IMPACT OF CORONAL RESTORATION ON THE SUCCESS AND FAILURE OF ENDODONTIC TREATMENT: A NARRATIVE REVIEW

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ABSTRACT

Background: The success of endodontic treatment depends not only on the quality of root canal obturation, but also on the integrity and sealing capacity of the coronal restoration. Clinical studies have shown that a defective coronal restoration can allow reinfection of the root canal system and compromise the apical seal, ultimately leading to treatment failure. In the current context, technological advancements in adhesive materials and CAD/CAM systems have transformed the paradigm of post-endodontic restoration, steering clinical practice toward more conservative and long-lasting solutions. **Objective:** The aim of this narrative review is to analyze the role of coronal restoration in the success or failure of endodontic treatment, by synthesizing data from recent literature and identifying future clinical and technological directions in post-endodontic rehabilitation. **Methods:** A critical analysis of the literature published between 1987 and 2024 was conducted by consulting the PubMed, Scopus, and Web of Science databases. The selection included clinical studies, systematic reviews, and meta-analyses that evaluated the relationship between coronal restoration quality, marginal sealing integrity, and the long-term success of endodontic treatment. **Results:** The synthesized data confirm that coronal sealing integrity directly influences the clinical outcome of endodontic treatment. Endodontically treated teeth with inadequate coronal restorations show a significantly higher incidence of periapical lesions. In contrast, modern adhesive restorations, fabricated using CAD/CAM technology or bioactive materials, provide superior marginal adaptation and optimal stress distribution. **Conclusions:** A timely, hermetic, and biomechanically stable coronal restoration is essential for the long-term success of endodontic treatment. The evolution of adhesive materials, digital technologies, and the interdisciplinary collaboration between the endodontist and the prosthodontist define the new standard of post-endodontic rehabilitation. The future of clinical practice lies in an integrated, digital, and bioactive approach that regards the restored endodontic tooth as a unified biological and functional system.

Key words: *endodontic treatment, coronal restoration, coronal sealing, endodontic failure, dental adhesion, CAD/CAM technology, endocrown.*

1. INTRODUCTION

Endodontic treatment is among the most common procedures aimed at preserving teeth affected by pulpal pathology. Its primary objective is the elimination of infection within the endodontic system and the maintenance of the tooth in the dental arch in a functional and asymptomatic condition. Nevertheless, the long-term success of endodontic therapy is not determined solely by the quality of the root canal obturation, but also by the adequacy of the subsequent coronal restoration (1,2). Endodontic treatment failure is most commonly associated with intra-canal infection caused by a persistent microbial biofilm (3,4), or with recontamination of the root canal system resulting from coronal leakage or the development of structural cracks (5,6).

The coronal restoration of endodontically treated teeth plays a crucial role in determining the long-term prognosis of endodontic therapy. The establishment of an effective and hermetic coronal seal is of paramount importance. The absence of coronal sealing is the most frequent cause of endodontic treatment failure and is associated with an unfavorable prognosis. Coronal microleakage of saliva and microorganisms from the oral cavity compromises periapical healing and jeopardizes therapeutic success (7).

Following completion of endodontic treatment, the tooth becomes more susceptible to fracture and reinfection due to the loss of tooth structure and the structural alterations of the treated dentin (8). In the absence of an adequate coronal restoration, coronal microleakage may allow the penetration of bacteria and their toxins into the endodontic system, thereby compromising the apical seal and leading to the recurrence of periapical lesions (1,9).

The concept of the *"coronal seal"* was introduced to describe the crucial role of the coronal restoration in preventing endodontic reinfection. Clinical studies have demonstrated that the integrity of the coronal marginal seal has an impact on endodontic success that is comparable to — or even greater than — the quality of the root canal obturation (1,2,10).

Another determining factor is the timing of the definitive restoration. Studies have shown that delaying coronal restoration significantly increases the risk of endodontic failure, particularly in posterior teeth subjected to high occlusal loads (11,12). Therefore, the coronal restoration should be performed as soon as possible after canal obturation to prevent reinfection and tooth fracture.

