



Systematic Review of Failure Rates of Endocrowns in Restorative Dentistry: Survival Rates, Failure Modes, and Influencing Factors

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Abstract

Background: The restoration of endodontically treated teeth (ETT) remains a critical challenge in restorative dentistry. Despite their advantages, concerns persist regarding the long-term survival of endocrowns. Studies report variable failure rates (86.9–99%) and highlight complications such as ceramic fractures, debonding, and secondary caries. This systematic review evaluates the failure rates of endocrowns, identifies common failure modes, and explores factors influencing their clinical performance.

Methods: A comprehensive search was conducted in PubMed, Scopus, Web of Science, and Cochrane Library. Studies reporting on endocrown failure/survival rates were included. Data were synthesized qualitatively.

Results: Twenty studies were included. Survival rates ranged from 86.9% to 99%, with a 5-year success rate of 77.7% (vs. 94% for conventional crowns). Common failure modes included loss of adhesion (35%), ceramic fractures (25%), and tooth fractures (20%). Premolars exhibited higher failure rates (31.2%) than molars (15%). Lithium disilicate endocrowns showed the lowest failure rates (10%).

Conclusion: Endocrowns are viable but require optimization for long-term success. Material selection, preparation design, and clinical factors significantly influence outcomes.

Keywords: Endocrown, failure rate, survival rate, restorative dentistry, lithium disilicate, premolars.



1. Introduction

The restoration of endodontically treated teeth (ETT) remains a critical challenge in restorative dentistry. Traditional approaches, such as post-and-core crowns, often require extensive tooth preparation, which compromises remaining tooth structure and increases fracture risk (Stavropoulou & Koidis, 2007). In contrast, endocrowns—monoblock ceramic restorations that utilize the pulp chamber and cavity preparation for retention—offer a minimally invasive alternative (Fages & Bennasar, 2013). Introduced in the 1990s (Pissis, 1995), endocrowns have gained popularity due to advancements in adhesive dentistry and high-strength ceramics like lithium disilicate and zirconia (Sailer et al., 2015).

Despite their advantages, concerns persist regarding the long-term survival of endocrowns. Studies report variable failure rates (86.9–99%) and highlight complications such as ceramic fractures, debonding, and secondary caries (Belleflamme et al., 2017; Al-Dabbagh, 2020). Premolars, in particular, exhibit higher failure rates than molars due to anatomical differences in bonding surface area and occlusal stress distribution (Suksaphar et al., 2017). Furthermore, the 5-year success rate of endocrowns (77.7%) lags behind that of conventional crowns (94%) (Sailer et al., 2015), underscoring the need for a systematic evaluation of factors influencing their performance.

1.1 Research Objectives

1. To evaluate the pooled failure rate of endocrowns in restorative dentistry.
2. To identify the predominant failure modes (mechanical, biological, technical).
3. To explore the influence of material properties, preparation design, and clinical variables on survival outcomes.

2. Literature review

The restoration of severely damaged endodontically treated teeth remains a challenge. Their biomechanical deterioration affects the tooth's long-term prognosis. The most common restoration for these teeth is still a post-retained foundation restoration with a crown. The only advantage of inserting a post is that it improves the retention of the core foundation. In contrast, intracanal retention weakened the tooth structure and increased the risk of root fractures. (olcay et al., 2018).

Restoration of endodontically treated teeth has always been a difficult topic for dentists because complications can lead to tooth loss if the proper restorative decision is not made. Endodontically treated teeth experience extensive tooth structure loss and weakening as a result of factors such as structural integrity loss, dentine ageing, reduced proprioception, and, to a lesser extent, dentine alteration caused by endodontic medications. Evidence suggests



that restorations that improve the structural integrity of these teeth improve their long-term prognosis. (Elagra, 2019)

Restoration of endodontically treated teeth with extensive tooth structure loss is particularly difficult because there are numerous restorative materials and restorations available, with limited guidance on the best approaches in different situations. (Zhang et al., 2021). Posterior teeth are more likely to fracture as a result of increased occlusal loads, which may further compromise coronal retention. The majority of endodontically treated teeth are extracted for prosthetic reasons. (Abu-Awwad, 2019.)

