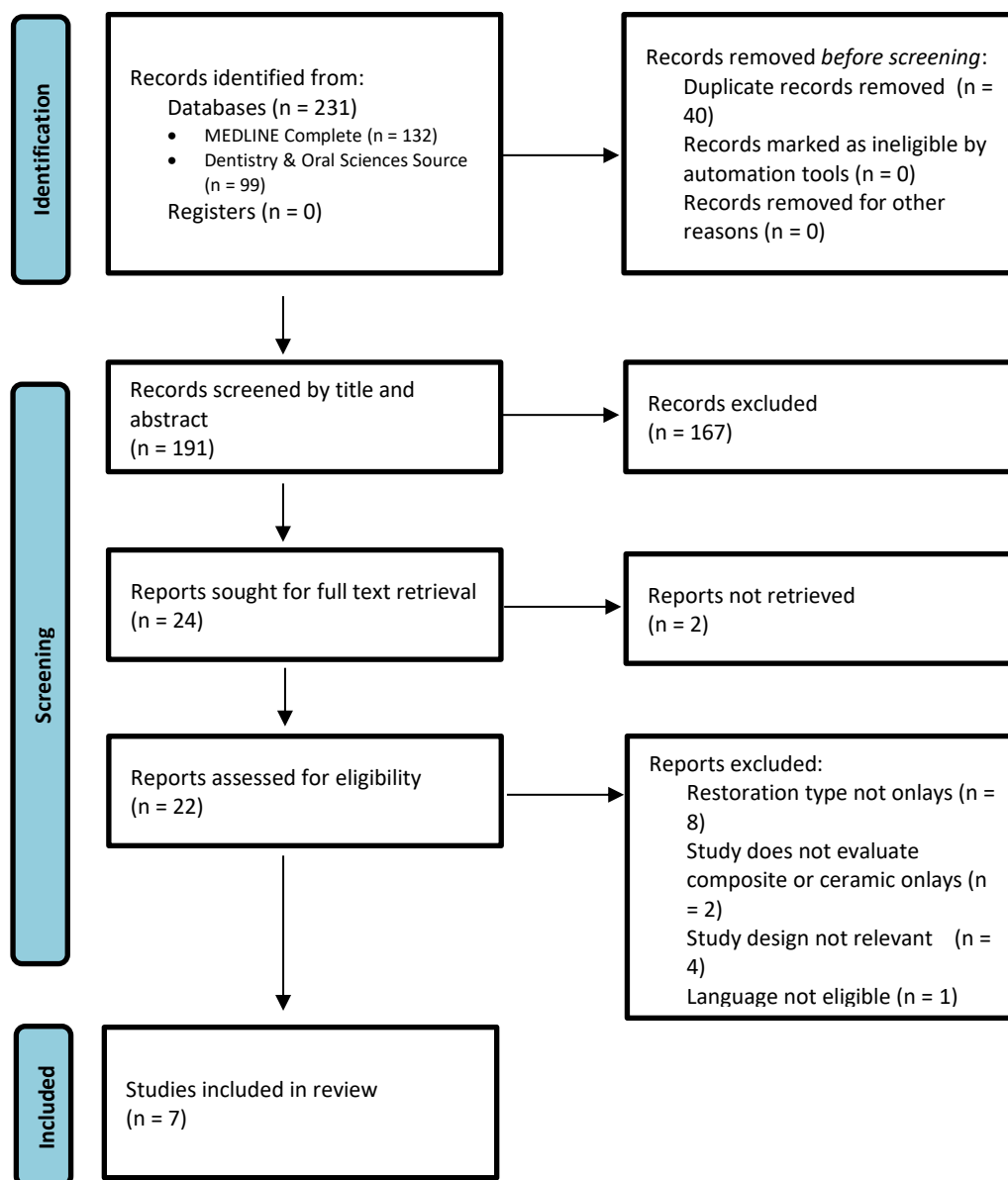


Figure 3. Flow diagram of the study selection process according to the PRISMA guidelines

Of the 24 articles selected for full-text assessment, full texts were sought for all. However, three articles could not be retrieved directly from the databases. The corresponding authors were contacted, and one provided the full text for free with a licence to use for thesis, resulting in 22 studies being included in the eligibility assessment.