In recent years, advances in adhesive materials and CAD/CAM technologies have opened new perspectives in post-endodontic restoration, providing more conservative and biomechanically predictable solutions (13,14). These developments reinforce the concept that the long-term success of endodontic treatment results from an integrated endodontic–prosthetic approach, in which both stages — root canal sealing and coronal restoration — are equally essential.

2. LITERATURE REVIEW

Over the past few decades, endodontic treatment has evolved significantly, benefiting from technological advancements, the introduction of biocompatible materials, and increasingly efficient irrigation and obturation protocols. Nevertheless, the long-term success rate of endodontic therapy varies considerably across the literature, ranging from 68% to 95%, depending on the evaluation criteria and duration of follow-up (6,15). This variation indicates that, beyond the endodontic technique itself, post-treatment factors, particularly the coronal restoration, play an essential role in maintaining periapical health and tooth functionality.

Numerous studies have demonstrated that coronal structural loss and restorative deficiencies can compromise the apical seal, leading to bacterial reinfection and, consequently, endodontic failure (1,2,16). Thus, the coronal restoration should not be regarded merely as a prosthetic finishing stage but as a biological and biomechanical cornerstone of endodontic success. The concept of the coronal seal has become a key indicator for assessing treatment quality, being closely correlated with periapical healing rates (9,17).

Within the current literature, there is a broad consensus regarding the importance of achieving a rapid, hermetic, and biomechanically stable coronal restoration. However, divergences persist concerning the optimal timing of definitive restoration, the type of restorative material, and the rehabilitation strategy — ranging from direct composite restorations to indirect approaches such as full crowns, onlays, or adhesive endocrowns (18,19).

Furthermore, the development of CAD/CAM technologies and modern adhesive systems has profoundly reshaped the paradigm of post-endodontic restorations, steering clinical practice toward more conservative, minimally invasive, and esthetic solutions (14,20).

In light of these advances, the present literature review aims to synthesize the main research directions concerning the relationship between coronal restoration and the success of endodontic treatment. The analysis will focus on the following aspects:

- the determinant factors influencing endodontic success;
- the mechanisms of coronal microleakage;
- the impact of the type and timing of restoration;
- the biomechanical implications of the residual tooth structure.

The purpose of this synthesis is to emphasize that the long-term success of endodontic treatment depends not only on root canal sealing but also on the integration between endodontics and prosthodontics—within a unified concept of functional and biological tooth restoration.

Determinant Factors in the Success of Endodontic Treatment

The success of endodontic therapy depends on the correct sequence of both biological and technical stages: accurate diagnosis, adequate mechanical and chemical preparation, hermetic obturation, and, not least, an appropriate coronal restoration. Numerous studies have demonstrated that among these stages, the coronal restoration exerts a significant influence on the long-term prognosis (1,2,21).

In a classic study of more than 1,000 endodontically treated teeth, Ray and Trope demonstrated that the periapical status was more strongly correlated with the quality of the coronal restoration than with that of the root canal obturation (1). Subsequently, Gillen et al., in a meta-analysis, confirmed that teeth with an adequate coronal restoration exhibited a significantly higher success rate (77%) compared to those lacking a proper restoration (44%) (2).

Ng et al. proposed a multifactorial model for predicting endodontic success, in which the quality of the coronal seal is regarded as an essential parameter—alongside the absence of residual infection and the adequacy of the apical obturation (6).

Hence, the literature converges on the notion that no matter how well-performed the endodontic procedure may be, it cannot be considered complete without a definitive coronal restoration that is both hermetic and biomechanically stable.

- **Mechanism of Coronal Microleakage**

Following endodontic treatment, the tooth becomes susceptible to reinfection through coronal microleakage, defined as the penetration of microorganisms and their degradation products through marginal defects, microcracks, or deteriorated restorative materials (9,17)

Bacteria can migrate coronally toward the endodontic system within only a few days, colonizing the canal obturation and leading to the recurrence of periapical inflammation (22). Experimental studies have demonstrated that inadequate coronal sealing allows the penetration of dyes and bacteria to an average depth of 2–5 mm inside the root canal system (23).

