

Clinical Success and Survival Rates of Endo Crowns in Restoring Endodontically Treated Teeth: A Systematic Review

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Abstract

The clinical success and survival rates of Endocrowns in restoring endodontically treated teeth are of significant interest to dental professionals. However, there is a need to evaluate the existing literature and conduct a systematic review to gain a comprehensive current use of Endocrowns and their outcomes in clinical practice. The review aims to provide a comprehensive analysis of the current evidence available to dental professionals regarding the use of Endo crowns as a restorative option for teeth that have undergone endodontic treatment. Databases such as PubMed (MEDLINE), Scopus, EMBASE, Cochrane Library, and Google Scholar were searched up to 2022 for clinical and in vitro studies on endocrown survival and success rates. A total of nine studies were included in this systematic review, most of which showed that Endocrowns are a reliable option for restoring endodontically treated teeth. Overall, the studies suggest that endocrown restorations can be a viable option with comparable clinical success rates to traditional crowns, but long-term effectiveness and patient selection need further investigation.

Keywords: Endocrowns, Endodontics, Randomized control trial, Microleakages, Restoration

INTRODUCTION

The type and quality of the coronal restoration determine the success of the restoration of teeth that have undergone endodontic treatment. The 5-year survival percentage of endodontically treated teeth restored with crowns is comparable to that of essential teeth repaired with crowns (94.2% vs. 95%). Conversely, endodontically treated teeth with no cuspal covering (restored with composite resin) had a worse success rate, with a 5-year survival rate of 63% [1].

A decrease in microleakages and the preservation and protection of the remaining tooth structure have been related to the enhanced survival of teeth treated endodontically with sufficient coronal cuspal covering. While cuspal coverage and preservation of the remaining coronal tooth structure have been reported to improve fracture resistance and the outcome of the endodontically treated tooth, immediate placement of a satisfactory coronal restoration has been reported to reduce microleakage and subsequently decrease the risk of endodontic treatment failure [2].

Undergoing advancements in adhesive dentistry, preparation designs for coronal restorations of teeth undergoing endodontic treatment have grown more conservative. As a result, these designs use fewer mechanical retention elements like undercuts, grooves, or boxes, with retention mostly based on adhesion to the tooth structure [3].

Endocrowns are conservative coronal restorations utilized to replace teeth that have undergone endodontic treatment but still have severe coronal tooth loss. Monoblock coronal restorations attach to the residual coronal tooth structure and the pulp chamber to keep them in place [4].

MATERIALS AND METHODS

A systematic literature review from 1999 to 2022 was performed using PubMed, Medline, and ScienceDirect databases. The keywords used were "endocrowns," "endodontics," and "randomized control trials." PRISMA flowchart was used to describe the selection process of searched articles (**Figure 1**).

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How to cite this article: AlShehri OM, Alnofal AM, Almutairi YM, Almonabhi ON, Alkhudhair HI, Alshamrani HH. Clinical Success and Survival Rates of Endo Crowns in Restoring Endodontically Treated Teeth: A Systematic Review. Arch Pharm Pract. 2023;14(S):A06231453.

Inclusion Criteria

- Case-control and randomized control studies
- Published between 1999 and 2023
- English language of publication
- In vivo (humans)
- Systematic reviews, meta-analyses, expert opinions, or narrative reviews
- Survey-based studies
- Out of the specified time range
- Language other than English
- In vitro