During the full-text evaluation, the predefined inclusion and exclusion criteria were applied in detail. During the screening stage, 17 studies were excluded for specific reasons, including studies that did not evaluate onlay restorations, studies that did not assess composite or ceramic materials, studies with unsuitable study designs, articles not available in an eligible language, or articles whose full text was not accessible.

After the final screening, 7 studies met all eligibility criteria and were included in the present review.

3.7. Data extraction

Data were extracted from all studies that met the inclusion criteria in order to allow a structured comparison of the selected articles. The information from each study was recorded in a data extraction table created specifically for this review.

The extracted data comprised the author and year of publication, country of origin, study design, sample size, type of restorative material evaluated, and follow-up period. Additionally, data on clinical performance were collected, including survival rates, reported complications, and failure outcomes when available.

The clinical performance of the restorations in the included studies was evaluated using standardised clinical assessment systems. Most studies employed the modified United States Public Health Service (USPHS) criteria (47), while some studies used the Fédération Dentaire Internationale (FDI) evaluation criteria (48). These systems assess several parameters of restoration performance, including marginal adaptation, marginal discoloration, surface texture, fracture, and secondary caries.

The purpose of this data extraction process was to collect comparable information from each study in order to analyse the clinical performance and longevity of composite and ceramic onlay restorations. The extracted data were then organised to allow comparison between the two restorative materials and to address the objectives of the review.

3.8. Methodological quality assessment

The methodological quality of the included studies was assessed according to the study design. Randomised clinical trials (RCT) were evaluated using the Cochrane Risk of Bias tool (RoB 2) described in the Cochrane Handbook for Systematic Reviews of Interventions (49). Observational studies were assessed using the Newcastle-Ottawa Scale (NOS), which evaluates studies according to selection of participants, comparability of groups and assessment of outcomes (50). The quality assessment was performed by the author in order to evaluate the potential risk of bias and methodological reliability of the included studies.

4. RESULTS

4.1. Study characteristics

A total of seven studies met the predefined eligibility criteria and were included in the present review. The main characteristics of the included studies are summarised in Table 1. Among the included studies, five were RCTs (51–55), one was a prospective cohort study (56), and one was a retrospective cohort study (57).

The number of patients included in the studies ranged from 20 to 86, while the number of evaluated restorations varied between 24 and 120. The follow-up periods reported in the studies ranged from 1 year to a maximum of 6 years, with several investigations reporting follow-up periods between 2 and 5 years.

Most studies evaluated onlay restorations, although one study included both onlays and overlays (56). The restorative materials assessed comprised different ceramic materials, mainly lithium disilicate ceramics such as IPS e.max CAD and IPS e.max Press, as well as resin-based materials, including indirect composite resins, hybrid ceramics, and resin nanoceramic CAD/CAM materials (e.g., Lava Ultimate and SHOFU Block HC).

The clinical performance of the restorations was primarily assessed using the modified USPHS criteria, which were applied in most of the included studies. Two studies assessed restoration performance using the FDI evaluation criteria (54,56). The detailed characteristics of all included studies are presented in Table 1.

4.2. Methodological quality / Risk of bias

The risk of bias of the included RCTs was assessed using the revised Cochrane Risk of Bias tool (RoB 2) (58). This tool evaluates potential bias across five domains: bias arising from the randomisation process, bias due to deviations from intended interventions, bias due to missing outcome data, bias in measurement of the outcome, and bias in selection of the reported results (58). Five studies included in this review were RCTs and were therefore assessed using the RoB 2 tool. The results of the domain-level risk of bias assessment for each study are presented in Table 2.

