

Clinical Performance of Onlay Restorations: A Systematic Review of Contemporary Materials and Cementation Techniques

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Abstract

Introduction: Onlay restorations have been generally accepted as a conservative, adhesive alternative to full-coverage crowns. Advances in ceramic, hybrid ceramic, and composite materials, as well as adhesive systems, have contributed to their increased use. This systematic review compiles the current evidence on the clinical performance, survival rates, failure mechanisms, and impact of cementation methods on the success of onlay restorations.

Methods: A literature review was performed to select clinical trials, retrospective studies, and in vitro studies on onlay restorations. The key variables were material type, cementation method, length of follow-up, and clinical success.

Results: A total of 18 studies were included, which involved lithium disilicate, hybrid ceramics, indirect composites, resin nanoceramics, and short fiber-reinforced composites (SFRC). The overall survival rates varied from 84% to 100% in short to medium-term follow-ups. Adhesive resin cements with selective enamel etching always yielded better results than self-adhesive cements. The risk of bias assessment using the JBI tools revealed inconsistent methodological quality among the 18 studies included. Some recent randomized clinical trials have shown low risk of bias and offered the best evidence available in the short term, while moderate risk of bias was prevalent in studies with inadequate reporting of allocation sequence, small sample size, or absence of blinding. The long-term evidence, which was mostly obtained from retrospective cohorts and trials with high attrition rates, was considered to be at high risk of bias. In general, the early clinical performance has been confirmed by low-risk studies, whereas the long-term results should be viewed with caution due to higher inherent bias.

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Introduction

Indirect onlay restorations are commonly used to restore structurally compromised posterior teeth. Modern materials such as lithium disilicate glass ceramics, zirconia-based ceramics, hybrid ceramics, and indirect resin composites, in combination with adhesive luting approaches, have improved survival and complication rates over traditional materials and approaches. High long-term survival rates of indirect partial coverage restorations have been reported in narrative and systematic reviews, with overall survival rates of onlays often in excess of 90%. [1]

However, many existing reviews either combine inlays, onlays, overlays, and full crowns into a single category, or include traditional materials and luting agents that are no longer representative of

current clinical practice, or fail to focus on the relationship between material type and cementation method.[2]

Recent clinical trials and studies (2020 onwards) have investigated lithium disilicate and zirconia-reinforced glass ceramic onlays, hybrid ceramics, and indirect composites using contemporary adhesive approaches, FDI guidelines, and long-term follow-up (3-10+ years).[3] There is a need for an updated synthesis to estimate the survival and complication rates of modern onlay materials, to compare the effectiveness of different cementation approaches (such as adhesive resin cements, self-adhesive or conventional cements), and to determine clinical and material-related predictors of failure.

Methodology

Eligibility Criteria (PICOS)

Population

- **Inclusion:** Human patients of any age receiving indirect onlay/overlay/partial coverage restorations in posterior teeth (premolars and molars), vital or endodontically treated.
- **Exclusion:**
 - Studies including only inlays, full crowns, veneers, or direct restorations without separate data for onlays/overlays.
 - Animal or in vitro studies.

Intervention

Onlay/overlay/partial coverage restorations fabricated using contemporary materials, including but not limited to:

- Lithium disilicate glass-ceramics (e.g., IPS e.max)
- Zirconia-reinforced or zirconia-based ceramics
- Hybrid ceramics / polymer-infiltrated ceramics
- Indirect resin composites / CAD-CAM composite blocks

Cementation strategies of interest include:

- Adhesive resin cements (total-etch, self-etch, universal adhesive protocols; immediate dentin sealing where reported)
- Self-adhesive resin cements
- Conventional cements (e.g., glass ionomer, resin-modified glass ionomer), if used with these materials

Comparators

- Other onlay materials (e.g., lithium disilicate vs indirect composite)
- Other cementation protocols (e.g., adhesive vs self-adhesive cement)
- Other partial coverage restorations, if a separate onlay subgroup is identifiable
- Single-arm studies (no comparator) will be included for descriptive and pooled survival analyses.