Exclusion Criteria

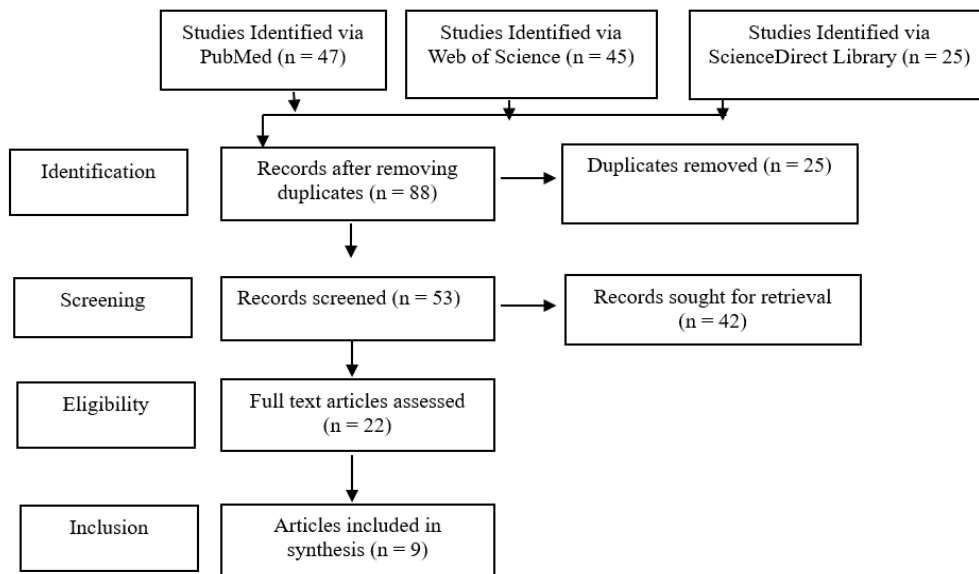


Figure 1. PRISMA Flow Diagram

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
Alley <i>et al.</i> , [4] (2004)	+	+	+	-	+	+	+
Mannocci <i>et al.</i> , [5] (2009)	-	+	+	+	+	+	+
Bindl <i>et al.</i> , [6] (1999)	+	+	-	+	-	+	+
Chang <i>et al.</i> , (2009) [7]	+	+	+	+	+	+	+
Otto <i>et al.</i> , [8] (2015)	+	+	+	+	+	+	-
Borgia <i>et al.</i> , [9] (2016)	+	+	+	+	+	+	+
Bernharta <i>et al.</i> , (2010) [10]	+	-	+	-	+	+	+
Biacchi <i>et al.</i> , (2012) [11]	+	+	+	-	+	+	+
Tzimas <i>et al.</i> , (2018) [12]	+	+	+	+	+	+	+

RESULTS AND DISCUSSION

A thorough study was carried out to assess the clinical success rates of endocrown restorations on teeth that had undergone endodontic treatment. At first, 2,584 possible records in total were located. After eliminating duplicates and non-qualifying articles from titles and abstracts, 9 complete articles remained. 7 of them were *in vitro* research, while 2 of them were clinical investigations.

In the retrospective chart review of three private general practices in various areas of Alabama, Alley *et al.* [4] (2004) did research that sought to evaluate the effectiveness of endodontic therapy delivered by specialists versus generalists. 350 of the roughly 3,000 charts reviewed satisfied the requirements for inclusion. Among these, 155 teeth received endodontic treatment from endodontists, who had a success rate of 98.1%, compared to generalists, who treated 195 teeth, with an 89.7% success rate. The success criterion was the existence of the treated tooth five years after treatment began. This little study concluded that specialized endodontic therapy was much more successful.

An *in vitro* study by Mannocci *et al.* [5] (2009) compared the clinical success rate of endodontically treated premolars repaired using fiber posts and direct composite restorations to a comparable procedure using full-coverage metal-ceramic crowns. There were no problems at the 1-year recall. Post-documentation and signs of a marginal gap between the tooth and restoration were among the failures seen at 2 and 3 years. The confidence interval for the failure rates between the two groups ranged from -17.5 to 12.6, and there was no discernible difference between them. Additionally, with confidence intervals ranging from -9.7 to 16.2 and -17.8 to 9.27, there was no significant difference between the two treatment groups' failure rates due to post-documentation and marginal gaps. Within the constraints of this investigation, it was determined that after three years of service, the clinical success rates of premolars that had undergone endodontic treatment and were restored with fiber posts and direct composite restorations were comparable to those of teeth that had received full-coverage metal-ceramic crowns.

The *in vitro* study by Bindl *et al.*, [6] (1999), the goal was to evaluate the clinical effectiveness and long-term survivability of CAD/CIM "endo-crowns" over 2 years. 13 patients with 19 CEREC "endo-crowns" (4 premolars and 15 molars) were examined at the start and end of an average 26-month period using modified USPHS criteria. In this study, researchers compared the ratings from the two evaluations. The 19 endo-crowns had an average longevity of 26.6 months, ranging from 14 to 35.5 months. Due to recurrent cavities, one molar's "endo-crown" collapsed after 28 months. Overall, the CEREC "endo-crowns" had outstanding clinical quality, and thus far, the clinical strategy has been workable.

Comparing the resistance to fracture and failure patterns between CEREC endo-crowns and CEREC classic-designed

crowns was the aim of the laboratory investigation done by Chang *et al.* (2009) [7]. Two sets (C and E) of twenty whole maxillary premolars were randomly selected. The specimen's crown part was cut to 1.5 mm above the cemento-enamel junction (CEJ). All specimens underwent vertical compaction gutta-percha obturation after endodontic treatment with a nickel-titanium rotary system. Group C had a mean fracture resistance standard deviation of 1163.30 N, while Group E had a standard deviation of 1446.68 N. Between the two groups, there was a significant difference in fracture resistance ($P < 0.05$). Both groups showed unfavorable fractures regarding failure patterns, with no discernible difference between them.