Table 1. Characteristics of the included studies

Author	Year	Country	Study	Material(s) evaluated	Patients (n)	Restorations (n)	Restoration type	Follow-up period	Evaluation criteria
Archibald (57)	2018	Canada	RC	IPS e.max Press / IPS e.max CAD	52	65 (37 clinically evaluated)	Onlays	Mean 3.5 years (up to 6 years)	Modified USPHS
Ashraf (51)	2025	Egypt	RCT	SHOFU Block HC	24	24	Onlays	1,5 years	Modified USPHS
Elmoselhy (52)	2024	Egypt	RCT	IPS e.max CAD vs indirect composite	50	50	Onlays	2 years	Modified USPHS
Fasbinder (53)	2020	USA	RCT	Lava Ultimate CAD/CAM vs IPS Empress CAD	86	120	Onlays	5 years	Modified USPHS
Souza (54)	2021	Spain	RCT	IPS e.max CAD vs Lava Ultimate	20	40	Onlays	1 year	FDI
Yurdagüven (56)	2024	Türkiye	PC	IPS e.max CAD	60	83	Onlays and overlays	5 years	FDI
Zhao (55)	2025	China	RCT	Direct composite resin vs Lava Ultimate	79	80	Onlays	2 years	Modified USPHS

RCT = Randomised controlled trial; PC = Prospective cohort study; RC = Retrospective cohort study

Table 2. Assessment of risk of bias in included RCTs by domains (RoB 2).

	D1	D2	D3	D4	D5	Overall
Ashraf 2025 (51)						
Elmoselhy 2024 (52)						
Fasbinder 2020 (53)						
Souza 2021 (54)						
Zhao 2025 (55)						

Domains:

D1: Bias arising from the randomisation process

D2: Bias due to deviations from intended intervention.

D3: Bias due to missing outcome data.

D4: Bias in measurement of the outcome.

D5: Bias in selection of the reported result.

Judgement

 Some concerns

 Low

Overall, the RCTs showed a generally low risk of bias across most domains. Four studies were judged to have a low risk of bias in the randomisation process, while one study presented some concerns due to insufficient information regarding allocation concealment. All studies showed a low risk of bias related to deviations from intended interventions and missing outcome data. The measurement of outcomes was considered to have a low risk of bias in most studies, although two studies presented some concerns due to limited information regarding blinding of outcome assessors.

Some concerns were identified in the domain related to the selection of the reported results, as none of the included RCTs reported a publicly available study protocol or pre-registered statistical analysis plan. A summary of the proportion of studies presenting low risk of bias or some concerns across the different domains is shown in Figure 4.

Overall, the risk of bias across the included RCTs was judged to present some concerns, primarily due to limited information regarding allocation concealment in one study and the absence of pre-registered study protocols.