Outcomes

Primary outcomes

1. Restoration survival rate at certain time points (e.g., 1, 3, 5, ≥ 10 years), defined as restorations not lost or requiring replacement.
2. Restoration success rate, defined as restorations without complications requiring repair, reintervention, or replacement according to the criteria used by authors (e.g., FDI, USPHS).

Secondary outcomes

- Types and frequency of technical complications: fracture/chipping, debonding, marginal defects, wear, loss of anatomy, etc.

- Types and frequency of biological complications: secondary caries, pulpitis, sensitivity, tooth fracture, periodontal problems.

- Changes in clinical scoring systems (e.g., FDI criteria, USPHS/Ryge, UERJ criteria).

- Patient-reported outcomes (satisfaction, esthetics, function) where available.

Study Design

Inclusion

- Randomized controlled trials (parallel or split-mouth)
- Non-randomized controlled clinical trials
- Prospective and retrospective cohort studies
- Case series with ≥ 10 patients or ≥ 20 onlays and a minimum 1-year mean follow-up

Exclusion

- Case reports or series below the above thresholds
- Cross-sectional studies without follow-up
- In vitro, mechanical, or finite element studies
- Narrative reviews, systematic reviews, editorials, letters (these will be used only for hand-searching references)

Information Sources

The electronic database searched was MEDLINE (via PubMed) and Manual search of reference lists of included studies and relevant reviews, including key prosthodontic and restorative dentistry journals (e.g., Journal of Prosthetic Dentistry, Journal of Esthetic and Restorative Dentistry, Clinical Oral Investigations, Operative Dentistry). The search period was from Jan 2020 to Dec 2025.

Search strategy: PubMed search (8-12-2025)

((onlay OR onlays OR overlay OR overlays OR 'partial crown' OR 'adhesive crown' OR cusp coverage OR cusp covered OR cusp covering) AND (survival OR longevity OR success OR failure OR clinical performance OR follow up) AND (Dental OR Dentist OR Teeth OR Dentistry)))) NOT (Denture[Title] OR Implan*[Title] OR overdentur*[Title] OR Dentures[Title])

Results:

The review included 18 studies which had their data extracted according to author information and publication year and study design and sample size and restoration type and cement type and follow-up period and study results. (Table 1)

The study assessed bias risk by applying the Joanna Briggs Institute (JBI) critical appraisal checklist which corresponds to each specific study design. The 18 studies included in this review showed varying study quality which ranged from low bias risk to high bias risk with randomized studies showing less bias and prospective studies showing more bias and retrospective studies showing the most bias.

The set of recent randomized controlled trials 13,15,18,22 demonstrated a low risk of bias because their randomization procedures received detailed documentation and their ethics committees granted approval and their outcome measurement followed USPHS/FDI criteria and they maintained proper patient follow-up and managed patient attrition correctly. The studies provided the most reliable short-term clinical information about how ceramic, hybrid ceramic, and nanocomposite onlay restorations perform.

The randomized trials 5,8,11,20 and the feldspathic vs. lithium disilicate split-mouth trial showed moderate risk of bias according to their assessment results. The trials established sound methodology yet they missed critical details about allocation concealment and examiner blinding and they had small sample sizes which prevented accurate statistical assessment. The researchers maintained consistent outcome assessment while most participants remained in the study until its conclusion.

The 15-year RCT13 and the retrospective cohort study6,12,21 resulted in four studies being classified as high risk of bias. The studies showed high bias risk because their long-term studies experienced major participant dropouts and their non-randomized cohorts failed to control confounding factors and their researchers selectively tracked only the participants who returned for follow-up. Researchers lack confidence in the long-term survival rates which originate from these studies because of these factors.

A single in-vitro experimental study10 demonstrated low internal risk of bias because it followed standardized preparation and testing procedures; however the study results require cautious interpretation because the research results must be considered with clinical trial results.

The 18 studies showed that their main risk of bias issue occurred due to researchers failing to report randomization and blinding procedures and certain trials having small sample sizes and participants dropping out during extended follow-up and non-randomized studies containing confounding factors. The analysis should evaluate these two factors for their potential impact on partial-coverage ceramic and composite restoration clinical performance and restoration longevity.

