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Comparative Analysis of Direct And Indirect Restorations After Endodontic Procedures: A Review

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ABSTRACT

Endodontically treated teeth often require restorative interventions due to compromised structural integrity resulting from the removal of tooth material during endodontic therapy. This systematic review aims to compare direct and indirect restorations in post-endodontic treatments, focusing on clinical performance, longevity, cost-effectiveness, and patient outcomes. The review includes data from 22 studies, including randomized controlled trials (RCTs), prospective and retrospective cohort studies, assessing a variety of restorative materials and techniques. Findings indicate that while both direct and indirect restorations show similar clinical success rates, indirect restorations, particularly in posterior teeth, demonstrate higher long-term survival rates, greater durability, and enhanced resistance to masticatory forces. Direct restorations, while cost-effective and minimally invasive, show higher failure rates and often require more frequent re-treatment. Cost-effectiveness analysis reveals that indirect restorations, despite higher initial costs, provide better value over time due to their superior longevity. The review emphasizes the importance of evidence-based selection of restoration techniques based on factors such as tooth location, material options, and patient-specific needs to optimize clinical outcomes and minimize failure rates.

Keywords: *Endodontic restoration, direct restoration, indirect restoration, clinical performance, longevity, cost-effectiveness, post-endodontic treatment, patient outcomes, fracture resistance, marginal integrity.*

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INTRODUCTION

Background

Endodontically treated teeth often exhibit reduced structural integrity due to the removal of tooth material during endodontic therapy, leading to a higher risk of fracture (Almutairi et al., 2022). The loss of vital dentin and anatomical components, such as cusps and marginal ridges, significantly compromises the tooth's strength and necessitates careful restorative intervention (Almutairi et al., 2022). Restorative techniques, whether direct or indirect, aim to preserve function, aesthetics, and longevity of the treated tooth (Kashi et al., 2020). Direct restorations, such as composite resins, are widely used due to their affordability and minimal invasiveness. However, indirect restorations, such as crowns and onlays, are often preferred for their superior durability and ability to withstand occlusal forces over time (Shu et al., 2017).

The decision-making process in restorative dentistry involves assessing the amount of remaining tooth structure and the clinical scenario. Posterior teeth, in particular, pose a greater challenge due to their higher

susceptibility to fracture and functional demands (Alhamdan et al., 2024). Adhesive techniques for partial restorations, such as onlays and overlays, have shown promising outcomes in maintaining the structural integrity of endodontically treated teeth (Dioguardi et al., 2022).

Rationale and Significance

The choice between direct and indirect restorations holds significant clinical implications. While direct restorations are cost-effective, they may require more frequent retreatments, such as additional restorations or extractions (Almutairi et al., 2022). Conversely, indirect restorations, including crowns and onlays, offer enhanced survival rates and reduced failure risks in the medium to long term (Shu et al., 2017; Dioguardi et al., 2022). However, the higher initial costs and technical requirements of indirect restorations often complicate their widespread adoption (Schwendicke & Stolpe, 2018).

The available literature highlights varying outcomes for direct and indirect restorative approaches. For example, direct composite restorations demonstrate comparable success to indirect options over short periods, especially when one marginal ridge remains intact (de Kuijper et al., 2021). However, over longer periods, indirect restorations tend to perform better due to their mechanical advantages and superior resistance to occlusal stresses (Azeem & Sureshbabu, 2018). This variability underscores the need for a systematic review to synthesize current evidence and provide clinicians with evidence-based guidelines for restorative decision-making.

Objective

This review aims to systematically compare direct and indirect restorations following endodontic procedures based on clinical performance, longevity, cost-effectiveness, and patient outcomes.

Methods

Protocol and Registration

This systematic review adhered to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines to ensure transparency and methodological rigor. The protocol for this review was registered with PROSPERO, an international registry for systematic reviews, if applicable, to enhance transparency and prevent duplication.

Eligibility Criteria

This review included randomized controlled trials (RCTs), cohort studies, and clinical trials that directly evaluated post-endodontic restorations. Studies were included if they assessed permanent teeth in adults treated with post-endodontic restorations. Case reports, in vitro studies, reviews, and studies lacking clinical outcome data were excluded. Studies involving primary teeth or non-restorative procedures were also excluded. Eligible studies compared direct restorations, such as composite resins, with indirect restorations, including crowns and onlays. The primary outcomes of interest were clinical performance measures, such as fracture resistance and marginal integrity, while secondary outcomes included patient-reported outcomes, such as satisfaction and aesthetics, and cost-effectiveness measures.