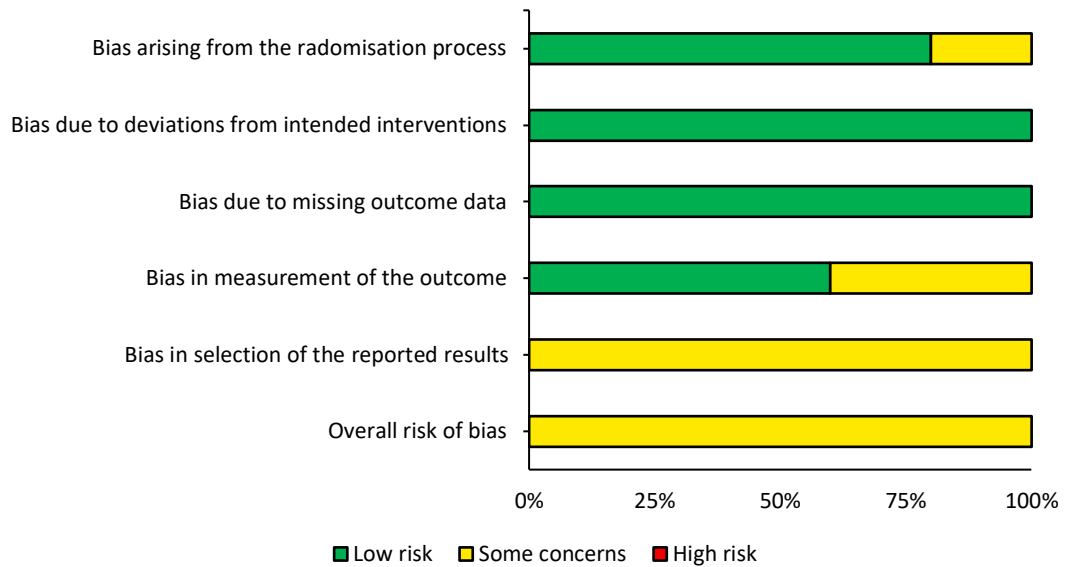


Figure 4. Risk of bias summary showing the proportion of studies with low risk of bias and some concerns for each domain of the RoB 2 assessment.

The methodological quality of the cohort studies was evaluated using the Newcastle-Ottawa Scale (NOS), which assesses risk of bias based on three main domains: selection of study groups, comparability between groups, and outcome assessment.

The included cohort studies achieved scores ranging from 5 to 6 out of a possible 9 points, indicating moderate methodological quality. Both studies received stars for representativeness of the exposed cohort, ascertainment of exposure, and outcome assessment. However, none of the studies included a non-exposed comparison cohort or adjusted for potential confounders, resulting in lower scores in the comparability domain. The detailed NOS assessment of the cohort studies is presented in **Error!**

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Table 3. Risk of bias assessment of cohort studies using the Newcastle-Ottawa Scale.

Study	Selection (max 4)	Comparability (max 2)	Outcome (max 3)	Total	Quality
Archibald 2018 (57)	★★★	—	★★	5/9	Moderate
Yurdagüven 2024 (56)	★★★	—	★★★	6/9	Moderate

The NOS assesses three domains: selection (up to four stars), comparability (up to two stars), and outcome (up to three stars), for a total of nine stars. Higher scores indicate lower risk of bias. In this review, scores of 7-9 indicated low risk, 5-6 moderate risk, and ≤4 high risk of bias (50).

4.3. Mechanical properties

The included clinical studies did not directly evaluate mechanical properties such as flexural strength, fracture toughness, or elastic modulus, as these parameters are

typically assessed through laboratory testing. Instead, the clinical investigations focused on evaluating the performance of the restorations under functional conditions using clinical evaluation criteria such as the modified USPHS criteria and the FDI criteria.

The restorative materials investigated across the included studies comprised several categories of indirect restorative materials, including lithium disilicate ceramics (IPS e.max CAD and IPS e.max Press), resin nanoceramic CAD/CAM materials such as Lava Ultimate, hybrid ceramic materials such as SHOFU Block HC, and indirect composite resin restorations. The clinical performance of these materials was assessed during follow-up periods ranging from 1 to 6 years.

4.4. Marginal adaptation

Marginal adaptation was one of the most frequently evaluated clinical parameters among the included studies. Overall, the available evidence indicated that ceramic, composite, and hybrid resin-based onlay restorations demonstrated clinically acceptable marginal integrity during the respective follow-up periods.

The assessment of marginal adaptation was primarily performed using the modified USPHS criteria, while two studies applied the FDI evaluation criteria. These clinical scoring systems assess the integrity of the restoration margins and identify potential defects such as marginal gaps, marginal discoloration, or deterioration over time.

In the majority of the included studies, marginal adaptation was evaluated using the modified USPHS criteria. Across these studies, most restorations received Alpha scores, indicating optimal marginal integrity at the time of evaluation (51–53,55). However, several investigations reported that a proportion of restorations shifted to Bravo scores during follow-up, reflecting minor marginal irregularities while still remaining clinically acceptable.

In a two-year randomized clinical trial comparing nano-composite and lithium disilicate onlays, the majority of restorations maintained Alpha scores for marginal integrity, although minor marginal defects were observed in a small proportion of lithium disilicate restorations. No statistically significant differences between the evaluated materials were reported (52). Similarly, in another RCT, a gradual reduction in Alpha scores and a corresponding increase in Bravo scores for marginal adaptation were observed during follow-up. However, these changes remained within clinically

acceptable limits and no statistically significant differences between the restorative materials were detected (55).