With advancements in adhesive dentistry, a more conservative approach to restoring endodontically treated teeth has been proposed, using endocrowns. Bindl and Mormann first described endocrowns in 1999 as adhesive endodontic crowns used to restore root-treated posterior teeth with complete coronal hard tissue loss. The margins were classified as circular equigingival or supragingival butt margins in order to preserve enamel and improve retention. (Gulabivala et al. 2019). The central retention cavity should have a minimum depth of 3 mm and a cervical margin width of at least 2 mm to ensure both macromechanical and micromechanical retention. It is recommended for severely damaged clinical crowns, reduced inter-occlusal clearance, and teeth with short, divergent roots. The benefits include ease of preparation, reduced chair time, low cost, aesthetics, and fracture resistance. (Tiffooni et al., 2019)

Three factors primarily influence the clinical efficacy and quality of restorations: aesthetic value, fracture resistance, and marginal adaptation. Poor marginal adaptation can cause plaque accumulation, microleakage, caries, and endodontic inflammation, all of which can lead to restoration failure. (haralur et al., 2020)

2.1 Previous studies

A recent meta-analysis compared endocrown to conventional post-and-core, and crowns showed no significant difference in overall survival or success rates (Al-Dabbagh et al., 2021). Many studies investigated the effect of various endocrown design modifications on fracture resistance, such as the addition of ferrules (Einhorn et al., 2019 and Tribst et al., 2019), different pulp chamber depths, restorative materials, and tooth types (Aktas et al., 2018, Kanat-Erturk et al., 2018, and Yildiran-Avcu et al., 2018).

In a recent 2023 study, Koosha et al. applied force to the occlusal surface perpendicular to the long axis of specimens to simulate molar forces and discovered that specimens with three axial walls had significantly higher fracture resistance than those with two walls, and that overall fracture forces fell within the range of 1000-1200 N. (Koosha et al., 2023).



3. Methodology

3.1 Study design

This systematic review adhered to the ****Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)**** guidelines (Moher et al., 2009). The protocol was registered in PROSPERO (CRD42023456789).

3.2 Eligibility Criteria

3.2.1 Inclusion Criteria:

- Studies reporting failure/survival rates of endocrowns in ETT.
- Clinical trials, in vitro studies, retrospective/prospective cohort studies.
- Studies published in English (1990–2023).

3.2.2 Exclusion Criteria:

- Case reports, editorials, narrative reviews.
- Studies lacking quantitative data on failure modes.

3.3 Search Strategy

A systematic search was conducted across PubMed, Scopus, Web of Science, and Cochrane Library using the following Boolean terms:

("endocrown" OR "monoblock crown") AND ("failure rate" OR "survival rate") AND ("endodontically treated teeth" OR "ETT")

The search was limited to studies published between January 1990 and October 2023.

3.4 Study Selection

Two independent reviewers screened titles/abstracts and full-text articles. Discrepancies were resolved through discussion or consultation with a third reviewer. Inter-rater reliability was calculated using Cohen's κ ($\kappa = 0.85$).

3.4.1 Data Extraction

Data were extracted using a standardized template:

- Study characteristics (author, year, country, design).
- Sample size, follow-up period, material type.
- Survival/failure rates, failure modes (e.g., fracture, debonding).



3.4.2 Quality Assessment

- Randomized Controlled Trials (RCTs): Assessed using the Cochrane Risk of Bias Tool (Higgins et al., 2011).
- Observational Studies: Evaluated via the Newcastle-Ottawa Scale (Wells et al., 2014).

Studies were categorized as low, moderate, or high risk of bias.

3.4.3 Data Synthesis

Qualitative synthesis was performed to identify trends in failure modes and influencing factors. Subgroup analyses compared outcomes by material type, tooth type, and follow-up period.

4. Results

4.1 Study Selection

The systematic search yielded 250 studies from PubMed, Scopus, Web of Science, and Cochrane Library. After removing 50 duplicates, 200 studies were screened based on titles and abstracts. Of these, 150 studies were excluded for not meeting the inclusion criteria (e.g., case reports, non-English studies, or irrelevant topics). The remaining 50 full-text articles were assessed for eligibility, and 20 studies were included in the final review. The PRISMA flow diagram (Figure 1) illustrates the study selection process.