Figure 1. PRISMA 2020 flow diagram of study selection.

Discussion

The systematic synthesis evaluated onlay restorations through three performance metrics which include clinical performance assessment and survival rate determination and failure rate assessment. The evidence demonstrates that adhesively luted, minimally invasive indirect

restorations maintain their status as effective solutions although their success depends on material properties and luting techniques and design elements.

Comparison of Survival and Clinical Performance Across Material Types

Lithium disilicate emerged as the most effective material in the studies which demonstrated survival rates exceeding 90 percent during medium to long-term research. The material demonstrated long-term predictability through retrospective studies which showed no significant changes over 15 years of follow-up. The existing literature demonstrates that the high flexural strength and reliable etchability and favorable adhesive bonding properties of the material serve as its primary factors for achieving long-term durability. The results for indirect resin composites presented two separate categories. The direct composite and ceramic materials showed equal performance results for both marginal integrity and USPHS values according to multiple short-term prospective studies. However, retrospective studies found that composite materials experienced reduced survival rates after 8 years, while their rates of chipping and surface damage increased. The existing literature has established that resin-based indirect materials exhibit hydrolytic instability together with increased wear rates and poor fatigue resistance. Hybrid ceramics and resin nanoceramics produced results which fell between two extremes. The materials demonstrated short-term clinical success with patient satisfaction, but their surface roughness and marginal discoloration and minor fractures occurred at slightly higher rates than lithium disilicate. The results depend on how cementation techniques and occlusal loading will affect their outcomes. SFRC-based restorations demonstrated superior performance through their early results which showed high potential. Direct SFRC onlays showed superior marginal sealing ability compared to indirect nanohybrid onlays. Endocrown configurations achieved 4-year survival rates which matched glass-ceramic restorations but offered superior reparability. SFRC has become an increasingly preferred conservative method for treating structurally compromised teeth which require stress distribution and shock absorption properties.

Influence of Cementation Protocols on Restoration Longevity

Cementation protocol was found to be one of the most influential factors in determining the long-term success. Several studies showed that self-adhesive resin cements were inferior to adhesive resin cements using selective enamel etching or full adhesive techniques. For instance, self-adhesive cementation was found to have significantly lower survival rates and marginal integrity in partial ceramic crowns, while adhesive techniques,

particularly those involving selective enamel etching, were found to have superior clinical performance and lower marginal degradation. The efficacy of enamel etching was further confirmed in a 15-year split-mouth randomized study, in which restorations placed without selective enamel etching were found to have drastically lower survival (42.9%) than those etched before cementation (78.1%). Recent studies have also introduced new cementation techniques, including the use of injectable composite resin as a luting agent. Early results indicate lower marginal discoloration and improved clinical performance compared with dual-cure resin cements, although long-term data are still scarce.

Effect of Restoration Design and Material Thickness

Design of preparation was another aspect that played an important role in influencing the outcome of restoration. Various studies comparing inlays and onlays revealed that onlays were superior, especially in endodontically compromised or weakened teeth. The findings revealed that onlays had fewer fractures, better marginal seal, and higher survival rates than inlays, thus proving the biomechanical superiority of cusp coverage. The importance of material thickness was highlighted in studies assessing the partial crowns made of zirconia-reinforced lithium silicate. Thin restorations (<0.75 mm) had significantly lower survival rates and higher fracture rates, while restorations with optimal thickness had almost perfect survival rates at 5 years. These findings are consistent with fracture mechanics, which state that material thickness is an important parameter in the catastrophic failure of ceramic restorations. Onlays also had better periodontal outcomes than full crowns in split-arch studies, thus proving the superiority of tissue-sparing and supragingival margin placement.