Longer-term observational studies also reported minor marginal deterioration over time. In a retrospective clinical evaluation of ceramic onlays, Bravo scores were observed in the majority of restorations, indicating minor marginal discrepancies, while a small proportion of restorations presented Charlie or Delta ratings corresponding to clinically unacceptable margins (57). Despite these findings, most restorations maintained clinically acceptable marginal integrity during the observation period.

Similarly, a prospective clinical study reported a slight increase in marginal discoloration over time, particularly between 1- and 5-year follow-up periods, reflecting gradual marginal changes associated with clinical aging rather than restoration failure (56).

Two studies evaluated marginal adaptation using the FDI evaluation criteria. In both investigations, all restorations were classified as clinically acceptable throughout the follow-up period. Although a slight reduction in the proportion of restorations receiving the highest scores was observed over time, particularly at longer follow-ups, no restorations were classified as clinically unacceptable, indicating stable marginal integrity for both ceramic and resin-based restorations (54,56).

A summary of the marginal adaptation outcomes reported in the included studies is presented in Table 4.

However, it should be noted that not all studies directly compared composite and ceramic materials. Several investigations evaluated hybrid CAD/CAM materials, such as resin nanoceramics, which may exhibit mechanical and clinical behaviour distinct from both conventional composites and ceramics.

Table 4. Summary of marginal adaptation outcomes reported in the included studies

Study	Material	Evaluation system	Follow-up	Outcome
Archibald 2018 (57)	IPS e.max CAD / Press	USPHS	Up to 6 years	Clinically acceptable
Ashraf 2025 (51)	SHOFU Block HC	USPHS	1 year	Clinically acceptable
Elmoselhy 2024 (52)	IPS e.max CAD vs composite	USPHS	2 years	Clinically acceptable
Fasbinder 2020 (53)	Lava Ultimate vs Empress CAD	USPHS	5 years	Clinically acceptable
Souza 2021 (54)	IPS e.max CAD vs Lava Ultimate	FDI	1 year	Clinically acceptable
Yurdagüven 2024 (56)	IPS e.max CAD	FDI	5 years	Clinically acceptable
Zhao 2025 (55)	Composite vs Lava Ultimate	USPHS	2 years	Clinically acceptable

Clinically acceptable outcomes correspond to Alpha or Bravo ratings in the USPHS system and scores indicating acceptable clinical performance (scores 1–3) in the FDI criteria.

4.6. Clinical longevity

Clinical longevity of onlay restorations was evaluated in several of the included studies through reported survival rates, restoration failures, and the need for replacement during the observation period. The follow-up periods among the included studies ranged from 1 to 6 years, allowing assessment of short- to medium-term clinical performance. Overall, the studies reported high survival rates for both ceramic and resin-based onlay restorations, with only a limited number of failures observed during follow-up. A summary of the reported survival outcomes across the included studies is presented in Table 5.

Among the studies with shorter follow-up periods, no restoration failures were reported. RCTs with follow-up periods of one to two years demonstrated survival rates of 100%, including studies evaluating hybrid ceramic blocks, lithium disilicate restorations, and resin-based materials (51,52,54,55).

Studies with longer observation periods also reported high survival rates. A five-year RCT evaluating chairside CAD/CAM restorations reported five failures among 120 restorations, corresponding to a survival rate of 95.8% (53). In contrast, a prospective clinical study evaluating ceramic onlays over a five-year period reported no restoration failures among the 26 evaluated restorations (56).

Table 5. Summary of reported survival and failure rates of onlay restorations in the included studies.

Study	Material	Follow-up	Restorations (n)	Failures (n)	Survival rate (%)
Archibald 2018 (57)	IPS e.max CAD / Press	Up to 6 years	65	0	100
Ashraf 2025 (51)	SHOFU Block HC	1 year	24	0	100
Elmoselhy 2024 (52)	IPS e.max CAD vs composite	2 years	50	0	100
Fasbinder 2020 (53)	Lava Ultimate vs Empress CAD	5 years	120	5	95.8
Souza 2021 (54)	IPS e.max CAD vs Lava Ultimate	1 year	40	0	100
Yurdagüven 2024 (56)	IPS e.max CAD	5 years	26	0	100
Zhao 2025 (55)	Composite vs Lava Ultimate	2 years	80	0	100

Additionally, a retrospective cohort study with a follow-up period of up to six years reported that the majority of ceramic onlays remained clinically acceptable, although minor marginal discrepancies and a limited number of clinically unacceptable ratings were observed (57).

