

# SUCCESS AND CURRENT PRACTICE OF DIRECT VS. INDIRECT RESTORATIONS AFTER ENDODONTIC TREATMENT: A SYSTEMATIC REVIEW

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## ABSTRACT

Endodontically treated and repaired teeth are often worried about fractures. Endodontic therapy is known to reduce the flexibility of teeth, which in turn reduces their resistance to fracture. During the construction of access cavities and endodontic treatment, it results from the drying of tooth structure and the loss of a significant amount of dentin and significant anatomical components such as cusps, marginal ridges, and the pulp chamber roof. The longevity of teeth that have had endodontic treatment depends on the quantity of dental structure still present and the kind of restorative material used. The procedure utilised to restore the tooth and the interactions that take place between the tooth, the restorative material, and the oral environment. When compared to teeth with indirect restorations, it was discovered that teeth with direct restorations experienced a higher frequency of following treatments, such as non-surgical retreatment, root-end surgery, extraction, and additional restorations. These differences were statistically significant, suggesting that the type of restoration influenced the need for additional treatments. In conclusion, the results of the systematic review indicate that the choice of restoration technique for root-canal-treated teeth has implications for cost-effectiveness, success rates, and longevity. Regarding specific restorations, metal-ceramic crowns performed better in terms of success rates than composite resin restorations, although there was no significant difference in survival.

**Key words:** Direct restorations, Indirect restorations, Systematic review, Endodontic treatment.

## Introduction

Endodontically treated and repaired teeth are often worried about fractures [1]. Endodontic therapy is known to reduce the flexibility of teeth, which in turn reduces their resistance to fracture [2].

During the construction of access cavities and endodontic treatment, it results from the drying of tooth structure and the loss of a significant amount of dentin and significant anatomical components such as cusps, marginal ridges, and the pulp chamber roof [3]. The longevity of teeth that have had endodontic treatment depends on the quantity of dental structure still present and the kind of restorative material used [4]. The process by which the tooth is restored and the interactions between the tooth, the restorative material, and the oral environment [5]. Dental specialists often advise placing prosthetic crowns ultimately over teeth undergoing endodontic treatment [6]. In certain circumstances, inlay and onlay restorations are also an option. Lithium disilicate, which has a high degree of transparency and a broad color spectrum, as well as indirect composite resins, which have been shown to strengthen the fracture resistance of teeth, are

examples of indirect restorative materials that are often utilized for the creation of inlays, onlays, and crowns [6].

Some scientists think cuspal covering is necessary to prevent breakage in teeth with large endodontically treated cavities [7]. Although full crowns and onlays prevent teeth from breaking, onlays are a more conservative treatment than full crowns [5].

Even though there are several restorative materials available for the restoration of teeth that have undergone endodontic treatment, composite resins, and ceramics are more often utilized for this purpose because of their excellent cosmetic features [8]. The maximal preservation of tooth structure is the real benefit of composite resins [9]. Contrarily, ceramics in the oral cavity offer more excellent compressive resistance and longevity than composite restorations [8]. There are some disagreements in this regard, but [6].

## Materials and Methods

This study used PubMed, Medline, and ScienceDirect to conduct a comprehensive literature search spanning 2000–2023. Search terms included "systematic review," "direct

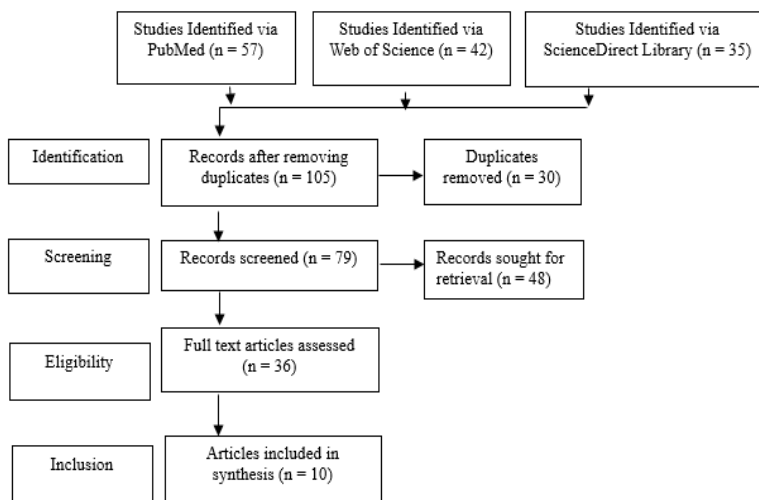
restorations," and "indirect restorations." To illustrate how we chose which papers to search, we used the PRISMA flowchart (**Figure 1**).