Failure Patterns and Identified Risk Factors

Failure modes were characterized by common patterns reported in the prosthodontic literature. Ceramic fractures and chipping were the most prevalent complications in ceramic onlays, especially in leucite-reinforced ceramics with longer follow-up periods. Composite restorations showed higher surface wear, marginal discoloration, and minor chipping. Biological complications, such as secondary caries, were rare but increased in restorations with suboptimal marginal fit or self-adhesive cementation. Debonding incidents were mainly found in self-adhesive techniques, thus further emphasizing the role of optimal adhesive bonding. Identified risk factors included bruxism, which was linked to higher fracture and failure rates, smoking, which significantly reduced long-term survival in resin-based restorations, suboptimal enamel for bonding, material thickness, high occlusal forces or

parafunctional habits, and poor oral hygiene and plaque accumulation. These results emphasize the need for individualized risk analysis in material selection and prosthodontic design. The overall quality of the included studies affects the confidence level of clinical recommendations that can be made from the current review. The best evidence from a number of well-designed, low-risk randomized clinical trials supports the short-term clinical success of modern ceramic, hybrid ceramic, and nanocomposite onlay restorations. These trials uniformly used rigorous randomization techniques, standardized USPHS/FDI criteria for outcome measures, carefully calibrated examiners, and high rates of follow-up, thus reducing the risk of selection and detection biases in the early stages of evaluation. In contrast, a higher proportion of studies providing mid- and long-term data tended to have moderate to high risk of bias. Issues such as incomplete documentation of allocation concealment, difficulties in blinding operators or evaluators, small sample size, and differential patient recall were some of the challenges faced in prospective studies. Retrospective cohort studies were more prone to confounding by patient, tooth, and operator-related variables, and survival probabilities derived from such studies may tend to over- or under-estimate actual clinical longevity. Moreover, long-term randomized trials with substantial attrition, such as 15-year trials, should be interpreted with caution, as the survivors may not be representative of the original sample.

These are the methodological issues that act as limiting factors in the level of confidence that can be placed on the long-term comparative results of materials. Although lithium disilicate and advanced resin-based CAD/CAM materials have shown positive results in early outcomes, the current evidence base on long-term survival differences is still affected by bias in observational and attrition-rich studies. Future multicenter randomized trials with better reporting and longer follow-up are needed to confirm long-term survival differences more clearly.

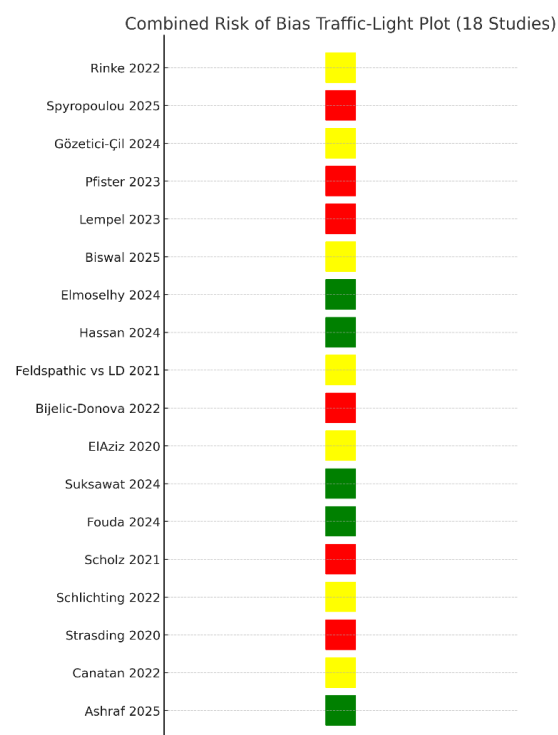


Figure 2- The traffic-light plot demonstrated variability in the methodological quality of the included studies. Five studies were judged to have a low overall risk of bias, seven had some concerns, and six were judged to have a high risk of bias.

Strengths and Limitations of the Current Evidence Base

One of the strengths of the current evidence base is the inclusion of a number of clinical trials with moderate to long-term follow-up, including a number of randomized controlled trials and one 15-year study.