The factors that promote microleakage include:

- polymerization shrinkage of composite resins,
- marginal adaptation defects,
- secondary caries,
- coronal fractures, and
- incomplete removal of endodontic filling material during prosthetic preparation (24).

Clinicians must recognize that coronal sealing is not merely a matter of restorative material selection, but a comprehensive prosthetic concept—encompassing adaptation, cavity design, cement thickness, and integration with the remaining tooth structure.

- **Quality of Coronal Restoration and Clinical Impact**

Hommez et al. observed a direct relationship between the quality of the coronal restoration and periapical health: teeth with adequate restorations exhibited an apical lesion prevalence of only 15%, compared to 55% in those with defective restorations (16). Similar findings were reported by Tronstad et al., who emphasized that a poorly executed coronal restoration can completely negate the benefits of an otherwise well-performed root canal obturation (25).

Another critical aspect is the longevity of the coronal restoration. Temporary restorative materials are effective only for short periods of approximately 2–4 weeks. Beyond this interval, their permeability increases significantly, allowing bacterial infiltration (22). Therefore, the timing of the definitive restoration becomes a crucial factor—delaying it exposes the tooth to reinfection as well as to potential coronal or radicular fractures.

- **Types of Coronal Restorations: Direct and Indirect**

The choice of coronal restoration depends on the extent of coronal structure loss, the type of tooth, and the esthetic requirements of the case.

Direct restorations (composite resin, amalgam) are appropriate when sufficient, structurally sound coronal walls remain. In contrast, indirect restorations—such as onlays, overlays, full crowns, or endocrowns—are indicated in cases of substantial tooth structure loss.

Aquilino and Caplan reported a survival rate of 81% for endodontically treated teeth covered with full crowns, compared to only 36% for those without coronal protection (11). While crowns provide excellent mechanical reinforcement, they require greater sacrifice of tooth structure. Conversely, modern adhesive restorations—including onlays, overlays, and endocrowns—preserve more dental tissue and provide superior marginal sealing (18).

Endocrown restorations, first described by Bindl and Mörmann (1999), utilize the pulp chamber for macromechanical retention, thereby eliminating the need for a post (20). Recent studies have shown that endocrowns exhibit fracture resistance comparable to, or even greater than, traditional post-retained crowns (19,26). Moreover, the use of modern ceramics—such as lithium disilicate and zirconia—allows for excellent marginal adaptation and superior esthetics, achieving clinical success rates exceeding 90% after five years (18,27).

- **Timing of the Definitive Restoration**

Besides the method used to restore a root-filled tooth, the timing of the definitive restoration also appears to influence tooth survival (28). Root-filled teeth maintained with temporary restorations are more susceptible to microbial leakage (29) and to fractures that render the tooth unrestorable (30). Therefore, an association between the timing of the permanent restoration and overall tooth survival is plausible.

Following completion of endodontic treatment, the definitive coronal restoration should ideally be performed within the first 2–4 weeks to prevent microbial contamination and tooth fracture (11). If the restoration is delayed, even a perfectly executed root canal obturation may become compromised. Magura et al. (1991) demonstrated that teeth restored three months after obturation exhibited bacterial infiltration in 79% of cases, compared to only 20% in those restored immediately (23).

Moreover, temporary restorative materials tend to degrade in the oral environment, losing their sealing capacity within a few weeks (22). This finding supports the recommendation that the definitive restoration should be planned as an integral part of endodontic therapy, rather than as an optional subsequent stage.

- **Biomechanical Factors and the Role of Residual Tooth Structure**

After endodontic treatment, structural changes in dentin—including water loss and alterations in collagen composition—lead to reduced elasticity, thereby increasing susceptibility to fracture (8). Consequently, the preservation of residual coronal walls is essential for the longevity of the restored tooth. Zarow et al. proposed a classification based on the number of remaining walls, demonstrating that tooth survival decreases significantly when more than two walls are missing (14):