*Inclusion criteria*

Case-control and randomized-control trials published in English between 2000 and 2023 were included.

*Exclusion criteria*

tabExpert opinion, narrative reviews, systematic reviews research conducted outside the given time frame studies conducted in languages other than English studies conducted in vitro



**Figure 1.** PRISMA Flow Diagram

*Risk of bias assessment*

Cochrane risk of bias assessment method was used to assess the quality of the studies included (**Table 1**).

**Table 1.** Summary of Cochrane Risk of Bias Assessment

Study	Selection Bias/Appropriate control selection/baseline characteristics similarity	Selection bias in randomization	Selection bias in allocation concealment	Performance-related bias in blinding	Reporting bias/Selective reporting of outcomes	Detection bias Blinding outcome assessors	Accounting for confounding bias
Schwendicke <i>et al.</i> , (2018)	-	+	+	+	+	+	+
Dawson <i>et al.</i> , (2017)	+	+	+	+	+	+	-
Lucarotti <i>et al.</i> , (2014)	+	+	+	+	+	+	+
Skupien <i>et al.</i> , (2016)	+	+	+	+	+	+	+
von Stein-Lausnitz <i>et al.</i> , (2018)	+	+	+	+	-	+	+
Fráter <i>et al.</i> , (2022)	+	+	+	+	+	+	+
Maravic <i>et al.</i> , (2022)	-	+	+	+	+	+	+
Zand (2016)	+	+	+	+	+	+	+
Bromberg <i>et al.</i> , (2016)	+	+	+	+	+	+	+
Yazdi <i>et al.</i> , (2020)	+	+	+	+	+	+	+

**Results and Discussion**

Schwendicke *et al.* (2018) [8] compared the prices of RBCs, FCs, and PCs to determine the most cost-effective for restoring root-canal-treated molars, as shown in **Table 2**.

This ratio climbed whether the price of direct repairs was reduced or the cost of indirect restorations rose. RBC was substantially more cost-effective if no teeth were replaced (the incremental cost-effectiveness ratio was 52.95 Euro/year). FC was more affordable and more effective when all teeth were replaced. Compared to FCs/PCs, RBCs have cheaper, lower pricing and less effectiveness. The willingness of patients or other payers to pay impacted whether or not both strategies were cost-effective.

This research done by Dawson *et al.* (2017) [10] reported that there was a statistically significant difference in the frequency of non-surgical retreatments, extractions, and additional restorations between teeth restored by direct restoration and indirect restoration within 6 months post root filling.

The research undertaken by Lucarotti *et al.* (2014) [11] assessed whether restorations on teeth with and without roots filled lasted. The study contained information on about 80,000 different adult patients, of whom 46% were males and 54% were women. Root fills comprised 30.073 of the total 538.967 restoration placements in the eleven years of data. Root canal-treated teeth had shorter re-intervention intervals than non-treated teeth, according to a study comparing the durability of restorations on treated and untreated teeth.

Skupien *et al.* (2016) [12] conducted a randomized clinical study to compare the durability of composite resin restorations with those of metal-ceramic crowns. They randomly assigned 47 patients (mean age 42,5 11.5) with 57 endodontically treated teeth to receive either a metal-ceramic crown or a composite resin repair. All teeth had one intact surface but significant coronal damage due to the endodontic treatment. Using FDI clinical criteria, we conducted a descriptive study, and using Kaplan-Meier statistics and log-rank tests, we analyzed the survival of restorations and teeth. Among the 57 restorations used on 47 patients, 27 were crowns, and 30 were composite resin fillings. There was a full recall after one to five years of follow-up. However, the success rate of metal-ceramic crowns was higher ( $p = 0.022$ ).