However, the following limitations still exist:

1. Heterogeneity of materials and study protocols: There is a large degree of variability in the design of preparations, cementation methods, criteria for assessment, and length of follow-up.
2. Lack of long-term data for newer materials: Hybrid ceramics, nanoceramics, and SFRC materials are still under-represented in long-term studies, and it is difficult to make concrete conclusions about their longevity.
3. Small number of trials and restorations: A few prospective trials had fewer than 30 restorations, which are less powerful statistically.
4. Lack of standardized criteria for outcomes: Although USPHS and FDI criteria are commonly used, a few

trials used modified criteria of these systems, making it difficult to compare the results.

5. Prevalence of single-center trials: The results may not be completely generalizable.

Clinical Implications
On the basis of the synthesis, the following conclusions can be drawn for clinical practice:

- Lithium disilicate remains the material of choice for long-term onlay restorations.
- Selective enamel etching and adhesive resin cementation are mandatory for optimal longevity.
- Onlays are biomechanically superior to inlays, particularly for weakened or endodontically treated teeth.
- Thickness cannot be compromised, particularly in ceramic-based systems.
- Hybrid ceramics and indirect composites are indicated for conservative restorations, although the practitioner must be aware of the potential for enhanced surface wear and discoloration over time.
- SFRC direct onlays are promising alternatives, particularly when repairability, cost-effectiveness, or conservative restorations are of prime importance.
- Patient-specific factors such as parafunctional habits, smoking, and oral hygiene practices must affect material choice.

Conclusion

The evidence synthesis demonstrates that adhesive bonded onlays function as an effective and permanent dental restoration method. Lithium disilicate remains superior in the long term experience although newer resin-based and hybrid materials deliver satisfactory results during the short and medium-term periods. The clinical outcomes depend on three factors which include the cementation technique and onlay design and the patient's specific risk characteristics. The evidence base needs to be strengthened through high-quality long-term randomized controlled trials which must include new materials as their primary testing focus. The current ceramic hybrid ceramic and nanocomposite onlay restorations produce successful short-term clinical results according to the existing evidence limits which show low failure rates and acceptable performance under USPHS/FDI standards. The highest level of certainty of evidence is found in recent low-risk RCTs which show that bonded partial coverage restorations deliver reliable performance during their initial years of use. The researchers need to be cautious when interpreting the data which shows long-term survival rates. The long-term follow-up data mainly comes from retrospective cohorts and clinical trials which The organization experienced

two different situations which together caused their employee turnover rate to rise. The studies present methodological limitations which create doubt about their results that demonstrate long-term material advantages and successful adhesive techniques. The existing evidence fails to establish any clear differences between lithium disilicate materials and advanced resin-based CAD/CAM materials for their extended performance period. The study results demonstrate that multicenter randomized trials require proper design and sufficient participants to achieve beneficial research outcomes which should include extended research tracking and precise methodological documentation. The trials will create evidence which shows which materials dentists should choose for their partial-coverage restoration bonding procedures. Dentists need to apply their best short-term evidence while considering each patient's unique attributes which include their occlusion pattern and tooth vitality status and their onlay restoration habits.

Future Directions

The evidence base for partial-coverage restorations requires improvement through long-term research studies which athletic researchers should conduct in multicenter randomized controlled trials with extended follow-up. The trials require proper randomization and allocation concealment and blind evaluation of endpoints while participant movement details need to be reported with complete transparency to protect against attrition bias. The standardization of outcome definitions through FDI or harmonized USPHS standards will enable researchers to conduct inter-study comparisons. The studies should investigate how occlusal design and bruxism and tooth vitality and adhesive system differences interact with other variables through controlled designs or stratification methods. Clinical trials which investigate new CAD/CAM materials and surface treatments and new adhesive systems will enable researchers to determine which materials demonstrate long-term benefits when comparing different material types. The study should examine how digital dentistry workflow parameters affect the survival outcomes of dental implants.