Across the included studies, survival rates ranged from 95.8% to 100% over follow-up periods of 1 to 6 years, with only five restoration failures reported among all evaluated restorations.

4.7. Wear behaviour

Wear behaviour of onlay restorations was not directly evaluated in the included clinical studies. None of the studies reported quantitative measurements of occlusal wear or volumetric material loss during the observation periods.

In most investigations, surface-related characteristics were assessed indirectly through clinical evaluation parameters such as anatomical form, occlusal contour, or surface roughness within the USPHS or FDI criteria. Across these studies, restorations generally maintained favourable scores for these parameters throughout the follow-up periods, indicating stable surface characteristics (51–57).

In one study, isolated cases of surface chipping were reported, however, these events did not require clinical intervention and the restorations remained in function (53).

4.8. Failure modes

Failure modes of the evaluated onlay restorations were reported in a limited number of the included studies. Across most investigations, no restoration failures requiring replacement were observed during the reported follow-up periods (51,52,54–57).

The only study reporting restoration failures was a five-year RCT evaluating chairside CAD/CAM onlay restorations (53). In this study, restoration fracture was the primary failure mode observed. A total of five restorations fractured during the follow-up period and required replacement. Four fractures occurred in leucite-reinforced ceramic restorations, while one fracture was reported in a resin nanoceramic restoration.

Additional clinical events not requiring replacement of the restorations were also described in the same study. These included isolated cases of surface chipping and fracture of adjacent tooth structure affecting restored teeth. In addition, two teeth restored with resin nanoceramic onlays required endodontic treatment during the follow-up period. In these situations, the onlay restorations remained functional and continued to be evaluated during clinical recall (53).

5. DISCUSSION

5.1. Interpretation of Findings

The results of this review show that onlay restorations generally perform very well in clinical practice. The survival rates reported in the included studies were high, usually between about 95% and 100%, with follow-up periods ranging from one to six years. In most studies, no restoration failures were reported, although one study observed a small number of failures related to restoration fracture (53).

When comparing different materials, the studies did not show clear differences between ceramic and resin-based onlays. It should be noted that only a limited number of studies directly compared these materials, and several investigations instead evaluated or compared hybrid CAD/CAM materials in addition to ceramics. In studies that compared these materials directly, both types of restorations showed similar outcomes within the limitations of the available evidence. For example, in the study by Fasbinder et al., ceramic and resin nanoceramic restorations performed similarly, even though slightly more fractures were observed in the ceramic group. Therefore, the comparison between ceramic and composite onlays in this review is based mostly on indirect evidence from studies evaluating different material categories.

Marginal adaptation also remained stable in most cases. Both ceramic and resin-based restorations generally remained within the clinically acceptable categories according to the USPHS or FDI evaluation criteria throughout the follow-up periods. This suggests that both material types are capable of maintaining good marginal integrity over time.

When failures occurred, they were most often related to restoration fracture rather than marginal deterioration or secondary caries. Overall, these findings indicate comparable clinical performance between ceramic and resin-based onlay restorations within the reported follow-up periods, directly addressing the objective of comparing their survival and failure patterns.

5.2. Advantages and Limitations of Composite Onlays

Resin-based onlay materials, including indirect composites and hybrid CAD/CAM materials, may offer several advantages in clinical practice. Their lower elastic modulus, which is closer to that of dentine, allows for greater absorption of occlusal stresses and results in higher damage tolerance compared with ceramic materials (54).

This biomechanical behaviour is associated with a reduced tendency for brittle fracture and more favourable, less catastrophic failure patterns. In addition, clinical evidence supports this tendency, as Fasbinder et al. reported a lower incidence of fractures in resin nanoceramic onlays compared with ceramic restorations over a five-year period (53).