In a private practice scenario by Otto *et al.*, [8] (2015), 55 patients underwent chairside manufacture of 40 shoulder crowns (control) and 25 endo crowns (test) utilizing the Cerec 3 (CAD/CAM) technique and Vita Mark II feldspathic ceramic. Using updated USPHS criteria, the crowns were evaluated at the start and up to 12 years later. For molars, the survival percentage for endo crowns was 90.5%, while for premolars, it was 75%. In this laboratory study, the survival rates between the two groups did not vary statistically significantly ($P > 0.05$). The durability of Vita Mark II Cerec 3 shoulder crowns on molars and premolars and endo crowns on molars was assessed to be very good for private practice. However, premolar endo crowns showed a somewhat increased chance of failure.

This research done by Borgia *et al.* [9] (2016) intends to provide the retrospective clinical results of 11 endocrowns implanted during an 8–19-year span in a single private practice. Eleven of the 130 patients who were randomly chosen were given endocrowns. There were three resin cements and three distinct restorative materials used. Cohen's Kappa coefficients for the restorations' quality assessments ranged from 0.78 to 1. Inferential statistical techniques were not possible because of the small sample size. Descriptive statistical techniques were used. The findings showed that ten endocrowns (90.9%) were operating well during the clinical assessment, whereas one (9.1%) had failed.

Over a two-year monitoring period, this clinical trial done by Bernhart *et al.* (2010) [10] evaluated the clinical prognosis of Cerec3D endocrowns. The dual-curing bonding compound Panavia™ F 2.0 was used to implant 20 Cerec endocrowns. 90% of the Cerec endocrowns survived after two years. Two of the twenty endocrowns failed because of fractures; the first fracture happened at 12 months, and the second fracture happened at 18 months. Throughout the examination, no signs of recurrent caries were seen. Three restorations had mild percussion symptoms in the first few weeks following installation. These results suggest that endo crowns may provide excellent cosmetic and functional outcomes compared to other restoration techniques. As a treatment option for molars that have undergone endodontic treatment, CAD/CAM-fabricated crowns have a lot of potential.

The *in vitro* research done by Biacchi *et al.* (2012) [11] compared the fracture strength of complete ceramic crowns made using two techniques: indirect conventional crowns held in place by glass fiber supports and endo crowns with a pulp chamber "anchorage." There were two sets of ten healthy mandibular molars (n=20). The Mann-Whitney nonparametric test's statistical analysis indicated significant differences between the two groups (p=0.002). Comparing Group GE to Group GC, Group GE showed more resistance to compressive stresses. In both groups, tooth fracture on the side of force application and/or restoration displacement on the opposite side were the most common failure patterns.

This clinical study done by Tzimas *et al.* (2018) [12] looks at the production and therapeutic efficacy of four endocrowns.

Computer-aided design/computer-aided-manufactured molar endocrowns were used in two clinical instances; one used feldspathic ceramic, and the other used a hybrid composite-ceramic repair. The latter two instances used premolar endocrown restorations made of a resin composite in a dental laboratory. Endocrown restorations, whether created from glass ceramic, resin composite, or hybrid materials, provide a good clinical option. However, for effective endocrown restorations, precise recommendations that need little modification must be followed. A cautious selection of patients is advised since little information is available on the long-term effectiveness of this restorative approach.

Table 2. Summary of findings from included studies.