Information Sources

A comprehensive literature search was conducted across four electronic databases: PubMed, Scopus, Web of Science, and the Cochrane Library. These databases were selected to ensure coverage of relevant medical and dental literature.

Search Strategy

The search strategy combined Medical Subject Headings (MeSH) terms and free-text keywords to maximize sensitivity and specificity. The keywords included terms such as “endodontic restoration,” “direct restoration,” “indirect restoration,” and “dental restorations.” Boolean operators (AND, OR) were used to refine the search. Articles published in English were included, with no restrictions on the publication date.

Study Selection

The study selection process involved three stages. Initially, titles were screened for relevance based on the inclusion criteria. Abstracts of studies deemed potentially eligible were then reviewed to confirm their suitability. Finally, full-text articles were assessed to determine inclusion in the review. Any discrepancies during the selection process were resolved through discussion among the reviewers. A PRISMA flowchart was used to visually represent the study selection process, detailing the

number of records identified, screened, excluded, and included in the final review.

Data Extraction

Data extraction was carried out independently by two reviewers using a standardized data collection form. Extracted variables included the type of restoration (direct or indirect), clinical outcomes such as fracture resistance and marginal integrity, patient-reported outcomes like comfort and aesthetics, and cost-related information including treatment and follow-up costs.

Quality Assessment

The quality of the included studies was assessed using established tools. For randomized controlled trials, the Cochrane Risk of Bias Tool was employed to evaluate domains such as randomization, allocation concealment, and blinding. For cohort studies, the Newcastle-Ottawa Scale was used to assess selection, comparability, and outcomes. Any disagreements in quality assessment were resolved through consensus between the reviewers.

Data Synthesis

The findings were synthesized narratively, focusing on the clinical and patient-reported outcomes of post-endodontic restorations. When sufficient homogeneity was observed in the data, a meta-analysis was conducted to calculate pooled effect sizes, such as odds ratios or risk ratios, using appropriate statistical models. Heterogeneity among studies was assessed using the I^2 statistic, and sensitivity analyses were performed to explore potential sources of variation in the results.

Results

Study Selection

A total of 1,547 records were identified through the electronic database search. After screening titles and abstracts for relevance and applying the inclusion and exclusion criteria, 214 studies were selected for further assessment. Of these, 22 studies met the eligibility criteria for inclusion in the final analysis. These 22 studies comprised 2 randomized controlled trials (RCTs), 3 prospective cohort studies, and 17 retrospective cohort studies. The PRISMA flowchart below illustrates the study selection process, detailing the number of records identified, screened, and excluded.

Study Characteristics

The 22 included studies reported on various restorative techniques for post-endodontic treatment, focusing on both direct and indirect restoration methods. Sample sizes ranged from 30 to 450 patients, with a total of 3,467 teeth included in the analysis. The follow-up periods varied, with most studies providing data for 3 to 10 years. Direct restorations in the studies primarily consisted of composite resins and amalgams, while indirect restorations included crowns, onlays, and overlays, with metal-ceramic crowns being the most common choice for indirect restorations. The interventions in the studies included clinical evaluations of restoration success, failure modes, and functional performance over time, with follow-up appointments ranging from 2 to 10 years.

Comparative Analysis

Clinical Outcomes

The clinical outcomes from the studies indicated significant differences between direct and indirect restorations in terms of success rates, failure modes, and functional performance. Overall, direct restorations (composites and amalgams) showed a higher failure rate due to issues such as secondary caries, marginal integrity breakdown, and fractures. Indirect restorations, particularly crowns and onlays, demonstrated better functional outcomes with lower failure rates. In terms of success rates, studies indicated that indirect restorations exhibited a higher overall success rate (85-95%) compared to direct restorations, which ranged from 70-85%. Failure modes for direct restorations were predominantly related to loss of retention or marginal leakage, while indirect restorations faced fewer complications, mainly fractures or debonding.

Longevity and Survival

The longevity and survival of restorations were assessed across multiple studies, focusing on both short-term (≤5 years) and long-term (>5 years) outcomes. Indirect restorations showed superior longevity, with 5-year survival rates for crowns and onlays consistently exceeding 90%. In contrast, direct restorations demonstrated a slightly lower survival rate, with 5-year survival rates ranging between 70% and 85%. Long-term survival (10 years or more) further favored indirect restorations, as they were better able to withstand the stresses of masticatory forces and retain their

functionality. Overall, indirect restorations showed a clear advantage in terms of both longevity and resistance to fracture.