Another possible advantage of resin-based materials is their greater elasticity. Compared with ceramics, resin-based materials can absorb occlusal forces more effectively, which may help reduce the risk of fracture. In addition, resin-based restorations can often be repaired intraorally if minor damage occurs, which can be an advantage for clinical management.

However, some limitations should also be considered. One important limitation is the relatively small number of clinical studies specifically evaluating indirect composite onlays. In the studies included in this review, only one investigation evaluated indirect composite restorations directly.

Another issue is that many materials described as “composite-like” are not traditional indirect composite resins but rather hybrid materials such as resin nanoceramics or hybrid ceramics. This variability in materials complicates direct comparisons between studies and limits the ability to draw clear conclusions specifically regarding traditional indirect composite onlays.

These findings suggest that resin-based onlays represent a viable alternative to ceramic restorations in terms of clinical performance, although the available evidence remains limited.

5.3. Advantages and Limitations of Porcelain Onlays

Ceramic onlays showed very good clinical performance in the studies included in this review. Several studies reported medium follow-up periods, in some cases up to five to six years, with high survival rates and favourable clinical results.

Lithium disilicate restorations, in particular, showed stable marginal adaptation during the follow-up periods. Ceramic materials are also known for their good aesthetic properties, including colour stability and an appearance that closely resembles natural tooth structure.

Despite these advantages, ceramic restorations may also have some limitations. When failures occurred in the included studies, they were most often related to restoration fracture. This may be explained by the more brittle nature of ceramic materials compared with resin-based materials.

In addition, ceramic onlays require careful preparation design and adhesive cementation. The success of these restorations therefore depends greatly on proper clinical technique.

Ceramic onlays remain a well-documented and reliable treatment option, particularly when medium-term clinical evidence is considered. The strong clinical performance of ceramic onlays in this review is supported by both medium-term observational studies and shorter-term clinical trials.

5.4. Clinical Decision-Making and Material Selection

The choice of restorative material for onlay restorations depends on several clinical factors, including the amount of remaining tooth structure, occlusal load, aesthetic demands, and the size of the cavity preparation.

Based on the studies included in this review, the available evidence does not clearly favour either ceramic or resin-based onlays. Both materials appear to provide favourable clinical outcomes when used under appropriate conditions.

From a clinical perspective, material selection may be influenced by their different mechanical properties. Ceramic materials provide high strength and stiffness, whereas resin-based materials are more elastic and may allow for better stress distribution in compromised teeth.

Occlusal factors, such as load, articulation, and the condition of the antagonist dentition, are also important in material selection. However, these variables were not systematically reported in the included studies, which limits the ability to directly relate clinical outcomes to specific occlusal conditions.

An important observation from this review is that most studies focus primarily on restoration performance rather than clearly defining clinical indications for each material. As a result, the available literature provides limited guidance on when one material should be preferred over another.

5.5. Limitations of Current Research and Future Perspectives

Several limitations of the available evidence should be considered when interpreting the findings of this review.

First, although a relatively high proportion of the included studies were RCTs, the overall number of available clinical studies remains limited. This restricts the strength of the evidence and reduces the ability to draw definitive conclusions.

Second, the follow-up periods varied considerably among the included studies. The available evidence is limited to short- and medium-term follow-up periods, with a lack of long-term data beyond six years. The current evidence may not be sufficient to fully assess long-term clinical performance. This is important because some complications, such as fracture, wear, or marginal deterioration, may occur over a longer period of time. In addition, possible differences between ceramic and resin-based onlays may become more noticeable with longer follow-up.

Another important limitation is the limited number of studies specifically evaluating indirect composite onlays. Many of the included studies instead assessed hybrid materials such as resin nanoceramics or hybrid ceramics. These materials differ from traditional indirect composite resins in their composition and mechanical behaviour, which may influence their clinical performance. As a result, the available evidence on conventional indirect composite onlays remains limited.