Author's name	Objectives	Study Title	Study Design	Sample Size	Treatment Comparison	Clinical Outcome
Alley <i>et al.</i> , [4] (2004)	Evaluate the clinical success rates of endo crown restorations on endodontically treated teeth.	Comparison of Specialists vs. Generalists	Retrospective Chart Review	350 teeth	General dentists vs. Endodontists	Generalists: 89.7% success rate; Endodontists: 98.1% success rate
Mammocci <i>et al.</i> , [5] (2009)	Compare the success of endodontic treatment provided by specialists versus generalists.	In Vitro Study on Premolars	In Vitro Study	Not specified	Fiber posts + Direct composite vs. Metal-ceramic crowns	Equivalent clinical success rates after 3 years
Bindl <i>et al.</i> , [6] (1999)	Compare the clinical success rate of endodontically treated premolars restored with fiber posts and direct composite restorations to full-coverage metal-ceramic crowns.	Long-Term Viability of CAD/CIM 'Endo-Crowns'	In Vitro Study	19 'Endo-Crowns'	Not specified	Clinical quality of 'Endo-Crowns' was excellent
Chang <i>et al.</i> , (2009) [7]	Assess the long-term viability and clinical efficacy of CAD/CIM 'endo-crowns'	Fracture Resistance of CEREC Endo-Crowns	Laboratory Study	20 intact maxillary premolars	CEREC Endo-Crowns vs. CEREC classic-designed crowns	CEREC Endo-Crowns had significantly higher fracture resistance
Otto <i>et al.</i> , [8] (2015)	Compare the resistance to fracture and failure patterns between CEREC endo-crowns and CEREC classic-designed crowns	Survival Rate of Endo Crowns vs. Shoulder Crowns	Clinical Study	55 patients	Endo crowns vs. Shoulder crowns	No statistically significant difference in survival rates

Borgia <i>et al.</i> , [9] (2016)	Assess the survival rate and longevity of Endo crowns and shoulder crowns fabricated using CAD/CAM method	Retrospective Clinical Outcomes of Endo Crowns	Clinical Study	11 Endo crowns	Not specified	90.9% functioning well, 9.1% failure rate
Bernhart <i>et al.</i> , [10] (2010)	Evaluate the clinical prognosis of Cerec3D endocrowns	clinical prognosis of Cerec3D endocrowns	Clinical trial	20 Cerec endocrowns	Cerec3D endocrowns with PanaviaTM F 2.0 bonding compound	90% survival rate after two years; two fractures occurred at 12 and 18 months; no recurrent caries observed; mild percussion symptoms in three restorations initially
Biacchi <i>et al.</i> , (2012) [11]	Compare fracture strength of complete ceramic crowns made using different techniques	strength of complete ceramic crowns made using different techniques	In Vitro Research	20 healthy mandibular molars (10 in each group)	Indirect conventional crowns with glass fiber supports vs. endocrowns with pulp chamber "anchorage."	Group GE (endocrowns) showed higher resistance to compressive stresses; common failure patterns were tooth fracture on the side of force application and/or restoration displacement on the opposite side.
Tzimas <i>et al.</i> , (2018) [12]	Assess the production and therapeutic efficacy of different types of endocrowns	therapeutic efficacy of different types of endocrowns	Clinical Study	Molar endocrowns: 2 clinical cases; Premolar endocrowns: Not specified	Molar endocrowns: Feldspathic ceramic vs. hybrid composite-ceramic repair; Premolar endocrowns: Resin composite	Endocrown restorations made from glass ceramic, resin composite, or hybrid materials were considered a good clinical option; precise recommendations and cautious patient selection are advised due to limited information on long-term effectiveness

This systematic review's main objective was to assess in vitro studies' results on the durability and efficacy of endo crowns. The investigation showed that endo crowns used to restore posterior teeth had fracture strengths that were on par with or higher than those of traditional crowns. In contrast to traditional crowns, however, endo crowns made of lithium disilicate ceramic showed a greater incidence of catastrophic failures. Endo crowns and conventional crowns had comparable results when used to restore endodontically treated molars and premolars regarding clinical survival and success rates, supporting the null hypothesis.

The study's findings confirmed the research hypothesis that teeth with limited tooth structure loss produced comparable failure rates and failure modes to teeth restored with full crown coverage when treated endodontically and restored using adhesive techniques, fiber posts, and composite materials. To reduce bias, it would have been better to include matched sets of teeth in the research plan. It was impossible to assemble sufficient participants with two premolars with

Class II carious lesions that needed endodontic treatment owing to practical limitations. As a result, just one tooth per subject was examined. Adhesive restoration methods were employed to retain the healthiest tooth structure possible.

Additionally, direct composite restoration of premolars was shown to be more predictable than molars, partly because less composite material was used for the restoration, which reduced polymerization contraction stress. Premolar interproximal margins are also easier to check and finish because of their accessibility. Since those studies were retrospective, it could not compare with earlier research on post-crown or composite restorations of teeth that had undergone endodontic treatment [13]. The integrated retention portion of the endo-crown, which protrudes apically, was filled into the pulp chamber's central retention cavity using computer-aided manufacturing. This integrated retention portion does not depend on macro mechanical retention as traditionally fitted crowns do. However, it's believed that adhesive bonding transfers lateral stress from

functional and balancing connections to the pulp chamber walls. The amount of potential tooth and crown surface area available for adhesive retention and transferring masticatory pressures to the root depends on the depth of the pulp cavity and the consequent (endo-) anchor at the base of the crown. These forces' strength and direction are yet unclear [14].