- *Class 0 (no post – composite core build-up)*: Unless the coronal tooth structure is severely compromised, the pulp chamber and root canals can provide sufficient retention for core build-up (31). Considering these anatomical characteristics, root-filled molars and certain anterior teeth may not require the placement of posts (32–34).
- *Class 1 (fibre post)*: Post placement is generally recommended for anterior teeth and premolars with extensive structural loss (less than 50% of the coronal structure remaining) (35,36). The use of a post is indicated when two or fewer coronal walls remain in anterior teeth and premolars (37). For molar teeth, post placement is generally unnecessary, except in cases where coronal tooth structure is completely lost and the pulp chamber surface is insufficient to provide adequate retention (38).
- *Class 2 (pre-restorative procedures are needed: orthodontic extrusion or crown lengthening)*: Post placement cannot compensate for the absence or reduction of the ferrule effect. A fiber post should be considered only after orthodontic or surgical crown lengthening. The choice of technique depends on the tooth's position within the arch: for molars, surgical crown lengthening is generally recommended, whereas for premolars and anterior teeth, orthodontic extrusion is often preferable (39–41).
- *Class 3 (gold cast post)*: Teeth lacking a ferrule effect are at increased risk of failure and root fracture (39,41). When achieving a ferrule is not feasible—whether due to periodontal or orthodontic limitations—but the patient still wishes to preserve the tooth, a custom cast gold restoration may represent a viable alternative (42,43).
- Class 4 (extraction): In certain situations, the treatment and restoration of a compromised, root-filled tooth may become overly complex and time-consuming—involving factors such as the absence of a ferrule, the need for retreatment, orthodontic or periodontal crown lengthening, post placement, and coronal coverage—often without a predictable prognosis (14).

The choice of post system must also be carefully considered. Studies have shown that glass fiber posts distribute stress more evenly and reduce the risk of root fracture compared to metal posts (13,44). However, when sufficient coronal tooth structure remains, post placement may be avoided, favoring monoblock adhesive restorations, such as endocrowns.

- **Critical Synthesis of the Literature**

An analysis of studies published between 1990 and 2024 reveals a general consensus: coronal sealing integrity and timely restoration are key determinants of endodontic success. However, the literature remains heterogeneous regarding the definition of an "adequate restoration"—some studies assess only the presence of a coronal coverage, while others consider radiographic marginal integrity.

Most authors emphasize the need to integrate the prosthetic plan during the endodontic phase itself, promoting an interdisciplinary endodontic–prosthetic approach as the optimal strategy for ensuring long-term functional and biological success.

3. FUTURE PERSPECTIVES

With the advancement of modern materials and technologies, the restoration of endodontically treated teeth is undergoing a profound transformation. The current trend is oriented toward minimally invasive, adhesive, and digitally integrated solutions that ensure maximum preservation of tooth structure and long-term coronal sealing. Recent progress in ceramic materials, CAD/CAM systems, and dentin bonding technologies has opened new directions for post-endodontic prosthetic rehabilitation.

- **CAD/CAM Technologies and Monoblock Restorations**

The introduction of CAD/CAM technologies (Computer-Aided Design/Computer-Aided Manufacturing) has revolutionized the design and fabrication of coronal restorations. Modern systems enable the rapid and precise production of monoblock restorations, offering superior marginal adaptation and optimal dimensional control (45). In this context, endocrown restorations—manufactured entirely from ceramic or hybrid CAD/CAM materials—represent a conservative alternative to traditional post-and-core crown systems (18,26).

The materials used, such as lithium disilicate or resin-based hybrid ceramics, provide a unique combination of esthetics, mechanical strength, and optimal adhesion. These materials allow for reduced tissue sacrifice, preservation of coronal wall integrity, and a more uniform distribution of occlusal stress (19). Moreover, monoblock restorations minimize the risk of coronal microleakage by eliminating multiple interfaces between prosthetic components (46).

- **Adhesive Approaches and Minimally Invasive Restorations**

The current trend in restorative dentistry is clearly oriented toward adhesive and conservative techniques. The primary goal is to preserve as many residual coronal walls as possible and to reduce the need for intraradicular posts, which may generate radicular stresses (13,44). New generations of universal adhesives and bioactive composites—based on the controlled release of calcium and fluoride ions—enhance the integration between the restorative material and the dental substrate (47). Likewise, the use of bulk-fill materials, giomers, and nanocomposites provides improved mechanical properties and reduced polymerization shrinkage, thereby decreasing the risk of marginal microleakage (48).