In addition, a considerable degree of heterogeneity was observed in the restorative materials evaluated across the included studies, including lithium disilicate ceramics, leucite-reinforced ceramics, hybrid ceramics, resin nanoceramics, and indirect composite resins. This variability makes direct comparison between studies more difficult and may limit the generalisability of the findings. This heterogeneity reflects the evolving nature of restorative materials, where newer hybrid materials blur the traditional distinction between composite and ceramic restorations. Additionally, the study by Zhao et al. included a specific patient group with molar-incisor hypomineralisation (MIH), which may influence adhesion, fracture resistance, and overall restoration performance (55).

Differences in adhesive and cementation protocols between materials may also influence clinical outcomes. Ceramic, hybrid, and resin-based restorations require different surface treatments and bonding strategies, which may affect retention and

fracture behaviour. Therefore, variations in luting procedures represent an additional factor that may limit direct comparison of failure rates between materials.

Another limitation relates to the definition of onlay restorations. Although the present review adopted the definition provided by the Glossary of Prosthodontic Terms, variations in terminology exist in the literature. Some studies did not clearly distinguish between onlays and more extensive restorations such as overlays, which may introduce additional heterogeneity.

Furthermore, although one of the objectives of this review was to analyse clinical indications, the included studies rarely reported explicit indication criteria. Most investigations focused primarily on restoration performance rather than providing detailed guidance regarding material selection. This limits the ability to draw strong conclusions regarding indications for composite and ceramic onlays.

Wear behaviour was also rarely evaluated directly. None of the included studies reported quantitative measurements of occlusal wear or material loss, and wear-related outcomes were generally assessed only indirectly through clinical evaluation criteria.

Finally, several studies included relatively small patient samples, which may limit the reliability of the findings.

Future research should focus on well-designed clinical studies with larger sample sizes, longer follow-up periods, and clearer classification of restorative materials. In addition, further studies specifically investigating indirect composite onlays and clearly defined clinical indications would be valuable to improve evidence-based decision-making in restorative dentistry.

6. CONCLUSIONS

The present review aimed to compare composite and porcelain onlays with regard to their clinical performance and indications based on the available scientific literature.

Based on the findings of this study, the following conclusions can be drawn:

1. In relation to the general objective, both composite and ceramic onlay restorations demonstrate comparable clinical performance, with high survival rates and favourable outcomes reported in the included studies. However, the available literature provides limited evidence regarding specific clinical indications, as most studies focus primarily on restoration performance rather than material selection criteria.
2. Regarding the types of failures, the most commonly reported failure mode for both composite and ceramic onlays was restoration fracture, while failures related to marginal degradation or secondary caries were rarely observed.
3. In terms of clinical longevity, both composite and ceramic onlays showed high survival rates, generally ranging between approximately 95% and 100%, with follow-up periods of up to six years, indicating favourable short- to medium-term performance.

Despite these findings, the available evidence remains limited due to heterogeneity in materials, variations in study design, and a lack of studies specifically evaluating indirect composite onlays. Further well-designed clinical studies with longer follow-up periods and clearer indication criteria are required.

7. SUSTAINABILITY

The selection of restorative materials for onlay restorations has important environmental, economic, and social implications. From an environmental perspective, restorations with high longevity reduce the need for replacement, thereby lowering material consumption, energy use, and clinical waste. This supports Sustainable Development Goal (SDG) 12: Responsible Consumption and Production (59).

From an economic and social perspective, both ceramic and composite onlays contribute to sustainable oral healthcare by preserving tooth structure and improving long-term patient outcomes. Composite restorations may offer advantages due to lower initial costs and easier repairability, reducing the overall treatment burden. Ceramic materials, although often more expensive, may provide greater long-term stability in certain cases, which can also reduce the need for retreatment. These aspects align with SDG 3: Good Health and Well-being, promoting accessible and effective dental care.

To improve sustainability, clinicians should prioritise appropriate material selection, minimally invasive approaches, and long-lasting restorations, while future research should focus on improving material efficiency, standardising clinical protocols, and enhancing long-term performance.

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