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TABLE 1. Summary of Included Studies

S No	Author & Year	Design	Sample Size	Restorations Compared	Follow-up	Key Outcomes
1	EIAziz et al., 2020	Randomized clinical trial	76 restorations	SFRC direct vs indirect nanohybrid onlay	12 months	SFRC showed superior marginal integrity; both groups showed 100% functional survival.
2	Strasding et al., 2020	Retrospective long-term follow-up study	36 patients, 132 restorations (107 inlays, 25 onlays)	IPS Empress leucite-reinforced glass-ceramic inlays/onlays luted with different composite resin cements	Mean 11.2 ± 4.3 years	11-year survival = 80.3%. Most common complications: ceramic fractures (10.6%) and chipping (2.3%). Biologic complications rare. Overall

3	Schohlz et al., 2021	Prospective randomized split-mouth clinical trial	50 patients, 150 PCC restorations (final evaluation in 31 patients)	PCCs luted with: Self-adhesive resin cement (RelyX Unicem 2) vs Conventional resin cement + universal adhesive (with/without selective enamel etching)	39 months	Lower survival with self-adhesive cement (69%) vs SB-E (88%) and SB+E (96%). Marginal staining and adaptation significantly worse in self-adhesive group. Conventional adhesive luting recommended.
4	Rinke et al., 2022	Prospective randomized clinical study	45 patients; 61 restorations	ZLS partial crowns with reduced material thickness: 0.5–0.74	5 years	Survival: 83% for thin group vs 100% for

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				mm vs 0.75–1.0 mm		≥0.75 mm. Success greater in premolars vs molars. Material thickness strongly affected fracture rates. Self-adhesive cement group required more recementations.			clinical trial	veneers (24 ceramic, 36 composite)	(e.max CAD) vs Composite (Lava Ultimate)		Partial chipping only in composite group. Survival: Ceramic 100%, Composite 84.7%. Composite showed more surface degradation; both clinically acceptable.
5	Bijelic-Donova et al., 2022	Prospective clinical study	18 restorations	SFRC direct vs glass-ceramic endocrown	4 years	Comparable survival (90.9% vs 85.7%); SFRC required more maintenance but was easier to repair.							
6	Schlichting et al., 2022	Prospective randomized	11 patients; 60 occlusal	CAD/CAM ultrathin occlusal veneers: Ceramic	Up to 3 years	No complete restoration loss.							
7	Canatan et al., 2022	Randomized controlled clinical trial	53 patients, 70 inlay/onlay restorations	CAD/CAM resin nanoceramic inlays/onlays cemented using RelyX U200 (self-adhesive resin cement) vs G-CEM LinkForce (adhesive resin cement)	18 months	Survival: 94.3% (RXU) vs 91.4% (GCL); no significant difference. Some debonding and fracture in GCL group; overall							

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						acceptable performance for both cements.
8	Lempel et al., 2023	Retrospective comparative clinical study	91 patients ; 145 restorations evaluated (LidiSi & RBC)	Lithium disilicate ceramic vs. laboratory-processed indirect resin composite inlays/onlays/overlays	Mean 7.8 ± 3.3 years (range 5–15 years)	Survival: 96.8% (LidiSi), 84.9% (RBC). Annual failure rate: 0.2% (LidiSi) vs 1.0% (RBC). Failure types: secondary caries, fractures, endodontic problems. Risk factors: material, oral hygiene, bruxism.
9	Pfister et al., 2023	Prospective RCT (split-mouth)	43 patients (19 recalled at 15 year	PCCs luted with RelyXUNicem with selective enamel etching	Up to 15 years	Survival: 78.1% (with etching) vs 42.9%
						s) vs without etching (with out etching). Selective enamel etching increased survival (p=0.004). Both groups exhibited marginal deterioration and discoloration.
10	Suksawat et al., 2024	In-vitro fracture resistance study	60 premolars	Resin nanoceramic, PICN, lithium disilicate, translucent zirconia	Lab oratory analysis	Zirconia was most fracture-resistant but also had most catastrophic failures; PICN and nanoceramic behaved similarly to dentin.
11	Fouda et al.,	Randomized	30 restorations	CAD/CAM composite	24 months	Overlays show