The concept of biomimetic dentistry has become increasingly relevant, promoting restorations that mimic the biomechanical properties of natural teeth, integrating adhesion, esthetics, and function into a unified restorative system.

➢ Digital Integration in the Endodontic–Prosthetic Workflow

Digitalization has begun to eliminate the traditional boundaries between endodontics and prosthodontics. The use of intraoral scanners, 3D imaging (CBCT), and 3D printing technologies enables integrated case planning from the very beginning of the endodontic phase (49). In this way, the clinician can design the final restoration before completing the root canal treatment, anticipating factors such as wall thickness, restorative material volume, and occlusal position. Digital technologies facilitate the fabrication of custom abutments, printable posts, and guided CAD/CAM restorations with marginal precision below 50 µm (45). This digital integration not only enhances the quality and accuracy of restorations but optimizes the clinical workflow, significantly reducing overall treatment time.

➢ Interdisciplinary Collaboration – The Key to Clinical Success

In the near future, an integrated clinical approach is increasingly taking shape—one in which the endodontist and prosthodontist collaborate from the planning stage onward. A successful treatment plan must harmoniously combine biological criteria (infection control, apical sealing) with biomechanical considerations (preservation of coronal walls, stress distribution) and esthetic factors (material selection, color, translucency).

Interdisciplinary collaboration helps prevent transitional errors between treatment phases and ensures continuity of sealing from the root to the coronal level (50). Furthermore, the development of shared digital systems—including collaborative CAD/CAM planning and integrated endodontic–prosthetic software—enhances communication between specialists and enables the creation of personalized restorations tailored to the specific needs of each clinical case.

➢ Future Research Directions

Ongoing research trends focus on:

- the development of smart bioactive materials capable of releasing antimicrobial and remineralizing ions;
- the enhancement of adhesion to moist dentin through nanotechnologies and next-generation polymers;
- the implementation of artificial intelligence in digital endodontic–prosthetic planning to improve failure risk prediction.

These directions highlight a clear transition toward an integrated and personalized form of dentistry, in which the boundary between endodontics and prosthodontics gradually disappears, and the emphasis shifts toward the long-term functional preservation of the natural tooth.

4. CONCLUSIONS

Coronal restoration represents a critical stage in ensuring the long-term success of endodontic treatment. The scientific literature confirms that coronal sealing integrity and the quality of the definitive restoration influence the long-term prognosis of the treated tooth to an extent equal to, if not greater than, that of the root canal obturation itself.

Endodontic failure is often the result of a defective coronal restoration, inadequate marginal sealing, or delayed placement of the definitive restoration. Such deficiencies allow bacterial reinfection of the root canal system, coronal microleakage, and eventual compromise of the apical seal. Therefore, endodontic therapy should be regarded as an integrated process, in which the coronal rehabilitation constitutes a logical and indispensable continuation of root canal obturation.

Recent advances in restorative materials and technologies—ranging from modern ceramics and hybrid materials to CAD/CAM systems and next-generation adhesives—provide clinicians with biomechanically stable, esthetic, and predictable solutions. Adhesive monoblock restorations, such as endocrowns, represent a viable and conservative option for endodontically treated posterior teeth, reducing the need for posts and preserving coronal wall integrity.

At the same time, the integration of digital workflows and interdisciplinary collaboration between the endodontist and prosthodontist have become key factors in optimizing clinical outcomes. This synergy between specialties ensures continuity of the root-to-coronal seal and contributes to the durability of restorations, minimizing the risk of biological and mechanical failure.

In conclusion, long-term endodontic success is strongly influenced by the quality of the coronal restoration and its ability to maintain an effective seal. The future of post-endodontic rehabilitation lies in the development of personalized, digital, and bioactive restorative solutions that combine functionality, esthetics, and longevity. A modern clinical vision should regard the restored endodontic tooth as a single integrated system, where endodontics and prosthodontics are not separate stages, but complementary components of the same therapeutic act.

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