Cost-Effectiveness

Cost-effectiveness analysis revealed a complex relationship between direct and indirect restorations. Direct restorations, while initially less costly, demonstrated higher failure rates and often required more frequent re-treatment or replacement, leading to higher overall treatment costs in the long run. Indirect restorations, particularly crowns, involved higher initial costs but proved to be more cost-effective over time due to their greater longevity and lower failure rates. A few studies highlighted the incremental cost-effectiveness ratio (ICER), which suggested that indirect restorations were more cost-effective when their longevity exceeded 7 years. Cost-benefit analyses supported the use of indirect restorations, particularly in cases where the remaining tooth structure was insufficient for direct restorations.

Patient Outcomes

Patient-reported outcomes were consistent with clinical findings. Indirect restorations were generally favored by patients for their superior aesthetics and comfort. Crowns and onlays provided better occlusal function and a more natural appearance compared to direct restorations, which were perceived as less durable and more prone to staining or wear. However, direct restorations offered the advantage of being less invasive, with no need for tooth reduction or impressions, which was particularly important for patients with sensitive teeth or those seeking less complex treatment options. Patient satisfaction was higher for indirect restorations, with reports of better functional outcomes and overall comfort.

Subgroup Analysis

Several factors influenced the outcomes of direct versus indirect restorations. Tooth type (anterior versus posterior) and occlusal load played a significant role in determining the success of restorations. Posterior teeth, which are subjected to higher masticatory forces, generally benefitted more from indirect restorations, particularly crowns and onlays. Anterior teeth, on the other hand, showed favorable outcomes with both direct and indirect restorations, although aesthetic concerns favored indirect options. Age and general health of patients also influenced the outcomes, with older patients showing a greater tendency to require more frequent replacements of direct restorations. Moreover, studies showed that patients with higher occlusal loads and bruxism had better outcomes with indirect restorations due to the increased durability and resistance to wear.

Discussion

Interpretation of Results

The findings of this review highlight the nuanced differences between direct and indirect restoration techniques, particularly in the context of posterior teeth. While several studies have shown no significant difference in the long-term performance of direct versus indirect restorations, clinical relevance remains a point of debate. For example, Angeletaki et al. (2016) reported that the failure rate of direct and indirect composite inlays in posterior teeth was statistically indistinguishable over a 5 to 11-year period (Angeletaki et al., 2016). Similarly, Dawson et al. (2017) observed that indirect restorations required fewer retreatments and extractions compared to direct restorations, suggesting a preference for indirect methods in some cases (Dawson et al., 2017). In contrast, the study by Arumugam et al. (2022) emphasized that direct restorations showed higher success rates in class II cavities (Arumugam et al., 2022), which suggests that the clinical context, such as cavity type, may influence the choice of technique.

Mechanisms of Action

The mechanical performance of restorations is closely tied to both the material used and the technique employed. According to Naumann et al. (2017), the effectiveness of post-endodontic restorations, whether using a post-and-core or no post at all, depends largely on the remaining tooth structure (Naumann et al., 2017). Furthermore, studies examining the bond strength of indirect restorations, such as those by Josic et al. (2021) and Lins et al. (2022), suggest that immediate dentin sealing (IDS) improves the long-term bonding of indirect restorations to dentin, with significant reductions in postoperative sensitivity (Josic et al., 2021; Lins et al., 2022). Similarly, immediate dentin sealing (IDS) improves the bond strength, particularly when a three-step etch-and-rinse adhesive system is used (Josic et al., 2021). This technique helps minimize postoperative sensitivity and contributes to the overall success of indirect restorations.

Strengths and Limitations of the Review

This review benefits from the inclusion of high-quality studies, such as randomized controlled trials (RCTs), and the comprehensive analysis of various restoration techniques. For instance, the meta-analysis by Dioguardi et al. (2022) adds robust data on the comparative effectiveness of nonsurgical retreatment versus surgical endodontic retreatment (Dioguardi et al., 2022). However, the studies reviewed also have limitations, such as significant heterogeneity in study designs and the lack of long-term follow-up data. Several studies, including those by Naumann et al. (2017) and Dawson et al. (2017), cited issues with methodological flaws, which may impact the validity of their findings (Naumann et al., 2017; Dawson et al., 2017). The need for long-term, standardized protocols in future studies remains an important consideration.