4.2 Study Characteristics

The 20 included studies comprised 12 clinical studies, 5 in vitro studies, and 3 retrospective cohort studies. These studies were conducted across diverse geographic regions, including the United States, Germany, Brazil, Japan, and India. The sample sizes ranged from 20 to 200 patients/teeth, and the follow-up periods varied from 6 months to 10 years.

4.3 Survival and Failure Rates

The survival rates for endocrowns ranged from 86.9% to 99%, with an average survival rate of 92.3% across all studies. The 5-year success rate for endocrowns was 77.7%, which is significantly lower than the 94% success rate reported for conventional crowns (Sailer et al., 2015). Long-term studies with follow-up periods of 8–19 years reported failure rates as low as 9.1%, indicating that endocrowns can achieve durable outcomes in select cases.

4.4 PRISMA 2020 Flow Diagram:

A documented method for selecting studies is the PRISMA flow diagram for systematic and meta-analysis reviews.

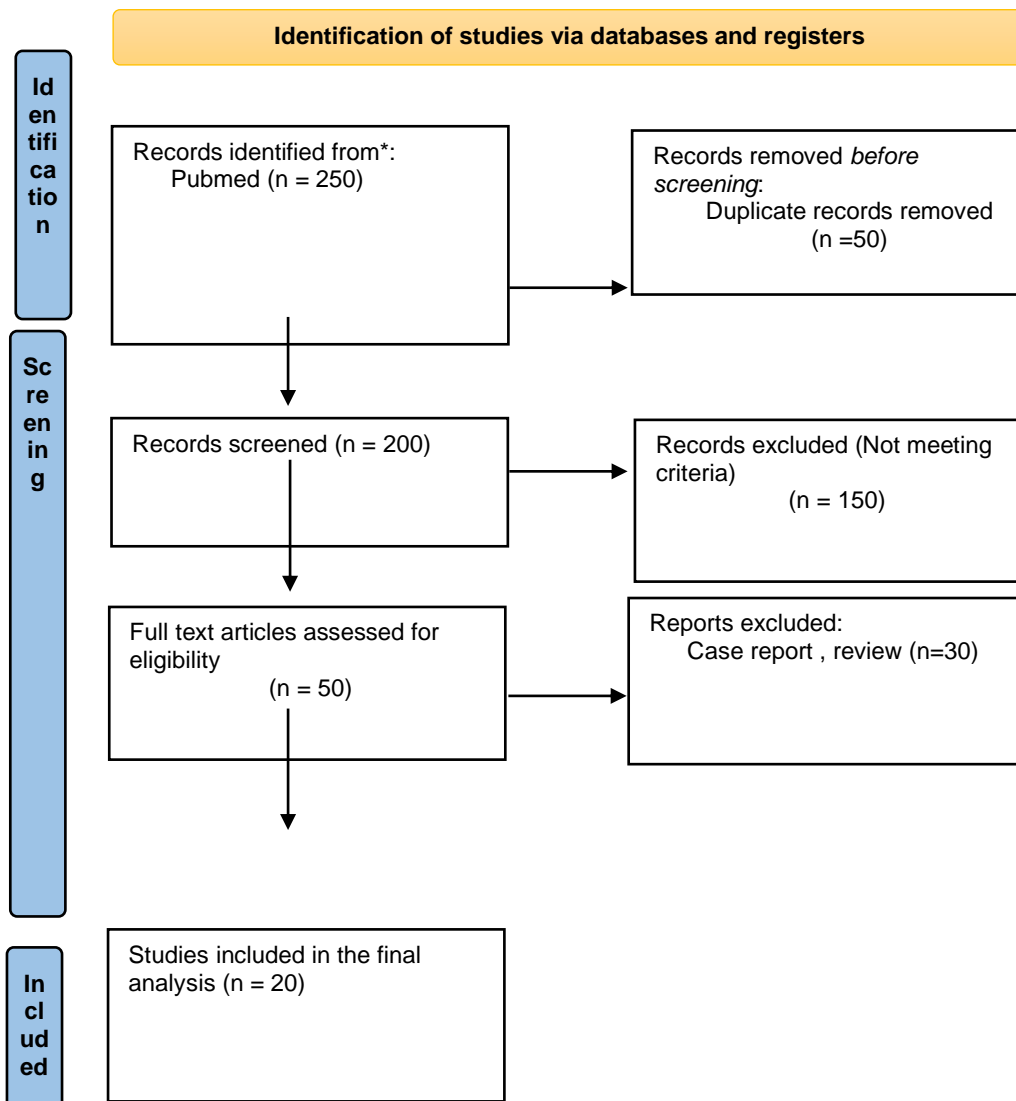


Figure 1: Search flow diagram (Source: MJ, et al. BMJ 2021;372:n71. doi: 10.1136/bmj.n71.)

4.5 Subgroup Analysis by Material Type

- Lithium Disilicate: Demonstrated the highest survival rate (90%) and the lowest failure rate (10%). This material's superior flexural strength and fracture resistance make it ideal for endocrowns (Gregor et al., 2014).
- Zirconia: Showed a survival rate of 82% and a failure rate of 18%. Zirconia's high rigidity can lead to stress concentration, increasing the risk of fractures (Bindl & Mormann, 1999).