This *in vitro* research examined how temperature cycling and fatigue loading affected the fracture resistance and fracture modes of CEREC endo-crowns and traditionally built CEREC ceramic crowns with glass fiber-reinforced composite supports. In clinical situations, the accumulation of microstructural damage during chewing, particularly in an aqueous environment, may result in catastrophic failures. Additionally, cyclic loading before testing dramatically decreased the fracture strength of all-ceramic crowns. Given how crucial heat cycling and fatigue loading are in determining the clinical performance of restorations, this *in vitro* research looked into these factors for both restorations [15, 16]. In private dental practice, the combined survival estimate of shoulder crowns and endocrowns, which reached 90.3% over a maximum of 12 years, reflects an extremely good result. The patient opinion survey, which shows a high degree of acceptability for the treatment techniques and results, lends further weight to this favorable assessment. In addition to receiving good marks for margin quality, anatomic shape, surface texture, and color match, the survival estimate was outstanding [17].

The molar/premolar ratio findings in the retrospective case series investigation were comparable to earlier *in vitro* studies by Otto and Mörmann [8] and Bindl *et al.* [7]. Following the results of the investigations mentioned above, the study discovered that the position of the teeth inside the dental arch had no impact on the clinical outcome. Additionally, the proportion of endocrowns (ECs) functioning was greater than Bindl *et al.* [7], where 14 ECs had loosened as opposed to none in our investigation, and equivalent to Otto and Mörmann [8]. Consequently, the clinical outcomes in this research were either superior to or comparable to those described in the papers under review. However, it's crucial to remember that the discrepancies in sample sizes between this research and the two papers mentioned above may restrict the applicability of the comparisons. On the other hand, several clinical investigations have shown that the coronal remnant is essential to the clinical effectiveness of Endocrown Tooth (ETT) restorations. Therefore, it's essential to prepare teeth for EC in a cautious manner. This definition states that the restoration must encompass the whole occlusal surface. To improve biomechanical behavior, onlays are largely responsible for transferring compressive pressures at the tooth-restoration adhesive contact. Given that increasing occlusal thickness was observed to improve fracture resistance, it was recommended to have an occlusal reduction of 3 mm. A 1.2 mm chamfer in the occlusal wall may also offer a ferrule effect, increasing both the teeth' fracture resistance and the restoration retention if the buccal and/or palatal/lingual walls are thicker than 2.0 mm [18].

An Endocrown approach conforms to the anatomical structure of the pulp chamber while preserving root tissue and minimizing internal preparation. The cavity is filled with ceramic material, which provides stiffness but lacks the mechanical qualities of dentinal tissue. Group GE, however, showed greater strength values when subjected to oblique compression stresses. This is explicable because Group GE employed ceramic in larger thickness and quantity than Group GC. The increased resistance seen in the dentin/enamel/ceramic group compared to the dentin/enamel/post/resin/ceramic group is probably due to the strong ability of lithium disilicate ceramics to attach to the tooth structure and the decreased number of bond interfaces. These findings align with prior *in vitro* investigations that have shown endocrowns to have a much greater fracture strength than traditional crowns. Studies conducted *in vivo* have further shown that endocrown restorations work well. It is important to note that while these restorations are rather simple to do, only reinforced ceramics should be used [19]. The clinical report findings showed that the minimally invasive method had a good short-term survival. The second example, which used a feldspathic CAD/CAM glass-ceramic material, had the greatest clinical results. Due to their superior bond with resin cement and tooth tissues, glass-ceramic materials such as feldspathic, leucite reinforced, or lithium disilicate are recommended to fabricate endodontic crowns in several clinical reports [19, 20].

CONCLUSION

The review revealed that endocrown restorations showed promising clinical outcomes, with high survival rates and minimal signs of recurrent caries. *In vitro* studies comparing different techniques and materials demonstrated favorable results for endocrowns in terms of fracture strength and resistance to compressive stresses. However, due to limited information on long-term effectiveness, cautious patient selection and adherence to precise recommendations are advised. Overall, CAD/CAM-fabricated endocrowns offer a potential treatment option for restoring endodontically treated molars.

ACKNOWLEDGMENTS: None

CONFLICT OF INTEREST: None

FINANCIAL SUPPORT: None

ETHICS STATEMENT: None

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