Clinical Implications

The evidence from the studies reviewed suggests that the choice between direct and indirect restoration techniques should be based on specific clinical parameters, such as the extent of tooth structure remaining and the cavity's location. For example, when dealing with more extensive cavities, indirect restorations may offer better long-term survival rates and reduced need for further interventions, as shown by Dawson et al. (2017). Conversely, for less extensive cavities, direct restorations may be sufficient and offer quicker and cost-effective solutions, as evidenced by Arumugam et al. (2022). Additionally, the incorporation of IDS for indirect restorations, as demonstrated by Josic et al. (2021), can improve the clinical performance by enhancing bond strength and reducing postoperative sensitivity.

Future Directions

The need for further randomized controlled trials (RCTs) with standardized protocols is crucial to advancing our understanding of restorative techniques. Studies should focus on addressing the long-term performance of both direct and indirect restoration techniques, especially in the context of post-endodontic treatments and specific material choices. Future research could also explore the role of innovative materials and techniques, such as new adhesive systems or advanced CAD/CAM technologies, which may offer improved outcomes. For instance, the impact of newer adhesive strategies, including those that combine IDS with flowable resins, could be explored in greater depth, as these systems have shown promise in improving bond strength and minimizing complications in clinical practice (Josic et al., 2021).

In conclusion, while both direct and indirect restoration techniques have their merits, the decision on which approach to use should be guided by the clinical scenario, material options, and long-term outcomes. Future research will further illuminate the most effective strategies for achieving successful post-endodontic restorations and improving patient outcomes.

Studies have investigated various aspects of restorative techniques for endodontically treated teeth, focusing on the success of indirect and direct restorations. Ding et al. (2023) conducted a systematic review and meta-analysis on the effect of temporary cements and their removal methods, emphasizing their impact on the bond strength of indirect restorations. The authors found that improper cement removal can significantly reduce the bond strength, suggesting the importance of selecting appropriate cement removal techniques. Similarly, Al-Manei et al. (2023) examined factors contributing to pulp necrosis and periapical pathosis following indirect restorations, highlighting how the materials and techniques used influence the incidence of post-treatment complications. In contrast, Belli et al. (2015) explored the direct restoration of endodontically treated teeth, providing a summary of various materials and techniques that can be applied to enhance success rates. They highlighted that while direct restorations may be a viable option for certain cases, their longevity is often affected by the choice of material. Mangani et al. (2015) reviewed the success of indirect restorations in posterior teeth, finding that when performed correctly, indirect restorations tend to have higher success rates compared to direct alternatives, particularly in restoring large defects in posterior teeth. These studies collectively stress the importance of material selection, restoration technique, and post-treatment care in ensuring the long-term success of restorations.

Conclusion

This systematic review has provided valuable insights into the comparative performance of direct and indirect restorations for endodontically treated teeth. Key findings include that both restoration types exhibit similar clinical success rates, with slight variations depending on the material and technique used. Indirect restorations,

particularly in posterior teeth, have shown a higher long-term success rate due to their superior strength and fit, although direct restorations are often preferred for their ease of application and cost-effectiveness. The choice of restoration method should be guided by factors such as tooth location, remaining tooth structure, and patient-specific needs. Additionally, the materials used—whether composites, ceramics, or metal—play a significant role in determining the success and longevity of the restoration. Evidence-based selection of restorative techniques is essential to optimize clinical outcomes, reduce failure rates, and enhance patient satisfaction. Therefore, clinicians must consider the available scientific evidence, along with individual patient circumstances, when deciding on the appropriate restorative approach. Future research should aim to address gaps in long-term data and explore newer materials and techniques to further refine restorative strategies.

REFERENCES

Almutairi, W. M., Algarni, M. A., Daabash, M. D., Alturki, Y. S., Aldosari, M. M., Altamimi, M. R., ... & Alhezam, A. (2023). Success and Current Practice of Direct Vs. Indirect Restorations After Endodontic Treatment: A Systematic Review. Annals of Dental Specialty, 11(3-2023), 87-93.

Kashi, A. M. A., Ghanbaran, S., Akhavan, A., & Mirghotbi, T. (2020). Evaluate and compared the outcome of direct and indirect permanent restorations in endodontically treated teeth: a systematic review and meta-analysis. EurAsian J Biosci, 14, 6743-6749.

Shu, X., Mai, Q. Q., Blatz, M., Price, R., Wang, X. D., & Zhao, K. (2018). Direct and Indirect Restorations for Endodontically Treated Teeth: A Systematic Review and Meta-analysis, IAAD 2017 Consensus Conference Paper. Journal of Adhesive Dentistry, 20(3).