This study by von Stein-Lausnitz *et al.* (2018) [13] evaluated the strength of restored Class III deficient maxillary central incisors with and without glass-fiber fiber posts in an ex vivo setting. We performed endodontic preparation of proximal Class III cavities on 72 extracted human maxillary central incisors. Kruskal-Wallis analysis indicated statistically significant variations in group carrying capacity ( $p 0.05$ ).

Less invasive veneers are preferable to full-coverage restorations. Reusing the same glass-fiber-fiber posts from the first installation did not improve the situation.

Fráter *et al.* (2022), [14] put all restorations through a cyclic loading machine that went up to 50,000 cycles or until they cracked to ensure they would hold up in the face of normal use. Kaplan-Meier analysis of survival was performed, followed by paired post hoc comparisons. There was no success among the 50,000 tooth repairs. Group B3, which used flowable SFRC with a fiber post and direct overlay instead of a cuspal covering, had the highest survival rate ( $p = 0.05$ ) of all non-surgical treatment options.

Maravi *et al.* (2022) [15] used finite element analysis (FEA) and an in vitro fracture resistance test. Using polymethyl methacrylate (PMMA) and periodontal ligament/alveolar bone (B), the authors created models for three types of composite restorations and measured the fracture resistance and Models received an occlusal two-point axial load of 850 N. There were calculated Von Mises stresses and strains. The fracture resistance (N) did not significantly differ across the groups.

By contrasting the fracture resistance of molars treated using direct methods with those restored using indirect techniques, Bromberg *et al.* (2016) [16] investigated this possibility. The authors prepared the mesio-occluso-distal cavity and performed typical endodontic operations. The authors measured the fracture resistance in newtons using a standardized testing apparatus. The authors used one-way ANOVA and the Tukey test ( $P > 0.05$ ) to analyze the data. Teeth that are in good shape are the least likely to break. When it came to resistance recovery, TFP ranked second only to ON. Similarly to IN, CR had the lowest recovery rate.

The purpose of Yazdi *et al.*'s (2020) [17] investigation was to investigate the resistance to fracture and the kind of fracture that might occur in endodontically treated premolars with direct and indirect onlay restorations. This in-vitro study employed 45 human maxillary premolars, 15 each from a control (healthy teeth), direct-only, and indirect-only group. Fracture resistance differed significantly ( $P 0.001$ ) across the three groups. When comparing the two groups of restorations to the group of healthy teeth, there was a statistically significant ( $P 0.001$ ) difference in fracture resistance. The fracture resistance of the direct onlay restorations and the indirect onlay restorations did not vary statistically significantly ( $P=0.6$ ). According to the Chi-square test, there was a statistically significant increase in the non-union rate in the indirect-only group ( $P=0.005$ ).