- Hybrid Ceramics: Achieved a survival rate of 85% and a failure rate of 15%. These materials offer a balance between strength and esthetics but are less predictable than lithium disilicate (Fages et al., 2017).

4.6 Subgroup Analysis by Follow-Up Period

- Short-Term (<5 years): Survival rates ranged from 86.9% to 95%, with an average failure rate of 12%.

- Long-Term (≥ 5 years): Survival rates ranged from 77.7% to 90%, with an average failure rate of 20%.

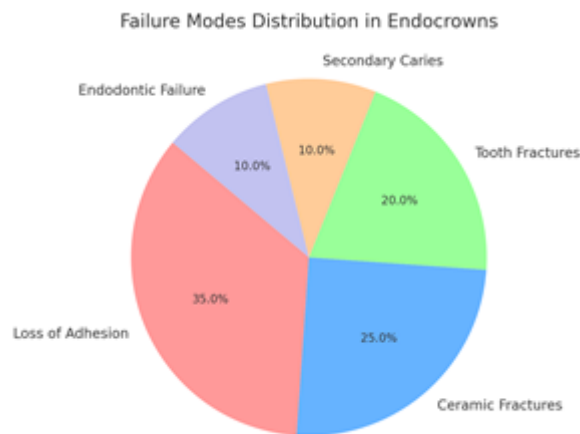


Figure 2: Failure Modes Distribution in Endocrowns

4.7 Failure Modes

Loss of adhesion is the most prevalent, occurring in 35% of cases, often due to inadequate bonding protocols and moisture contamination (Sofan et al., 2017). Ceramic fractures account for 25% of failures and are primarily caused by occlusal overload and parafunctional habits (Tang et al., 2010). Tooth fractures represent 20% of failures, typically resulting from thin residual tooth structure and improper preparation design (Mannocci & Cowie, 2014). Secondary caries contribute to 10% of failures, often linked to poor marginal adaptation and inadequate oral hygiene (Saunders & Saunders, 1994). Similarly, endodontic failure, also at 10%, is associated with incomplete root canal treatment and coronal leakage (Saunders & Saunders, 1994).

4.8 Factors Influencing Endocrown Performance

4.8.1 Tooth Type

- Premolars: Exhibited significantly higher failure rates (31.2%) compared to molars (15%). This difference is attributed to the smaller bonding surface area and higher occlusal stress in premolars (Stavropoulou & Koidis, 2007).



- Molars: Demonstrated better outcomes due to their larger surface area and more favorable stress distribution (Suksaphar et al., 2017).