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	2024	clinical trial	ons	te inlays vs overlays		ed better marginal adaptation, fewer fractures, and fewer secondary caries than inlays.			blind ed, parallel-group trial		composi te (Brilliant Crios)	year s	inal integrity, discoloration) favoring composite; no differences at 12–24 months; both materials clinically successful over 2 years.	
12	Göz etici-Çil et al., 2024	Prospective clinical trial	63 patients ; 80 resin composite indirect restorations	Indirect resin composite onlays/overlays using PBE	6 months , 1, 2, 3 years	Overall success: 87.5 %; survival: 93.8 %. Failures: partial loss (5), material chipping (4), secondary caries (1). Onlays showed better survival than overlays.		14	Hassan et al., 2024	Randomized controlled split-mouth clinical trial	20 patients (40 onlays)	Lithium disilicate (IPS e.max CAD) vs Hybrid resin nano-ceramic (VocoGradio)	Baseline, 1 year , 2 years	No significant differences between materials in any USP HS parameter ; survival rate 90% for both groups; color match and marginal
13	Elmoselhy et al., 2024	Randomized controlled , double-	50 restorations (25 per group)	Lithium disilicate (IPS e.max CAD) vs Nano-hybrid	Baseline, 6 months , 1 year , 2	Significant difference at 6 months (marg								

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						discoloration changed within groups over time.
15	Fouda et al., 2024	Randomized controlled trial, parallel-group, equivalence design	30 restorations (15 per group)	CAD/CAM nano-hybrid composite inlays vs overlays (Brilliant Crios)	Baseline, 6 months, 1 year, 2 years	Overlays (cuspal reduction) performed better clinically than inlays; marginal integrity similar; overlays recommended for structurally compromised ETT.
16	Biswal et al., 2025	Prospective randomized split-mouth clinical trial	-	Lithium disilicate onlays vs Lithium disilicate full crowns	Baseline, 1 year, 2 years	Both restorations clinically successful; onlays had better periodontal
						1 results; crowns had more periodontal deterioration at 1-2 years.
17	Spyropoulou et al., 2025	Retrospective clinical study	51 patients; 112 restorations	Lithium disilicate vs indirect composite resin onlays/overlays	3–11 years	Composite survival: 94.2% at 5 years, less than 60% at 8+ years. Lithium disilicate: 90.9% at 5 years, 85.2% at 5.5 years, stable long-term. Smoking was a significant risk factor. LidiS ionlays had better

						survival than LidiSi overlays.
18	Ashraf et al., 2025	Randomized, parallel-arm, triple-blind clinical trial	28 patients (14 per group)	Hybrid ceramic onlays cemented with Injectabl e resin composite vs Dual-cure resin cement	18 months	Similar performance for most USP HS criteria. Less marginal discoloration in injectable composite group at 18 months. One failure in dual-cure group; survival significantly favored injectable composite.

Table 2: Combined Risk of Bias Table (18 Studies, JBI-Based)

SN o	Study	Study Design	JBI Tool	Overall Risk of Bias
1	Strasding 2020	Retrospective Cohort	JBI Checklist	High
2	ElAziz 2020	RCT	JBI Checklist	Moderate
3	Feldspathi	RCT	JBI	Moderate

	c vs LD 2021		Checklist	te
4	Scholz 2021	RCT	JBI Checklist	High
5	Canatan 2022	RCT	JBI Checklist	Moderate
6	Bijelic-Donova 2022	RCT	JBI Checklist	High
7	Schlichting 2022	RCT	JBI Checklist	Moderate
8	Rinke 2022	RCT	JBI Checklist	Moderate
9	Lempel 2023	Retrospective Cohort	JBI Checklist	High
10	Pfister 2023	RCT	JBI Checklist	High
11	Hassan 2024	RCT	JBI Checklist	Low
12	Elmoselhy 2024	RCT	JBI Checklist	Low
13	Fouda 2024	RCT	JBI Checklist	Low
14	Suksawat 2024	In-vitro Experimental	JBI Checklist	Low
15	Gözetici-Çil 2024	Prospective Trial	JBI Checklist	Moderate
16	Spyropoulou 2025	Retrospective Cohort	JBI Checklist	High
17	Ashraf 2025	RCT	JBI Checklist	Low
18	Biswal 2025	RCT	JBI Checklist	Moderate