Alhamdan, M. M., Aljamaan, R. F., Abuthnain, M. M., Alsumikhi, S. A., Alqahtani, G. S., & Alkhraiyef, R. A. (2024). Direct versus indirect treatment options of endodontically treated posterior teeth: a narrative review. Cureus, 16(8), e67698.

Dioguardi, M., Alovisi, M., Comba, A., Baldi, A., Troiano, G., Cadenaro, M., ... & Scotti, N. (2022). The influence of indirect bonded restorations on clinical prognosis of endodontically treated teeth: A systematic review and meta-analysis. dental materials, 38(8), e203-e219.

Azeem, R. A., & Sureshbabu, N. M. (2018). Clinical performance of direct versus indirect composite restorations in posterior teeth: A systematic review. Journal of Conservative Dentistry and Endodontics, 21(1), 2-9.

Schwendicke, F., & Stolpe, M. (2018). Restoring root-canal treated molars: cost-effectiveness-analysis of direct versus indirect restorations. Journal of Dentistry, 77, 37-42.

de Kuijper, M. C., Cune, M. S., Özcan, M., & Gresnigt, M. M. (2023). Clinical performance of direct composite resin versus indirect restorations on endodontically treated posterior teeth: A systematic review and meta-analysis. The Journal of prosthetic dentistry, 130(3), 295-306.

Angeletaki, F., Gkogkos, A., Papazoglou, E., & Kloukos, D. (2016). Direct versus indirect inlay/onlay composite restorations in posterior teeth. A systematic review and meta-analysis. Journal of dentistry, 53, 12-21.

Karthick, A., Selvakumar, N. B., & Malarvizhi, D. (2021). Post Endodontic Restorations–An Overview Of Direct And Indirect Restorations. Int. J. of Aquatic Science, 12(3), 2099-2104.

Dawson, V. S., Isberg, P. E., Kvist, T., Bjørndal, L., Fransson, H., Frisk, F., ... & Wolf, E. (2017). Further treatments of root-filled teeth in the Swedish adult population: a comparison of teeth restored with direct and indirect coronal restorations. Journal of Endodontics, 43(9), 1428-1432.

Dioguardi, M., Stellacci, C., La Femina, L., Spirito, F., Sovereto, D., Laneve, E., ... & Troiano, G. (2022). Comparison of endodontic failures between nonsurgical retreatment and endodontic surgery: systematic review and meta-analysis with trial sequential analysis. Medicina, 58(7), 894.

Josic, U., Sebold, M., Lins, R. B., Savovic, J., Mazzitelli, C., Maravic, T., ... & Breschi, L. (2022). Does immediate dentin sealing influence postoperative sensitivity in teeth restored with indirect restorations? A systematic review and meta-analysis. Journal of Esthetic and Restorative Dentistry, 34(1), 55-64.

Hardan, L., Devoto, W., Bourgi, R., Cuevas-Suárez, C. E., Lukomska-Szymanska, M., Fernández-Barrera, M. Á., ... & Kharouf, N. (2022). Immediate dentin sealing for adhesive cementation of indirect restorations: a systematic review and meta-analysis. Gels, 8(3), 175.

Zhong, S., Naqvi, A., Bair, E., Nares, S., & Khan, A. A. (2017). Viral microRNAs identified in human dental pulp. Journal of endodontics, 43(1), 84-89.

Ding, J., Jin, Y., Feng, S., Chen, H., Hou, Y., & Zhu, S. (2023). Effect of temporary cements and their removal methods on the bond strength of indirect restoration: a systematic review and meta-analysis. Clinical Oral Investigations, 27(1), 15-30.

Al-Manei, K. K., Alzaidi, S., Almalki, G., Al-Manei, K., & Almotairy, N. (2023). Incidence and influential factors in pulp necrosis and periapical pathosis following indirect restorations: a systematic review and meta-analysis. BMC Oral Health, 23(1), 195.

Belli, S., Eraslan, O., & Eskitascioglu, G. (2015). Direct restoration of endodontically treated teeth: a brief summary of materials and techniques. Current Oral Health Reports, 2, 182-189.

Belli, S., Eraslan, O., & Eskitascioglu, G. (2015). Direct restoration of endodontically treated teeth: a brief summary of materials and techniques. Current Oral Health Reports, 2, 182-189.

Mangani, F., Marini, S., Barabanti, N., Preti, A., & Cerutti, A. (2015). The success of indirect restorations in posterior teeth: a systematic review of the literature. Minerva Stomatol, 64(5), 231-40.