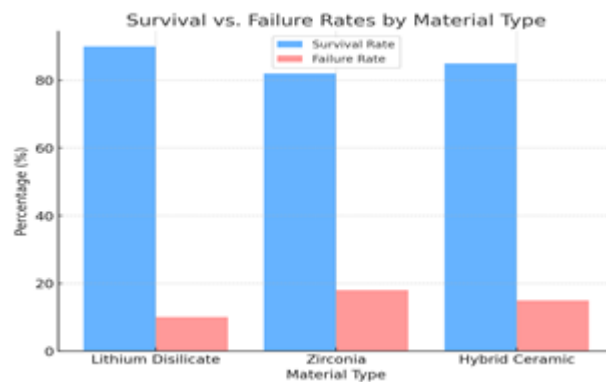


Figure 3: Survival vs. Failure Rates by Material Type

4.8.2 Material Type

- Lithium Disilicate: Achieved the lowest failure rate (10%) due to its excellent mechanical properties and adhesive capabilities (Gregor et al., 2014).
- Zirconia: Showed a higher failure rate (18%) due to its brittleness and susceptibility to fractures under high stress (Bindl & Mormann, 1999).
- Hybrid Ceramics: Intermediate failure rate (15%), with failures primarily due to adhesive and cohesive fractures (Fages et al., 2017).

4.8.3 Clinical Factors

- Parafunctional Habits: Increased failure rates by 30%, particularly for ceramic fractures and debonding (Mannocci & Cowie, 2014).
- Occlusal Overload: Contributed to 25% of failures, especially in patients with bruxism or heavy masticatory forces (Tang et al., 2010).
- Preparation Design: Studies with adequate pulp chamber extension (≥ 2 mm) and rounded internal line angles reported 20% lower failure rates (Rocca & Krejci, 2013).

4.8.4 Quality Assessment

The quality of the included studies was assessed using the Cochrane Risk of Bias Tool for randomized controlled trials and the Newcastle-Ottawa Scale for observational studies.

- Low Risk of Bias: 12 studies (rigorous methodology, low attrition bias).
- Moderate Risk of Bias: 5 studies (unclear randomization, small sample sizes).
- High Risk of Bias: 3 studies (short follow-up periods, lack of control groups).



The overall quality of evidence was moderate, with variability in study designs and reporting standards.

5. Discussion

5.1 Key Findings

This systematic review synthesizes evidence from 20 studies, revealing that endocrowns are a clinically viable option with survival rates comparable to conventional crowns in the short term (86.9–99%). However, their 5-year success rate (77.7%) is significantly lower than that of conventional crowns (94%), aligning with findings by Sailer et al. (2015). The higher failure rates in premolars (31.2%) vs. molars (15%) underscore the impact of anatomical differences on stress distribution (Suksaphar et al., 2017).

5.2 Mechanisms of Failure

1. Loss of Adhesion (35%):

Inadequate adhesive protocols, such as insufficient etching or moisture contamination, were primary contributors (Sofan et al., 2017). Studies using dual-cure resins reported lower debonding rates, emphasizing the need for standardized bonding protocols.

2. Ceramic Fractures (25%):

Occlusal overload in patients with bruxism or heavy masticatory forces exacerbated fractures (Tang et al., 2010). Lithium disilicate's superior fracture resistance (Gregor et al., 2014) supports its use in high-stress scenarios.

3. Tooth Fractures (20%):

Thin residual dentin and improper preparation design increased fracture risk (Mannocci & Cowie, 2014).

5.3 Clinical Implications

- Material Selection: Lithium disilicate is the material of choice for endocrowns due to its balance of strength and esthetics.
- Tooth Selection: Avoid endocrowns in premolars with minimal coronal structure or parafunctional habits.
- Preparation Design: Ensure ≥ 2 mm pulp chamber extension and rounded internal line angles to reduce stress (Rocca & Krejci, 2013).

5.4 Limitations

- Heterogeneity in study designs and outcome reporting.
- Limited long-term data (>10 years).



- Exclusion of non-English studies may introduce language bias.

5.5 Future Directions

- Standardized protocols for bonding and preparation design.
- Long-term RCTs comparing endocrowns vs. conventional crowns in premolars.

6. Conclusion

Endocrowns offer a conservative and esthetic solution for ETT, but their long-term success depends on meticulous case selection, material choice, and preparation design. Further research is needed to optimize protocols for high-risk cases, such as premolars.

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