**Table 2.** Summary of findings from each study.

Author's name	Objective	Samples	Test	Teeth	Restoration	Results
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Schwendicke <i>et al.</i> , (2018) [8]	The research aimed to compare the cost-effectiveness of root-canal-treated molar restoration using RBCs with FCs or PCs. RBCs.	1		molar	molar restoration using RBCs with FCs or PCs.	FC was more economical and more successful when all teeth were replaced.	
Dawson <i>et al.</i> , (2017) [10]	This research aimed to compare the results of teeth restored with direct or indirect restorations and assess the frequency of non-surgical retreatment, root-end surgery, extraction, and subsequent restoration.	248,299		chi-square tests	direct or indirect restorations, root-end surgery, extraction, and subsequent restoration of root-filled teeth	There was a statistically significant difference in the number of non-surgical retreatments, extractions, and further restorations between teeth repaired by direct restoration and indirect restoration within 6 months following root filling.	
Lucarotti <i>et al.</i> , (2014) [11]	The study was conducted to assess whether restorations on teeth with and without roots filled survived	538,967		18 years or older	direct restoration, an indirect restoration, or a root filling	Teeth with root fillings have shorter re-intervention intervals than those without.	
Skupien <i>et al.</i> , (2016) [12]	This randomized clinical research evaluated the lifespan of metal-ceramic crowns and composite resin restorations on endodontically treated teeth that received a glass fiber post using 2 distinct cementation techniques.	57		Kaplan-Meier statistics,	metal-ceramic crowns and composite resin restorations	There was no difference in survival according to the log-rank test.	
von Stein-Lausnitz <i>et al.</i> , (2018) [13]	This ex vivo study assessed the load capacity of Class III defective maxillary central incisors that had undergone direct or indirect endodontic restoration, either with or without glass-fiber posts.	72		Mann-Whitney U-test, Kruskal-Wallis test	maxillary central incisors	direct or indirect endodontic restoration, either with or without glass-fiber posts.	Direct composite restorations of Class III abnormalities in maxillary central incisors undergoing endodontic treatment are as loadable as indirect crown restorations.
Fräter <i>et al.</i> , (2022) [14]	This in vitro research looked at how endodontically treated (ET) premolars were restored with various post-core and cuspal covering restorations regarding fatigue survival and fracture behaviour.	108		Kaplan-Meier survival analysis	maxillary premolars	post-core and cuspal covering restorations	Compared to the other groups, Group C3's use of flowable SFRC as the luting-core material with fibre post and CAD/CAD overlays demonstrated improved fatigue survival performance (p >0.05).
Maravić <i>et al.</i> , (2022) [15]	The goal of the research was to use finite element analysis (FEA) and an in vitro fracture resistance test to examine the biomechanical characteristics of severely damaged premolars that had composite restorations.	850			severely damaged premolars	direct restoration-DR; endo-crown-EC; post, core, and crown-C	There were no discernible variations in fracture resistance (N) across groups.
Bromberg <i>et al.</i> , (2016) [16]	The authors looked into this possibility by comparing the fracture resistance of molars that were repaired using direct procedures with that of molars restored using indirect techniques.	50		Tukey test	sound third molars	sound teeth, onlays (ON), inlays (IN), direct CR, and transfixed fiberglass post (TFP) with direct CR.	The recovery rate in CR was the lowest and was comparable to IN's.
Yazdi <i>et al.</i> , (2020) [17]	This study examined endodontically treated premolars with direct and indirect onlay restorations to determine their resistance to fracture and the kind of fracture that could occur	45		Chi-square test	maxillary premolars	direct and indirect	The fracture resistance of healthy teeth and the two restoration groups differed significantly (P >0.001) in pairwise comparisons.

Restorations in teeth with root canal fillings all achieve a ten-year survival rate to re-intervention of 34%, according to the present research. Although they don't perform as well as crowns on teeth without root fillings, 60% of crowned molar teeth with root fillings, 57% of crowned premolar teeth with root fillings, and 42% of crowned incisor teeth with root fillings [1, 5] continue to provide appropriate service. The survival rate found in this study is considered satisfactory since it was calculated using only endodontically treated molars with an ETC score of II and III, and because majority of the molars had undergone endodontic retreatment. An estimated 79% of 196 endodontically treated teeth survived for at least 20 years [2, 3] according to a prospective cohort analysis.

Against the propagation of fatigue fractures, PFC materials provide little protection due to their basic characteristics [18]. If the SFRC-core is to primarily function as a crack-stopper, the distance between the stress initiation point on the surface and the SFRC-core is crucial. The thickness of the PFC on the surface, therefore, may have an impact on how well the material resists fatigue and what kind of failure mode it exhibits. One possible explanation for the persistence of non-restorable fracture patterns in the SFRC-core groups is the adoption of a PFC surface layer 2 mm thick in this investigation. This agrees with previous research showing the need of a thick SFRC and PFC layer [19, 20].

The dentin of the CB group revealed the greatest levels of von Mises stresses near the base of the post-preparation cavity, as opposed to the vestibular cervical portion of the tooth, as was the case in the other groups studied. Endodontic access by pulp chamber roof removal, root canal enlargement, and extended use of high-concentration chemicals reduces a tooth's fracture resistance. In addition, healthy teeth are more resilient to cracks than MOD alternatives [19-21].

Clinically, complete crown restorations in premolars and molars fail at equal rates. The preservation of tooth tissue has taken on uttermost importance with the advent of minimally invasive dentistry. Therefore, in recent years, direct restorations and restorations like end crowns have been created and promoted. These restorations are designed to retain healthy dental tissues while maintaining their retentive shape. Clinically, however, premolars seem to have endocrine failure at a greater incidence than molars [22, 23].

After a mean service period of 27 months, a retrospective analysis found that 1960 posteriorly treated teeth had a 94.1% survival rate. Due to the lack of 95% confidence intervals, comparing the two studies mentioned above with the present investigation is difficult. The rough failure rate with a root-filled molar for 174 molars endodontically treated by 12 general dentists was 2.7. Although these differences are not always statistically significant, they are important for the present investigation [24]. Premolars with endodontic treatment might be difficult to restore because of their unique form and location inside the tooth arch.

Premolars are more vulnerable to high loads in axial and shear directions than anterior teeth. Still, they are also more delicate than molars due to their smaller crowns and steeper cusps, particularly once a significant amount of tissue has been lost. Additionally, compared to molars, the pulp chamber of premolars is much smaller than that of molars, giving retention to the endocrine system [25, 26].

According to a new systematic review, FEA and in vitro research have shown that end crowns in premolars work just as well as complete crowns, but not in a clinical situation. This could be the result of several things. First, it is doubtful that the static fracture often employed in vitro experiments would occur in the patient's mouth. Fatigue is almost always the culprit when restorations fail during intraoral usage [27]. As a result, it was shown that thermal or thermomechanical aging, which was not considered in the current study, greatly affected the attachment strengths of posts to root dentin. The present study has also shown that in vitro studies cannot accurately replicate the intraoral environment or tooth-loading conditions during mastication [28]. Instead, they can only partially mimic the distribution of stresses within the tooth-restoration complex [29, 30].

This research compared the effectiveness of direct and indirect onlays for repairing endodontically treated premolars in terms of fracture resistance and failure causes. The findings revealed that fracture resistance was best in those with natural teeth and lowest in people with direct onlay restorations. This study compared the fracture resistance and failure mechanisms of direct and indirect onlays that restore endodontically treated premolars. The results showed that the fracture resistance was lowest for direct onlay restorations and highest for natural teeth. However, the direct and indirect groups showed no significant differences in fracture resistance [31, 32]. Observational data reveal that a clinical setting may generate masticatory forces of up to 725 N at the rear teeth [33].

Static axial loads and the reactions of direct composite restorations, composite endocrines, posts, cores, and crowns are adequate for repairing endodontically treated molars with extensive tissue loss. It is also necessary to think about how various models of the supporting tissues could alter the results [34] when combining an in vitro experiment with FEA in the same investigation.

The average lifespan of a root-filled molar was 1037 years, with 18 failures during that time. Endodontic experts have been demonstrated to improve tooth survival rates when compared to general dentists while doing endodontic treatment [35, 36].

This study used resin composite for almost all (99.2%) of the direct restorations. The material choice may not be as important as direct or indirect cuspal coverage and preservation of tooth structure. More research is needed in clinical trials to determine the effect of bonded restorations



with cuspal covering, directly or indirectly, on the survival of endodontically treated teeth. Despite the availability of adhesive rehabilitation for endodontically treated teeth, most of the molars in this study received entire contour crowns as indirect restorations. The tooth structure may be better preserved with a partial indirect restoration [26].

### Conclusion

In conclusion, the results of the systematic review indicate that the choice of restoration technique for root-canal-treated teeth has implications for cost-effectiveness, success rates, and longevity. The results of the systematic review indicate that the choice of restoration technique for root-canal-treated teeth has implications for cost-effectiveness, success rates, and longevity. RBCs were found to be less expensive but less efficient compared to FCs or PCs. The cost-effectiveness ratio varied depending on the replacement of teeth and the willingness of patients or payers to pay. The study also showed that compared to indirect restorations, direct restorations required more follow-up care. Additionally, compared to teeth without root fillings, teeth with root fillings had shorter re-intervention intervals. When it comes to specific restorations, metal-ceramic crowns performed better in terms of success rates compared to composite resin restorations, although there was no significant difference in survival.

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